ESR service routers

ESR-10, ESR-12V, ESR-12VF, ESR-14VF, ESR-20, ESR-21, ESR-100, ESR-200, ESR-1000, ESR-1200, ESR-1500, ESR-1700

User manual, Functionality description (29.10.2020)
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Contents

1 Introduction

1.1 Abstract

Today, large-scale communication network development projects are becoming increasingly common. One of the main tasks in implementation of large multiservice networks is the creation of reliable high-performance transport network that will serve as a backbone in multilayer architecture of next-generation networks.

ESR series firewalls could be used in large enterprise networks, SMB networks and operator's networks. Devices provide high performance and bandwidth, and feature protection of transmitted data.

This manual provides descriptions, algorithms, and examples of how to configure the ESR series service router functionality (hereafter referred to as the router or device).

1.2 Target Audience

This user manual is intended for technical personnel that performs device installation, configuration and monitoring via command line interface (CLI) as well as the system maintenance and firmware update procedures. Qualified technical personnel should be familiar with the operation basics of TCP/IP protocol stacks and Ethernet networks design concepts.

1.3 Notes and warnings

Notes contain important information, tips or recommendations on device operation and setup.

Warnings inform users about hazardous conditions which may cause injuries or device damage and may lead to the device malfunctioning or data loss.

2 Interface management

2.1 VLAN Configuration

VLAN (Virtual Local Area Network) is a logical (virtual) local area network that represents a group of devices, which communicate on channel level regardless of their physical location. VLAN operation is based on the use of additional Ethernet header fields according to 802.1q standard. In fact, VLAN isolates the broadcast domain by limiting the switching of only those Ethernet frames which have the same VLAN-ID in the Ethernet header.

2.1.1 Configuration algorithm

Step	Description	Command	Keys
1	Create VLAN	`esr(config)# vlan <VID>`	<VID> – VLAN identifier, set in the range of [2..4094]. It is also possible to create multiple vlan (comma separated), vlan range (hyphen separated) or combined entry containing commas and hyphens.
2	Specify vlan name (optionally)	`esr(config-vlan)# name <vlan-name>`	<vlan-name> – up to 255 characters.
3	Disable monitoring of the status of interfaces on which processing of the given VLAN Ethernet frames is allowed (optional).	`esr(config-vlan)# force-up`	
4	Disable the processing of incoming untagged Ethernet frames based on the default VLAN's switching table (VLAN-ID – 1) (optional).	`esr(config-if-gi)# no switchport forbidden default-vlan`	
5	Set L2 interface operation mode.	`esr(config-if-gi)# mode switchport`	
6	Set the combined mode of the physical interface.	`esr(config-if-gi)# mode hybrid`	Only for ESR-1000/1200/1500/1700
7	Set L2 interface operation mode	`esr(config-if-gi)# switchport access`	Only for ESR-10/12V(F)/14VF/ 20/21/100/200. This mode is the default mode and is not displayed in the configuration.
		`esr(config-if-gi)# switchport trunk`	Only for ESR-10/12V(F)/14VF/ 20/21/100/200.
		`esr(config-gi)# switchport general`	Only for ESR-1000/1200/1500/1700. This mode is the default mode and is not displayed in the configuration.
8	Configure VLAN list on the interface in tagged mode	`esr(config-if-gi)# switchport trunk allowed vlan add <VID>`	For ESR-10/12V(F)/14VF/ 20/21/100/200. <VID> – VLAN ID, specified in the range [2..4094]. It is also possible to create multiple vlan (with a comma) or vlan range (with a hyphen).

Step	Description	Command	Keys
		`esr(config-if-gi)# switchport general allowed vlan add <VID> tagged`	For ESR-1000/1200/1500/1700. <VID> – VLAN ID, specified in the range [2..4094]. It is also possible to create multiple vlan (with a comma) or vlan range (with a hyphen).
9	Configure VLAN on the interface in tagged mode (optionally)	`esr(config-if-gi)# switchport trunk native-vlan <VID>`	For ESR-10/12V(F)/14VF/ 20/21/100/200. <VID> – VLAN ID, specified in the range [2..4094].
		`esr(config-if-gi)# switchport general allowed vlan add <VID> untagged`	For ESR-1000/1200/1500/1700. <VID> – VLAN identifier, set in the range of [2..4094].
10	Enable the processing of Ethernet frames of all created VLANs on the interface (optionally)	`esr(config-if-gi)# switchport trunk allowed vlan auto-all`	Only for ESR-10/12V(F)/14VF/ 20/21/100/200.
		`esr(config-if-gi)# switchport general allowed vlan auto-all`	Only for ESR-1000/1200/1500/1700.

2.1.2 Configuration example 1. VLAN removal from the interface

Objective:

On the basis of the factory configuration, remove gi1/0/1 port from VLAN 2.

Solution:

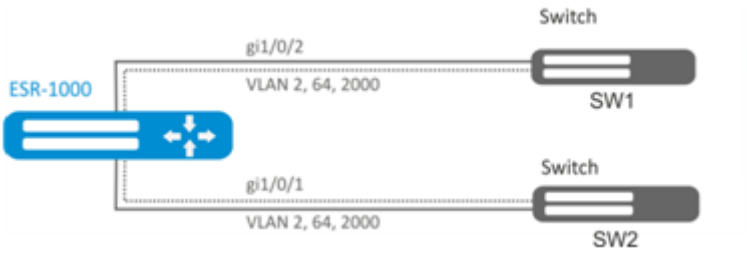
Remove VLAN 2 from gi1/0/1 port:

```
esr(config)# interface gi 1/0/1
esr(config-if-gi)# switchport general allowed vlan remove 2 untagged
esr(config-if-gi)# no switchport general pvid
```

2.1.3 Configuration example 2. Enabling VLAN processing in tagged mode

Objective:

Configure gi1/0/1 and gi1/0/2 ports for packet transmission and reception in VLAN 2, VLAN 64, VLAN 2000.



Solution:

Create VLAN 2, VLAN 64, VLAN 2000 on ESR-1000:

```
esr-1000(config)# vlan 2,64,2000
```

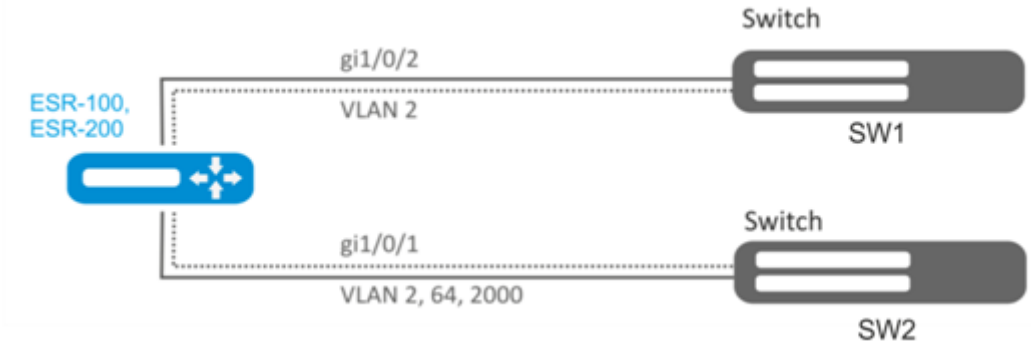
Specify VLAN 2, VLAN 64, VLAN 2000 for gi1/0/1-2 port:

```
esr-1000(config)# interface gi1/0/1
esr-1000(config-if-gi)# mode switchport
esr-1000(config-if-gi)# switchport forbidden default-vlan
esr-1000(config-if-gi)# switchport general allowed vlan add 2,64,2000 tagged
```

2.1.4 Configuration example 3. Enabling VLAN processing in tagged and untagged modes

Objective:

Configure gi1/0/1 ports for packet transmission and reception in VLAN 2, VLAN 64, VLAN 2000 in trunk mode, configure gi1/0/2 port in access mode for VLAN 2 on ESR-100/ESR -200.



Solution:

Create VLAN 2, VLAN 64, VLAN 2000 on ESR-100/ ESR-200:

```
esr(config)# vlan 2,64,2000
```

Specify VLAN 2, VLAN 64, VLAN 2000 for gi1/0/1 port:

```
esr(config)# interface gi1/0/1
esr(config-if-gi)# mode switchport
esr(config-if-gi)# switchport forbidden default-vlan
esr(config-if-gi)# switchport mode trunk
esr(config-if-gi)# switchport trunk allowed vlan add 2,64,2000
```

Specify VLAN2 to gi1/0/2 port:

```
esr(config)# interface gi1/0/2
esr(config-if-gi)# mode switchport
esr(config-if-gi)# switchport access vlan 2
```

2.2 LLDP configuration

Link Layer Discovery Protocol (LLDP) is a data link layer protocol allowing network equipment to notify the devices operating in a local network of its existence and to transmit parameters to it as well as to receive similar information.

2.2.1 Configuration algorithm

Step	Description	Command	Keys
1	Enable LLDP on the router.	`esr(config)# lldp enable`	
2	Enable the LLDPDU receiving and proceeding on the physical interface.	`esr(config-if-gi)# lldp receive`	
3	Enable LLDPDU transmission on the physical interface.	`esr(config-if-gi)# lldp transmit`	
8	Set the LLDPDU sending period (optionally).	`esr(config)# lldp timer <SEC>`	<SEC> – time interval in seconds, takes values of [1..32768]. Default value: 30
4	Set the period during which the router keeps the information received via LLDP (optionally)	`esr(config)# lldp hold-multiplier <SEC>`	<SEC> – time interval in seconds, takes values of [1..10]. Default value: 4
5	Set IP address which will be transmitted to LLDP TLV as the management-address (optionally).	`esr(config)# lldp management-address <ADDR>`	<ADDR> – IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]. One of the existent is set by default

Step	Description	Command	Keys
6	Set the system-description field which will be transmitted to LLDP TLV as the system-description (optionally).	`esr(config)# lldp system-description <DESCRIPTION>`	<DESCRIPTION> – system description, set by the string of up to 255 characters. By default contains the information of the router model and firmware version.
7	Set the system-name field which will be transmitted to LLDP TLV as the system-name (optionally).	`esr(config)# lldp system-name <NAME>`	<NAME> – system name, set by the string of up to 255 characters. By default coincides with the specified hostname

2.2.2 Configuration example

Objective:

Organize the LLDPDU exchange and proceeding between ESR-1 and ESR-2 routers.

Solution:

1. R1 configuration
   Enable LLDP globally on the router:

   ```
   esr(config)# lldp enable
   ```

   Enable the receiving and transmission of LLDPDU on the gi 1/0/1 interface.

   ```
   esr(config)# interface gigabitethernet 1/0/1
   esr(config-if-gi)# lldp receive
   esr(config-if-gi)# lldp transmit
   ```

2. R2 configuration
   Enable LLDP globally on the router:

   ```
   esr(config)# lldp enable
   ```

   Enable the receiving and transmission of LLDPDU on the gi 1/0/1 interface.

```
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)# lldp receive
esr(config-if-gi)# lldp transmit
```

To view LLDP neighbors information, use the following command:

```
esr# show lldp neighbors
```

To view more detailed information on the certain interface neighbor, use the following command:

```
esr# show lldp neighbors gigabitethernet 1/0/1
```

To view LLDP statistics, use the following command:

```
esr# show lldp statistics
```

2.3 LLDP MED configuration

LLDP MED is LLDP standard enhancement which allows to transmit network policies: VLAN ID, DSCP, priority.

2.3.1 Configuration algorithm

Step	Description	Command	Keys
1	Enable LLDP on the router	`esr(config)# lldp enable`	
2	Enable LLDPDU transmission on the physical interface.	`esr(config-if-gi)# lldp transmit`	
3	Enable MED LLDP enhancement on the router	`esr(config)# lldp med fast-start enable`	
4	Create network policy.	`esr(config)# network-policy <NAME>`	<NAME> – network-policy name, set by the string of up to 31 characters.
5	Specify the application type.	`esr(config-net-policy)# application <APP_TYPE>`	<APP-TYPE> – type of the application for which network-policy will be enabled. Takes the following values: • voice; • voice-signaling; • guest-voice; • guest-voice-signaling; • softphone-voice; • video-conferencing; • streaming-video; • video-signaling.

Step	Description	Command	Keys
6	Set the DSCP value (optional).	`esr(config-net-policy)# dscp <DSCP>`	<DSCP> – DSCP code value, takes values in the range of [0..63].
7	Set the CoS value (optional).	`esr(config-net-policy)# priority <PRIORITY>`	<COS> – priority value, takes the following values: • best-effort – COS0; • background – COS1; • excellent-effort – COS2; • critical-applications – COS3; • video – COS4; • voice – COS5; • internetwork-control – COS6; • network-control – COS7.
8	Set VLAN ID value.	`esr(config-net-policy)# vlan <VID> [tagged]`	<VID> – VLAN ID, takes values of [1..4094]; • **tagged** – key, during the installation of which, the subscriber device will send Ethernet frames of the specified application in a tagged form.
9	Set a network policy on the interface.	`esr(config-if-gi)# lldp network-policy <NAME>`	<NAME> – network-policy name, set by the string of up to 31 characters.

2.3.2 Voice VLAN configuration example

Voice VLAN — VLAN ID, in receiving of which an IP phone switches to the trunk mode with the specified VLAN ID for VoIP traffic reception and transmission. VLAN ID transmission is performed by LLDP MED enhancement.

Objective:

VoIP traffic and data traffic should be grouped in different VLANs - vid 10 for data and vid 20 for VoIP - and the sending of Voice VLAN from the gi 1/0/1 ESR port should be configured. Voice VLAN should be supported and enabled on the IP phone.

Solution:

First create VLAN 10 and 20 and configure the gi 1/0/1 interface in the trunk mode:

```
esr(config)# vlan 10,20
esr(config-vlan)# exit
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)# mode switchport
esr(config-if-gi)# switchport mode trunk
esr(config-if-gi)# switchport trunk allowed vlan add 10,20
esr(config-if-gi)# exit
```

Enable LLDP and MED capability in LLDP globally on the router:

```
esr(config)# lldp enable
esr(config)# lldp med fast-start enable
```

Create and configure network policy in the way that VLAN ID 20 is specified for the voice application:

```
esr(config)# network-policy VOICE_VLAN
esr(config-net-policy)# application voice
esr(config-net-policy)# vlan 20 tagged
esr(config-net-policy)# exit
```

Configure LLDP on the interface and set a network policy:

```
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)# lldp transmit
esr(config-if-gi)# lldp receive
esr(config-if-gi)# lldp network-policy VOICE_VLAN
esr(config-if-gi)# exit
```

2.4 Sub-interface termination configuration

To terminate Ethernet frames of a certain VLAN on a specific physical interface, you need to create a sub-interface with the number of VLAN, frames of which will be terminated. When creating two sub-interfaces having the same VLAN but located on different physical/aggregated interfaces, switching of Ethernet frames between these sub-interfaces will not be possible as external segments will be separate broadcast domains. For data exchange between subscribers of different sub-interfaces (even with the same VLAN-ID) routing will be used, i.e. data exchange will occur at the third level of the OSI model.

2.5 Configuration algorithm

Step	Description	Command	Keys

1	Create a sub-interface of a physical interface (possible if the physical interface is in routeport or hybrid mode).	`esr(config)# interface gigabitethernet <PORT>.<S-VLAN>`
		or
		`interface tengigabitethernet <PORT>.<S-VLAN>`
		or
		`interface port-channel <CH>.<S-VLAN>`
			<PORT> – physical interface number.
			
			<CH> – aggregated interface number.
			
			<S-VLAN> – identifier of created S-VLAN.
			
			If a physical interface is included in bridge-group, it will be impossible to create sub-interface.

2	Specify sub-interface description (optionally).	`esr(config-subif)# description <DESCRIPTION>`	<DESCRIPTION> – interface description, set by the string of up to 255 characters.
3	Specify VRF instance, in which the given sub-interface will operate (optionally).	`esr(config-subif)# ip vrf forwarding <VRF>`	<VRF> – VRF name, set by the string of up to 31 characters.
4	Specify the IPv4/IPv6 address and subnet mask for the interface to be configured or enable IP address obtain dynamically.	`esr(config-subif)# ip address <ADDR/LEN>`	<ADDR/LEN> – IP address and subnet mask length, defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32]. For advanced IPv4 addressing features see section IP addressing configuration.
		`esr(config-subif)# ipv6 address <IPV6-ADDR/LEN>`	<IPV6-ADDR/LEN> – IP address and prefix of a subnet, defined as X:X:X:X::X/EE where each X part takes values in hexadecimal format [0..FFFF] and EE takes values of [1..128]. For advanced IPv6 addressing features see section IPv6 addressing configuration. You can specify several IPv4/IPv6 addresses separated by commas. Up to 8 IPv4/IPv6 addresses can be assigned to the interface.
		`esr(config-subif)# ip address dhcp`	For advanced DHCP client operation features, see section DHCP client management.

Step	Description	Command	Keys
5	Disable the Firewall features on the interface or enable the interface in the security zone (see Firewall configuration).	`esr(config-subif)# ip firewall disable`	
		`esr(config-subif)# security-zone <NAME>`	<NAME> – security zone name, set by the string of up to 31 characters.
6	Set the time interval during which statistics on the sub-interface load is collected. (optionally).	`esr(config-subif)# load-average <TIME>`	<TIME> – interval in seconds, takes values of [5..150].

7	Set the lifetime of IPv4/IPv6 entries in the ARP table studied on the given interface (optionally).	`esr(config-subif)# ip arp reachable-time <TIME>`
		or
		`esr(config-subif)# ipv6 nd reachable-time <TIME>`
			<TIME> – lifetime of dynamic MAC addresses, in milliseconds. Allowed values are from 5000 to 100000000 milliseconds. Real time of the entry update varies from [0,5;1,5]*<TIME>.

8	Change MTU (MaximumTransmitionUnit) size. MTU above 1500 will be active only when using the «system jumbo-frames» command (optional).	`esr(config-subif)# mtu <MTU>`	<MTU> – MTU value in bytes. Default value: 1500.
9	Enable recording of the current interface usage statistics (optional).	`esr(config-subif)# history statistics`	
10	Override the MSS (Maximum segment size) field in incoming TCP packets (optional).	`esr(config-subif)# ip tcp adjust-mss <MSS>` `esr(config-subif)# ipv6 tcp adjust-mss <MSS>`	<MSS> – MSS value, takes values in the range of [500..1460]. Default value: 1460

It is also possible to configure the sub-interface:

- QoS in basic or advanced mode (see section QoS management);
- proxy (see section HTTP/HTTPS traffic proxying);
- traffic monitoring (see sections Netflow configuration and sFlow configuration);
- routing protocols functionality (see section Routing management);
- VRRF protocol (see section Redundancy management);
- BRAS functionality (see section BRAS (Broadband Remote Access Server) management);
- IDS/IPS functionality (see section IPS/IDS configuration).

2.5.1 Sub-interface configuration example

Objective:

Configure subnet 192.168.3.1/24 in VLAN: 828 on the physical interface gigabitethernet 1/0/1.

Solution:

Create sub-interface for VLAN: 828

```
esr(config)# interface gigabitethernet 1/0/1.828
```

Configure IP address from necessary subnet.

```
esr(config)# interface gigabitethernet 1/0/1.828
esr(config-subif)# ip address 192.168.3.1/24
esr(config-subif)# exit
```

⚠ In addition to assigning an IP address, you must either disable the firewall or configure the corresponding security zone on the sub interface.

2.6 Q-in-Q termination configuration

Q-in-Q is a technology of packet transmission with two 802.1q tags. The technology is used for extending quantity of VLANs in data networks. 802.1q header, which is closer to payload, is an Inner Tag also known as C-VLAN (Customer VLAN). 802.1q header, which is comes before C-VLAN, is an Outer Tag also known as S-VLAN (Service VLAN). Using of double tags in Ethernet frames is describing by 802.1ad protocol.

2.6.1 Configuration algorithm

Step	Description	Command	Keys

1	Create a sub-interface of a physical interface (possible if the physical interface is in routeport or hybrid mode).	`esr(config)# interface gigabitethernet <PORT>.<S-VLAN>`
		or
		`interface tengigabitethernet <PORT>.<S-VLAN>`
		or
		`interface port-channel <CH>.<S-VLAN>`
			<PORT> – physical interface number.
			<CH> – aggregated interface number.
			<S-VLAN> – identifier of created S-VLAN.
			If a physical interface is included in bridge-group, it will be impossible to create sub-interface.

Step	Description	Command	Keys

2	Create Q-in-Q interface.	`esr(config)# interface gigabitethernet <PORT>.<S-VLAN>.<C-VLAN>`
		or
		`esr(config)# interface tengigabitethernet <PORT>.<S-VLAN>.<C-VLAN>`
		or
		`esr(config)# interface port-channel <CH>.<S-VLAN>.<C-VLAN>`
			<PORT> – physical interface number.
			
			<CH> – aggregated interface number.
			
			<S-VLAN> – identifier of created S-VLAN.
			
			<C-VLAN> – identifier of created C-VLAN.
			
			If a physical interface or a sub-interface is included in bridge-group, it will be impossible to create sub-interface.

3	Specify Q-in-Q interface description (optionally).	`esr(config-qinq-if)# description <DESCRIPTION>`	<DESCRIPTION> – interface description, set by the string of up to 255 characters.
4	Specify VRF instance, in which the given Q-in-Q interface will operate (optionally).	`esr(config-qinq-if) # ip vrf forwarding <VRF>`	<VRF> – VRF name, set by the string of up to 31 characters.
5	Specify the IPv4/IPv6 address and subnet mask for the interface to be configured or enable IP address obtain dynamically.	`esr(config-qinq-if)# ip address <ADDR/LEN>`	<ADDR/LEN> – IP address and subnet mask length, defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32]. For advanced IPv4 addressing features see section IP addressing configuration.
		`esr(config-qinq-if)# ipv6 address <IPV6-ADDR/LEN>`	<IPV6-ADDR/LEN> – IP address and prefix of a subnet, defined as X:X:X:X::X/EE where each X part takes values in hexadecimal format [0..FFFF] and EE takes values of [1..128]. For advanced IPv6 addressing features see section IPv6 addressing configuration. You can specify several IPv4/IPv6 addresses separated by commas. Up to 8 IPv4/IPv6 addresses can be assigned to the interface.
		`esr(config-qinq-if)# ip address dhcp`	For advanced DHCP client operation features, see section DHCP client management.

Step	Description	Command	Keys
6	Disable the Firewall features on the interface or enable the interface in the security zone (see Firewall configuration).	`esr(config-qinq-if)# ip firewall disable`	
		`esr(config-qinq-if)# security-zone <NAME>`	<NAME> – security zone name, set by the string of up to 31 characters.
7	Set the time interval during which statistics on the sub-interface load is collected. (optionally).	`esr(config-subif)# load-average <TIME>`	<TIME> – interval in seconds, takes values of [5..150].

8	Set the lifetime of IPv4/IPv6 entries in the ARP table studied on the given interface (optionally).	`esr(config-subif)# ip arp reachable-time <TIME>`
		or
		`esr(config-subif)# ipv6 nd reachable-time <TIME>`
			<TIME> – lifetime of dynamic MAC addresses, in milliseconds. Allowed values are from 5000 to 100000000 milliseconds. Real time of the entry update varies from [0,5;1,5]*<TIME>.

9	Change MTU (MaximumTransmitionUnit) size. MTU above 1500 will be active only when using the 'system jumbo-frames' command (optionally).	`esr(config-subif)# mtu <MTU>`	<MTU> – MTU value in bytes. Default value: 1500.
10	Enable recording of the current interface usage statistics (optional).	`esr(config-subif)# history statistics`	
11	Override the MSS (Maximum segment size) field in incoming TCP packets (optional).	`esr(config-subif)# ip tcp adjust-mss <MSS>` `esr(config-subif)# ipv6 tcp adjust-mss <MSS>`	<MSS> – MSS value, takes values in the range of [500..1460]. Default value: 1460

It is also possible to configure the sub-interface:

- QoS in basic or advanced mode (see section QoS management);
- proxy (see section HTTP/HTTPS traffic proxying);
- traffic monitoring (see sections Netflow configuration and sFlow configuration);
- routing protocols functionality (see section Routing management);
- VRRF protocol (see section Redundancy management);
- BRAS functionality (see section BRAS (Broadband Remote Access Server) management);
- IDS/IPS functionality (see section IPS/IDS configuration).

2.6.2 Q-in-Q configuration example

Objective:

Configure the termination of subnet 192.168.1.1/24 combination C-VLAN: 741, S-VLAN: 828 on the physical interface gigabitethernet 1/0/1.

Solution:

Create sub-interface for S-VLAN: 828

```
esr(config)# interface gigabitethernet 1/0/1.828
esr(config-subif)# exit
```

Create a Q-in-Q interface for the S-VLAN: 741 and configure the IP address from the required subnet.

```
esr(config)# interface gigabitethernet 1/0/1.828.741
esr(config-qinq-if)# ip address 192.168.1.1/24
esr(config-qinq-if)# exit
```

⚠ Besides assigning IP address, it is necessary to disable firewall or to configure corresponding security zone on Q-in-Q interface.

2.7 USB modems configuration

The use of USB modems allows organizing additional link channel for router operation. When connecting USB modems, you may use USB hubs. Up to 10 USB modems can be configured in the system at the same time.

2.7.1 USB modems configuration algorithm

Step	Description	Command	Keys
1	After USB modem connection, wail until the system detects the connected device.		
2	Define which number of the device is allocated to the connected USB modem.	`esr# show cellulars status modem`	The connected device identifier will be specified in 'USB port' field
3	Create parameter profile for USB modem and switch to the profile configuration mode.	`esr(config)# cellular profile <ID>`	<ID> – identifier of USB modem parameter profile, set in the range of [1..10].
4	Specify parameter profile description (optional).	`esr(config-cellular-profile)# description <DESCRIPTION>`	<DESCRIPTION> – profile description, set by the string of up to 255 characters.

Step	Description	Command	Keys
5	Set mobile network access point	`esr(config-cellular-profile)# apn <NAME>`	<NAME> – mobile network access point, set by the string of up to 31 characters.
6	Set the name of mobile network user (if authentication by login/password required by cellular carrier).	`esr(config-cellular-profile)# user <NAME>`	<NAME> – user name, set by the string of up to 31 characters.
7	Set the password of mobile network user (if authentication by login/password required by cellular carrier).	`esr(config-user)# password ascii-text { <CLEAR-TEXT> | encrypted <ENCRYPTED-TEXT> }`	<CLEAR-TEXT> – unencrypted password, set by the string of [1..64] characters, may include [0-9a-fA-F] characters. <ENCRYPTED-TEXT> – unencrypted password, set by the string of [2..128] characters.
8	Activate user (if authentication by login/password required by cellular carrier).	`esr(config-user)# enable`	
9	Set the dial-up number for connection to the mobile network.	`esr(config-cellular-profile)# number <WORD>`	<WORD> – dial-up number for connection to a mobile network, set by the string of up to 15 characters.
10	Set the method of user authentication in the mobile network (optional).	`esr(config-cellular-profile)# allowed-auth <TYPE>`	<TYPE> – method of user authentication in a mobile network [none, PAP, CHAP, MSCHAP, MSCHAPv2, EAP]. Default value: PAP
11	Limit the possibility of the use of IP addresses in mobile network.	`esr(config-cellular-profile)# ip-version { ipv4 | ipv6 }`	• **ipv4** – IPv4 family; • **ipv6** – IPv6 family;
12	Create USB modem in the router configuration and switch to the modem configuration mode.	`esr(config)# cellular modem <ID>`	<ID> – USB modem identifier, set in the range of [1..10].
13	Specify modem description (optional).	`esr(config-cellular-modem)# description <DESCRIPTION>`	<DESCRIPTION> – modem description, set by the string of up to 255 characters.
14	Specify VRF instance, in which the given modem will operate (optionally).	`esr(config-cellular-modem)# ip vrf forwarding <VRF>`	<VRF> – VRF name, set by the string of up to 31 characters.

Step	Description	Command	Keys
15	Set USB modem identifier allocated by the system (specified in item 2).	`esr(config-cellular-modem)# device <WORD>`	<WORD> – identifier of connected modem's USB port, set in the range of [1..12].
16	Set the previously established parameter profile to the USB modem.	`esr(config-cellular-modem)# profile <ID>`	<ID> – identifier of USB modem parameter profile, set in the range of [1..10].
17	Set SIM card unlock code (if necessary).	`esr(config-cellular-modem)# pin <WORD>`	<WORD> – SIM card unblock code [4..8]. Only digits are allowed.
18	Allow the use of any USB modem operation mode (optionally).	`esr(config-cellular-modem)# allowed-mode <MODE>`	<MODE> – acceptable USB modem operation mode [2g, 3g, 4g]. By default: all modes supported by the modem are allowed.
19	Set the size of the largest received packet (optional).	`esr(config-cellular-modem)# mru { <MRU> }`	<MRU> – MRU value, takes values in the range of [128..16383]. Default value: 1500.
20	Change the maximum size of processed MTU (MaximumTransmissionUnit) packets. MTU above 1500 will be active only when using the «system jumbo-frames» command (optional).	`esr(config-cellular-modem)# mtu <MTU>`	<MTU> – MTU value in bytes. Default value: 1500.
21	Set the preferable USB modem operation mode in the mobile network (optional).	`esr(config-cellular-modem)# preferred-mode { <MODE> }`	<MODE> – preferable USB modem operation mode [2g, 3g, 4g].
22	Disable the Firewall features on the interface or enable the interface in the security zone (see Firewall configuration).	`esr(config-subif)# ip firewall disable`	
		`esr(config-subif)# security-zone <NAME>`	<NAME> – security zone name, set by the string of up to 31 characters.
23	Activate USB modem.	`esr(config-cellular-modem)# enable`	

It is also possible to configure the sub-interface:

- QoS in basic or advanced mode (see section QoS management);
- proxy (see section HTTP/HTTPS traffic proxying);
- traffic monitoring (see sections Netflow configuration and sFlow configuration);
- routing protocol functionality (see sections Policy-based routing and MultiWAN).

⚠ For the full modem mobile network functionality, you must additionally configure the routing and NAT functionality.

2.7.2 Configuration example

Objective:

Configure connection to the Internet by using USB modem.

Solution:

For example, consider the connection to the cellular operator MTS.

After modem connection, wait until the system detects the device. Determine the port of the device that was assigned to the connected USB modem:

```
esr# show cellular status modem
Number
device  USB port    Manufacturer    Model   Current state   Interface   Link    state
1       1-2         huawei          E3372   Disabled        --          Down
```

Create the parameter profile for USB modem:

```
esr(config)# cellular profile 1
```

Specify the required APN or any other necessary address. Below you can see the example of connection to MTS APN:

```
esr(config-cellular-profile)# apn internet.mts.ru
```

If necessary, create user name, password, dial-up number and authentication number:

```
esr(config-cellular-profile)# user mts
esr(config-ppp-user)# password ascii-text mts
esr(config-cellular-profile)# number *99#
esr(config-cellular-profile)# allowed-auth PAP
```

Proceed to configuring the USB modem and set the identifier corresponding to the device port that was defined at the beginning:

```
esr(config)# cellular modem 1
esr(config-cellular-modem)# device 1-2
```

Set the corresponding parameter profile and activate the modem:

```
esr(config-cellular-modem)# profile 1
esr(config-cellular-modem)# enable
```

2.8 PPP through E1 configuration

PPP (Point-to-Point Protocol) — point-to-point link layer protocol, used to establish direct communication between two network nodes. It can provide connection authentication, encryption and data compression.

To establish a PPP connection through the E1 stream, you must have a ToPGATE-SFP media converter in the ESR router.

2.8.1 Configuration algorithm

Step	Description	Command	Keys
1	Put physical interface in switch mode	`esr(config-if-gi)# mode switchport`	
2	Set the operation mode of the e1 interface	`esr(config-if-gi)# switchport mode e1`	
3	Set the synchronization source	`esr(config-if-gi)# switchport e1 clock source <SOURCE>`	<SOURCE> – synchronization source: • **Internal** (default) – synchronize with an internal source; • **line** – synchronize with a linear signal.
4	Specify MTU (Maximum Transmition Unit) size for physical interfaces	`esr(config-if-gi)# mtu <MTU>`	<MTU> – MTU value, for E1 and Multilink interfaces may take values in the range of [128..1500].
5	Specify frame check hash algorithm (optionally)	`esr(config-if-gi)# switchport e1 crc <FCS>`	<FCS> – frame check sequence: • **16** (default) – FCS16; • **32** – FCS32.
6	Set check for transmission errors (optionally)	`esr(config-if-gi)# switchport e1 framing <CRC>`	<CRC> – cyclic redundancy check: • **crc-4** – use CRC-4 algorithm; • **no-crc4** (default) – do not use check.
7	Set transmitting bits inversion (optionally)	`esr(config-if-gi)# switchport e1 invert data`	
8	Set linear encoding type (optionally)	`esr(config-if-gi)# switchport e1 linecode <CODE>`	<CODE> – linear encoding type; • **ami** – alternate mark inversion; • **hdb3** (default) – high density bipolar of order 3.

Step	Description	Command	Keys
9	Set amount of timeslots	`esr(config-if-gi)# switchport e1 timeslots <RANGE>`	<RANGE> – amount of timeslots
10	Use E1 as a single entity, without time slots (optional)	`esr(config-if-gi)# switchport e1 unframed`	
11	Configure E1	`esr(config)# interface e1 1/<SLOT>/1`	<SLOT> – slot number.
12	Enable CHAP authentication for PPP (optionally)	`esr(config-e1)# ppp authentication chap`	
13	Specify the router name that is sent to a remote party for CHAP authentication (optionally)	`esr(config-e1)# ppp chap hostname <NAME>`	<NAME> – router name
14	Set authentication password (optionally)	`esr(config-e1)# ppp chap password ascii-text <CLEAR-TEXT>`	<CLEAR-TEXT> – unencrypted password, set by the string of [1..64] characters, may include [0-9a-fA-F] characters
15	Enable authentication override (optionally)	`esr(config-e1)# ppp chap refuse`	
16	Set authentication username (optionally)	`esr(config-e1)# ppp chap username <NAME>`	<NAME> – user name
17	Allow any non-null IP address to be accepted as a local IP address from the neighbour (optionally)	`esr(config-e1)# ppp ipcp accept-address`	
18	Set IP address that is sent to a remote party for the further allocation (optionally)	`esr(config-e1)# ppp ipcp remote-address <ADDR>`	<ADDR> – IP address of a remote gateway
19	Set the amount of attempts to send Configure-Request packets before the remote peer is found to be unable to respond (optionally)	`esr(config-e1)# ppp max-configure <VALUE>`	<VALUE> – number of retries
20	Set the amount of attempts to send Configure-NAK packets before all options are confirmed (optionally)	`esr(config-e1)# ppp max-failure <VALUE>`	<VALUE> – number of retries
21	Set the amount of attempts to send Terminate-Request packets before the session is aborted (optionally)	`esr(config-e1)# ppp max-terminate <VALUE>`	<VALUE> – number of retries

Step	Description	Command	Keys
22	Set MRU (Maximum Receive Unit) size for the interface (optionally)	`esr(config-e1)# ppp mru <MRU>`	<MRU> – MRU value
23	Enable MLPPP mode (optionally)	`esr(config-e1)# ppp multilink`	
24	Add the group to MLPPP (optionally)	`esr(config-e1)# ppp multilink-group <GROUP-ID>`	<GROUP-ID> – group number
25	Specify the time interval in seconds after which the router sends a keepalive message (optionally)	`esr(config-e1)# ppp timeout keepalive <TIME>`	<TIME> – time in seconds
26	Specify the interval after which the router sends a keepalive message (optionally)	`esr(config-e1)# ppp timeout retry <TIME>`	<TIME> – time in seconds

2.8.2 Configuration example

Objective:

Configure PPP connection to the opposite side with IP address 10.77.0.1/24 via ToPGARE-SFP using 1-8 channel slots for data transmission; the clock source is the opposite side.

Solution:

Switch gigabitethernet 1/0/3 interface on which ToPGATE-SFP is set into E1 operation mode:

```
esr# configure
esr(config)# interface gigabitethernet 1/0/3
esr(config-if-gi)# description "*** ToPGATE ***"
esr(config-if-gi)# switchport mode e1
esr(config-if-gi)# switchport e1 timeslots 1-8
esr(config-if-gi)# switchport e1 clock source line
esr(config-if-gi)# switchport e1 slot 3
esr(config-if-gi)# exit
```

Enable interface e1 1/3/1:

```
esr(config)# interface e1 1/3/1
esr(config-e1)# security-zone trusted
esr(config-e1)# ip address 10.77.0.1/24
esr(config-e1)# exit
```

The configuration changes come into effect after applying the following commands:

```
esr# commit
Configuration has been successfully committed
esr# confirm
Configuration has been successfully confirmed
```

2.9 MLPPP Configuration

Multilink PPP (MLPPP) is an aggregated channel that encompasses methods of traffic transition via multiple physical channels while having a single logical connection. This option allows to enhance bandwidth and enables load balancing.

2.9.1 Configuration algorithm

Step	Description	Command	Keys
1	Configure aggregation group.	`esr(config)# interface multilink <IF>`	<IF> – interface name.
2	Specify the description of configured aggregation group (optionally).	`esr(config-multilink )# description <DESCRIPTION>`	<DESCRIPTION> – aggregation group description, set by the string of up to 255 characters.
3	Specify the time interval during which the statistics on the aggregation group load is averaged (optionally).	`esr(config-multilink )# load-average <TIME>`	<TIME> – interval in seconds, takes values of [5..150]. Default value: 5.
4	Specify MTU (Maximum Transmission Unit) size for the aggregation group (optionally). MTU above 1500 will be active only when using the "system jumbo-frames” command.	`esr(config-multilink )# mtu <MTU>`	<MTU> – MTU value, takes values in the range of [1280..1500]. Default value: 1500.
5	Enable CHAP authentication.	`esr(config-multilink)# ppp authentication chap`	

Step	Description	Command	Keys
6	Enable authentication override (optionally).	`esr(config-multilink)# ppp chap refuse`	
7	Specify the router name that is sent to a remote party for CHAP authentication.	`esr(config-multilink)# ppp chap hostname <NAME>`	<NAME> – router name, set by the string of up to 31 characters
8	Specify the password that is sent with the router name to a remote party for CHAP authentication.	`esr(config-multilink)# ppp chap password ascii-text { <CLEAR-TEXT> | encrypted <ENCRYPTED-TEXT> }`	<CLEAR-TEXT> – unencrypted password, set by the string of [8..64] characters, may include [0-9a-fA-F] characters. <ENCRYPTED-TEXT> – unencrypted password, set by the string of [16..128] characters.
9	Allow any non-null IP address to be accepted as a local IP address from the neighbour (optionally).	`esr(config-multilink)# ppp ipcp accept-address`	
10	Set IP address that is sent to a remote party for the further allocation.	`esr(config-multilink)# ppp iccp remote-address <ADDR>`	<ADDR> – IP address of a remote gateway.
11	Specify a user for remote party authentication and switch to the specified user configuration mode.	`esr(config-multilink)# chap username <NAME>`	<NAME> – user name, set by the string of up to 31 characters.
12	Set encrypted or unencrypted password for a specific user to authenticate the remote party.	`esr(config-ppp-user)# password ascii-text { <CLEAR-TEXT> | encrypted <ENCRYPTED-TEXT> }`	<CLEAR-TEXT> – unencrypted password, set by the string of [8..64] characters, may include [0-9a-fA-F] characters. <ENCRYPTED-TEXT> – unencrypted password, set by the string of [16..128] characters.
13	Set the amount of attempts to send Configure-Request packets before the remote peer is found to be unable to respond (optional).	`esr(config-multilink)#  ppp max-configure  <VALUE>`	<VALUE> – time in seconds, takes values of [1..255]. Default value: 10.
14	Set the amount of attempts to send Configure-NAK packets before all options are confirmed (optionally).	`esr(config-multilink)# ppp max-failure <VALUE>`	<VALUE> – time in seconds, takes values of [1..255].

Step	Description	Command	Keys
15	Set the amount of attempts to send Terminate-Request packets before the session is aborted (optionally).	`esr(config-multilink)# ppp max-terminate <VALUE>`	<VALUE> – time in seconds, takes values of [1..255]. Default value: 2.
16	Set MRU (Maximum Receive Unit) size for the interface.	`esr(config-multilink)# ppp mru <MRU>`	<MRU> – MRU value, takes values in the range of [128..1485]. Default value: 1500.
17	Specify the time interval in seconds after which the router sends a keepalive message (optionally).	`esr(config-multilink)# ppp timeout keepalive <TIME>`	<TIME> – time in seconds, takes values of [1..32767]. Default value: 10.
18	Specify the time interval in seconds after which the router sends a keepalive message (optionally).	`esr(config-multilink)# ppp timeout retry <TIME>`	<TIME> – time in seconds, takes values of [1..255]. Default value: 3.
19	Specify the maximum packet size for MLPP interface.	`esr(config-multilink)# mrru <MRRU>`	<MRRU> – maximum size of a received packet for MLPP interface, takes value in the range of [1500..10000].
20	Bind e1 port to the physical interface.	`esr(config-if-gi)# switchport e1 <SLOT>`	<SLOT> – slot identifier, takes values in the range of [0..3].
21	Put the physical port into SFPe1 module operation mode.	`esr(config-if-gi)# switchport mode e1`	
22	Enable MLPPP mode on E1 interface.	`esr(config-e1)# ppp multilink`	
23	Include E1 interface in the aggregation group.	`esr(config-e1)# ppp multilink-group <GROUP-ID>`	<GROUP-ID> – group identifier, takes values in the range of [1..4].

2.9.2 Configuration example

Objective:

Configure MLPPP connection to the opposite side with IP address 10.77.0.1/24 via MXE device.

Solution:

Switch gigabitethernet 1/0/10 interface into E1 operation mode:

```
esr# configure
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)# switchport mode e1
esr(config-if-gi)# switchport e1 slot 0
esr(config-if-gi)# exit
esr(config)# interface gigabitethernet 1/0/2
esr(config-if-gi)# switchport mode e1
esr(config-if-gi)# switchport e1 slot 1
esr(config-if-gi)# exit
```

Configure MLPPP 3:

```
esr(config)# interface multilink 3
esr(config-multilink)# ip address 10.77.0.2/24
esr(config-multilink)# security-zone trusted
esr(config-multilink)# exit
esr(config)# exit
```

Enable interface e1 1/0/1, interface e1 1/0/2 into MLPPP 3 aggregation group:

```
esr(config)# interface e1 1/0/1
esr(config-e1)# ppp multilink
esr(config-e1)# ppp multilink-group 3
esr(config-e1)# exit
esr(config)# interface e1 1/0/2
esr(config-e1)# ppp multilink
esr(config-e1)# ppp multilink-group 3
esr(config-e1)# exit
```

2.10 Bridge configuration

Bridge is a method of connection for two Ethernet segments on data-link level without any higher level protocols, such as IP. Packet transmission is based on Ethernet addresses, not on IP addresses. Given that the transmission is performed on data-link level (Level 2 of the OSI model), higher level protocol traffic passes through the bridge transparently.

2.10.1 Configuration algorithm

Step	Description	Command	Keys
1	Add a network bridge to the system and switch to its configuration mode.	`esr(config)# bridge <BRIDGE-ID>`	<BRIDGE-ID> – bridge identification number, takes values in the range of: · for ESR-10/12V(F)/14VF – [1..50]; · for ESR-20/21/100/200 – [1..250]; · for ESR-1000/1200/1500/1700 – [1..500].
2	Enable network bridge.	`esr(config-bridge )#  enable`	
3	Specify VRF instance, in which the given modem will operate (optionally).	`esr(config-bridge )# ip vrf forwarding <VRF>`	<VRF> – VRF name, set by the string of up to 31 characters.
4	Specify the configured network bridge description (optionally).	`esr(config-bridge)# description <DESCRIPTION>`	<DESCRIPTION> – network bridge description, set by the string of up to 255 characters.
5	Connect sub interface, qinq interface, L2GRE tunnel or L2TPv3 tunnel with the network bridge. Connected interfaces/tunnels and network bridges automatically become participants of the shared L2 domain (optionally).	`esr(config-if-gi)# bridge-group <BRIDGE-ID>` `esr(config-if-l2tpv3)# bridge-group <BRIDGE-ID>`	<BRIDGE-ID> – bridge identification number, takes values in the range of: · for ESR-10/12V(F)/14VF – [1..50]; · for ESR-20/21/100/200 – [1..250]; · for ESR-1000/1200/1500/1700 – [1..500].
6	Connect the current network bridge with VLAN. All interfaces and L2 tunnels that are members of the assigned VLAN are automatically included in the network bridge and become members of the shared L2 domain (optionally)	`esr(config-bridge)# vlan <VID>`	<VID> – VLAN identifier, set in the range of [1..4094].

Step	Description	Command	Keys
7	Specify the size of MTU packets that can be passed by the bridge (optionally; possible if only VLAN is included in the bridge). MTU above 1500 will be active only when using the "system jumbo-frames" command.	`esr(config-bridge)# mtu <MTU>`	<MTU> – MTU value, takes values in the range of: · for ESR-10/12V(F)/14VF – [552..9600]; · for ESR-20/21 – [552..9500]; · for ESR-100/200/1000/1200/1500/1700 – [552..10000]. Default value: 1500
8	Specify the IPv4/IPv6 address and subnet mask for the interface to be configured or enable IP address obtain dynamically.	`esr(config-bridge)# ip address <ADDR/LEN>`	<ADDR/LEN> – IP address and subnet mask length, defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32]. For advanced IPv4 addressing features see section IP addressing configuration.
		`esr(config-bridge)# ipv6 address <IPV6-ADDR/LEN>`	<IPV6-ADDR/LEN> – IP address and prefix of a subnet, defined as X:X:X:X::X/EE where each X part takes values in hexadecimal format [0..FFFF] and EE takes values of [1..128]. For advanced IPv6 addressing features see section IPv6 addressing configuration. You can specify several IPv4/IPv6 addresses separated by commas. Up to 8 IPv4/IPv6 addresses can be assigned to the interface.
		`esr(config-bridge)# ip address dhcp`	For advanced DHCP client operation features, see section DHCP client management.
9	Disable the Firewall features on the interface or enable the interface in the security zone (see Firewall configuration).	`esr(config-bridge)# ip firewall disable`	
		`esr(config-bridge)# security-zone <NAME>`	<NAME> – security zone name, set by the string of up to 31 characters.
9	Enable recording of the current interface usage statistics (optional).	`esr(config-bridge)# history statistics`	

Step	Description	Command	Keys
8	Specify the time interval during which the statistics on the bridge load is averaged (optionally).	`esr(config-bridge)# load-average <TIME>`	<TIME> – interval in seconds, takes values of [5..150]. Default value: 5
9	Specify the network bridge MAC address different from a system one (optionally).	`esr(config-bridge)# mac-address <ADDR>`	<ADDR> – network bridge MAC address, defined as XX:XX:XX:XX:XX:XX where each part takes the values of [00..FF].
10	Enable interface isolation mode on the bridge. In this mode, the traffic exchange between members of the network bridge is prohibited. (Optionally; relevant only for ESR-1000/1200/1500/1700)	`esr(config-bridge)# protected-ports [ exclude vlan ]`	exclude vlan – when specifying the given key, VLAN (connected with bridge) is excluded from the isolated interfaces list.
11	Prohibit unknown-unicast traffic switching (when a destination MAC address is not included in the switching table) in the given bridge. (Optionally; relevant only for ESR-1000/1200/1500/1700)	`esr(config-bridge)# unknown-unicast-forwarding disable`	

12	Set the lifetime of IPv4/IPv6 entries in the ARP table studied on the given bridge (optionally).	`esr(config-bridge)# ip arp reachable-time <TIME>`
		
		`or`
		
		`esr(config-bridge)# ipv6 nd reachable-time <TIME>`
			<TIME> – lifetime of dynamic MAC addresses, in milliseconds. Allowed values are from 5000 to 100000000 milliseconds. Real time of the entry update varies from [0,5;1,5]*<TIME>.

It is also possible to configure the sub-interface:

- QoS in basic or advanced mode (see section QoS management);
- proxy (see section HTTP/HTTPS traffic proxying);
- traffic monitoring (see sections Netflow configuration and sFlow configuration);
- routing protocols functionality (see section Routing management);
- VRRF protocol (see section Redundancy management);
- BRAS functionality (see section BRAS (Broadband Remote Access Server) management);
- IDS/IPS functionality (see section IPS/IDS configuration).

2.10.2 Example of bridge configuration for VLAN and L2TPv3 tunnel

Objective:

Combine router interfaces related to LAN and L2TPv3 tunnel passing through the public network into a single L2 domain. For combining, use VLAN 333.

Solution:

Create VLAN 333:

```
esr(config)# vlan 333
esr(config-vlan)# exit
```

Create 'trusted' security zone:

```
esr(config)# security-zone trusted
esr(config-zone)# exit
```

Add gi1/0/11, gi1/0/12 interfaces to VLAN 333:

```
esr(config)# interface gigabitethernet 1/0/11-12
esr(config-if)# mode switchport
esr(config-if)# switchport general allowed vlan add 333 tagged
```

Create bridge 333, map VLAN 333 to it and specify membership in 'trusted' zone:

```
esr(config)# bridge 333
esr(config-bridge)# vlan 333
esr(config-bridge)# security-zone trusted
esr(config-bridge)# enable
```

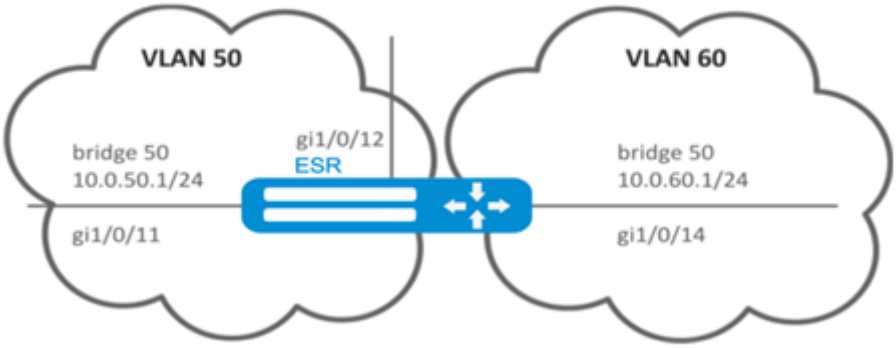
Specify the affilation of L2TPv3 tunnel to bridge mapped to LAN (for L2TPv3 tunnel configuration, see Section L2TPv3 tunnel configuration). In general, bridge and tunnel identifiers should not match the VID, unlike this example.

```
esr(config)# tunnel l2tpv3 333
esr(config-l2tpv3)# bridge-group 333
```

2.10.3 Example of bridge configuration for VLAN

Objective:

Configure routing between VLAN 50 (10.0.50.0/24) and VLAN 60 (10.0.60.0/24). VLAN 50 should belong to 'LAN1', VLAN 60 – to 'LAN2', enable free traffic transmission between zones.



Solution:

Create VLAN 50, 60:

```
esr(config)# vlan 50,60
esr(config-vlan)# exit
```

Create 'LAN1' and 'LAN2' security zones:

```
esr(config)# security-zone LAN1
esr(config-zone)# exit
esr(config)# security-zone LAN2
esr(config-zone)# exit
```

Map VLAN 50 to gi1/0/11, gi1/0/12 interfaces:

```
esr(config)# interface gigabitethernet 1/0/11-12
esr(config-if-gi)# switchport general allowed vlan add 50 tagged
```

Map VLAN 60 to gi1/0/14 interface:

```
esr(config)# interface gigabitethernet 1/0/14
esr(config-if-gi)# switchport general allowed vlan add 60 tagged
```

Create bridge 50, map VLAN 50, define IP address 10.0.50.1/24 and membership in 'LAN1' zone:

```
esr(config)# bridge 50
esr(config-bridge)# vlan 50
esr(config-bridge)# ip address 10.0.50.1/24
esr(config-bridge)# security-zone LAN1
esr(config-bridge)# enable
```

Create bridge 60, map VLAN 60, define IP address 10.0.60.1/24 and membership in 'LAN2' zone:

```
esr(config)# bridge 60
esr(config-bridge)# vlan 60
esr(config-bridge)# ip address 10.0.60.1/24
esr(config-bridge)# security-zone LAN2
esr(config-bridge)# enable
```

Create firewall rules that enable free traffic transmission between zones:

```
esr(config)# security zone-pair LAN1 LAN2
esr(config-zone-pair)# rule 1
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)# exit
esr(config)# security zone-pair LAN2 LAN1
esr(config-zone-pair)# rule 1
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)# exit
esr(config)# exit
```

To view an interface membership in a bridge, use the following command:

```
esr# show interfaces bridge
```

2.10.4 Configuration example of the second VLAN tag adding/removing

Objective:

The gigabitethernet 1/0/1 interface receives Ethernet frames with various VLAN tags. It is necessary to redirect them to the gigabitethernet 1/0/2 interface, adding the second VLAN-ID 828. When Ethernet frames with VLAN-ID 828 come on the gigabitethernet 1/0/2, this tag must be removed and sent to the gigabitethernet 1/0/1 interface.

Solution:

Create the bridge without VLAN and IP address on the route.

```
esr(config)# bridge 1
esr(config-bridge)# enable
esr(config-bridge)# exit
```

Include the gigabitethernet 1/0/1 interface in bridge 1.

```
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)# bridge-group 1
esr(config-if-gi)# exit
```

Include the gigabitethernet 1/0/2.828 sub interface in bridge 1.

```
esr(config)# interface gigabitethernet 1/0/2.828
esr(config-subif)# bridge-group 1
esr(config-subif)# exit
```

⚠ When adding the second VLAN tag to an Ethernet frame, its size is increased by 4 bytes. MTU must be increased by 4 bytes or more on the gigabitethernet 1/0/2 router interface and on all equipment transmitting Q-in-Q frames.

2.11 Dual-Homing configuration

⚠ In the current firmware version, this functionality is supported only by ESR-1000 router.

Dual-Homing is a technology based on redundant links that creates a secure connection in order to prevent failures of the key network resources.

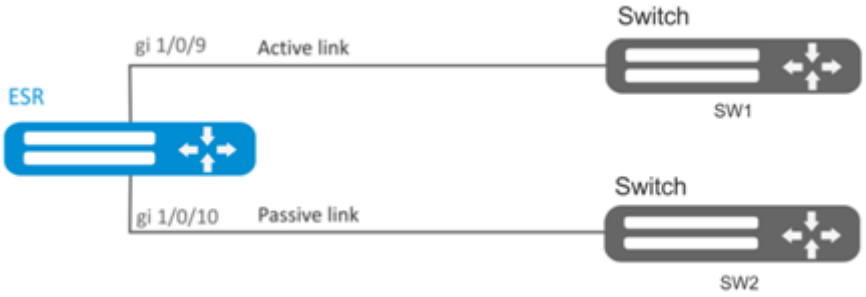
2.11.1 Configuration algorithm

Step	Description	Command	Keys
1	Specify a redundant interface to which the switching will occur when the connection is lost on a primary one.	`esr(config-if-gi)# backup interface<IF> vlan <VID>`	<IF> – interface to which the switching will occur <VID> – VLAN ID, set in the range of [2..4094]. You can also specify it by the range with "-" or by comma-separated list..
2	Specify the number of packets copies with the same MAC address that will be sent to an active interface when switching (optionally).	`esr(config)# backup-interface mac-duplicate <COUNT>`	<COUNT> – amount of packets copies, takes values of [1..4].
3	Specify the number of packets per second that will be sent to an active interface when switching (optionally).	`esr(config)# backup-interfacemac-per-second<COUNT>`	<COUNT> – amount of MAC addresses per second, takes value of [50..400].
4	Specify that it is necessary to carry out the switching to the primary interface when restoring the communication (optionally).	`esr(config)# backup-interface preemption`	

2.11.2 Configuration example

Objective:

Establish redundancy of the ESR router L2 connections for VLAN 50-55 using SW1 and SW2 devices.



Solution:

First, do the following:

Create VLAN 50-55:

```
esr(config)# vlan 50-55
```

You should disable STP for gigabitethernet 1/0/9 and gigabitethernet 1/0/10 interfaces, i.e. these protocols cannot operate simultaneously:

```
esr(config)# interface gigabitethernet 1/0/9-10
esr(config-if-gi)# spanning-tree disable
```

Add gigabitethernet 1/0/9 and gigabitethernet 1/0/10 interfaces into VLAN 50-55 in 'general' mode.

```
esr(config-if-gi)# switchport general allowed vlan add 50-55
esr(config-if-gi)# exit
```

Main configuration step:

Make gigabitethernet 1/0/10 redundant for gigabitethernet 1/0/9:

```
esr(config)# interface gigabitethernet 1/0/9
esr(config-if-gi)# backup interface gigabitethernet 1/0/10 vlan 50-55
```

To view information on redundant interfaces, use the following command:

```
esr# show interfaces backup
```

2.12 Mirroring configuration (SPAN/RSPAN)

> ⚠ In the current firmware version the RSPAN functionality is supported only by ESR-1000/1200/1500/1700 routers

Traffic mirroring is a feature of the router that allows for redirection of traffic from a specific port of the router to another port of the same router (local mirroring) or to a remote device (remote mirroring).

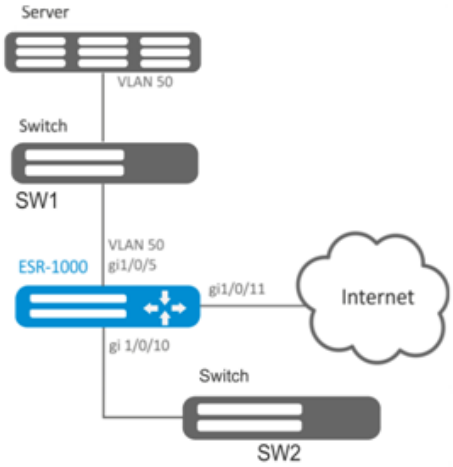
2.12.1 Configuration algorithm

Step	Description	Command	Keys
1	Define VLAN over which the mirrored traffic will be transmitted (in case of using remote mirroring).	`esr(config)# port monitor remote vlan <VID> <DIRECTION>`	<VID> – VLAN ID, set in the range of [2..4094]; <DIRECTION> – traffic direction: • **tx** – mirroring only outgoing traffic to the specified VLAN; • **rx** – mirroring only incoming traffic to the specified VLAN.
2	Enable the remote mirroring mode (in case of using remote mirroring).	`esr(config)# port monitor remote`	
3	Define the mode of the port transmitting mirrored traffic (optional).	`esr(config)# port monitor mode <MODE>`	<MODE> – mode: • **network** – combined data transfer and mirroring (default); • **monitor-only** – mirroring only.
4	Enable mirroring in the interface configuration mode.	`esr(config-if-gi)# port monitor interface <IF> [ <DIRECTION> ]`	<IF> – interface from which the frames will be mirrored; <DIRECTION> – traffic direction: • **tx** – mirroring only output traffic; • **rx** – mirroring only input traffic;

2.12.2 Configuration example

Objective:

Establish remote mirroring of traffic through VLAN 50 from gi1/0/11 interface to be sent to server for processing purposes.



Solution:

First, do the following:

- Create VLAN 50:
- On gi 1/0/5 interface, add VLAN 50 in 'general' mode.

Main configuration step:

Specify VLAN that will be used for transmission of mirrored traffic:

```
esr1000(config)# port monitor remote vlan 50
```

For gi 1/0/5 interface, specify a port for mirroring:

```
esr1000(config)# interface gigabitethernet 1/0/5
esr1000(config-if-gi)# port monitor interface gigabitethernet 1/0/11
```

For gi 1/0/5 interface, specify the remote mirroring mode:

```
esr1000(config-if-gi)# port monitor remote
```

2.13 LACP configuration

LACP is a link aggregation protocol that allows multiple physical links to be combined into a single logical link. This process allows to increase the communication link bandwidth and robustness.

2.13.1 Configuration algorithm

Step	Description	Command	Keys
1	Set the system priority for LACP.	`esr(config)# lacp system-priority <PRIORITY>`	<PRIORITY> – priority, set in the range of [1..65535]. Default value: 1.

Step	Description	Command	Keys
2	Set the load balancing mechanism for channel aggregation groups.	`esr(config)# port-channel load-balance { src-dst-mac-ip | src-dst-mac | src-dst-ip | src-dst-mac-ip-port }`	• **src-dst-mac-ip** – balancing mechanism is based on source and destination MAC addresses and IP addresses; • **src-dst-mac** – balancing mechanism is based on the MAC address of a sender and receiver; • **src-dst-ip** – balancing mechanism is based on the IP address of a sender and receiver; • **src - dst - mac - ip - port** – balancing mechanism is based on source and destination MAC address, IP address and port.
3	Set LACP administration timeout.	`esr(config)# lacp timeout {short | long }`	• **long** – long timeout; • **short** – short timeout. Default value: long.
4	Create and switch to the aggregated interface configuration mode.	`esr(config)# interface port-channel <ID>`	<ID> – sequence number of a channel aggregation group, takes values of [1..12].
5	Configure the required parameters of aggregated channel.		
6	Switch to the physical interface configuration mode.	`esr(config)# interface <IF-TYPE><IF-NUM>`	<IF-TYPE> interface type (gigabitethernet or tengigabitethernet). <IF-NUM> – F/S/P – F frame (1), S – slot (0), P – port.
7	Include a physical interface in the channel aggregation group specifying the mode of the channel aggregation group formation.	`esr(config-if-gi)# channel-group <ID> mode <MODE>`	<ID> – sequence number of a channel aggregation group, takes values of [1..12]. <MODE> – mode of the channel aggregation group formation: • **auto** – add interface to the dynamic aggregation group with the support of LACP; • **on** – add interface to the static aggregation group.

Step	Description	Command	Keys
8	Set the Ethernet interface LACP priority.	`esr(config-if-gi)# lacp port-priority <PRIORITY>`	<PRIORITY> – priority, set in the range of [1..65535]. Default value: 1
9	Set the time interval during which statistics on the sub-interface load is collected. (optionally).	`esr(config-subif)# load-average <TIME>`	<TIME> – interval in seconds, takes values of [5..150].

10	Set the lifetime of IPv4/IPv6 entries in the ARP table studied on the given interface (optionally).	`esr(config-subif)# ip arp reachable-time <TIME>`
		or
		`esr(config-subif)# ipv6 nd reachable-time <TIME>`
			<TIME> – lifetime of dynamic MAC addresses, in milliseconds. Allowed values are from 5000 to 100000000 milliseconds. Real time of the entry update varies from [0,5;1,5]*<TIME>.

11	Change MTU (MaximumTransmitionUnit) size. MTU above 1500 will be active only when using the «system jumbo-frames» command (optional).	`esr(config-subif)# mtu <MTU>`	<MTU> – MTU value in bytes. Default value: 1500.
12	Enable recording of the current interface usage statistics (optional).	`esr(config-subif)# history statistics`	
13	Override the MSS (Maximum segment size) field in incoming TCP packets (optional).	`esr(config-subif)# ip tcp adjust-mss <MSS>` `esr(config-subif)# ipv6 tcp adjust-mss <MSS>`	<MSS> – MSS value, takes values in the range of [500..1460]. Default value: 1460

It is also possible to configure the aggregated interface:

- IPv4/IPv6 addressing (see sections IP addressing configuration, IPv6 addressing configuration and DHCP client management);
- Firewall (see section Firewall configuration);
- QoS in basic or advanced mode (see section QoS management);
- proxy (see section HTTP/HTTPS traffic proxying);
- traffic monitoring (see sections Netflow configuration and sFlow configuration);
- routing protocols functionality (see section Routing management);
- VRRF protocol (see section Redundancy management)
- BRAS functionality (see section BRAS (Broadband Remote Access Server) management);
- IDS/IPS functionality (see section IPS/IDS configuration).

2.13.2 Configuration example

Objective:

Configure aggregated link between ESR router and the switch.

Solution:

1 First, do the following settings:

For gi1/0/1, gi1/0/2 interfaces disable security zone with 'no security-zone' command.

2 Main configuration step:

Create port-channel 2 interface:

```
esr(config)# interface port-channel 2
```

Add gi1/0/1, gi1/0/2 physical interfaces into the created link aggregation group:

```
esr(config)# interface gigabitethernet 1/0/1-2
esr(config-if-gi)# channel-group 2 mode auto
```

Further port-channel configuration is performed by analogy to the common physical interface.

2.14 AUX configuration

AUX configuration is used to specify parameters for interacting with external devices connected via serial interfaces to the ESR.

⚠ For ESR-21

2.14.1 Configuration algorithm

Step	Description	Command	Keys
1	Switch to the serial interface configuration mode.	`esr(config)# line aux <NUM>`	<NUM> – a number of a serial interface from the range [1..3].

Step	Description	Command	Keys

2	Set the necessary serial interface parameters to communicate with the connected device (optional).
	
	These parameters are usually specified in the operation manual of the device to be connected.
	
	By default, the standard values will be used.
		`esr(config-line-aux) databits <BITS>`
		
		`esr(config-line-aux) flowcontrol <FMODE>`
		
		`esr(config-line-aux) parity <PMODE>`
		
		`esr(config-line-aux) speed <SPEED>`
		
		`esr(config-line-aux) stopbits <STOP-BITS>`
			<BITS> – a number of data bits sent [7..8].
			
			Default is "8",
			
			<FMODE> – data flow control mode. Takes the following values:
			
			• software – sowtware flow control;
			• hardware – hardware flow control;
			• disabled – flow control disabled;
			
			Default is "disabled",
			
			<PMODE> – parity bit setting mode. Takes the following values:
			
			• odd – a check for oddness;
			• even – a check for evenness;
			• none – parity bit is not set;
			
			Default is "none",
			
			<SPEED> – a speed of a serial interface in bps.
			
			Takes the following values:
			
			• 300;
			• 1200;
			• 2400;
			• 4800;
			• 9600;
			• 19200;
			• 38400;
			• 57600;
			• 115200;
			
			Default is "115200",
			
			<STOP-BITS> – the number of stop bits transmitted[1..2];
			
			Default is "1".

3	Specify serial interface description (optional).	`esr(config-line-aux)# description <DESCRIPTION>`	<DESCRIPTION> – interface description, set by the string of up to 255 characters.

Step	Description	Command	Keys
4	When using the device to be connected as a modem, set the serial interface to modem mode (optional). Note: cannot be used in conjunction with the «transport telnet port» command.	`esr(config-line-aux)# modem inout`	
5	When using the ESR as a terminal server to control a connected device on the serial interface, set the TCP port number to be used as the TCP port number to connect to the ESR via telnet (optional). Note: cannot be used in conjunction with the «modem inout» command.	`esr(config-line-aux)# transport telnet port <PORT>`	<PORT> – TCP port number for console server mode. Takes values in the range of [1..65535].

2.14.2 Configuration examples

Objective 1:

Configure IP communication between two ESRs on the serial port, using modems in Leased line mode (automatic modem mode), connected to each other by a telephone cable

⚠ Modems should be previously entered into automatic connection setting mode

⚠ **Modem compatibility verified**
Modem Zyxel U-336E Plus

Solution:
Configure the first ESR-21

Configure negotiation parameters:

```
esr-21-1(config)# line aux 2
esr-21-1(config-line-aux)# flowcontrol hardware
esr-21-1(config-line-aux)# exit
esr-21-1(config)#
```

Configure the required RS-232 interfaces:

```
esr-21-1(config)# interface serial 1/0/2
esr-21-1(config-serial)# ip address 1.1.1.1/24
esr-21-1(config-serial)# exit
esr-21-1(config)#
```

Configure firewall for security zones:

```
esr-21-1(config)# security zone xx
esr-21-1(config-zone)# exit
esr-21-1(config)# security zone-pair xx self
esr-21-1(config-zone-pair)#   rule 1
esr-21-1(config-zone-pair-rule)# action permit
esr-21-1(config-zone-pair-rule)# enable
esr-21-1(config-zone-pair-rule)# exit
esr-21-1(config-zone-pair)# exit
esr-21-1(config)#
```

Specify that the interfaces belong to the security zone:

```
esr-21-1(config)# interface serial 1/0/2
esr-21-1(config-serial)# security-zone xx
esr-21-1(config-serial)# exit
esr-21-1(config)#
```

Configure the second ESR-21

Configure negotiation parameters:

```
esr-21-2(config)# line aux 2
esr-21-2(config-line-aux)# flowcontrol hardware
esr-21-2(config-line-aux)# exit
esr-21-2(config)#
```

Configure the required RS-232 interfaces:

```
esr-21-2(config)# interface serial 1/0/2
esr-21-2(config-serial)# ip address 1.1.1.2/24
esr-21-2(config-serial)# exit
esr-21-2(config)#
```

Configure firewall for security zones:

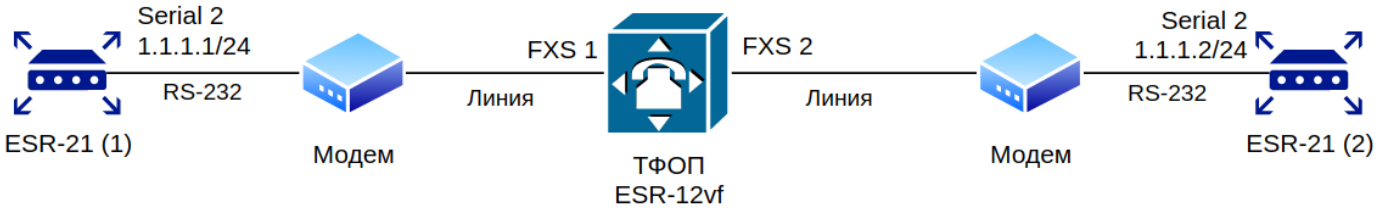
```
esr-21-2(config)# security zone xx
esr-21-2(config-zone)# exit
esr-21-2(config)# security zone-pair xx self
esr-21-2(config-zone-pair)#   rule 1
esr-21-2(config-zone-pair-rule)# action permit
esr-21-2(config-zone-pair-rule)# enable
esr-21-2(config-zone-pair-rule)# exit
esr-21-2(config-zone-pair)# exit
esr-21-2(config)#
```

Specify that the interfaces belong to the security zone:

```
esr-21-2(config)# interface serial 1/0/2
esr-21-2(config-serial)# security-zone xx
esr-21-2(config-serial)# exit
esr-21-2(config)#
```

Objective 2:

Set up IP connectivity between two ESRs on a Serial port, using Dial-Up modems and the Public Switched Telephone Network (PSTN)



The ESR-12vf with the following configuration is used as a PSTN emulation:

```
dialplan pattern factory_test
  description "dialplan for factory test"
  pattern "S5, L5 (00[1-3]@{local} | [xABCD*#].S)"
  enable
exit
sip profile 1
  dialplan pattern "factory_test"
  enable
  proxy primary
    enable
    ip address proxy-server 192.0.2.5
    registration
    ip address registration-server 192.0.2.5
  exit
exit
interface voice-port 1
  sip user phone 001
  profile sip 1
exit
interface voice-port 2
  sip user phone 002
  profile sip 1
  caller-id mode fsk-bell
exit
```

Modem compatibility verified

- Modem ZyXEL OMNI 56K (MINI)
- Modem Acorp-M56SCD

Solution:

Configure the first ESR-21

Configure the parameters for negotiation with the modem:

```
esr-21-1(config)# line aux 2
esr-21-1(config-line-aux)# flowcontrol hardware
esr-21-1(config-line-aux)# modem inout
esr-21-1(config-line-aux)# exit
esr-21-1(config)#
```

Configure the required RS-232 interfaces:

```
esr-21-1(config)# interface serial 1/0/2
esr-21-1(config-serial)# ip address 1.1.1.1/24
esr-21-1(config-serial)# exit
esr-21-1(config)#
```

Configure firewall for security zones:

```
esr-21-1(config)# security zone xx
esr-21-1(config-zone)# exit
esr-21-1(config)# security zone-pair xx self
esr-21-1(config-zone-pair)#   rule 1
esr-21-1(config-zone-pair-rule)# action permit
esr-21-1(config-zone-pair-rule)# enable
esr-21-1(config-zone-pair-rule)# exit
esr-21-1(config-zone-pair)# exit
esr-21-1(config)#
```

Specify that the interfaces belong to the security zone:

```
esr-21-1(config)# interface serial 1/0/2
esr-21-1(config-serial)# security-zone xx
esr-21-1(config-serial)# exit
esr-21-1(config)#
```

Enable dialing by number:

```
esr-21-1(config)# interface serial 1/0/2
esr-21-1(config-serial)# dialer string 002
esr-21-1(config-serial)# dialer
esr-21-1(config-serial)# exit
esr-21-1(config)#
```

Configure the second ESR-21

Configure negotiation parameters:

```
esr-21-2(config)# line aux 2
esr-21-2(config-line-aux)# flowcontrol hardware
esr-21-2(config-line-aux)# modem inout
esr-21-2(config-line-aux)# exit
esr-21-2(config)#
```

Configure the required RS-232 interfaces:

```
esr-21-2(config)# interface serial 1/0/2
esr-21-2(config-serial)# ip address 1.1.1.2/24
esr-21-2(config-serial)# exit
esr-21-2(config)#
```

Configure firewall for security zones:

```
esr-21-2(config)# security zone xx
esr-21-2(config-zone)# exit
esr-21-2(config)# security zone-pair xx self
esr-21-2(config-zone-pair)#   rule 1
esr-21-2(config-zone-pair-rule)# action permit
esr-21-2(config-zone-pair-rule)# enable
esr-21-2(config-zone-pair-rule)# exit
esr-21-2(config-zone-pair)# exit
esr-21-2(config)#
```

Specify that the interfaces belong to the security zone:

```
esr-21-2(config)# interface serial 1/0/2
esr-21-2(config-serial)# security-zone xx
esr-21-2(config-serial)# exit
esr-21-2(config)#
```

Objective 3:

Use additional modem settings for Objective 2

- for modem 1 enable the 22bis protocol
- disable the speakers on both modems

Solution

Create a line with additional modem initialization parameters for the first ESR-21, where

- AT&N1" – enable 22bis on modem mode
- ATM0L0 – disable modem speaker

```
esr-21-1(config)# chat-script dial_test "ABORT 'BUSY' ABORT 'NO CARRIER' ABORT ERROR '' AT OK
AT&F OK AT&N14 OK ATM0L0 OK ATD\\T CONNECT '"
esr-21-1(config)#
```

Enable the use of the modem initialization string:

```
esr-21-1(config)# interface serial 1/0/2
esr-21-1(config-serial)# dialer string 001 modem-script dial_test
esr-21-1(config-serial)# exit
esr-21-1(config)#
```

Create a line with additional modem initialization parameters for the second ESR-21, where

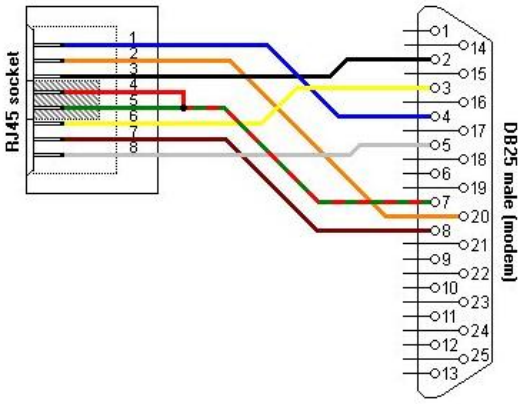
```
esr-21-2(config)# chat-script answer_test "ABORT 'BUSY' ABORT 'NO CARRIER' '' AT OK AT&F OK
ATM0L0 RING ATAr CONNECT '"
esr-21-2(config)#
```

Enable the use of the modem initialization string:

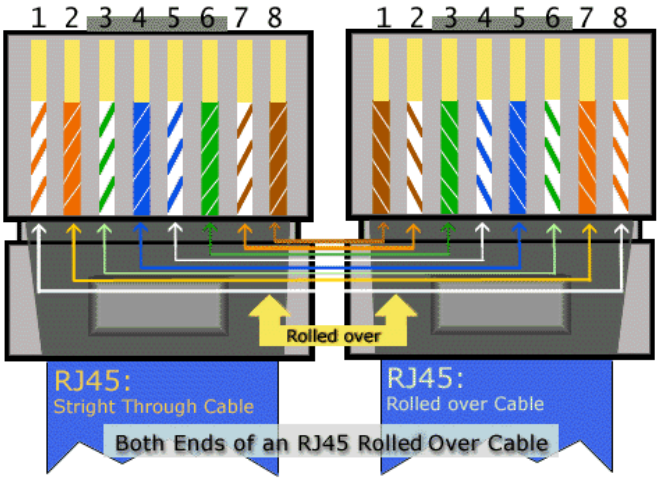
```
esr-21-2(config)# interface serial 1/0/2
esr-21-2(config-serial)# dialer string 000 modem-script answer_test
esr-21-2(config-serial)# exit
esr-21-2(config)#
```

2.14.3 Adapter soldering schemes

RJ-45 <--> DB-25 pinout



RJ-45 <--> RJ-45 pinout (rolled over cable)



3 Tunneling management

3.1 GRE tunnel configuration

GRE (Generic Routing Encapsulation) is a network packet tunneling protocol. Its main purpose is to encapsulate packets of the OSI model network layer into IP packets. GRE may be used for VPN establishment on 3rd level of OSI model. In ESR router implemented static unmanageable GRE tunnels, i.e. tunnels are created manually via configuration on local and remote hosts. Tunnel parameters for each side should be mutually agreeable, otherwise transferred data will not be decapsulated by the partner.

3.1.1 Configuration algorithm

Step	Description	Command	Keys
1	Configure L3 interface from which a GRE tunnel will be built.		
2	Create a GRE tunnel and switch to its configuration mode.	`esr(config)# tunnel gre <INDEX>`	<INDEX> – tunnel identifier, set in the range of: • for ESR-10/12V(F)/14VF – [1..10]; • for ESR-20/21/100/200 – [1..250]; • for ESR-1000/1200/1500/1700 – [1..500].
3	Specify VRF instance, in which the given GRE tunnel will operate (optionally).	`esr(config-gre )# ip vrf forwarding <VRF>`	<VRF> – VRF name, set by the string of up to 31 characters.

Step	Description	Command	Keys
4	Specify the description of the configured tunnel (optionally).	`esr(config-gre)# description <DESCRIPTION>`	<DESCRIPTION> – tunnel description, set by the string of up to 255 characters.
5	Set local IP address for tunnel installation.	`esr(config-gre)# local address <ADDR>`	<ADDR> – gateway IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
		`esr(config-gre)# local interface <IF>`	<IF> – interface IP address of which is used for the tunnel installation.
6	Set remote IP address for tunnel installation.	`esr(config-gre)# remote address <ADDR>`	<ADDR> – gateway IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
7	Specify the GRE tunnel encapsulation mode.	`esr(config-gre)# mode <MODE>`	<MODE> – GRE tunnel encapsulation mode: • **ip** – encapsulation of IP in GRE; • **ethernet** – encapsulation of Ethernet frames in GRE. Default value: ip
8	Set the IP address of a tunnel local side (only in ip mode).	`esr(config-gre)# ip address <ADDR/LEN>`	<ADDR/LEN> – IP address and prefix of a subnet, defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32]. You can specify up to 8 IP addresses separated by commas. For advanced IPv4 addressing features see section IP addressing configuration.
9	Assign the broadcast domain for encapsulation in the tunnel's GRE packets (only in ethernet mode).	`esr(config-gre)# bridge-group <BRIDGE-ID>`	<BRIDGE-ID> – bridge identification number, takes values in the range of: • for ESR-10/12V(F)/14VF – [1..50]; • for ESR-20/21/100/200 – [1..250]; • for ESR-1000/1200/1500/1700 – [1..500]

Step	Description	Command	Keys
10	Disable the Firewall features on the interface or enable the interface in the security zone (see Firewall configuration).	`esr(config-gre)# security-zone<NAME>`	<NAME> – security zone name, set by the string of up to 12 characters.
		`esr(config-gre)# ip firewall disable`	
11	Specify MTU size (MaximumTransmissionUnit) for the tunnel (optionally). MTU above 1500 will be active only when using the "system jumbo-frames" command.	`esr(config-gre)# mtu <MTU>`	<MTU> – MTU value, takes values in the range of: • for ESR-10/12V(F)/14VF – [1280..9600]; • for ESR-20/21 – [1280..9500]; • for ESR-100/200/1000/1200/1500/1700 [1280..10000]. Default value: 1500.
12	Specify the TTL lifetime for tunnel packets (optionally).	`esr(config-gre)# ttl <TTL>`	<TTL> – TTL value, takes values in the range of [1..255]. Default value: Inherited from encapsulated packet.
13	Specify DSCP for the use in IP header of encapsulated packet (optionally).	`esr(config-gre)# dscp <DSCP>`	<DSCP> – DSCP code value, takes values in the range of [0..63]. Default value: inherited from encapsulated packet.
14	Enable key transmitting in GRE tunnel header (according to RFC 2890) and set the key value. Configured only on the both tunnel sides. (optional).	`esr(config-gre)# key <KEY>`	<KEY> – KEY value, takes values in the range of [1..2000000]. Default value: key is not transmitted.
15	Enable the calculation of the checksum and entry it to the GRE header of the packets to be sent. Also it is necessary to enable verifying of the checksum on the remote side. (optionally)	`esr(config-gre)# local checksum`	

Step	Description	Command	Keys
16	Enable verification of the presence and consistency of checksum values in the headers of GRE packets being received. Also it is necessary to enable calculation of the checksum on the remote side. (optionally)	`esr(config-gre)# remote checksum`	
17	Enable the check for tunnel remote gateway availability (optionally)	`esr(config-gre)# keepalive enable`	
18	Change the keepalive packets timeout from the opposing party (optional)	`esr(config-gre)# keepalive timeout <TIME>`	<TIME> – time in seconds, takes values of [1..32767]. Default value: 10
19	Change the number of attempts to check the availability of a tunnel remote gateway (optionally)	`esr(config-gre)# keepalive retries <VALUE>`	<VALUE> – number of attempts, takes values in the range of [1..255]. Default value: 5
20	Specify the IP address for the keepalive mechanism (mandatory in ethernet mode)	`esr(config-gre)# keepalive dst-address <ADDR>`	<ADDR> – IP address to check GRE tunnel capability.
21	Change the time interval during which the statistics on the tunnel load is averaged (optional).	`esr(config-gre)# load-average <TIME>`	<TIME> – interval in seconds, takes values of [5..150]. Default value: 5
22	Enable sending snmp-trap about tunnel enabling/disabling.	`esr(config-gre)# snmp init-trap`	
23	Enable the mechanism of IP addresses iterative query using DHCP on the specified interfaces when the GRE tunnel is disconnected via keepalive (optionally)	`esr(config-gre)# keepalive dhcp dependent-interface <IF>`	<IF> – physical/logical interface on which IP address obtaining via DHCP is enabled.
24	Specify the time interval between GRE tunnel disabling and IP address iterative query on the interface/ interfaces specified by the keepalive dhcp dependent-interface command (optionally)	`esr(config-gre)# keepalive dhcp link-timeout <SEC>`	<SEC> – time interval between GRE tunnel disabling and IP address requery via DHCP on the interfaces
25	Override the MSS (Maximum segment size) field in incoming TCP packets (optional).	`esr(config-gre)# ip tcp adjust-mss <MSS>`	<MSS> – MSS value, takes values in the range of [500..1460]. Default value: 1460

Step	Description	Command	Keys
26	Enable recording of the current tunnel usage statistics (optional).	`esr(config-gre)# history statistics`	
27	Enable the tunnel.	`esr(config-gre)# enable`	

It is also possible to configure the GRE tunnel:

- QoS in basic or advanced mode (see section QoS management);
- proxy (see section HTTP/HTTPS traffic proxying);
- traffic monitoring (see sections Netflow configuration and sFlow configuration);
- routing protocols functionality (see section Routing management);
- BRAS functionality (see section BRAS (Broadband Remote Access Server) management).

3.1.2 IP-GRE tunnel configuration example

Objective:

Establish L3-VPN for company offices using IP network with GRE protocol for traffic tunneling.

- IP address 115.0.0.1 is used as a local gateway for the tunnel;
- IP address 114.0.0.10 is used as a remote gateway for the tunnel;
- IP address of the tunnel at the local side is 25.0.0.1/24.

Solution:

Pre-configure interfaces on the routers for connection with WAN, enable GRE packets reception from a security zone where WAN connected interfaces operate.

Create GRE 10 tunnel:

```
esr(config)# tunnel gre 10
```

Specify local and remote gateways (IP addresses of WAN border interfaces):

```
esr(config-gre)# local address 115.0.0.1
esr(config-gre)# remote address 114.0.0.10
```

Specify tunnel IP address 25.0.0.1/24:

```
esr(config-gre)# ip address 25.0.0.1/24
```

Also, the tunnel should belong to the security zone in order to create rules that allow traffic to pass through the firewall. To define the tunnel inherence to a zone, use the following command:

```
esr(config-gre)# security-zone untrusted
```

Enable tunnel:

```
esr(config-gre)# enable
esr(config-gre)# exit
```

Create route to the partner's local area network on the router. Specify previously created GRE tunnel as a destination interface.

```
esr(config)# ip route 172.16.0.0/16 tunnel gre 10
```

When settings are applied, traffic will be encapsulated into the tunnel and sent to the partner regardless of their GRE tunnel existence and settings validity.

Optionally, you may specify the following parameters for GRE tunnel:

- Enable GRE header checksum calculation and inclusion into a packet with encapsulated packet for outbound traffic:

  ```
  esr(config-gre)# local checksum
  ```

- Enable check for GRE checksum presence and validity for inbound traffic:

  ```
  esr(config-gre)# remote checksum
  ```

- Specify a unique identifier:

  ```
  esr(config-gre)# key 15808
  ```

- Specify DSCP, MTU, TTL values:

  ```
  esr(config-gre)# dscp 44
  esr(config-gre)# mtu 1426
  esr(config-gre)# ttl 18
  ```

- Enable and configure keepalive mechanism:

  ```
  esr(config-gre)# keepalive enable
  esr(config-gre)# keepalive timeout <TIME>
  esr(config-gre)# keepalive retries <VALUE>
  ```

To view the tunnel status, use the following command:

```
esr# show tunnels status gre 10
```

To view sent and received packet counters, use the following command:

```
esr# show tunnels counters gre 10
```

To view the tunnel configuration, use the following command:

```
esr# show tunnels configuration gre 10
```

IPv4-over-IPv4 tunnel configuration is performed in the same manner.

⚠ During tunnel creation, you should enable GRE protocol (47) in the firewall.

3.2 DMVPN configuration

DMVPN (*Dynamic Multipoint Virtual Private Network*)– technology for creating virtual private networks, with the ability to dynamically create tunnels between hosts. The advantage of this solution is its high scalability and ease of setup when connecting branches to the head office. DMVPN is used in the Hub-and-Spoke topology, and allows the construction of direct VPN Spoke-to-Spoke tunnels in addition to the usual Spoke-to-Hub tunnels. This means that branches can communicate with each other directly, without the need for traffic to pass through the Hub.

To establish such a connection, clients (NHC) over an encrypted IPsec tunnel send their internal (tunnel) address and external (NBMA) address to the NHRP server (NHS). When a client wants to connect to another NHC, it sends a request to the server to find out its external address. Having received a response from the server, the client can now independently establish a connection to the remote branch.

3.2.1 Configuration algorithm

Step	Description	Command	Keys
1	Check the availability of 'external' IP addresses located on physical interfaces.		
2	Prepare IPsec tunnels for use with dynamic GRE tunnels.		See section Policy-based IPsec VPN configuration.
2	Create a GRE tunnel and switch to its configuration mode.	`esr(config)# tunnel gre <INDEX>`	<INDEX> – tunnel identifier.
3	Switch the GRE tunnel to multipoint mode.	`esr(config-gre )# multipoint`	
4	Set an open password for NHRP packets (optional).	`esr(config-gre)# ip nhrp authentication <WORD>`	<WORD> – unencrypted password, set by the string of [1..8] characters, may include [0-9a-fA-F] characters.

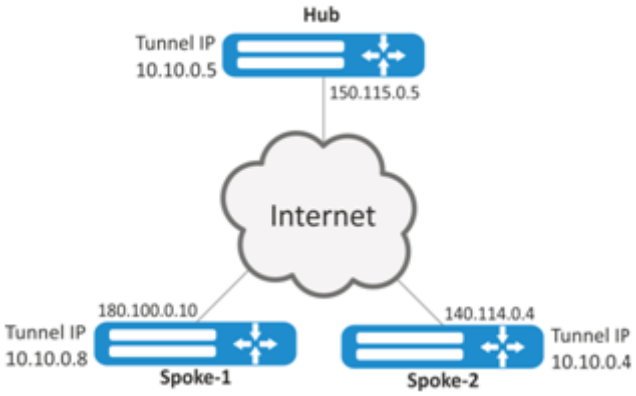
Step	Description	Command	Keys
5	Specify the time during which a record about this client will exist on the NHS (optional).	`esr(config-gre)# ip nhrp holding-time <TIME>`	<TIME> – the time in seconds during which a record about this client will exist on the server takes the values [1..65535]. Default value: 7200
6	Set the 'logic (tunnel)' address of the NHRP server.	`esr(config-gre)# ip nhrp nhs <ADDR> [ no-registration ]`	<ADDR/LEN> – address, defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32]; • **no-registration** — do not register on the NHRP server.
7	Match the 'internal' tunnel address with the 'external' NBMA address.	`esr(config-gre)# ip nhrp map <ADDR> <ADDR>`	<ADDR> – IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
8	Define the destination of multicast traffic.	`esr(config-gre)# ip nhrp multicast { dynamic | nhs | <ADDR> }`	• **dynamic** — send to all peers with which there is a connection; • **nhs** — send to all static configured servers; <ADDR> – send to specifically configured server, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
9	Enable the ability to send NHRP Traffic Indication packets. Running on the NHS (optionally).	`esr(config-gre)# ip nhrp redirect`	
10	Enable the ability to create shortest routes. Running on the NHC (optionally).	`esr(config-gre)# ip nhrp shortcut`	
11	Map IPsec-VPN to the mGRE tunnel (optionally).	`esr(config-gre)# ip nhrp ipsec <WORD> { static | dynamic }`	<WORD> – VPN name, set by the string of up to 31 characters. • **static** — static connection, used for connection to NHS; • **dynamic** — dynamically established connection, configured for communication between NHC.
12	Enable NHRP.	`esr(config-gre)# ip nhrp enable`	

Step	Description	Command	Keys
13	Organize IP connectivity using the dynamic routing protocol.		
Other settings are the same as for the static GRE-tunnel (see section GRE-tunnel configuration)			

3.2.2 Configuration example

Objective:

Organize DMVPN between company offices using mGRE tunnels, NHRP (Next Hop Resolution Protocol), Dynamic Routing Protocol (BGP), Ipsec. In our example, we will have a HUB router and two branches. The HUB is the DMVPN server (NHS), and the branches are DMVPN clients (NHC).



External IP addres of Hub — 150.115.0.5;

External IP address of Spoke-1 — 180.100.0.10;

External IP address of Spoke-2 — 140.114.0.4.

IPsec VPN parameters:

IKE:

- Diffie-Hellman group: 2;
- encryption algorithm: AES128;
- authentication algorithm: SHA1.

IPsec:

- encryption algorithm: AES128;
- authentication algorithm: SHA1.

Solution:

1. Hub configuration
   Create GRE tunnel:

   ```
   esr# configure
   esr(config)# tunnel gre 5
   ```

   Specify the IP address of the interface bordering the ISP:

```
esr(config-gre)# local address 150.115.0.5
```

Specify MTU value:

```
esr(config-gre)# mtu 1416
```

Specify ttl value:

```
esr(config-gre)# ttl 16
```

Specify IPaddress of GRE tunnel:

```
esr(config-gre)# ip address 10.10.0.5/24
```

Switch the GRE tunnel into multipoint mode to be able to connect to multiple points:

```
esr(config-gre)# multipoint
```

Proceed to NHRP configuration. Configure multicast to dynamically learnt addresses:

```
esr(config-gre)# ip nhrp multicast dynamic
```

Configure the dynamic routing protocol for the Hub. In our example, this will be BGP:

```
esr(config)# router bgp 65005
esr(config-bgp)# address-family ipv4
esr(config-bgp-af)# neighbor 10.10.0.8
esr(config-bgp-neighbor)# remote-as 65008
esr(config-bgp-neighbor)# enable
esr(config-bgp-neighbor)# exit
esr(config-bgp-af)# neighbor 10.10.0.4
esr(config-bgp-neighbor)# remote-as 65004
esr(config-bgp-neighbor)# enable
esr(config-bgp-neighbor)# exit
esr(config-bgp-af)# enable
```

Configure IPsec for the Hub:

```
esr(config)# security ike proposal IKEPROP
esr(config-ike-proposal)# encryption algorithm aes128
esr(config-ike-proposal)# dh-group 2
esr(config-ike-proposal)# exit
```

```
esr(config)# security ike policy IKEPOLICY
esr(config-ike-policy)# pre-shared-key ascii-text encrypted 8CB5107EA7005AFF
esr(config-ike-policy)# proposal IKEPROP
esr(config-ike-policy)# exit
```

```
esr(config)# security ike gateway IKEGW
esr(config-ike-gw)# ike-policy IKEPOLICY
esr(config-ike-gw)# local address 150.115.0.5
esr(config-ike-gw)# local network 150.115.0.5/32 protocol gre
esr(config-ike-gw)# remote address any
esr(config-ike-gw)# remote network any
esr(config-ike-gw)# mode policy-based
esr(config-ike-gw)# exit
```

```
esr(config)# security ipsec proposal IPSECPROP
esr(config-ipsec-proposal)# encryption algorithm aes128
esr(config-ipsec-proposal)# exit
```

```
esr(config)# security ipsec policy IPSECPOLICY
esr(config-ipsec-policy)# proposal IPSECPROP
esr(config-ipsec-policy)# exit
```

```
esr(config)# security ipsec vpn IPSECVPN
esr(config-ipsec-vpn)# mode ike
esr(config-ipsec-vpn)# ike establish-tunnel route
esr(config-ipsec-vpn)# ike gateway IKEGW
esr(config-ipsec-vpn)# ike ipsec-policy IPSECPOLICY
esr(config-ipsec-vpn)# enable
```

Map IPsec to the GRE tunnel so that clients can establish an encrypted connection:

```
esr(config-gre)# ip nhrp ipsec IPSECVPN dynamic
```

Enable NHRP and the tunnel:

```
esr(config-gre)# ip nhrp enable
esr(config-gre)# enable
```

2. Spoke configuration
   Perform the standard DMVPN configuration on the tunnel:

```
esr# configure
esr(config-gre)# tunnel gre 8
esr(config-gre)# mtu 1416
esr(config-gre)# ttl 16
esr(config-gre)# multipoint
esr(config-gre)# local address 180.100.0.10
esr(config-gre)# ip address 10.10.0.8/24
```

Specify the time while the client record will be stored on the server:

```
esr(config-gre)# ip nhrp holding-time 300
```

Specify the tunnel address of NHS:

```
esr(config-gre)# ip nhrp nhs 10.10.0.5/24
```

Specify the tunnel address – real:

```
esr(config-gre)# ip nhrp map 10.10.0.5 150.115.0.5
```

Configure the multicast to the NHRP server:

```
esr(config)# ip nhrp multicast nhs
```

Configure the BGP for spoke:

```
esr(config)# router bgp 65008
esr(config-bgp)# address-family ipv4
esr(config-bgp-af)# neighbor 10.10.0.5
esr(config-bgp-neighbor)# remote-as 65005
esr(config-bgp-neighbor)# enable
esr(config-bgp-neighbor)# exit
esr(config-bgp-af)# enable
```

Configure IPsec. When creating the IKE protocol gateway for NHS, specify particular destination addresses. When creating an IKE gateway for NHC – the destination address will be any:

```
esr(config)# security ike proposal IKEPROP
esr(config-ike-proposal)# encryption algorithm aes128
esr(config-ike-proposal)# dh-group 2
esr(config-ike-proposal)# exit
```

```
esr(config)# security ike policy IKEPOLICY
esr(config-ike-policy)# pre-shared-key ascii-text encrypted 8CB5107EA7005AFF
esr(config-ike-policy)# proposal IKEPROP
esr(config-ike-policy)# exit
```

```
esr(config)# security ike gateway IKEGW_HUB
esr(config-ike-gw)# ike-policy IKEPOLICY
esr(config-ike-gw)# local address 180.100.0.10
esr(config-ike-gw)# local network 180.100.0.10/32 protocol gre
esr(config-ike-gw)# remote address 150.115.0.5
esr(config-ike-gw)# remote network 150.115.0.5/32 protocol gre
esr(config-ike-gw)# mode policy-based
esr(config-ike-gw)# exit
```

```
esr(config)# security ike gateway IKEGW_SPOKE
esr(config-ike-gw)# ike-policy IKEPOLICY
esr(config-ike-gw)# local address 180.100.0.10
esr(config-ike-gw)# local network 180.100.0.10/32 protocol gre
esr(config-ike-gw)# remote address any
esr(config-ike-gw)# remote network any
esr(config-ike-gw)# mode policy-based
esr(config-ike-gw)# exit
```

```
esr(config)# security ipsec proposal IPSECPROP
esr(config-ipsec-proposal)# encryption algorithm aes128
esr(config-ipsec-proposal)# exit
```

```
esr(config)# security ipsec policy IPSECPOLICY
esr(config-ipsec-policy)# proposal IPSECPROP
esr(config-ipsec-policy)# exit
```

```
esr(config)# security ipsec vpn IPSECVPN_HUB
esr(config-ipsec-vpn)# mode ike
esr(config-ipsec-vpn)# ike establish-tunnel route
esr(config-ipsec-vpn)# ike gateway IKEGW_HUB
esr(config-ipsec-vpn)# ike ipsec-policy IPSECPOLICY
esr(config-ipsec-vpn)# enable
```

```
esr(config)# security ipsec vpn IPSECVPN_SPOKE
esr(config-ipsec-vpn)# mode ike
esr(config-ipsec-vpn)# ike establish-tunnel route
esr(config-ipsec-vpn)# ike gateway IKEGW_SPOKE
esr(config-ipsec-vpn)# ike ipsec-policy IPSECPOLICY
esr(config-ipsec-vpn)# enable
```

Map IPsec to the GRE tunnel, in order to be able to establish an encrypted connection with the server and with other network clients:

```
esr(config-gre)# ip nhrp ipsec IPSECVPN_HUB static
esr(config-gre)# ip nhrp ipsec IPSECVPN_SPOKE dynamic
```

Enable NHRP and the tunnel:

```
esr(config-gre)# ip nhrp enable
esr(config-gre)# enable
```

To view the NHRP records status, use the following command:

```
esr# show ip nhrp
```

You can clear NHRP records with the command:

```
esr# clear ip nhrp
```

3.3 L2TPv3 tunnel configuration

L2TPv3 (Layer 2 Tunnelling Protocol Version 3) is a protocol used for tunneling of 2nd level OSI model packets between two IP nodes. IP or UDP is used as an encapsulation protocol. L2TPv3 may be used as an alternative to MPLS P2P L2VPN (VLL) for L2 VPN establishment. In ESR router implemented static unmanageable L2TPv3 tunnels, i.e. tunnels are created manually via configuration on local and remote hosts. Tunnel parameters for each side should be mutually agreeable, otherwise transferred data will not be decapsulated by the partner.

3.3.1 Configuration algorithm

Step	Description	Command	Keys
1	Configure L3 interface from which a L2TPv3 tunnel will be built.		
2	Create a L2TPv3 tunnel and switch to its configuration mode.	`esr(config)# tunnel l2tpv3 <INDEX>`	<INDEX> – tunnel identifier, set in the range of: · for ESR-10/12V(F)/14VF – [1..10]; · for ESR-20/21/100/200 – [1..250]; · for ESR-1000/1200/1500/1700 – [1..500].
3	Specify the description of the configured tunnel (optionally).	`esr(config-l2tpv3)# description <DESCRIPTION>`	<DESCRIPTION> – tunnel description, set by the string of up to 255 characters.
4	Set local IP address for tunnel installation.	`esr(config-l2tpv3)# local address <ADDR>`	<ADDR> – gateway IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
5	Set remote IP address for tunnel installation.	`esr(config-l2tpv3)# remote address <ADDR>`	<ADDR> – gateway IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].

Step	Description	Command	Keys
6	Select encapsulation method for L2TPv3 tunnel.	`esr(config-l2tpv3)# protocol <TYPE>`	<TYPE> – encapsulation type, possible values: • **ip** – encapsulation in an IP packet; • **udp** – encapsulation in UDP datagrams.
7	Set local session identifier.	`esr(config-l2tpv3)# local session-id <SESSION-ID>`	<SESSION-ID> – session identifier, takes values in the range of [1..200000].
8	Set remote session identifier.	`esr(config-l2tpv3)# remote session-id <SESSION-ID>`	<SESSION-ID> – session identifier, takes values in the range of [1..200000].
9	Define local UDP port (if UDP was selected as encapsulation method).	`esr(config-l2tpv3)# local port <UDP>`	<UDP> – UDP port number in the range of [1..65535].
10	Define remote UDP port (if UDP was selected as encapsulation method).	`esr(config-l2tpv3)# remote port <UDP>`	<UDP> – UDP port number in the range of [1..65535].
11	Assign the broadcast domain for encapsulation in the tunnel's L2TPV3 packets.	`esr(config-l2tpv3)# bridge-group <BRIDGE-ID>`	<BRIDGE-ID> – bridge identification number, takes values in the range of: • for ESR-10/12V(F)/14VF – [1..50]; • for ESR-20/21/100/200 – [1..250]; • for ESR-1000/1200/1500/1700 – [1..500]
12	Enable the tunnel.	`esr(config-l2tpv3)# enable`	
13	Specify MTU size (MaximumTransmissionUnit) for the tunnels (optionally). MTU above 1500 will be active only when using the "system jumbo-frames" command.	`esr(config-l2tpv3)# mtu <MTU>`	<MTU> – MTU value, takes values in the range of: • for ESR-10/12V(F)/14VF – [1280..9600]; • for ESR-20/21 – [1280..9500]; • for ESR-100/200/1000/1200/1500/1700 [1280..10000]. Default value: 1500.

Step	Description	Command	Keys
14	Define the local cookie value to check the conformance of data being transmitted and session (optionally).	`esr(config-l2tpv3)# local cookie <COOKIE>`	<COOKIE> – COOKIE value, the parameter takes values of 8 or 16 characters in hexadecimal form.
15	Define the remote cookie value to check the conformance of data being transmitted and session (optionally).	`esr(config-l2tpv3)# remote cookie <COOKIE>`	<COOKIE> – COOKIE value, the parameter takes values of 8 or 16 characters in hexadecimal form.
16	Specify the time interval during which the statistics on the tunnel load is averaged (optionally).	`esr(config-l2tpv3)# load-average <TIME>`	<TIME> – interval in seconds, takes values of [5..150]. Default value: 5.
17	Enable recording of the current tunnel usage statistics (optional).	`esr(config-subif)# history statistics`	
It is also possible to configure the L2TPv3 tunnel: • QoS in basic or advanced mode (see section QoS management); • BRAS functionality (see section BRAS (Broadband Remote Access Server) management).			

3.3.2 L2TPv3 tunnel configuration example

Objective:

Establish L2 VPN for company offices using IP network with L2TPv3 protocol for traffic tunneling.

- UDP is used as an encapsulation protocol, port number at the local side and port number at the partner's side is 519;
- IP address 21.0.0.1 is used as a local gateway for the tunnel;
- IP address 183.0.0.10 is used as a remote gateway for the tunnel;
- Tunnel identifier at the local side equals 2, at the partner's side - 3;
- Tunnel identifier inside the tunnel equals 100, at the partner's side - 200;
- Forward traffic into the tunnel from the bridge with identifier 333.

Solution:

Create L2TPv3 333 tunnel:

```
esr# configure
esr(config)# tunnel l2tpv3 333
```

Specify local and remote gateways (IP addresses of WAN border interfaces):

```
esr(config-l2tpv3)# local address 21.0.0.1
esr(config-l2tpv3)# remote address 183.0.0.10
```

Specify identifiers for session inside the tunnel for local and remote sides:

```
esr(config-l2tpv3)# protocol udp
esr(config-l2tpv3)# local port 519
esr(config-l2tpv3)# remote port 519
```

Specify tunnel identifiers for local and remote sides:

```
esr(config-l2tpv3)# local session-id 100
esr(config-l2tpv3)# remote session-id 200
```

Define the inherence of L2TPv3 tunnel to a bridge that should be mapped to remote office network (for bridge configuration, see Section Configuration example of bridge for VLAN and L2TPv3 tunnel):

```
esr(config-l2tpv3)# bridge-group 333
```

Enable previously created tunnel and exit:

```
esr(config-l2tpv3)# enable
esr(config-l2tpv3)# exit
```

Create sub-interface for switching of traffic coming from the tunnel into LAN with VLAN id 333:

```
esr(config)# interface gi 1/0/2.333
```

Define the inherence of sub-interface to a bridge that should be mapped to LAN (for bridge configuration, see Section Configuration of PPP via E1):

```
esr(config-subif)# bridge-group 333
esr(config-subif)# exit
```

When settings are applied, traffic will be encapsulated into the tunnel and sent to the partner regardless of their L2TPv3 tunnel existence and settings validity.

Tunnel settings for the remote office should mirror local ones. IP address 183.0.0.10 should be used as a local gateway. IP address 21.0.0.1 should be used as a remote gateway for the tunnel. Encapsulation protocol port number at the local side should be 520, at the partner's side – 519. Session identifier inside the tunnel should be equal to 200, at the partner's side – 100. Also, the tunnel should belong to a bridge that should be connected with the partner's network.

To view the tunnel status, use the following command:

```
esr# show tunnels status l2tpv3 333
```

To view sent and received packet counters, use the following command:

```
esr# show tunnels counters l2tpv3 333
```

To view the tunnel configuration, use the following command:

```
esr# show tunnels configuration l2tpv3 333
```

⚠ In addition to tunnel creation, you should enable UDP inbound traffic in the firewall with source port 519 and destination port 519.

3.4 IPsec VPN configuration

IPsec is a set of protocols that enable security features for data transferred via IP protocol. This set of protocols allows for identity validation (authentication), IP packet integrity check and encryption, and also includes protocols for secure key exchange over the Internet.

3.4.1 Route-based IPsec VPN configuration algorithm

Step	Description	Command	Keys
1	Create a VTI tunnel and switch to its configuration mode.	`esr(config)# tunnel vti <TUN>`	<TUN> – device tunnel name.
2	Specify the local IP address of the VTI tunnel.	`esr(config-vti)#local address <ADDR>`	<ADDR> – IP address of a local gateway.
3	Specify the remote IP address of the VTI tunnel.	`esr(config-vti)#remote address <ADDR>`	<ADDR> – IP address of a remote gateway.
4	Specify the IP address of the VTI tunnel local side.	`esr(config-vti)# ip address <ADDR/LEN>`	<ADDR/LEN> – IP address and prefix of a subnet, defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32].
5	Include the VTI tunnel in a security zone and configure interaction rules between zones or disable firewall for VTI tunnel.	`esr(config-vti)# security-zone<NAME>` `esr(config-vti)# ip firewall disable`	<NAME> – security zone name, set by the string of up to 12 characters.
6	Enable the tunnel.	`esr(config-vti)#enable`	

Step	Description	Command	Keys
7	Create an IKE profile and switch to its configuration mode.	`esr(config)# security ike proposal <NAME>`	<NAME> – IKE protocol name, set by the string of up to 31 characters.
8	Specify the description of the configured IKE profile (optionally).	`esr(config-ike-proposal)# description<DESCRIPTION>`	<DESCRIPTION> – tunnel description, set by the string of up to 255 characters.
9	Specify IKE authentication algorithm. (optionally)	`esr(config-ike-proposal)# authentication algorithm <ALGORITHM>`	<ALGORITHM> – authentication algorithm, takes values of: md5, sha1, sha2-256, sha2_384, sha2-512. Default value: sha1
10	Specify IKE encryption algorithm. (optionally)	`esr(config-ike-proposal)# encryption algorithm <ALGORITHM>`	<ALGORITHM> – encryption protocol, takes the following values: des, 3des, blowfish128, blowfish192, blowfish256, aes128, aes192, aes256, aes128ctr, aes192ctr, aes256ctr, camellia128, camellia192, camellia256. Default value: 3des
11	Define Diffie-Hellman group number. (optionally)	`esr(config-ike-proposal)# dh-group <DH-GROUP>`	<DH-GROUP> – Diffie-Hellman group number, takes values of [1, 2, 5, 14, 15, 16, 17, 18]. Default value: 1
12	Specify IKE authentication mode. (optionally)	`esr(config-ike-proposal)# authentication method <METHOD>`	<METHOD> – key authentication method. May take the following values: • **pre-shared-key** – authentication method using pre-received encryption keys; • **rsa-public-key** – authentication method using RSA certificate. Default value: pre-shared-key
13	Create an IKE policy and switch to its configuration mode.	`esr(config)# security ike policy <NAME>`	<NAME> – IKE policy name, set by the string of up to 31 characters.
14	Specify the lifetime of IKE protocol connection (optionally).	`esr(config-ike-proposal)# lifetime seconds <SEC>`	<SEC> – time interval, takes values of [4..86400] seconds. Default value: 3600

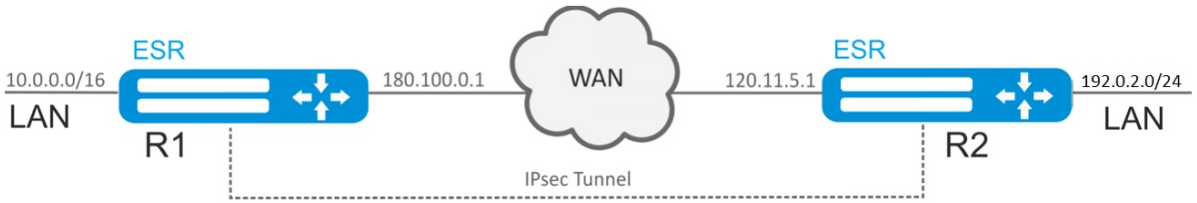
Step	Description	Command	Keys
15	Bind IKE profile to IKE policy.	`esr(config-ike-policy)# proposal <NAME>`	<NAME> – IKE protocol name, set by the string of up to 31 characters.
16	Specify authentication key. (mandatory if pre-shared-key is selected as authentication mode)	`esr(config-ike-policy)# pre-shared-key ascii-text<TEXT>`	<TEXT> – string [1..64] ASCII characters.
17	Create an IKE gateway and switch to its configuration mode.	`esr(config)# security ike gateway <NAME>`	<NAME> – IKE protocol gateway name, set by the string of up to 31 characters.
18	Bind IKE policy to IKE gateway.	`esr(config-ike-gw)# ike-policy <NAME>`	<NAME> – IKE protocol policy name, set by the string of up to 31 characters.
19	Specify IKE version (optionally).	`esr(config-ike-gw)# version <VERSION>`	<version> – IKE protocol version: v1-only or v2-only. Default value: v1-only
20	Set the route-based mode.	`esr(config-ike-gw)# mode route-based`	
21	Specify the action for DPD (optionally).	`esr(config-ike-gw)# dead-peer-detection action <MODE>`	<MODE> – DPD operation mode: • **restart** – connection restarts; • **clear** – conection stops; • **hold** – connection holds; • **none** – the mechanism is disabled, no action is taken. Default value: none
22	Specify the interval between sending messages via DPD mechanism (optionally).	`esr(config-ike-gw)# dead-peer-detection interval <SEC>`	<SEC> – interval between sending messages via DPD mechanism, takes values of [1..180] seconds. Default value: 2
23	Specify the time period of response to DPD mechanism messages (optionally).	`esr(config-ike-gw)# dead-peer-detection timeout <SEC>`	<SEC> – time interval of response to DPD mechanism messages, takes values of [1..180] seconds. Default value: 30 seconds
24	Bind VTI tunnel to IKE gateway.	`esr(config-ike-gw)# bind-interface vti <VTI>`	<VTI> – VTI ID.

Step	Description	Command	Keys
25	Create IPsec profile.	`esr(config)# security ipsec proposal <NAME>`	<NAME> – IPsec protocol profile name, set by the string of up to 31 characters.
26	Specify IPsec authentication algorithm. (optionally)	`esr(config-ipsec-proposal)# authentication algorithm <ALGORITHM>`	<ALGORITHM> – authentication algorithm, takes values of: md5, sha1, sha2-256, sha2_384, sha2-512. Default value: sha1
27	Specify IPsec encryption algorithm. (optionally)	`esr(config-ipsec-proposal)# encryption algorithm <ALGORITHM>`	<ALGORITHM> – encryption protocol, takes the following values: des, 3des, blowfish128, blowfish192, blowfish256, aes128, aes192, aes256, aes128ctr, aes192ctr, aes256ctr, camellia128, camellia192, camellia256. Default value: 3des
28	Specify encapsulation protocol for IPsec (optionally).	`esr(config-ipsec-proposal)# protocol <PROTOCOL>`	<PROTOCOL> – encapsulation protocol, takes the following values: Default value: esp
29	Create an IPsec policy and switch to its configuration mode.	`esr(config)# security ipsec policy <NAME>`	<NAME> – IPsec policy name, set by the string of up to 31 characters.
30	Bind IPsec profile to IPsec policy.	`esr(config-ipsec-policy)# proposal <NAME>`	<NAME> – IPsec protocol profile name, set by the string of up to 31 characters.
31	Specify the lifetime of IPsec tunnel (optionally).	`esr(config-ipsec-policy)# lifetime { seconds <SEC> | packets <PACKETS> | kilobytes <KB> }`	<SEC> – IPsec tunnel lifetime after which the re-approval is carried out. Takes values in the range of [1140..86400] seconds. <PACKETS> – number of packets after transmitting of which the IPsec tunnel re-approval is carried out. Takes values in the range of [4..86400]. <KB> – traffic amount after transmitting of which the IPsec tunnel re-approval is carried out. Takes values in the range of [4..86400] seconds. Default value: 28800 seconds

Step	Description	Command	Keys
32	Create IPsec VPN policy and switch to its configuration mode.	`esr(config)# security ipsec vpn <NAME>`	<NAME> – VPN name, set by the string of up to 31 characters.
33	Define the matching mode of data required for VPN enabling.	`esr(config-ipsec-vpn)# mode <MODE>`	<MODE> – VPN operation mode.
34	Bind IPsec policy to IPsec VPN.	`esr(config-ipsec-vpn)# ike ipsec-policy <NAME>`	<NAME> – IPsec policy name, set by the string of up to 31 characters.
35	Set the DSCP value for the use in IP headers of IKE outgoing packets (optionally).	`esr(config-ipsec-vpn)# ike dscp <DSCP>`	<DSCP> – DSCP code value, takes values in the range of [0..63]. Default value: 63
36	Set VPN activation mode.	`esr(config-ipsec-vpn)# ike establish-tunnel <MODE>`	<MODE> – VPN activation mode: • **by-request** – connection is enabled by an opposing party; • **route** – connection is enabled when there is traffic routed to the tunnel; • **immediate** – tunnel is enabled automatically after applying the configuration.
37	Bind IKE gateway to IPsec VPN.	`esr(config-ipsec-vpn)# ike gateway <NAME>`	<NAME> – IKE gateway name, set by the string of up to 31 characters.
38	Set the time interval value in seconds after which the connection is closed, if no packet has been received or sent via SA (optionally).	`esr(config-ipsec-vpn)# ike idle-time <TIME>`	<TIME> – interval in seconds, takes values of [4..86400].
39	Disable key re-approval before the IKE connection is lost due to the timeout, the number of transmitted packets or bytes (optionally).	`esr(config-ipsec-vpn)# ike rekey disable`	

Step	Description	Command	Keys
40	Configure the start of IKE connection keys re-approval before the expiration of the lifetime (optionally).	`esr(config-ipsec-vpn)# ike rekey margin { seconds <SEC>	packets <PACKETS>	kilobytes <KB> }`	<SEC> – time interval in seconds remaining before the connection release (set by the lifetimeseconds command, see 22.2.13). Takes values in the range of [4..86400]. <PACKETS> – number of packets remaining before the connection release (set by the lifetimepackets command). Takes values in the range of [4..86400]. <KB> – traffic volume in kilobytes remaining before the connection release (set by the lifetimekilobytes command). Takes values in the range of [4..86400]. Default value: • Keys re-approval before the expire of time – 540 seconds before. • Keys re-approval before the expire of traffic volume and amount of packets – disabled.
41	Set the level of margin seconds, margin packets, margin kilobytes values random spread (optionally).	`esr(config-ipsec-vpn)# ike rekey randomization <VALUE>`	<VALUE> – maximum ratio of values spread, takes values of [1..100]. Default value: 100%
42	Specify the description for IPsec-VPN (optionally).	`esr(config-ipsec-vpn)# description <DESCRIPTION>`	<DESCRIPTION> – profile description, set by the string of up to 255 characters.
43	Enable IPsec VPN.	`esr(config-ipsec-vpn)# enable`	

3.4.2 Route-based IPsec VPN configuration example



Objective:

Configure IPsec tunnel between R1 and R2.

- R1 IP address: 120.11.5.1;

- R2 IP address – 180.100.0.1;

IKE:

- Diffie-Hellman group: 2;
- encryption algorithm: AES 128 bit;
- authentication algorithm: MD5.

IP sec:

- encryption algorithm: AES 128 bit;
- authentication algorithm: MD5.

Solution:

1. R1 configuration
   Configure external network interface and identify its inherence to a security zone:

```
esr# configure
esr(config)# interface gi 1/0/1
esr(config-if-gi)# ip address 180.100.0.1/24
esr(config-if-gi)# security-zone untrusted
esr(config-if-gi)# exit
```

   Create VTI tunnel. Traffic will be routed via VTI into IPsec tunnel. Specify IP addresses of WAN border interfaces as local and remote gateways:

```
esr(config)# tunnel vti 1
esr(config-vti)# local address 180.100.0.1
esr(config-vti)# remote address 120.11.5.1
esr(config-vti)# enable
esr(config-vti)# exit
```

   To configure security zones rules, you should create ISAKMP port profile:

```
esr(config)# object-group service ISAKMP
esr(config-object-group-service)# port-range 500
esr(config-object-group-service)# exit
```

Create a static route to the remote LAN. For each subnet located beyond the IPsec tunnel, specify a route via VTI tunnel:

```
esr(config)# ip route 192.0.2.0/24 tunnel vti 1
```

Create IKE protocol profile. Select Diffie-Hellman group 2, AES 128 bit encryption algorithm and MD5 authentication algorithm in the profile. The given security parameters are used for IKE connection protection:

```
esr(config)# security ike proposal ike_prop1
esr(config-ike-proposal)# dh-group 2
esr(config-ike-proposal)# authentication algorithm md5
esr(config-ike-proposal)# encryption algorithm aes128
esr(config-ike-proposal)# exit
```

Create IKE protocol policy. For the policy, specify the list of IKE protocol profiles that may be used for node and authentication key negotiation:

```
esr(config)# security ike policy ike_pol1
esr(config-ike-policy)# pre-shared-key hexadecimal 123FFF
esr(config-ike-policy)# proposal ike_prop1
esr(config-ike-policy)# exit
```

Create IKE protocol gateway. For this profile, specify VTI tunnel, policy, protocol version and mode of traffic redirection into the tunnel.

```
esr(config)# security ike gateway ike_gw1
esr(config-ike-gw)# ike-policy ike_pol1
esr(config-ike-gw)# mode route-based
esr(config-ike-gw)# bind-interface vti 1
esr(config-ike-gw)# version v2-only
esr(config-ike-gw)# exit
```

Create security parameters profile for IPsec tunnel. For the profile, select Diffie-Hellman group 2, AES 128 bit encryption algorithm and MD5 authentication algorithm. Use the following parameters to secure IPsec tunnel:

```
esr(config)# security ipsec proposal ipsec_prop1
esr(config-ipsec-proposal)# authentication algorithm md5
esr(config-ipsec-proposal)# encryption algorithm aes128
esr(config-ipsec-proposal)# exit
```

Create a policy for IPsec tunnel. For the policy, specify the list of IPsec tunnel profiles that may be used for node negotiation:

```
esr(config)# security ipsec policy ipsec_pol1
esr(config-ipsec-policy)# proposal ipsec_prop1
esr(config-ipsec-policy)# exit
```

Create IPsec VPN. For VPN, specify IKE protocol gateway, IPsec tunnel policy, key exchange mode and connection establishment method. When all parameters are entered, enable tunnel using the *enable* command.

```
esr(config)# security ipsec vpn ipsec1
esr(config-ipsec-vpn)# mode ike
esr(config-ipsec-vpn)# ike establish-tunnel route
esr(config-ipsec-vpn)# ike gateway ike_gw1
esr(config-ipsec-vpn)# ike ipsec-policy ipsec_pol1
esr(config-ipsec-vpn)# enable
esr(config-ipsec-vpn)# exit
esr(config)# exit
```

2. R2 configuration
Configure external network interface and identify its inherence to a security zone:

```
esr# configure
esr(config)# interface gi 1/0/1
esr(config-if)# ip address 120.11.5.1/24
esr(config-if)# security-zone untrusted
esr(config-if)# exit
```

Create VTI tunnel. Traffic will be routed via VTI into IPsec tunnel. Specify IP addresses of WAN border interfaces as local and remote gateways:

```
esr(config)# tunnel vti 1
esr(config-vti)# remote address 180.100.0.1
esr(config-vti)# local address 120.11.5.1
esr(config-vti)# enable
esr(config-vti)# exit
```

To configure security zones rules, you should create ISAKMP port profile:

```
esr(config)# object-group service ISAKMP
esr(config-object-group-service)# port-range 500
esr(config-object-group-service)# exit
```

Create a static route to the remote LAN. For each subnet located beyond the IPsec tunnel, specify a route via VTI tunnel:

```
esr(config)# ip route 10.0.0.0/16 tunnel vti 1
```

Create IKE protocol profile. Select Diffie-Hellman group 2, AES 128 bit encryption algorithm and MD5 authentication algorithm in the profile. The given security parameters are used for IKE connection protection:

```
esr(config)# security ike proposal ike_prop1
esr(config-ike-proposal)# dh-group 2
esr(config-ike-proposal)# authentication algorithm md5
esr(config-ike-proposal)# encryption algorithm aes128
esr(config-ike-proposal)# exit
esr(config)#
```

Create IKE protocol policy. For the policy, specify the list of IKE protocol profiles that may be used for node and authentication key negotiation:

```
esr(config)# security ike policy ike_pol1
esr(config-ike-policy)# pre-shared-key hexadecimal 123FFF
esr(config-ike-policy)# proposal ike_prop1
esr(config-ike-policy)# exit
```

Create IKE protocol gateway. For this profile, specify VTI tunnel, policy, protocol version and mode of traffic redirection into the tunnel.

```
esr(config)# security ike gateway ike_gw1
esr(config-ike-gw)# ike-policy ike_pol1
esr(config-ike-gw)# mode route-based
esr(config-ike-gw)# bind-interface vti 1
esr(config-ike-gw)# version v2-only
esr(config-ike-gw)# exit
```

Create security parameters profile for IPsec tunnel. For the profile, select Diffie-Hellman group 2, AES 128 bit encryption algorithm and MD5 authentication algorithm. Use the following parameters to secure IPsec tunnel:

```
esr(config)# security ipsec proposal ipsec_prop1
esr(config-ipsec-proposal)# authentication algorithm md5
esr(config-ipsec-proposal)# encryption algorithm aes128
esr(config-ipsec-proposal)# exit
```

Create a policy for IPsec tunnel. For the policy, specify the list of IPsec tunnel profiles that may be used for node negotiation:

```
esr(config)# security ipsec policy ipsec_pol1
esr(config-ipsec-policy)# proposal ipsec_prop1
esr(config-ipsec-policy)# exit
```

Create IPsec VPN. For VPN, specify IKE protocol gateway, IPsec tunnel policy, key exchange mode and connection establishment method. When all parameters are entered, enable tunnel using the *enable* command.

```
esr(config)# security ipsec vpn ipsec1
esr(config-ipsec-vpn)# mode ike
esr(config-ipsec-vpn)# ike establish-tunnel route
esr(config-ipsec-vpn)# ike gateway ike_gw1
esr(config-ipsec-vpn)# ike ipsec-policy ipsec_pol1
esr(config-ipsec-vpn)# enable
esr(config-ipsec-vpn)# exit
esr(config)# exit
```

To view the tunnel status, use the following command:

```
esr# show security ipsec vpn status ipsec1
```

To view the tunnel configuration, use the following command:

```
esr# show security ipsec vpn configuration ipsec1
```

⚠ In the firewall, you should enable ESP and ISAKMP protocol (UDP port 500).

3.4.3 Policy-based IPsec VPN configuration algorithm

Step	Description	Command	Keys
1	Create an IKE instance and switch to its configuration mode.	`esr(config)# security ike proposal <NAME>`	<NAME> – IKE protocol name, set by the string of up to 31 characters.
2	Specify the description of the configured tunnel (optionally).	`esr(config-ike-proposal)# description<DESCRIPTION>`	<DESCRIPTION> – tunnel description, set by the string of up to 255 characters.
3	Specify IKE authentication algorithm.	`esr(config-ike-proposal)# authentication algorithm <ALGORITHM>`	<ALGORITHM> – authentication algorithm, takes values of: md5, sha1, sha2-256, sha2_384, sha2-512.
4	Specify IKE encryption algorithm.	`esr(config-ike-proposal)# encryption algorithm <ALGORITHM>`	<ALGORITHM> – encryption protocol, takes the following values: des, 3des, blowfish128, blowfish192, blowfish256, aes128, aes192, aes256, aes128ctr, aes192ctr, aes256ctr, camellia128, camellia192, camellia256.
5	Define Diffie-Hellman group number.	`esr(config-ike-proposal)# dh-group <DH-GROUP>`	<DH-GROUP> – Diffie-Hellman group number, takes values of [1, 2, 5, 14, 15, 16, 17, 18].
6	Specify the authentication mode.	`esr(config-ike-proposal)# authentication method <METHOD>`	<METHOD> – key authentication method. May take the following values: • **pre-shared-key** – authentication method using pre-received encryption keys; • **rsa-public-key** – authentication method using RSA certificate.
7	Create an IKE profile policy and switch to its configuration mode.	`esr(config)# security ike policy <NAME>`	<NAME> – IKE policy name, set by the string of up to 31 characters.
8	Specify the lifetime of IKE protocol connection (optionally).	`esr(config-ike-proposal)# lifetime seconds <SEC>`	<SEC> – time interval, takes values of [4..86400] seconds.

Step	Description	Command	Keys
9	Bind the policy to profile.	`esr(config-ike-policy)# proposal <NAME>`	<NAME> – IKE protocol name, set by the string of up to 31 characters.
10	Specify authentication key.	`esr(config-ike-policy)#pre-shared-key ascii-text<TEXT>`	<TEXT> – string [1..64] ASCII characters.
11	Create an IKE gateway and switch to its configuration mode.	`esr(config)# security ike gateway <NAME>`	<NAME> – IKE protocol gateway name, set by the string of up to 31 characters.
12	Bind IKE policy.	`esr(config-ike-gw)# ike-policy <NAME>`	<NAME> – IKE protocol policy name, set by the string of up to 31 characters.
13	Specify IKE version (optionally).	`esr(config-ike-gw)# version <VERSION>`	<version> – IKE protocol version: **v1-only** or **v2-only**.
14	Set the mode of traffic redirection into the tunnel.	`esr(config-ike-gw)#mode<MODE>`	<MODE> – mode of traffic redirection into the tunnel, takes the following values: • **policy-based** — traffic is redirected based on the subnets specified in the policies; • **route-based** — traffic is redirected based on routes whose gateway is a tunnel interface.
15	Specify the action for DPD (optionally).	`esr(config-ike-gw)# dead-peer-detection action <MODE>`	<MODE> – DPD operation mode: • **restart** – connection restarts; • **clear** – conection stops; • **hold** – connection holds; • **none** – the mechanism is disabled, no action is taken.
16	Specify the interval between sending messages via DPD mechanism (optionally).	`esr(config-ike-gw)#dead-peer-detection interval <SEC>`	<SEC> – interval between sending messages via DPD mechanism, takes values of [1..180] seconds.
17	Specify the time period of response to DPD mechanism messages (optionally).	`esr(config-ike-gw)# dead-peer-detection timeout <SEC>`	<SEC> – time interval of response to DPD mechanism messages, takes values of [1..180] seconds.
18	Specify IKE version (optionally).	`esr(config-ike-gw)# version <VERSION>`	<version> – IKE protocol version: **v1-only** or **v2-only**.

Step	Description	Command	Keys
19	Set sender's IP subnets.	`esr(config-ike-gw)# local network <ADDR/LEN> [ protocol { <TYPE> | <ID> } [ port <PORT> ] ]`	<ADDR/LEN> – subnet IP address and mask of a sender. The parameter is defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32]. <TYPE> – protocol type, takes the following values: esp, icmp, ah, eigrp, ospf, igmp, ipip, tcp, pim, udp, vrrp, rdp, l2tp, gre; <ID> – IP identification number, takes values of [0x00-0xFF]; <PORT> – TCP/UDP port, takes values of [1..65535].
20	Specify the IP address of IPsec tunnel local gateway.	`esr(config-ike-gw)#local address <ADDR>`	<ADDR> – IP address of a local gateway.
21	Specify the IP address of IPsec tunnel remote gateway.	`esr(config-ike-gw)#remote address <ADDR>`	<ADDR> – IP address of a remote gateway.
22	Set recipient's subnet IP address as well as IP and port.	`esr(config-ike-gw)# remote network <ADDR/LEN> [ protocol { <TYPE> | <ID> } [ port <PORT> ] ]`	<ADDR/LEN> – subnet IP address and mask of a sender. The parameter is defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32]. <TYPE> – protocol type, takes the following values: esp, icmp, ah, eigrp, ospf, igmp, ipip, tcp, pim, udp, vrrp, rdp, l2tp, gre; <ID> – IP identification number, takes values of [0x00-0xFF]; <PORT> – TCP/UDP port, takes values of [1..65535].
23	Create IPsec profile.	`esr(config)# security ipsec proposal <NAME>`	<NAME> – IPsec protocol profile name, set by the string of up to 31 characters.
24	Specify IPsec authentication algorithm.	`esr(config-ipsec-proposal)# authentication algorithm <ALGORITHM>`	<ALGORITHM> – authentication algorithm, takes values of: md5, sha1, sha2-256, sha2_384, sha2-512.

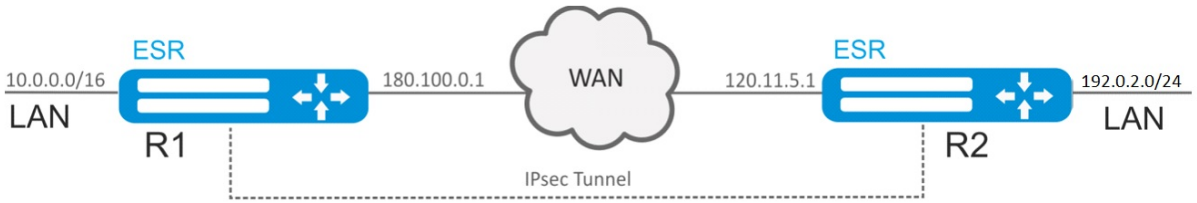
Step	Description	Command	Keys
26	Specify IPsec encryption algorithm.	`esr(config-ipsec-proposal)# encryption algorithm <ALGORITHM>`	<ALGORITHM> – encryption protocol, takes the following values: des, 3des, blowfish128, blowfish192, blowfish256, aes128, aes192, aes256, aes128ctr, aes192ctr, aes256ctr, camellia128, camellia192, camellia256.
26	Specify protocol (optionally).	`esr(config-ipsec-proposal)# protocol <PROTOCOL>`	<PROTOCOL> – encapsulation protocol, takes the following values:
27	Create an IPsec profile policy and switch to its configuration mode.	`esr(config)# security ipsec policy <NAME>`	<NAME> – IPsec policy name, set by the string of up to 31 characters.
28	Bind the policy to profile.	`esr(config-ipsec-policy)# proposal <NAME>`	<NAME> – IPsec protocol profile name, set by the string of up to 31 characters.
29	Specify the lifetime of IPsec tunnel (optionally).	`esr(config-ipsec-policy)# lifetime { seconds <SEC> | packets <PACKETS> | kilobytes <KB> }`	<SEC> – IPsec tunnel lifetime after which the re-approval is carried out. Takes values in the range of [1140..86400] seconds. <PACKETS> – number of packets after transmitting of which the IPsec tunnel re-approval is carried out. Takes values in the range of [4..86400]. <KB> – traffic amount after transmitting of which the IPsec tunnel re-approval is carried out. Takes values in the range of [4..86400] seconds.
30	Create IPsec VPN policy and switch to its configuration mode.	`esr(config)# security ipsecvpn <NAME>`	<NAME> – VPN name, set by the string of up to 31 characters.
31	Define the matching mode of data required for VPN enabling.	`esr(config-ipsec-vpn)# mode <MODE>`	<MODE> – VPN operation mode.
32	Bind IPsec policy to VPN.	`esr(config-ipsec-vpn)#ike ipsec-policy <NAME>`	<NAME> – IPsec policy name, set by the string of up to 31 characters.
33	Set the DSCP value for the use in IP headers of IKE outgoing packets (optionally).	`esr(config-ipsec-vpn)#ike dscp <DSCP>`	<DSCP> – DSCP code value, takes values in the range of [0..63].

Step	Description	Command	Keys
34	Set VPN activation mode.	`esr(config-ipsec-vpn)#ike establish-tunnel <MODE>`	<MODE> – VPN activation mode: • **by-request** – connection is enabled by an opposing party; • **route** – connection is enabled when there is traffic routed to the tunnel; • **immediate** – tunnel is enabled automatically after applying the configuration.
35	Bind IKE gateway to VPN.	`esr(config-ipsec-vpn)# ike gateway <NAME>`	<NAME> – IKE gateway name, set by the string of up to 31 characters.
36	Set the time interval value in seconds after which the connection is closed, if no packet has been received or sent via SA (optionally).	`esr(config-ipsec-vpn)# ike idle-time <TIME>`	<TIME> – interval in seconds, takes values of [4..86400].
37	Disable key re-approval before the IKE connection is lost due to the timeout, the number of transmitted packets or bytes (optionally).	`esr(config-ipsec-vpn)# ike rekey disable`	
38	Configure the start of IKE connection keys re-approval before the expiration of the lifetime (optionally).	`esr(config-ipsec-vpn)# ike rekey margin { seconds <SEC> | packets <PACKETS> | kilobytes <KB> }`	<SEC> – time interval in seconds remaining before the connection release (set by the lifetimeseconds command). Takes values in the range of [4..86400]. <PACKETS> – number of packets remaining before the connection release (set by the lifetimepackets command). Takes values in the range of [4..86400]. <KB> – traffic volume in kilobytes remaining before the connection release (set by the lifetimekilobytes command). Takes values in the range of [4..86400].
39	Set the level of margin seconds, margin packets, margin kilobytes values random spread (optionally).	`esr(config-ipsec-vpn)# ike rekey randomization <VALUE>`	<VALUE> – maximum ratio of values spread, takes values of [1..100].
40	Describe VPN (optionally).	`esr(config-ipsec-vpn)# description <DESCRIPTION>`	<DESCRIPTION> – profile description, set by the string of up to 255 characters.

Step	Description	Command	Keys
41	Enable IPsec VPN.	`esr(config-ipsec-vpn)# enable`	

3.4.4 Policy-based IPsec VPN configuration example

Objective:



Configure IPsec tunnel between R1 and R2.

R1 IP address: 120.11.5.1;

R2 IP address – 180.100.0.1;

IKE:

- Diffie-Hellman group: 2;
- encryption algorithm: AES 128 bit;
- authentication algorithm: MD5.

IPsec:

- encryption algorithm: AES 128 bit;
- authentication algorithm: MD5.

Solution:

1. R1 configuration
   Configure external network interface and identify its inherence to a security zone:

```
esr# configure
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)# ip address 120.11.5.1/24
esr(config-if-gi)# security-zone untrusted
esr(config-if-gi)# exit
```

   To configure security zones rules, you should create ISAKMP port profile:

```
esr(config)# object-group service ISAKMP
esr(config-object-group-service)# port-range 500
esr(config-object-group-service)# exit
```

   Create IKE protocol profile. Select Diffie-Hellman group 2, AES 128 bit encryption algorithm and MD5 authentication algorithm in the profile. The given security parameters are used for IKE connection protection:

```
esr(config)# security ike proposal ike_prop1
esr(config-ike-proposal)# dh-group 2
esr(config-ike-proposal)# authentication algorithm md5
esr(config-ike-proposal)# encryption algorithm aes128
esr(config-ike-proposal)# exit
```

Create IKE protocol policy. For the policy, specify the list of IKE protocol profiles that may be used for node and authentication key negotiation:

```
esr(config)# security ike policy ike_pol1
esr(config-ike-policy)# pre-shared-key hexadecimal 123FFF
esr(config-ike-policy)# proposal ike_prop1
esr(config-ike-policy)# exit
```

Create IKE protocol gateway. For this profile, specify VTI tunnel, policy, protocol version and mode of traffic redirection into the tunnel.

```
esr(config)# security ike gateway ike_gw1
esr(config-ike-gw)# ike-policy ike_pol1
esr(config-ike-gw)# local address 180.100.0.1
esr(config-ike-gw)# local network 10.0.0.0/16
esr(config-ike-gw)# remote address 120.11.5.1
esr(config-ike-gw)# remote network 192.0.2.0/24
esr(config-ike-gw)# mode policy-based
esr(config-ike-gw)# exit
```

Create security parameters profile for IPsec tunnel. For the profile, select Diffie-Hellman group 2, AES 128 bit encryption algorithm and MD5 authentication algorithm. Use the following parameters to secure IPsec tunnel:

```
esr(config)# security ipsec proposal ipsec_prop1
esr(config-ipsec-proposal)# authentication algorithm md5
esr(config-ipsec-proposal)# encryption algorithm aes128
esr(config-ipsec-proposal)# exit
```

Create a policy for IPsec tunnel. For the policy, specify the list of IPsec tunnel profiles that may be used for node negotiation:

```
esr(config)# security ipsec policy ipsec_pol1
esr(config-ipsec-policy)# proposal ipsec_prop1
esr(config-ipsec-policy)# exit
```

Create IPsec VPN. For VPN, specify IKE protocol gateway, IPsec tunnel policy, key exchange mode and connection establishment method. When all parameters are entered, enable tunnel using the *enable* command.

```
esr(config)# security ipsec vpn ipsec1
esr(config-ipsec-vpn)# mode ike
esr(config-ipsec-vpn)# ike establish-tunnel immediate
esr(config-ipsec-vpn)# ike gateway ike_gw1
esr(config-ipsec-vpn)# ike ipsec-policy ipsec_pol1
esr(config-ipsec-vpn)# enable
esr(config-ipsec-vpn)# exit
esr(config)# exit
```

2. R2 configuration
Configure external network interface and identify its inherence to a security zone:

```
esr# configure
esr(config)# interface gi 1/0/1
esr(config-if)# ip address 120.11.5.1/24
esr(config-if)# security-zone untrusted
esr(config-if)# exit
```

To configure security zones rules, you should create ISAKMP port profile:

```
esr(config)# object-group service ISAKMP
esr(config-addr-set)# port-range 500
esr(config-addr-set)# exit
```

Create IKE protocol profile. Select Diffie-Hellman group 2, AES 128 bit encryption algorithm and MD5 authentication algorithm in the profile. The given security parameters are used for IKE connection protection:

```
esr(config)# security ike proposal ike_prop1
esr(config-ike-proposal)# dh-group 2
esr(config-ike-proposal)# authentication algorithm md5
esr(config-ike-proposal)# encryption algorithm aes128
esr(config-ike-proposal)# exit
esr(config)#
```

Create IKE protocol policy. For the policy, specify the list of IKE protocol profiles that may be used for node and authentication key negotiation:

```
esr(config)# security ike policy ike_pol1
esr(config-ike-policy)# pre-shared-key hexadecimal 123FFF
esr(config-ike-policy)# proposal ike_prop1
esr(config-ike-policy)# exit
```

Create IKE protocol gateway. For this profile, specify VTI tunnel, policy, protocol version and mode of traffic redirection into the tunnel.

```
esr(config)# security ike gateway ike_gw1
esr(config-ike-gw)# ike-policy ike_pol1
esr(config-ike-gw)# remote address 180.100.0.1
esr(config-ike-gw)# remote network 10.0.0.0/16
esr(config-ike-gw)# local address 120.11.5.1
esr(config-ike-gw)# local network 192.0.2.0/24
esr(config-ike-gw)# mode policy-based
esr(config-ike-gw)# exit
```

Create security parameters profile for IPsec tunnel. For the profile, select Diffie-Hellman group 2, AES 128 bit encryption algorithm and MD5 authentication algorithm. Use the following parameters to secure IPsec tunnel:

```
esr(config)# security ipsec proposal ipsec_prop1
esr(config-ipsec-proposal)# authentication algorithm md5
esr(config-ipsec-proposal)# encryption algorithm aes128
esr(config-ipsec-proposal)# exit
```

Create a policy for IPsec tunnel. For the policy, specify the list of IPsec tunnel profiles that may be used for node negotiation:

```
esr(config)# security ipsec policy ipsec_pol1
esr(config-ipsec-policy)# proposal ipsec_prop1
esr(config-ipsec-policy)# exit
```

Create IPsec VPN. For VPN, specify IKE protocol gateway, IPsec tunnel policy, key exchange mode and connection establishment method. When all parameters are entered, enable tunnel using the *enable* command.

```
esr(config)# security ipsec vpn ipsec1
esr(config-ipsec-vpn)# mode ike
esr(config-ipsec-vpn)# ike establish-tunnel immediate
esr(config-ipsec-vpn)# ike gateway ike_gw1
esr(config-ipsec-vpn)# ike ipsec-policy ipsec_pol1
esr(config-ipsec-vpn)# enable
esr(config-ipsec-vpn)# exit
esr(config)# exit
```

To view the tunnel status, use the following command:

```
esr# show security ipsec vpn status ipsec1
```

To view the tunnel configuration, use the following command:

```
esr# show security ipsec vpn configuration ipsec1
```

⚠ In the firewall, you should enable ESP and ISAKMP protocol (UDP port 500).

3.4.5 Remote Access IPsec VPN configuration algorithm

Remote Access IPsec VPN – scenario for organizing temporary VPN connections in which the IPsec VPN server is waiting for incoming connections, and clients make temporary connections to the server to gain access to network resources.

An additional feature of RA IPsec VPN is the ability to use the second IPsec authentication factor – Extended Authentication (XAUTH), where the second authentication factor is the login-password pair for the IPsec VPN client.

Step	Description	Command	Keys
1	Create an IKE instance and switch to its configuration mode.	`esr(config)# security ike proposal <NAME>`	<NAME> – IKE protocol name, set by the string of up to 31 characters.
2	Specify the description of the configured tunnel (optionally).	`esr(config-ike-proposal)# description <DESCRIPTION>`	<DESCRIPTION> – tunnel description, set by the string of up to 255 characters.
3	Specify IKE authentication algorithm (optionally).	`esr(config-ike-proposal)# authentication algorithm <ALGORITHM>`	<ALGORITHM> – authentication algorithm, takes values of: md5, sha1, sha2-256, sha2_384, sha2-512. Default value: sha1
4	Specify the IP address of the VTI tunnel local side (optional).	`esr(config-vti)# ip address <ADDR/LEN>`	<ADDR/LEN> – IP address and prefix of a subnet, defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..31].
5	Define Diffie-Hellman group number (optionally).	`esr(config-ike-proposal)# dh-group <DH-GROUP>`	<DH-GROUP> – Diffie-Hellman group number, takes values of [1, 2, 5, 14, 15, 16, 17, 18]. Default value: 1
6	Create an IKE profile policy and switch to its configuration mode.	`esr(config)# security ike policy <NAME>`	<NAME> – IKE policy name, set by the string of up to 31 characters.
7	Specify the authentication mode.	`esr(config-ike-policy)# authentication method <METHOD>`	<METHOD> – key authentication method. May take the following values: • **xauth-psk-key** – two-factor authentication method using a login-password pair and previously obtained encryption keys.
8	Set the client mode (only for client).	`esr(config-ike-policy)# authentication mode client`	
9	Specify the lifetime of IKE protocol connection (optionally).	`esr(config-ike-policy)# lifetime seconds <SEC>`	<SEC> – time interval, takes values of [4..86400] seconds. Default value: 3600
10	Bind the policy to profile.	`esr(config-ike-policy)# proposal <NAME>`	<NAME> – IKE protocol name, set by the string of up to 31 characters.

Step	Description	Command	Keys
11	Specify authentication key.	`esr(config-ike-policy)#pre-shared-key ascii-text <TEXT>`	<TEXT> – string [1..64] ASCII characters.
12	Create an access profile.	`esr(config)# access profile <NAME>`	<NAME> – access profile name, set by the string of up to 31 characters.
13	Create user name.	`esr(config-access-profile)# user <LOGIN>`	<LOGIN> – login for client, set by the string of up to 31 characters.
14	Specify a password for a user	`esr(config-profile)# password ascii-text <TEXT>`	<TEXT> – string [8..32] ASCII characters.
15	Create a destination address pool (only for server).	`esr(config)# address-assignment pool <NAME>`	<NAME> – destination addresses pool name, set by the string of up to 31 characters.
16	Set the subnet from which IP clients will be issued (only for server).	`esr(config-pool)# ip prefix <ADDR/LEN>`	<ADDR/LEN> – address and prefix of the subnet.
17	Create an IKE gateway and switch to its configuration mode.	`esr(config)# security ike gateway <NAME>`	<NAME> – IKE protocol gateway name, set by the string of up to 31 characters.
18	Bind IKE policy.	`esr(config-ike-gw)# ike-policy <NAME>`	<NAME> – IKE protocol policy name, set by the string of up to 31 characters.
19	Set the mode of traffic redirection into the tunnel.	`esr(config-ike-gw)# mode <MODE>`	<MODE> – mode of traffic redirection into the tunnel, takes the following values: • **policy-based** — traffic is redirected based on the subnets specified in the policies.
20	Specify the action for DPD (optionally).	`esr(config-ike-gw)# dead-peer-detection action <MODE>`	<MODE> – DPD operation mode: • **restart** – connection restarts; • **clear** – conection stops; • **hold** – connection holds; • **none** – the mechanism is disabled, no action is taken. Default value: none

Step	Description	Command	Keys
21	Specify the interval between sending messages via DPD mechanism (optionally).	`esr(config-ike-gw)#dead-peer-detection interval <SEC>`	<SEC> – interval between sending messages via DPD mechanism, takes values of [1..180] seconds. Default value: 2
22	Specify the time period of response to DPD mechanism messages (optionally).	`esr(config-ike-gw)# dead-peer-detection timeout <SEC>`	<SEC> – time interval of response to DPD mechanism messages, takes values of [1..180] seconds. Default value: 30
23	Specify IKE version (optionally).	`esr(config-ike-gw)# version <VERSION>`	<version> – IKE protocol version: **v1-only** or **v2-only**. Default value: v1-only
24	Set the IP subnet of the source (only for server).	`esr(config-ike-gw)# local network <ADDR/LEN> [ protocol { <TYPE> | <ID> } [ port <PORT> ] ]`	<ADDR/LEN> – subnet IP address and mask of a sender. The parameter is defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32]. <TYPE> – protocol type, takes the following values: esp, icmp, ah, eigrp, ospf, igmp, ipip, tcp, pim, udp, vrrp, rdp, l2tp, gre; <ID> – IP identification number, takes values of [0x00-0xFF]; <PORT> – TCP/UDP port, takes values of [1..65535].
25	Specify the IP address of IPsec tunnel local gateway.	`esr(config-ike-gw)#local address <ADDR>`	<ADDR> – IP address of a local gateway.
26	Specify the IP address of IPsec tunnel remote gateway.	`esr(config-ike-gw)#remote address [any | <ADDR/LEN> [ protocol { <TYPE> | <ID> } [ port <PORT> ] ]`	Any – set as a remote address – any client address in the server configuration; <ADDR/LEN> – IP address and subnet mask of the server, in client configuration.
27	Set the pool for dynamic allocation of IP addresses to clients (only for server).	`esr(config-ike-gw)# remote network dynamic pool <NAME>`	<NAME> – destination addresses pool name, set by the string of up to 31 characters.
28	Set the dynamic establishment mode of the remote subnet (only for client).	`esr(config-ike-gw)# remote network dynamic client`	

Step	Description	Command	Keys
29	Set access profile for XAUTH parameters (only for server).	`esr(config-ike-gw)# xauth access-profile <NAME>`	<NAME> – access profile name, set by the string of up to 31 characters.
30	Set access profile and login for XAUTH parameters (only for client).	`esr(config-ike-gw)# xauth access-profile <NAME> client <LOGIN>`	<NAME> – access profile name, set by the string of up to 31 characters; <LOGIN> – login for client, set by the string of up to 31 characters.
31	Define a dedicated IP termination interface for building IPsec VPN (only for client).	`esr(config-ike-gw)# assign-interface loopback <INDEX>`	<INDEX> – interface index, takes values of [1..65535].
32	Create IPsec profile.	`esr(config)# security ipsec proposal <NAME>`	<NAME> – IPsec protocol profile name, set by the string of up to 31 characters.
33	Specify IPsec authentication algorithm (optionally).	`esr(config-ipsec-proposal)# authentication algorithm <ALGORITHM>`	<ALGORITHM> – authentication algorithm, takes values of: md5, sha1, sha2-256, sha2_384, sha2-512. Default value: sha1
34	Specify IPsec encryption algorithm (optionally).	`esr(config-ipsec-proposal)# encryption algorithm <ALGORITHM>`	<ALGORITHM> – encryption protocol, takes the following values: des, 3des, blowfish128, blowfish192, blowfish256, aes128, aes192, aes256, aes128ctr, aes192ctr, aes256ctr, camellia128, camellia192, camellia256. Default value: 3des
35	Specify protocol (optionally).	`esr(config-ipsec-proposal)# protocol <PROTOCOL>`	<PROTOCOL> – encapsulation protocol, takes the values.
36	Create an IPsec profile policy and switch to its configuration mode.	`esr(config)# security ipsec policy <NAME>`	<NAME> – IPsec policy name, set by the string of up to 31 characters.
37	Bind the policy to profile.	`esr(config-ipsec-policy)# proposal <NAME>`	<NAME> – IPsec protocol profile name, set by the string of up to 31 characters.

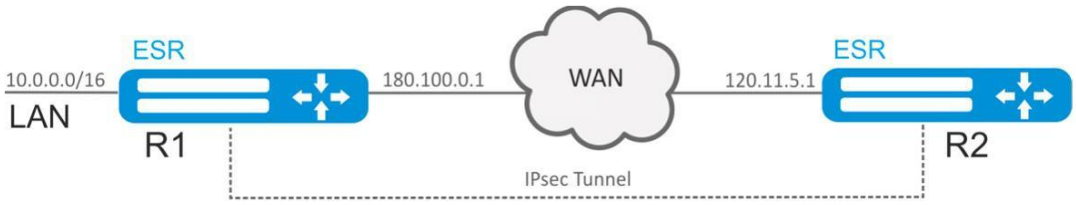
Step	Description	Command	Keys
38	Specify the lifetime of IPsec tunnel (optionally).	`esr(config-ipsec-policy)# lifetime { seconds <SEC> | packets <PACKETS> | kilobytes <KB> }`	<SEC> – IPsec tunnel lifetime after which the re-approval is carried out. Takes values in the range of [1140..86400] seconds. Default value: 540 <PACKETS> – number of packets after transmitting of which the IPsec tunnel re-approval is carried out. Takes values in the range of [4..86400]. Default value: disabled. <KB> – traffic amount after transmitting of which the IPsec tunnel re-approval is carried out. Takes values in the range of [4..86400] seconds. Default value: disabled.
39	Create IPsec VPN policy and switch to its configuration mode.	`esr(config)# security ipsec vpn <NAME>`	<NAME> – VPN name, set by the string of up to 31 characters.
40	Define the matching mode of data required for VPN enabling.	`esr(config-ipsec-vpn)# mode <MODE>`	<MODE> – VPN operation mode, takes the following values: ike, manual.
41	Bind IPsec policy to VPN.	`esr(config-ipsec-vpn)#ike ipsec-policy <NAME>`	<NAME> – IPsec policy name, set by the string of up to 31 characters.
42	Set the DSCP value for the use in IP headers of IKE outgoing packets (optionally).	`esr(config-ipsec-vpn)#ike dscp <DSCP>`	<DSCP> – DSCP code value, takes values in the range of [0..63]. Default value: 63
43	Set VPN activation mode.	`esr(config-ipsec-vpn)#ike establish-tunnel <MODE>`	<MODE> – VPN activation mode: • **by-request** – connection is activated by the opposite side, available for the server; • **route** – the connection is activated when traffic routed to the tunnel appears; it is available for the server; • **immediate** – tunnel is enabled automatically after applying the configuration, it is available for the client;

Step	Description	Command	Keys
44	Bind IKE gateway to VPN.	`esr(config-ipsec-vpn)# ike gateway <NAME>`	<NAME> – IKE gateway name, set by the string of up to 31 characters.
45	Set the time interval value in seconds after which the connection is closed, if no packet has been received or sent via SA (optionally).	`esr(config-ipsec-vpn)# ike idle-time <TIME>`	<TIME> – interval in seconds, takes values of [4..86400]. Default value: 0
46	Disable key re-approval before the IKE connection is lost due to the timeout, the number of transmitted packets or bytes (optionally).	`esr(config-ipsec-vpn)# ike rekey disable`	Default value: disabled.
47	Configure the start of IKE connection keys re-approval before the expiration of the lifetime (optionally).	`esr(config-ipsec-vpn)# ike rekey margin { seconds <SEC> | packets <PACKETS> | kilobytes <KB> }`	<SEC> – time interval in seconds remaining before the connection release (set by the lifetimeseconds command). Takes values in the range of [4..86400]. Default value: 540 <PACKETS> – number of packets remaining before the connection release (set by the lifetimepackets command). Takes values in the range of [4..86400]. Default value: disabled. <KB> – traffic volume in kilobytes remaining before the connection release (set by the lifetimekilobytes command). May take values [4..86400] Default value: disabled.
48	Set the level of margin seconds, margin packets, margin kilobytes values random spread (optionally).	`esr(config-ipsec-vpn)# ike rekey randomization <VALUE>`	<VALUE> – maximum ratio of values spread, takes values of [1..100]. Default value: 100
49	Describe VPN (optionally).	`esr(config-ipsec-vpn)# description <DESCRIPTION>`	<DESCRIPTION> – profile description, set by the string of up to 255 characters.
50	Enable IPsec VPN.	`esr(config-ipsec-vpn)# enable`	

Step	Description	Command	Keys
51	Enable XAUTH clients reconnection mode with one login/password (server only) (optional).	`esr(config-ipsec-vpn)# security ike session uniqueids <MODE>`	<MODE> – reconnect mode, may take the following values: no – established XAUTH connection will be deleted if an «INITIAL_CONTACT» notification is sent for a new XAUTH connection by the initiator of the connection, the previously used IP address will be assigned. Otherwise, the established XAUTH connection will be withheld. A new IP address will be assigned to the new XAUTH connection. • never – established XAUTH connection will be withheld. A new IP address will be assigned to the new XAUTH connection. The «INITIAL_CONTACT» notification will be ignored anyway. • replace – established XAUTH connection will be deleted. The previously used IP address will be used for the new XAUTH connection. • keep – established XAUTH connection will be withheld. A new XAUTH connection will be rejected.

3.4.6 Remote Access IPsec VPN configuration example

Objective:



Configure Remote Access IPsec VPN between R1 and R2 using the second IPsec authentication factor, XAUTH. Configure router R1 as the IPsec VPN server, and router R2 as the IPsec VPN client.

R2 IP address: 120.11.5.1;

R1 IP address: 180.100.0.1;

For IPsec VPN clients:

- issue addresses from the subnet pool 192.0.2.0/24
- provide access to the LAN subnet 10.0.0.0/16

IKE:

- Diffie-Hellman group: 2;
- encryption algorithm: 3DES;

- authentication algorithm: SHA1.

IPsec:

- encryption algorithm: 3DES;
- authentication algorithm: SHA1.

XAUTH:

- login: client1;
- password: password123.

Solution:

1. R1 configuration
   Configure external network interface and identify its inherence to a security zone:

```
esr# configure
esr(config)# security zone untrusted
esr(config-zone)# exit
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)# security-zone untrusted
esr(config-if-gi)# ip address 180.100.0.1/24
esr(config-if-gi)# exit
```

   To configure security zones rules, you should create ISAKMP port profile:

```
esr(config)# object-group service ISAKMP
esr(config-object-group-service)# port-range 500,4500
esr(config-object-group-service)# exit
```

   Create IKE protocol profile. Select Diffie-Hellman group 2, 3DES encryption algorithm and SHA1 authentication algorithm in the profile. The given security parameters are used for IKE connection protection:

```
esr(config)# security ike proposal IKEPROP
esr(config-ike-proposal)# dh-group 2
esr(config-ike-proposal)# authentication algorithm sha1
esr(config-ike-proposal)# encryption algorithm 3des
esr(config-ike-proposal)# exit
```

   Create IKE protocol policy. For the policy, specify the list of IKE protocol profiles that may be used for node, authentication key and XAUTH authentication method by key negotiation:

```
esr(config)# security ike policy IKEPOLICY
esr(config-ike-policy)# pre-shared-key hexadecimal 123FFF
esr(config-ike-policy)# authentication method xauth-psk-key
esr(config-ike-policy)# proposal IKEPROP
esr(config-ike-policy)# exit
```

   Create an access profile and get in it a pair of username and password for the IPsec VPN client:

```
esr(config)# access profile XAUTH
esr(config-access-profile)# user client1
esr(config-profile)# password ascii-text password123
esr(config-profile)# exit
esr(config-access-profile)# exit
```

Create a pool of destination addresses from which IP clients will be issued IPsec VPN:

```
esr-1000(config)# address-assignment pool CLIENT_POOL
esr-1000(config-pool)# ip prefix 192.0.2.0/24
esr-1000(config-pool)# exit
```

Create IKE protocol gateway. In this profile, you need to specify the IKE protocol policy, the local subnet, the destination address pool as the remote subnet, set the mode of traffic redirection to the tunnel according to the policy and use the second authentication factor XAUTH:

```
esr(config)# security ike gateway IKEGW
esr(config-ike-gw)# ike-policy IKEPOLICY
esr(config-ike-gw)# local address 180.100.0.1
esr(config-ike-gw)# local network 10.0.0.0/16
esr(config-ike-gw)# remote address any
esr(config-ike-gw)# remote network dynamic pool CLIENT_POOL
esr(config-ike-gw)# dead-peer-detection action clear
esr(config-ike-gw)# mode policy-based
esr(config-ike-gw)# xauth access-profile XAUTH
esr(config-ike-gw)# exit
```

Create security parameters profile for IPsec tunnel. Specify 3DES encryption algorithm and SHA1 authentication algorithm in the profile. Use the following parameters to secure IPsec tunnel:

```
esr(config)# security ipsec proposal IPSECPROP
esr(config-ipsec-proposal)# authentication algorithm sha1
esr(config-ipsec-proposal)# encryption algorithm 3des
esr(config-ipsec-proposal)# exit
```

Create a policy for IPsec tunnel. For the policy, specify the list of IPsec tunnel profiles that may be used for node negotiation:

```
esr(config)# security ipsec policy IPSECPOLICY
esr(config-ipsec-policy)# proposal IPSECPROP
esr(config-ipsec-policy)# exit
```

Create IPsec VPN. For VPN, specify IKE protocol gateway, IPsec tunnel policy, key exchange mode and waiting mode for the incoming IPsec connection – *by-request*. When all parameters are entered, enable tunnel using the *enable* command.

```
esr(config)# security ipsec IPSECVPN
esr(config-ipsec-vpn)# mode ike
esr(config-ipsec-vpn)# ike establish-tunnel by-request
esr(config-ipsec-vpn)# ike gateway IKEGW
esr(config-ipsec-vpn)# ike ipsec-policy IPSECPOLICY
esr(config-ipsec-vpn)# enable
esr(config-ipsec-vpn)# exit
```

Allow esp protocol and udp ports 500, 4500 in the firewall configuration for establishing IPsec VPN:

```
esr(config)# security zone-pair untrusted self
esr(config-zone-pair)# rule 1
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol udp
esr(config-zone-pair-rule)# match destination-port ISAKMP
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)#   rule 2
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol esp
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)# end
```

2. R2 configuration
Configure external network interface and identify its inherence to a security zone:

```
esr# configure
esr(config)# interface gi 1/0/1
esr(config-if)# ip address 120.11.5.1/24
esr(config-if)# security-zone untrusted
esr(config-if)# exit
```

To configure security zones rules, you should create ISAKMP port profile:

```
esr(config)# object-group service ISAKMP
esr(config-addr-set)# port-range 500,4500
esr(config-addr-set)# exit
```

Create IKE protocol profile. Select Diffie-Hellman group 2, 3DES encryption algorithm and SHA1 authentication algorithm in the profile. The given security parameters are used for IKE connection protection:

```
esr(config)# security ike proposal IKEPROP
esr(config-ike-proposal)# dh-group 2
esr(config-ike-proposal)# authentication algorithm sha1
esr(config-ike-proposal)# encryption algorithm 3des
esr(config-ike-proposal)# exit
```

Create IKE protocol policy. For the policy, specify the list of IKE protocol profiles that may be used for node, authentication key, XAUTH authentication method by key and client authentication mode negotiation:

```
esr(config)# security ike policy IKEPOLICY
esr(config-ike-policy)# pre-shared-key hexadecimal 123FFF
esr(config-ike-policy)# authentication method xauth-psk-key
esr(config-ike-policy)# authentication mode client
esr(config-ike-policy)# proposal IKEPROP
esr(config-ike-policy)# exit
```

Create an access profile and get in it a pair of username and password:

```
esr(config)# access profile XAUTH
esr(config-access-profile)# user client1
esr(config-profile)# password ascii-text password123
esr(config-profile)# exit
esr(config-access-profile)# exit
```

Create a loopback interface for terminating the IP address received from the IPsec VPN server:

```
esr(config)# interface loopback 8
esr(config-loopback)# exit
```

Create IKE protocol gateway. Specify the policy, the termination interface, the dynamic setting mode of the remote subnet, the access profile selection for XAUTH, and the mode of redirecting traffic to the tunnel by policy in this profile:

```
esr(config)# security ike gateway IKEGW
esr(config-ike-gw)# ike-policy IKEPOLICY
esr(config-ike-gw)# assign-interface loopback 8
esr(config-ike-gw)# local address 120.11.5.1
esr(config-ike-gw)# remote address 180.100.0.1
esr(config-ike-gw)# remote network dynamic client
esr(config-ike-gw)# mode policy-based
esr(config-ike-gw)# xauth access-profile xauth client client1
esr(config-ike-gw)# exit
```

Create security parameters profile for IPsec tunnel. Specify 3DES encryption algorithm and SHA1 authentication algorithm in the profile. Use the following parameters to secure IPsec tunnel:

```
esr(config)# security ipsec proposal IPSECPROP
esr(config-ipsec-proposal)# authentication algorithm md5
esr(config-ipsec-proposal)# encryption algorithm aes128
esr(config-ipsec-proposal)# exit
```

Create a policy for IPsec tunnel. For the policy, specify the list of IPsec tunnel profiles that may be used for node negotiation:

```
esr(config)# security ipsec policy IPSECPOLICY
esr(config-ipsec-policy)# proposal IPSECPROP
esr(config-ipsec-policy)# exit
```

Create IPsec VPN. For VPN, specify IKE protocol gateway, IPsec tunnel policy, key exchange mode and connection establishment method. When all parameters are entered, enable tunnel using *enable* command.

```
esr(config)# security ipsec vpn IPSECVPN
esr(config-ipsec-vpn)# mode ike
esr(config-ipsec-vpn)# ike establish-tunnel immediate
esr(config-ipsec-vpn)# ike gateway IKEGW
esr(config-ipsec-vpn)# ike ipsec-policy IPSECPOLICY
esr(config-ipsec-vpn)# enable
esr(config-ipsec-vpn)# exit
```

Allow esp protocol and udp ports 500,4500 in the firewall configuration for establishing IPsec VPN:

```
esr(config)# security zone-pair untrusted self
esr(config-zone-pair)# rule 1
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol udp
esr(config-zone-pair-rule)# match destination-port ISAKMP
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)#   rule 2
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol esp
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)# end
```

To view the tunnel status, use the following command:

```
esr# show security ipsec vpn status IPSECVPN
```

To view the tunnel configuration, use the following command:

```
esr# show security ipsec vpn configuration IPSECVPN
```

⚠ In the firewall, you should enable ESP and ISAKMP protocol (UDP port 500, 4500).

3.5 LT tunnels configuration

LT (англ. Logical Tunnel) is a type of tunnels dedicated for transmission of routing information and traffic between different virtual routers (VRF Lite) configured on a router. LT tunnel might be used for organization of interaction between two or more VRF using firewall restrictions.

3.5.1 Configuration algorithm

Step	Description	Command	Keys
1	Create LT tunnels for each of existing VRF.	`esr(config)# tunnel lt <ID>`	<ID> – tunnel identifier, set in the range of [1..128].
2	Specify the description of the configured tunnels (optionally).	`esr(config-lt)# description <DESCRIPTION>`	<DESCRIPTION> – tunnel description, set by the string of up to 255 characters.
3	Include each LT tunnel in the corresponding VFR.	`esr(config-lt)# ip vrf forwarding <VRF>`	<VRF> – VRF name, set by the string of up to 31 characters.
4	Include each LT tunnel in a security zone and configure interaction rules between zones or disable firewall for LT tunnel.	`esr(config-lt)# security-zone<NAME>`	<NAME> – security zone name, set by the string of up to 12 characters.

Step	Description	Command	Keys
		`esr(config-lt)# ip firewall disable`	
5	For each LT tunnel, set the opposite LT tunnel number (in another VRF).	`esr(config-lt)# peer lt <ID>`	<ID> – tunnel identifier, set in the range of [1..128].
6	For each LT tunnel, specify IP address for packets routing. For interacting LT tunnels, IP addresses should locate in one IP subnet.	`esr(config-lt)# ip address <ADDR/LEN>`	<ADDR/LEN> – IP address and prefix of a subnet, defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32].
7	Enable the tunnels.	`esr(config-lt)# enable`	
8	For each VRF configure required routing protocols via LT tunnel.		
9	Specify the time interval during which the statistics on the tunnel load is averaged (optionally)	`esr(config-lt)# load-average <TIME>`	<TIME> – interval in seconds, takes values of [5..150]. Default value: 5
10	Specify the size of MTU packets that can be passed by the bridge (optionally; possible if only VLAN is included in the bridge). MTU above 1500 will be active only when using the "system jumbo-frames" command.	`esr(config-lt)# mtu <MTU>`	<MTU> – MTU value, takes values in the range of: • for ESR-10/12V(F)/14VF – [1280..9600]; • for ESR-20/21 – [1280..9500]; • for ESR-100/200/1000/1200/1500/1700 [1280..10000]. Default value: 1500.

3.5.2 Configuration example

Objective:

Organize interaction between hosts terminated in two VRF vrf_1 and vrf_2.

Initial configuration:

```
hostname esr
ip vrf vrf_1
exit
ip vrf vrf_2
exit
interface gigabitethernet 1/0/1
  ip vrf forwarding vrf_1
  ip firewall disable
  ip address 10.0.0.1/24
exit
interface gigabitethernet 1/0/2
  ip vrf forwarding vrf_2
  ip firewall disable
  ip address 10.0.1.1/24
exit
```

Solution:

Create LT tunnels for each VRF, specifying IP address from one subnet:

```
esr(config)# tunnel lt 1
esr(config-lt)# ip vrf forwarding vrf_1
esr(config-lt)# ip firewall disable
esr(config-lt)# ip address 192.168.0.1/30
esr(config-lt)# exit
esr(config)# tunnel lt 2
esr(config-lt)# ip vrf forwarding vrf_2
esr(config-lt)# ip firewall disable
esr(config-lt)# ip address 192.168.0.2/30
esr(config-lt)# exit
```

Designate LT tunnel from VRF, which is necessary to establish link with, for each LT tunnel and activate them.

```
esr(config)# tunnel lt 1
esr(config-lt)# peer lt 2
esr(config-lt)# enable
esr(config-lt)# exit
esr(config)# tunnel lt 2
esr(config-lt)# peer lt 1
esr(config-lt)# enable
esr(config-lt)# exit
```

⚠ If none of dynamic routing protocols is configured in VRF, specify static routes for each VRF:

```
esr(config)# ip route vrf vrf_1 0.0.0.0/0 192.168.0.2
esr(config)# ip route vrf vrf_2 0.0.0.0/0 192.168.0.1
```

4 QoS management

QoS (Quality of Service) is a technology that provides various traffic classes with various service priorities. QoS service allows network applications to co-exist in a single network without altering the bandwidth of other applications.

4.1 Basic QoS

In basic mode on ESR routers, classification (routing traffic to the queue) and relabeling works only on the input (QoS must be enabled on the interface through which traffic arrives)

4.1.1 Configuration algorithm

Step	Description	Command	Keys
1	Enable QoS on the interface/tunnel/ network bridge. If QoS policy is not assigned on the interface, the interface operates in BasicQoS mode.	`esr(config-if-gi)# qos enable`	
2	Set the trust mode for 802.1p and DSCP codes values in incoming packets. (optionally)	`esr(config)# qos trust <MODE>`	<MODE> – trust mode for 802.1p and DSCP codes values, takes one of the following values: • **dscp** – trust mode for DSCP codes values in IP header. Not IP packets will be sent to the default queue. • **cos** – trust mode for 802.1p codes values in 802.1q tag. Untagged packets will be sent to the default queue. • **cos-dscp** – trust mode for DSCP codes values in IP packets and for 802.1p codes values in other packets.

Step	Description	Command	Keys
3	Set the match between DSCP codes values of incoming packets and outgoing queues. The given match works for incoming interfaces/tunnels/bridge on which QoS is enabled. (optionally)	`esr(config)# qos map dscp-queue <DSCP> to <QUEUE>`	<DSCP> – service classifier in a packet IP header, takes values in the range of [0..63]; <QUEUE> – queue identifier, takes values in the range of [1..8]. Default values: • DSCP: (0-7), queue 1 • DSCP: (8-15), queue 2 • DSCP: (16-23), queue 3 • DSCP: (24-31), queue 4 • DSCP: (32-39), queue 5 • DSCP: (40-47), queue 6 • DSCP: (48-55), queue 7 • DSCP: (56-63), queue 8
4	Set the match between 802.1p codes values of incoming packets and outgoing queues. The given match works for incoming interfaces/tunnels/bridge on which QoS is enabled. (optionally)	`esr(config)# qos map cos-queue <COS> to <QUEUE>`	<COS> – service classifier in 802.1q packet tag, takes values in the range of [0..7]; <QUEUE> – queue identifier, takes values in the range of [1..8]. Default values: • CoS: (0), queue 1 • CoS: (1), queue 2 • CoS: (2), queue 3 • CoS: (3), queue 4 • CoS: (4), queue 5 • CoS: (5), queue 6 • CoS: (6), queue 7 • CoS: (7), queue 8
5	Set the match between DSCP codes values of incoming packets and outgoing DSCP codes. (if remarking is required) The given match works for incoming interfaces/tunnels/bridge on which QoS is enabled.	`esr(config)# qos map dscp-queue <DSCP> to <DSCP>`	<DSCP> – service classifier in a packet IP header, takes values in the range of [0..63].
6	Enable DSCP codes changes according to the DSCP-Mutation table. (if remarking is required)	`esr(config)# qos dscp mutation`	

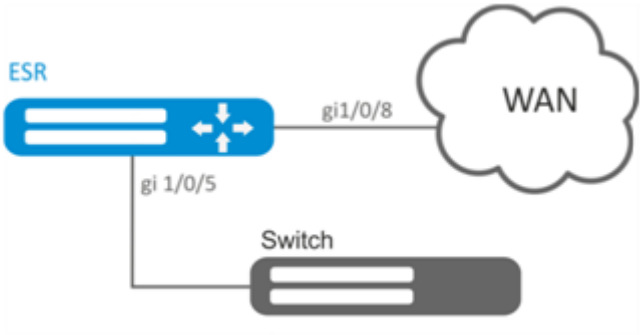
Step	Description	Command	Keys
7	Set the number of the default queue to which all traffic except IP falls into the trust mode for DSCP priorities.	`esr(config)# qos queue default <QUEUE>`	<QUEUE> – queue identifier, takes values in the range of [1..8].
8	Set the amount of priority queues. The remaining queues are weighted. (optionally)	`esr(config)# priority-queue out num-of-queues <VALUE>`	<VALUE> – amount of queues, takes values of [0..8], where: • **0** – all queues take part in WRR (WRR – weight-based queue processing mechanism); • **8** – all queues are served as «strictpriority» (strictpriority – priority queue is served as soon as the packets appear). The priority queues are allocated, starting from the 8th one, decreasing the queue number. Default value: 8
9	Define the weights for corresponding weighted queues.	`esr(config)# qos wrr-queue <QUEUE> bandwidth <WEIGHT>`	<QUEUE> – queue identifier, takes values in the range of [1..8]; <WEIGHT> – weight value, takes values in the range of [1..255]. The default value: weight 1 for all queues.
10	Set the outgoing traffic rate limiting for a certain queue or interface in total. The command is relevant only for BasicQoS mode of the interface. If the incoming traffic was classified by advanced QoS, the limiting will not work. (if the incoming rate limiting is required)	`esr(config-if-gi)# traffic-shape { <BANDWIDTH> [BURST] | queue <QUEUE><BANDWIDTH> [BURST] }`	<QUEUE> – queue identifier, takes values in the range of [1..8]. <BANDWIDTH> – average traffic rate in Kbps, takes the value of [3000..10000000] for TengigabitEthernet interfaces and [64..1000000] for other interfaces and tunnels; <BURST> – size of the restrictive threshold in KB, takes the value [4..16000]. 128 KB. Default value: Disabled.

Step	Description	Command	Keys
11	Set the incoming traffic rate limiting. (if the outgoing rate limiting is required)	`esr(config-if-gi)# rate-limit <BANDWIDTH> [BURST]`	<BANDWIDTH> – average traffic rate in Kbps, takes the value of [3000..10000000] for TengigabitEthernet interfaces and [64..1000000] for other interfaces and tunnels; <BURST> – size of the restrictive threshold in KB, takes the value [4..16000]. 128 KB. Default value: Disabled.

4.1.2 Configuration example

Objective:

Configure the following restrictions on gigabitethernet 1/0/8 interface: transfer DSCP 22 traffic into 8th priority queue, DSCP 14 traffic into 7th weighted queue, limit transfer rate to 60Mbps for 7th queue.



Solution:

In order to make 8th queue a priority queue, and 2nd to 8th queues weighted ones, limit the quantity of priority queues to 1:

```
esr(config)# priority-queue out num-of-queues 1
```

Redirect DSCP 22 traffic into 1st priority queue:

```
esr(config)# qos map dscp-queue 22 to 1
```

Redirect DSCP 14 traffic into 7th priority queue:

```
esr(config)# qos map dscp-queue 14 to 7
```

Enable QoS on the inbound interface from LAN side:

```
esr(config)# interface gigabitethernet 1/0/5
esr(config-if-gi)# qos enable
esr(config-if-gi)# exit
```

Enable QoS on the inbound interface from WAN side:

```
esr(config)# interface gigabitethernet 1/0/8
esr(config-if-gi)# qos enable
```

Limit transfer rate to 60Mbps for 7th queue:

```
esr(config-if)# traffic-shape queue 7 60000
esr(config-if)# exit
```

To view QoS statistics, use the following command:

```
esr# show qos statistics gigabitethernet 1/0/8
```

4.2 Advanced QoS

4.2.1 Configuration algorithm

In advanced mode on ESR routers, classification of incoming traffic is possible on both incoming and outgoing interfaces.

Step	Description	Command	Keys
1	Create access lists to define the traffic to which the advanced QoS should be applied.		See Section Access list (ACL) configuration.
2	Create QoS class and switch to the class parameters configuration mode.	`esr(config)# class-map <NAME>`	<NAME> – name of the class being created, set by the string of up to 31 characters.
3	Specify QoS class description (optionally).	`esr(config-class-map)# description <description>`	<description> – up to 255 characters..
4	Specify the traffic related to the configured class by access control list (ACL).	`esr(config-class-map)# match access-group <NAME>`	<NAME> – access control list name, set by the string of up to 31 characters.

Step	Description	Command	Keys
5	Specify DSCP code value which will be set in IP packets corresponding to the class being configured. (cannot be assigned simultaneously with IP Precedence and CoS fields). (if remarking is required)	`esr(config-class-map)# set dscp <DSCP>`	<DSCP> – DSCP code value, takes values in the range of [0..63].
6	Specify IP Precedence code value which will be set in IP packets corresponding to the class being configured (cannot be assigned simultaneously with DSCP and CoS fields). (if remarking is required)	`esr(config-class-map)# set ip-precedence <IPP>`	<IPP> – IP Precedence code value, takes values in the range of [0..7].
7	Specify 802.1p priority value which will be set in packets corresponding to the class being configured (cannot be assigned simultaneously with DSCP and IP Precedence fields). (if remarking is required)	`esr(config-class-map)# set  cos <COS>`	<COS> – priority 802.1p value, takes values of [0..7].
8	Create QoS policy and switch to the policy parameters configuration mode.	`esr(config)# policy-map <NAME>` `esr(config-policy-map)#`	<NAME> – name of the policy being created, set by the string of up to 31 characters.
9	Specify QoS policy description (optionally).	`esr(config-policy-map)# description <description>`	<description> – up to 255 characters..
10	Set the committed outgoing bandwidth for the policy in total.	`esr(config-policy-map)# shape average <BANDWIDTH> [BURST]`	<BANDWIDTH> – committed bandwidth in Kbps, takes the value of [64..10000000]; <BURST> – size of the restrictive threshold in KB, takes the value [128..16000]. 128 KB.
11	Enable automatic bandwidth allocation between classes without bandwidth configuration, including the default class. (if required)	`esr(config-policy-map)# shape auto-distribution`	

12	Include the specified QoS class in the policy and switch to the class parameters configuration mode within the policy.	`esr(config-policy-map)# class <NAME>`
		
		`esr(config-class-policy-map)#`
			<NAME> – name of the class being bound, set by the string of up to 31 characters. When specifying the “class-default” value, the incoming unclassified traffic falls into the given class.

Step	Description	Command	Keys
13	Include QoS policy in QoS class to create hierarchical QoS.	`esr(config-class-policy-map)# service-policy <NAME>`	<NAME> – policy name, set by the string of up to 31 characters. Inserted policy must already be created.
14	Set the committed outgoing bandwidth for the class within the policy. (if required)	`esr(config-class-policy-map)# shape average <BANDWIDTH> [BURST]`	<BANDWIDTH> – committed bandwidth in Kbps, takes the value of [64..10000000]; <BURST> – size of the restrictive threshold in KB, takes the value [4..16000]. 128 KB.
15	Set the shared outgoing bandwidth for a specific class. The class may occupy the bandwidth if a lower priority class has not occupied its committed bandwidth. (if required)	`esr(config-class-policy-map)# shape peak <BANDWIDTH> [BURST]`	
16	Specify class operation mode. (optionally)	`esr(config-class-policy-map)# mode <MODE>`	<MODE> – class mode: • **fifo** – FIFO mode (First In, First Out); • **gred** – GRED mode (Generalized RED); • **red** – RED mode (Random Early Detection); • **sfq** – SFQ mode (SFQ queue allocates flow-based packets transmission). Default value: **FIFO**.
17	Specify the class priority in WRR process. (if required)	`esr(config-class-policy-map)# priority class <PRIORITY>`	<PRIORITY> – priority of class in WRR process, takes values of [1..8]. Classes with the highest priority are proceeded first.
18	Switch the class to the StrictPriority mode and specify the class priority. (if required)	`esr(config-class-policy-map)# priority level <PRIORITY>`	<PRIORITY> – priority level in StrictPriority process, takes values of [1..8]. Classes with the highest priority are proceeded first. The default value: tha class operates in WRR mode, the priority is not specified.
19	Specify the limited number of virtual queues. (optionally)	`esr(config-class-policy-map)# fair-queue <QUEUE-LIMIT>`	<QUEUE-LIMIT> – limited number of virtual queues, takes values in the range of [16..4096]. Default value: 16.

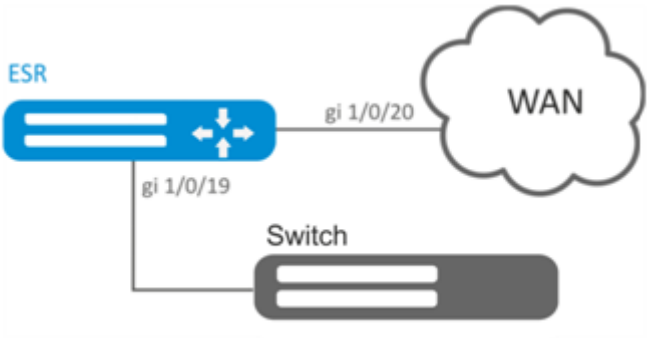
Step	Description	Command	Keys
20	Specify the limited number of packets for a virtual queue. (optionally)	`esr(config-class-policy-map)# queue-limit <QUEUE-LIMIT>`	<QUEUE-LIMIT> – limited number of packets in a virtual queue, takes values in the range of [2..4096]. Default value: 127.
21	Specify RED (Random Early Detection) parameters. (if required)	`esr(config-class-policy-map)# random-detect <LIMIT> <MAX> <MIN> <PROBABILITY>`	<LIMIT> – limited size of a queue in bytes, takes values of in the range of [1..1000000]; <MAX> – maximum size of a queue in bytes, takes value in the range of [1..1000000]; <MIN> – minimum size of a queue in bytes, takes value in the range of [1..1000000]; <PROBABILITY> – probability of packet drop, takes values of [0..100]. When specifying the values, the following rules should be fulfilled: • <MAX>> 2 * <MIN> • <LIMIT>> 3 * <MAX>
22	Specify GRED (Generalized Random Early Detection) parameters. (if required)	`esr(config-class-policy-map)# random-detect precedence <PRECEDENCE><LIMIT><MAX><MIN><PROBABILITY>`	<PRECEDENCE> – IPPrecendence value [0..7]; <LIMIT> – limited size of a queue in bytes, takes values of in the range of [1..1000000]; <MAX> – maximum size of a queue in bytes, takes value in the range of [1..1000000]; <MIN> – minimum size of a queue in bytes, takes value in the range of [1..1000000]; <PROBABILITY> – probability of packet drop, takes values of [0..100]. When specifying the values, the following rules should be fulfilled: • <MAX>> 2 * <MIN> • <LIMIT>> 3 * <MAX>

Step	Description	Command	Keys
23	Enable tcp headers compression protocol for the certain class traffic. (if required)	`esr(config-class-policy-map)# compression header ip tcp`	
24	Enable QoS on the interface/tunnel/ network bridge.	`esr(config-if-gi)# qos enable`	
25	Define the QoS policy on a configured interface/tunnel/network bridge to classify input and prioritize output traffic.	`esr(config-if-gi)# service-policy { input | output } <NAME>`	<NAME> – QoS policy name, set by the string of up to 31 characters.

4.2.2 Configuration example

Objective:

Classify incoming traffic by a subnet (10.0.11.0/24, 10.0.12.0/24), label it by DSCP (38 and 42) and segregate by a subnet (40Mbps and
60Mbps), limit general bandwidth to 250Mbps, process the rest of traffic using SFQ mechanism.



Solution:

Configure access control lists for filtering by a subnet, proceed to global configuration mode:

```
esr(config)# ip access-list extended fl1
esr(config-acl)# rule 1
esr(config-acl-rule)# action permit
esr(config-acl-rule)# match protocol any
esr(config-acl-rule)# match source-address 10.0.11.0 255.255.255.0
esr(config-acl-rule)# match destination-address any
esr(config-acl-rule)# enable
esr(config-acl-rule)# exit
esr(config-acl)# exit
esr(config)# ip access-list extended fl2
esr(config-acl)# rule 1
esr(config-acl-rule)# action permit
esr(config-acl-rule)# match protocol any
esr(config-acl-rule)# match source-address 10.0.12.0 255.255.255.0
esr(config-acl-rule)# match destination-address any
esr(config-acl-rule)# enable
esr(config-acl-rule)# exit
esr(config-acl)# exit
```

Create classes fl1 and fl2, specify the respective access control lists, configure labelling:

```
esr(config)# class-map fl1
esr(config-class-map)# set dscp 38
esr(config-class-map)# match access-group fl1
esr(config-class-map)# exit
esr(config)# class-map fl2
esr(config-class-map)# set dscp 42
esr(config-class-map)# match access-group fl2
esr(config-class-map)# exit
```

Create policy and define general bandwidth limits:

```
esr(config)# policy-map fl
esr(config-policy-map)# shape average 250000
```

Map class to policy, configure bandwidth limit and exit:

```
esr(config-policy-map)# class fl1
esr(config-class-policy-map)# shape average 40000
esr(config-class-policy-map)# exit
esr(config-policy-map)# class fl2
esr(config-class-policy-map)# shape average 60000
esr(config-class-policy-map)# exit
```

For the rest of traffic, configure a class with SFQ mode:

```
esr(config-policy-map)# class class-default
esr(config-class-policy-map)# mode sfq
esr(config-class-policy-map)# fair-queue 800
esr(config-class-policy-map)# exit
esr(config-policy-map)# exit
```

Enable QoS on the interfaces, policy on gi 1/0/19 interface ingress for classification purposes and gi1/0/20 egress for applying restrictions and SFQ mode for default class:

```
esr(config)# interface gigabitethernet 1/0/19
esr(config-if-gi)# qos enable
esr(config-if-gi)# service-policy input fl
esr(config-if-gi)# exit
esr(config)# interface gigabitethernet 1/0/20
esr(config-if-gi)# qos enable
esr(config-if-gi)# service-policy output fl
esr(config-if-gi)# exit
```

To view the statistics, use the following command:

```
esr# do show qos policy statistics gigabitethernet 1/0/20
```

5 Routing management

5.1 Static routes configuration

Static routing is a type of routing in which routes are defined explicitly during the router configuration without dynamic routing protocols.

5.1.1 Configuration algorithm

You can add a static route by using the following command in global configuration mode:

```
esr(config)# ip route [ vrf <VRF> ] <SUBNET> { <NEXTHOP> | interface <IF> | tunnel <TUN>
| wan load-balance rule <RULE> [<METRIC>] | blackhole | unreachable | prohibit }
[ <METRIC> ] [ track <TRACK-ID> ] [ bfd ]
```

- <VRF> – VRF name, set by the string of up to 31 characters.
- <SUBNET> – destination address, can be specified in the following format:
- BBB.CCC.DDD – host IP address, where each part takes values of [0..255].
- BBB.CCC.DDD/NN – network IP address with prefix mask, where AAA-DDD take values of [0..255] and NN takes values of [1..32].
- <NEXTHOP> – gateway IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255];

- <IF> – an IP interface name specified in the form described in Section Types and naming order of router interfaces;
- <TUN> – the name of the tunnel is specified as described in section Types and naming order of router tunnels;
- <RULE> – wan rule number, set in the range of [1..50];
- blackhole – when specifying the command, the packets to this subnet will be removed by the device without sending notifications to a sender;
- unreachable – when specifying the command, the packets to this subnet will be removed by the device, a sender will receive in response ICMP Destination unreachable (Host unreachable, code 1);
- prohibit – when specifying the command, the packets to this subnet will be removed by the device, a sender will receive in response ICMP Destination unreachable (Communication administratively prohibited, code 13);
- bfd – when specifying the given key, the removal of static route in case of next-hop unavailability is activated.

To add static IPv6 route to the given subnet, use the following command:

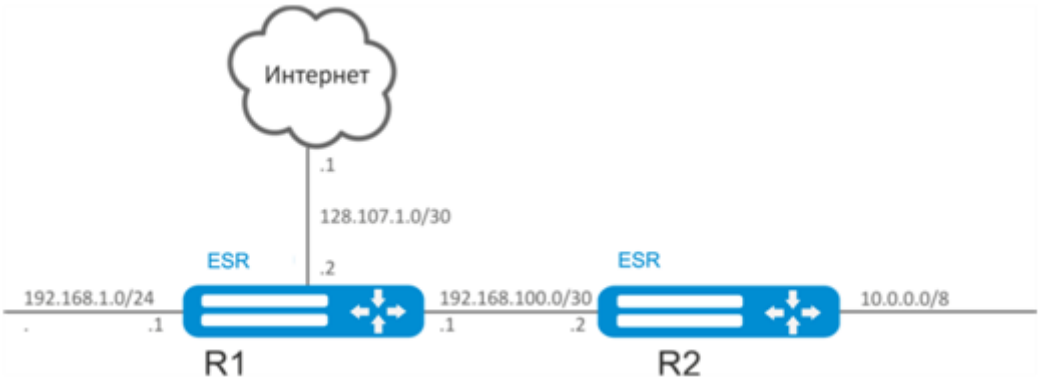
```
ipv6 route [ vrf <VRF> ] <SUBNET> { <NEXTHOP> [ resolve ] | interface <IF> | wan load-balance rule <RULE> | blackhole | unreachable | prohibit } [ <METRIC> ] [ bfd ]
```

- <VRF> – VRF name, set by the string of up to 31 characters.
- <SUBNET> – destination address, can be specified in the following formats:
  - X:X:X:X::X – host IPv6 address defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF].
  - X:X:X:X::X/EE – IPv6 address and mask of a subnet, defined as X:X:X:X::X/EE where each X part takes values in hexadecimal format [0..FFFF] and EE takes values of [1..128].
- <IPV6-ADDR> – client IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF];
- resolve – when specifying the given parameter, gateway IPv6 address will be recursively calculated through the routing table. If the recursive calculation fails to find a gateway from a directly connected subnet, then this route will not be installed into the system;
- <IF> – an IP interface name specified in the form described in Section Types and naming order of router interfaces;
- blackhole – when specifying the command, the packets to this subnet will be removed by the device without sending notifications to a sender;
- unreachable – when specifying the command, the packets to this subnet will be removed by the device, a sender will receive in response ICMP Destination unreachable (Host unreachable, code 1);
- prohibit – when specifying the command, the packets to this subnet will be removed by the device, a sender will receive in response ICMP Destination unreachable (Communication administratively prohibited, code 13);
- <METRIC> – route metric, takes values of [0..255].
- bfd – when specifying the given key, the removal of static route in case of next-hop unavailability is activated.

5.1.2 Static routes configuration example

Objective:

Configure Internet access for users in LAN 192.168.1.0/24 and 10.0.0.0/8 using the static routing. On R1 device, create gateway for Internet access. Traffic within LAN should be routed within LAN zone, traffic from the Internet should belong to WAN zone.



Solution:

Specify the device name for R1 router:

```
esr# hostname R1
```

Specify 192.168.1.1/24 address and the “LAN” zone for the gi1/0/1 interface. R1 interface will be connected to 192.168.1.0/24 network via this interface:

```
esr(config)# interface gi1/0/1
esr(config-if-gi)# security-zone LAN
esr(config-if-gi)# ip address 192.168.1.1/24
esr(config-if-gi)# exit
```

Specify 192.168.100.1/30 address and the 'LAN' zone for the gi1/0/2 interface. R1 will be connected to R2 device via the given interface for the further traffic routing:

```
esr(config)# interface gi1/0/2
esr(config-if-gi)# security-zone LAN
esr(config-if-gi)# ip address 192.168.100.1/30
esr(config-if-gi)# exit
```

Specify 128.107.1.2/30 address and the “WAN” zone for the gi1/0/3 interface. R1 interface will be connected to the Internet via this interface:

```
esr(config)# interface gi1/0/3
esr(config-if-gi)# security-zone WAN
esr(config-if-gi)# ip address 128.107.1.2/30
esr(config-if-gi)# exit
```

Create a route for interaction with 10.0.0.0/8 network using R2 device as a gateway (192.168.100.2):

```
esr(config)# ip route 10.0.0.0/8 192.168.100.2
```

Create a route for interaction with the Internet using the provider gateway as a nexthop (128.107.1.1):

```
esr(config)# ip route 0.0.0.0/0 128.107.1.1
```

Specify the device name for R2 router:

```
esr# hostname R2
```

Specify 10.0.0.1/8 address and the 'LAN' zone for the gi1/0/1 interface. R2 interface will be connected to 10.0.0.0/8 network via this interface:

```
esr(config)# interface gi1/0/1
esr(config-if-gi)# security-zone LAN
esr(config-if-gi)# ip address 10.0.0.1/8
esr(config-if-gi)# exit
```

Specify 192.168.100.2/30 address and the 'LAN' zone for the gi1/0/2 interface. R2 will be connected to R1 device via the given interface for the further traffic routing:

```
esr(config)# interface gi1/0/2
esr(config-if-gi)# security-zone LAN
esr(config-if-gi)# ip address 192.168.100.2/30
esr(config-if-gi)# exit
```

Create a default route by specifying the IP address of R1 router gi1/0/2 interface (192.168.100.1) as a nexthop:

```
esr(config)# ip route 0.0.0.0/0 192.168.100.1
```

You can use the following command to check the routing table:

```
esr# show ip route
```

5.2 RIP Configuration

RIP is a distance-vector dynamic routing protocol that uses hop count as a routing metric. The maximum amount of hops allowed for RIP is 15. By default, each RIP router transmits full routing table into the network every 30 seconds. RIP operates at 3rd level of TCP/IP stack via UDP port 520.

5.2.1 Configuration algorithm

Step	Description	Command	Keys
1	Configure RIP precedence for the main routing table (optionally).	`esr(config)# ip protocols rip preference <VALUE>`	<VALUE> – protocol precedence, takes values in the range of [1..255]. Default value: RIP (100).

Step	Description	Command	Keys
2	Configure RIP routing tables capacity (optionally).	`esr(config)# ip protocols rip max-routes <VALUE>`	<VALUE> – amount of RIP routes in the routing table, takes values in the range of[1..10000]; Default value: 10000.
3	Create IP subnets lists that will be used for further filtration of advertised and received IP routes.	`esr(config)# ip prefix-list <NAME>`	<NAME> – name of a subnet list being configured, set by the string of up to 31 characters.

4	Permit or deny the prefixes lists.	`esr(config-pl)# permit {object-group <OBJ-GROUP-NETWORK-NAME> <ADDR/LEN> | <IPV6-ADDR/LEN> } [ { eq <LEN> | le <LEN> | ge <LEN> [ le <LEN> ] } ]`
		
		`esr(config-pl)# deny {object-group <OBJ-GROUP-NETWORK-NAME> <ADDR/LEN> | <IPV6-ADDR/LEN> } [ { eq <LEN> | le <LEN> | ge <LEN> [ le <LEN> ] }`
			<OBJ-GROUP-NETWORK-NAME> – IP addresses profile name, set by the string of up to 31 characters;
			
			<LEN> – prefix length, takes values of [1..32] in prefix IP lists;
			
			• **eq** – when specifying the command, the prefix length mast match the specified one;
			• **le** – when specifying the command, the prefix length mast be less than or match the specified one;
			• **ge** – when specifying the command, the prefix length mast be more than or match the specified one;
			• **default-route** – default route filtration.

5	Switch to the RIP process configuration mode.	`esr(config)# router rip`
		
		`esr(config-rip)#`	

6	Enable RIP.	`esr(config-rip)# enable`	
7	Specify RIP authentication algorithm (optionally).	`esr(config-rip)# authentication algorithm { cleartext | md5 }`	• **cleartext** – password, transmitted in clear text; • **md5** – password is hashed by md5 algorithm.
8	Set the password for neighbour authentication (optionally).	`esr(config-rip)# authentication key ascii-text { <CLEAR-TEXT> | encrypted <ENCRYPTED-TEXT> }`	<CLEAR-TEXT> – password, set by the string of 8 to 16 characters; <ENCRYPTED-TEXT> – encrypted password of 8 to 16 bytes (from 16 to 32 characters) in hexadecimal format (0xYYYY ...) or (YYYY ...).

Step	Description	Command	Keys
9	Specify the list of passwords for authentication via md5 hashing algorithm (optionally).	`esr(config-rip)# authentication key-chain <KEYCHAIN>`	<KEYCHAIN> – key list identifier, set by the string of up to 16 characters.
10	Disable routes advertising on the interfaces/tunnels/bridge where it is not necessary (optionally).	`esr(config-rip)# passive-interface {<IF> | <TUN> }`	<IF> – interface and identifier; <TUN> – tunnel name and number.
11	Set time interval after which the advertising is carried out (optionally).	`esr(config-rip)# timers update <TIME>`	<TIME> – time in seconds, takes values of [1..65535]. Default value: 180 seconds.
12	Set time interval of route entry correctness without updating (optionally).	`esr(config-rip)# timers invalid <TIME>`	<TIME> – time in seconds, takes values of [1..65535]. Default value: 180 seconds.
13	Set time interval after which the route removing is carried out (optionally).	`esr(config-rip)# timers flush <TIME>`	<TIME> – time in seconds, takes values of [1..65535]. When setting the value, consider the following rule: «timersinvalid + 60». Default value: 240 seconds.
14	Enable subnets advertising.	`esr(config-rip)# network <ADDR/LEN>`	<ADDR/LEN> – subnet address, set in the following format: AAA.BBB.CCC.DDD/NN – network IP address with prefix mask, where AAA-DDD take values of [0..255] and EE takes values of [1..32].
15	Add subnets filtration in incoming or outgoing updates (optionally).	`esr(config-rip)# prefix-list <PREFIX-LIST-NAME> { in | out }`	<PREFIX-LIST-NAME> – name of a subnet list being configured, set by the string of up to 31 characters. • **in** – incoming routes filtration; • **out** – advertised routes filtration.
16	Enable advertising of routes received in an alternative way (optionally).	`esr(config-rip)# redistribute static [ route-map <NAME> ]`	<NAME> – name of the route map that will be used for advertised static routes filtration and modification, set by the string of up to 31 characters.

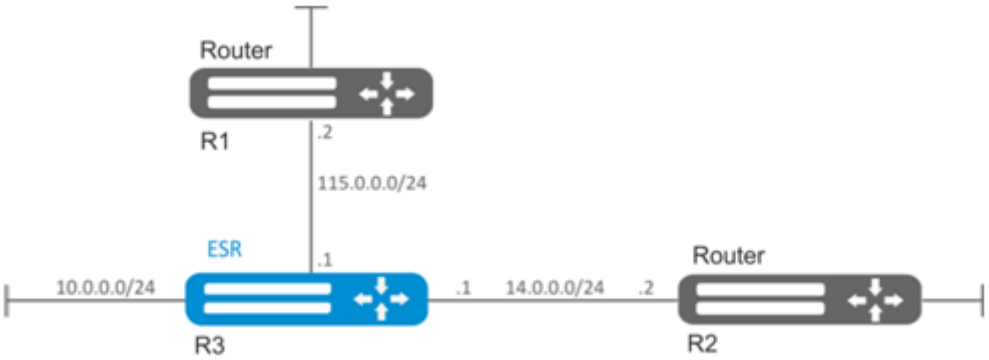
Step	Description	Command	Keys
		`esr(config-rip)# redistribute connected [ route-map <NAME> ]`	<NAME> – name of the route map that will be used for filtration and modification of advertised directly connected subnets, set by the string of up to 31 characters.
		`esr(config-rip)# redistribute ospf <ID><ROUTE-TYPE> [ route-map <NAME> ]`	<ID> – process number, takes values of [1..65535]. <ROUTE-TYPE> – route type: • **intra-area** – OSPF process routes advertising within a zone; • **inter-area** – OSPF process routes advertising between zones; • **external1** – OSPF format 1 external routes advertising; • **external2** – OSPF format 2 external routes advertising; <NAME> – name of the route map that will be used for advertised OSFP routes filtration and modification, set by the string of up to 31 characters.
		`esr(config-rip)# redistribute bgp <AS> [ route-map <NAME> ]`	<AS> – stand alone system number, takes values of [1..4294967295]. <NAME> – name of the route map that will be used for advertised BGP routes filtration and modification, set by the string of up to 31 characters.
17	Switch to the interface/tunnel/ network bridge configuration mode.	`esr(config)# interface <IF-TYPE><IF-NUM>`	<IF-TYPE> – interface type; <IF-NUM> – F/S/P – F frame (1), S – slot (0), P – port.
		`esr(config)# tunnel <TUN-TYPE><TUN-NUM>`	<TUN-TYPE> – tunnel type; <TUN-NUM> – tunnel number.
		`esr(config)# bridge <BR-NUM>`	<BR-NUM> – bridge number.
18	Set RIP routes metric value on the interface (optionally).	`esr(config-if-gi)# ip rip metric <VALUE>`	<VALUE> – metric size, takes values of [0..32767]. Default value: 5.

Step	Description	Command	Keys
19	Set the routes advertising mode via RIP (optionally).	`esr(config-if-gi)# ip rip mode <MODE>`	<MODE> – routes advertising mode: • **multicast** – routes are advertised in multicast mode; • **broadcast** – routes are advertised in broadcast mode; • **unicast** – routes are advertised to the neighbours in unicast mode; Default value: multicast.
20	Specify a neighbour's IP address for establishment of a relation in routes advertising unicast mode (optionally).	`esr(config-if-gi)# ip rip neighbor <ADDR>`	<ADDR> – IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
21	Enable subnet summarization (optionally).	`esr(config-if-gi)# ip rip summary-address <ADDR/LEN>`	<ADDR/LEN> – IP address and subnet mask, defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32].

5.2.2 RIP configuration example

Objective:

Configure RIP on the router in order to exchange the routing information with neighbouring routers. The router should advertise static routes and subnets 115.0.0.0/24, 14.0.0.0/24, 10.0.0.0/24. Routes should be advertised each 25 seconds.



Solution:

Pre-configure IP addresses on interfaces according to the network structure shown in figure.

Switch to the RIP configuration mode:

```
esr(config)# router rip
```

Specify the networks to be advertised by protocol: 115.0.0.0/24, 14.0.0.0/24 и 10.0.0.0/24:

```
esr(config-rip)# network 115.0.0.0/24
esr(config-rip)# network 14.0.0.0/24
esr(config-rip)# network 10.0.0.0/24
```

To advertise static routes by the protocol, execute the following command:

```
esr(config-rip)# redistribute static
```

Configure timer, responsible for routing information transmission:

```
esr(config-rip)# timers update 25
```

When all required settings are done, enable the protocol:

```
esr(config-rip)# enable
```

To view the RIP routing table, use the following command:

```
esr# show ip rip
```

⚠ In addition to RIP protocol configuration, open UDP port 520 in the firewall.

5.3 OSFP configuration

OSPF is a dynamic routing protocol, based on link-state technology and using shortest path first Dijkstra algorithm.

5.3.1 Configuration algorithm

Step	Description	Command	Keys
1	Configure OSFP precedence for the main routing table (optionally).	`esr(config)# ip protocols ospf preference <VALUE>`	<VALUE> – protocol precedence, takes values in the range of [1..255]. Default value: 150.
		`esr(config-vrf)# ip protocols ospf preference <VALUE>`	

Step	Description	Command	Keys
2	Configure OSFP routing tables capacity (optionally).	`esr(config)# ip protocols ospf max-routes <VALUE>`	<VALUE> – amount of OSPF routes in the routing table, takes values in the range of: • for ESR-1000/1200/1500/1700 [1..500000]; • for ESR-20/21/100/200 [1..300000]; • for ESR-10/12V(F)/14VF – [1..30000] Default value for the global mode: • for ESR-1000/1200/1500/1700 – (500000); • for ESR-20/21/100/200 – (300000); • for ESR-10/12V(F)/14VF – (30000). Default value for VRF: 0
		`esr(config)# ipv6 protocols ospf max-routes <VALUE>`	
3	Enable the output of OSPF neighbor state information (optionally).	`esr(config)# router ospf log-adjacency-changes`	
		`esr(config)# ipv6 router ospf log-adjacency-changes`	
4	Create IP subnets lists that will be used for further filtration of advertised and received IP routes.	`esr(config)# ip prefix-list <NAME>`	<NAME> – name of a subnet list being configured, set by the string of up to 31 characters.
		`esr(config)# ipv6 prefix-list <NAME>`	

Step	Description	Command	Keys
5	Permit or deny the prefixes lists.	`esr(config-pl)# permit [ { object-group <OBJ-GROUP-NETWORK-NAME> | <ADDR/LEN> | <IPV6-ADDR/LEN> } ] [ { eq <LEN> | le <LEN> | ge <LEN> [ le <LEN> ] } ]`	<OBJ-GROUP-NETWORK-NAME> – IPv4/IPv6 addresses profile name, set by the string of up to 31 characters; <ADDR> – IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <LEN> – prefix length, takes values of [1..32] in prefix IP lists; • **eq** – when specifying the command, the prefix length mast match the specified one; • **le** – when specifying the command, the prefix length mast be less than or match the specified one; • **ge** – when specifying the command, the prefix length mast be more than or match the specified one;
		`esr(config-pl)# deny [ { object-group <OBJ-GROUP-NETWORK-NAME> | <ADDR/LEN > | <IPV6-ADDR/LEN> } ] [ { eq <LEN> | le <LEN> | ge <LEN> [ le <LEN> ] } ]`	
6	Add OSFP process to the system and switch to the OSFP process parameters configuration mode.	`esr(config)# router ospf <ID> [vrf <VRF>]`	<ID> – stand alone system number, takes values of [1..65535]. <VRF> – VRF instance name, set by the string of up to 31 characters, within which the routing protocol will operate.
		`esr(config)# ipv6 router ospf <ID> [vrf <VRF>]`	
7	Set the router identifier for the given OSFP process.	`esr(config-ospf)# router-id <ID>`	<ID> – router identifier, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
		`esr(config-ipv6-ospf)# router-id <ID>`	
8	Define OSFP process routes precedence.	`esr(config-ospf)# preference <VALUE>`	<VALUE> – OSFP process routes precedence, takes values in the range of [1..255]. Default value: 10.
		`esr(config-ipv6-ospf)# preference <VALUE>`	
9	Enable compatibility with RFC 1583 (optionally).	`esr(config-ospf)# compatible rfc1583`	
		`esr(config-ipv6-ospf)# compatible rfc1583`	

Step	Description	Command	Keys
11	Add subnets filtration in incoming or outgoing updates (optionally).	`esr(config-ospf)# prefix-list <PREFIX-LIST-NAME> { in | out }`	<PREFIX-LIST-NAME> – name of a subnet list being configured, set by the string of up to 31 characters. • **in** – incoming routes filtration; • **out** – advertised routes filtration.
		`esr(config-ipv6-ospf)# prefix-list <PREFIX-LIST-NAME> { in | out }`	
12	Enable advertising of routes received in an alternative way (optionally).	`esr(config-ospf)# redistribute static [ route-map <NAME> ]`	<NAME> – name of the route map that will be used for advertised static routes filtration and modification, set by the string of up to 31 characters.
		`esr(config-ipv6-ospf)# redistribute static [ route-map <NAME> ]`	
		`esr(config-ospf)# redistribute connected [ route-map <NAME> ]`	<NAME> – name of the route map that will be used for filtration and modification of advertised directly connected subnets, set by the string of up to 31 characters.
		`esr(config-ipv6-ospf)# redistribute connected [ route-map <NAME> ]`	
		`esr(config-ospf)# redistribute rip [ route-map <NAME> ]`	<NAME> – name of the route map that will be used for advertised RIP routes filtration and modification, set by the string of up to 31 characters.
		`esr(config-ospf)# redistribute bgp <AS> [ route-map <NAME> ]`	<AS> – stand alone system number, takes values of [1..4294967295]. <NAME> – name of the route map that will be used for advertised BGP routes filtration and modification, set by the string of up to 31 characters.
		`esr(config-ipv6-ospf)# redistribute bgp <AS> [ route-map <NAME> ]`	
13	Enable OSFP process.	`esr(config-ospf)# enable`	
		`esr(config-ipv6-ospf)# enable`	
14	Create OSFP area and switch to the scope configuration mode.	`esr(config-ospf)# area <AREA_ID>`	<AREA_ID> – area identifier, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
		`esr(config-ipv6-ospf)# area <AREA_ID>`	

Step	Description	Command	Keys
15	Enable subnets advertising.	`esr(config-ospf-area)# network <ADDR/LEN>`	<ADDR/LEN> – subnet address, set in the following format: AAA.BBB.CCC.DDD/NN – network IP address with prefix mask, where AAA-DDD take values of [0..255] and EE takes values of [1..32].
		`esr(config-ipv6-ospf-area)# network <IPV6-ADDR/LEN>`	<IPV6-ADDR/LEN> – IPv6 address and mask of a subnet, defined as X:X:X:X::X/EE where each X part takes values in hexadecimal format [0..FFFF] and EE takes values of [1..128].
16	Specify the area type	`esr(config-ospf-area)# area-type <TYPE> [ no-summary ]`	<TYPE> – area type: • **stub** – sets stub value (stub area); no-summary – command in conjunction with the 'stub' parameter forms the 'totallystubby' area (only the default route is used to transfer information outside the area). • **nssa** – sets nssa value (NSSA area); no-summary – command in conjunction with the 'nssa' parameter forms the 'totallynssa' area (by default the route is generated as an inter-place one).
		`esr(config-ipv6-ospf-area)# area-type <TYPE> [ no-summary ]`	
17	Enable the default route generation for NSSA area and its advertising as NSSA-LSA.	`esr(config-ospf-area)# default-information-originate`	
		`esr(config-ipv6-ospf-area)# default-information-originate`	

Step	Description	Command	Keys
18	Enable the subnet summarization or hiding.	`esr(config-ospf-area)# summary-address <ADDR/LEN> { advertise | not-advertise }`	<ADDR/LEN> – IP address and subnet mask, defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32]; • **advertise** – if a command is specified, instead of the specified subnets, the total subnet will be advertised; • **not-advertise** – when specifying the command, the subnets included in a subnet specified will not be advertised.
		`esr(config-ipv6-ospf-area)# summary-address <IPV6-ADDR/LEN> { advertise | not-advertise }`	<IPV6-ADDR/LEN> – IPv6 address and mask of a subnet, defined as X:X:X:X::X/EE where each X part takes values in hexadecimal format [0..FFFF] and EE takes values of [1..128]; • **advertise** – when specifying the command instead of the subnets included in a subnet specified, a total subnet will be advertised; • **not-advertise** – the subnets included in a subnet specified will not be advertised.
19	Enable OSFP area.	`esr(config-ospf-area)# enable`	
		`esr(config-ipv6-ospf-area)# enable`	
20	Establish a virtual connection between the main and remote areas having several areas between them.	`esr(config-ospf-area)# virtual-link <ID>`	<ID> – identifier of the router with which the virtual connection is established, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
		`esr(config-ipv6-ospf-area)# virtual-link <ID>`	

Step	Description	Command	Keys
21	Set the time interval in seconds after which the router re-sends a packet that has not received a delivery confirmation (for example, a DatabaseDescription packet or LinkStateRequest packets).	`esr(config-ospf- vlink)# restransmit-interval <TIME>` `esr(config-ipv6-ospf-vlink)# restransmit-interval <TIME>`	<TIME> – time in seconds, takes values of [1..65535]. Default value: 5 seconds.
22	Set the time interval in seconds after which the router sends the next hello packet.	`esr(config-ospf- vlink)# hello-interval <TIME>` `esr(config-ipv6-ospf-vlink)# hello-interval <TIME>`	<TIME> – time in seconds, takes values of [1..65535]. Default value: 10 seconds.
23	Set the time interval in seconds after which the neighbor is considered to be idle. This interval should be a multiple of the 'hello interval' value.	`esr(config-ospf- vlink)# dead-interval <TIME>` `esr(config-ipv6-ospf-vlink)# dead-interval <TIME>`	<TIME> – time in seconds, takes values of [1..65535]. Default value: 40 seconds.
24	Set the time interval in seconds after which the router selects DR in the network.	`esr(config-ospf- vlink)# wait-interval <TIME>` `esr(config-ipv6-ospf-vlink)# wait-interval <TIME>`	<TIME> – time in seconds, takes values of [1..65535]. Default value: 40 seconds
25	Define authentication algorithm.	`esr(config-ospf- vlink)# authentication algorithm <ALGORITHM>`	<ALGORITHM> – authentication algorithm: • **cleartext** – password, transmitted in unencrypted form (available only for RIP and OSPF-VLINK); • **md5** – password is hashed by md5 algorithm.
26	Set the password for neighbour authentication.	`esr(config-ospf- vlink)# authentication key ascii-text { <CLEAR-TEXT> | encrypted <ENCRYPTED-TEXT> }`	<CLEAR-TEXT> – password, set by the string of 8 to 16 characters. <ENCRYPTED-TEXT> – encrypted password of 8 to 16 bytes (from 16 to 32 characters) in hexadecimal format (0xYYYY ...) or (YYYY ...).
27	Specify the list of passwords for authentication via md5 hashing algorithm.	`esr(config-ospf- vlink)# authentication key chain <KEYCHAIN>`	<KEYCHAIN> – key list identifier, set by the string of up to 16 characters.

Step	Description	Command	Keys
28	Enable virtual connection.	`esr(config-ospf- vlink)# enable`	
29	Switch to the interface/tunnel/ network bridge configuration mode.	`esr(config)# interface <IF-TYPE><IF-NUM>`	<IF-TYPE> – interface type; <IF-NUM> – F/S/P – F frame (1), S – slot (0), P – port.
		`esr(config)# tunnel <TUN-TYPE><TUN-NUM>`	<TUN-TYPE> – tunnel type; <TUN-NUM> – tunnel number.
		`esr(config)# bridge <BR-NUM>`	<BR-NUM> – bridge number.
30	Define the interface / tunnel / network bridge inherence to a specific OSPF process.	`esr(config-if-gi)# ip ospf instance <ID>`	<ID> – process number, takes values of [1..65535].
		`esr(config-if-gi)# ipv6 ospf instance <ID>`	
31	Define the interface inherence to a specific OSPF process area.	`esr(config-if-gi)# ip ospf area <AREA_ID>`	<AREA_ID> – area identifier, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
		`esr(config-if-gi)# ipv6 ospf area <AREA_ID>`	
32	Enable the routing via OSFP on the interface.	`esr(config-if-gi)# ip ospf`	
		`esr(config-if-gi)# ipv6 ospf`	
33	Enable the mode in which the OSPF process will ignore MTU interface value in incoming Database Description packets.	`esr(config-if-gi)# ip ospf mtu-ignore`	
		`esr(config-if-gi)# ipv6 ospf mtu-ignore`	
34	Specify OSFP authentication algorithm.	`esr(config-if-gi)# ip ospf authentication algorithm <ALGORITHM>`	<ALGORITHM> – authentication algorithm: • **cleartext** – password, transmitted in clear text; • **md5** – password is hashed by md5 algorithm.

Step	Description	Command	Keys
35	Set the password for OSPF neighbor authentication when transmitting an unencrypted password.	`esr(config-if-gi)# ip ospf authentication key ascii-text { <CLEAR-TEXT> | encrypted <ENCRYPTED-TEXT> }`	<CLEAR-TEXT> – password, set by the string of 8 to 16 characters; <ENCRYPTED-TEXT> – encrypted password of 8 to 16 bytes (from 16 to 32 characters) in hexadecimal format (0xYYYY ...) or (YYYY ...).
36	Specify the list of passwords for neighbor authentication via md5 hashing algorithm.	`esr(config-if-gi)# ip ospf authentication key-chain <KEYCHAIN>`	<KEYCHAIN> – key list identifier, set by the string of up to 16 characters.

37	Set the time interval in seconds after which the router selects DR in the network.	`esr(config-if-gi)# ip ospf wait-interval <TIME>`
		
		`esr(config-if-gi)# ipv6 ospf wait-interval <TIME>`
			<TIME> – time in seconds, takes values of [1..65535].
			
			Default value: 40 seconds.

38	Set the time interval in seconds after which the router re-sends a packet that has not received a delivery confirmation (for example, a DatabaseDescription packet or LinkStateRequest packets).	`esr(config-if-gi)# ip ospf restransmit-interval <TIME>`
		
		`esr(config-if-gi)# ipv6 ospf restransmit-interval <TIME>`
			<TIME> – time in seconds, takes values of [1..65535].
			
			Default value: 5 seconds.

39	Set the time interval in seconds after which the router sends the next hello packet.	`esr(config-if-gi)# ip ospf hello-interval <TIME>`
		
		`esr(config-if-gi)# ipv6 ospf hello-interval <TIME>`
			<TIME> – time in seconds, takes values of [1..65535].
			
			Default value: 10 seconds.

40	Set the time interval in seconds after which the neighbor is considered to be idle. This interval should be a multiple of the 'hello interval' value.	`esr(config-if-gi)# ip dead-interval <TIME>`
		
		`esr(config-if-gi)# ipv6 dead-interval <TIME>`
			<TIME> – time in seconds, takes values of [1..65535].
			
			Default value: 40 seconds.

41	Set the time interval during which NBMA interface waits before sending a HELLO packet to a neighbor, even if the neighbor is idle.	`esr(config-if-gi)# ip poll-interval <TIME>`
		
		`esr(config-if-gi)# ipv6 poll-interval <TIME>`
			<TIME> – time in seconds, takes values of [1..65535].
			
			Default value: 120 seconds.

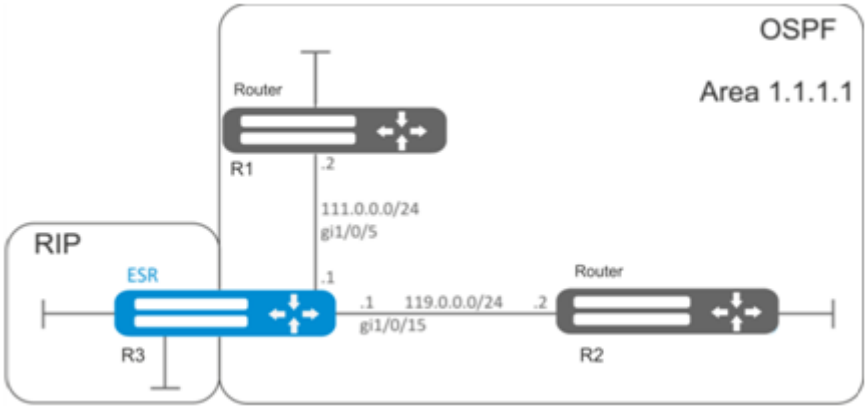
Step	Description	Command	Keys
42	Set static IP address of a neighbor to establish a relation in NMBA and P2MP (Point-to-MultiPoint) networks.	`esr(config-if-gi)# ip ospf neighbor <IP> [ eligible ]`	<IP> – neighbor's IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]. **eligible** – optional parameter, allows the device to take part in DR selection process in NMBA networks. The interface priority should be greater than zero.
		`esr(config-if-gi)# ip ospf neighbor <IP> [ eligible ]`	<IPV6-ADDR> – neighbor's IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF]; **eligible** – optional parameter, allows the device to take part in DR selection process in NMBA networks. The interface priority should be greater than zero.
43	Define the network type for OSPF neighborhood establishment.	`esr(config-if-gi)# ip ospf network <TYPE>`	<TYPE> – network type: • **broadcast** – broadcast connection type; • **non-broadcast** – NBMA connection type; • **point-to-multipoint** – point-to-multipoint connection type; • **point-to-multipoint non-broadcast** – point-to-multipoint NBMA connection type; • **point-to-point** – point-to-point connection type. Default value: broadcast.
		`esr(config-if-gi)# ipv6 ospf network <TYPE>`	
44	Set the router priority that is used for DR and BDR selection.	`esr(config-if-gi)# ip ospf priority <VALUE>`	<VALUE> – interface priority, takes values of [1..65535]. Default value: 120.
		`esr(config-if-gi)# ipv6 ospf priority <VALUE>`	
45	Set the metric size on the interface or tunnel.	`esr(config-if-gi)# ip ospf cost <VALUE>`	<VALUE> – metric size, takes values of [0..32767]. Default value: 150.
		`esr(config-if-gi)# ipv6 ospf cost <VALUE>`	

Step	Description	Command	Keys
47	Enable BFD protocol for OSPF protocol.	`esr(config-if-gi)# ip ospf bfd-enable`	
		`esr(config-if-gi)# ipv6 ospf bfd-enable`	

5.3.2 OSPF configuration example

Objective:

Configure OSPF protocol on the router in order to exchange the routing information with neighbouring routers. The router should be in 1.1.1.1 identifier area and announce routes received via RIP.



Solution:

Pre-configure IP addresses on interfaces according to the network structure shown in figure.

Create OSPF process with identifier 10 and proceed to the OSPF protocol configuration mode:

```
esr(config)# router ospf 10
```

Create and enable the required area:

```
esr(config-ospf)# area 1.1.1.1
esr(config-ospf-area)# enable
esr(config-ospf-area)# exit
```

Enable advertising of the routing information from RIP:

```
esr(config-ospf)# redistribute rip
```

Enable OSFP process:

```
esr(config-ospf)# enable
esr(config-ospf)# exit
```

Neighbouring routers are connected to gi1/0/5 and gi1/0/15 interfaces. To establish the neighbouring with other routers, map them to OSPF process and the area. Next, enable OSPF routing for the interface.

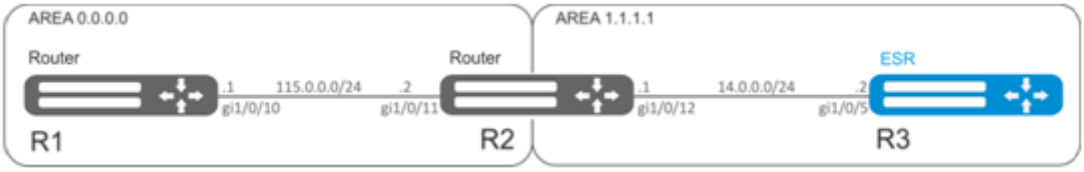
```
esr(config)# interface gigabitethernet 1/0/5
esr(config-if-gi)# ip ospf instance 10
esr(config-if-gi)# ip ospf area 1.1.1.1
esr(config-if-gi)# ip ospf
esr(config-if-gi)# exit
```

```
esr(config)# interface gigabitethernet 1/0/15
esr(config-if-gi)# ip ospf instance 10
esr(config-if-gi)# ip ospf area 1.1.1.1
esr(config-if-gi)# ip ospf
esr(config-if-gi)# exit
esr(config)# exit
```

5.3.3 OSPF stub area configuration example

Objective:

Change 1.1.1.1 area type, area should be stub. Stub router should advertise routes received via RIP.



Solution:

Pre-configure OSPF protocol and IP addresses on interfaces according to the network structure shown in figure.

Change area type to stub. For each router from 1.1.1.1 area, execute the following command in the configuration mode:

```
esr(config-ospf-area)# area-type stub
```

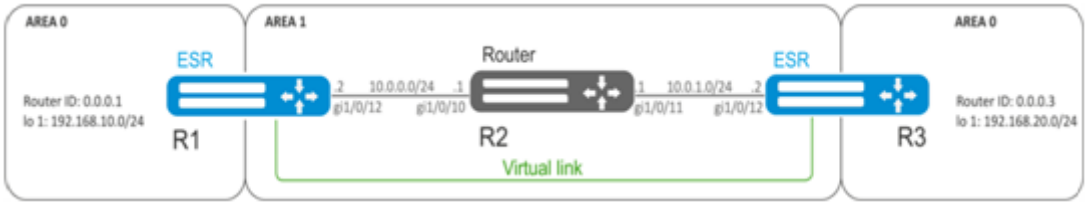
For R3 stub router, enable advertising of the routing information from RIP:

```
esr(config-ospf)# redistribute rip
```

5.3.4 Virtual link configuration example

Objective:

Merge two backbone areas using virtual link.



Solution:

Virtual link is a specialized connection that allows you to merge a split zone or connect a zone to the backbone zone trough the third zone. Virtual link is configured between two Area Border Routers (ABR).

Pre-configure OSPF protocol and IP addresses on interfaces according to the network structure shown in figure.

For R1 router, proceed to 1.1.1.1 area configuration mode:

```
esr(config-ospf)# area 1.1.1.1
```

Create and enable virtual link with the identifier 0.0.0.3:

```
esr(config-ospf-area)# virtual-link 0.0.0.3
esr(config-ospf-vlink)# enable
```

For R3 router, proceed to 1.1.1.1 area configuration mode:

```
esr(config-ospf)# area 1.1.1.1
```

Create and enable virtual link with the identifier 0.0.0.1:

```
esr(config-ospf-area)# virtual-link 0.0.0.1
esr(config-ospf-vlink)# enable
```

Review the routing table on R1 router:

```
esr# show ip route
C     * 10.0.0.0/24        [0/0]   dev gi1/0/12,                  [direct 00:49:34]
O     * 10.0.1.0/24        [150/20] via 10.0.0.1 on gi1/0/12,     [ospf1 00:49:53]  (0.0.0.3)
O     * 192.168.20.0/24    [150/30] via 10.0.0.1 on gi1/0/12,     [ospf1 00:50:15]  (0.0.0.3)
C     * 192.168.10.0/24    [0/0]   dev lo1,                       [direct 21:32:01]
```

Review the routing table on R3 router:

```
esr# show ip route
O     * 10.0.0.0/24         [150/20] via 10.0.1.1 on gi1/0/12,      [ospf1 14:38:35]  (0.0.0.2)
C     * 10.0.1.0/24         [0/0]   dev gi1/0/12,                   [direct 14:35:34]
C     * 192.168.20.0/24     [0/0]   dev lo1,                        [direct 14:32:58]
O     * 192.168.10.0/24     [150/30] via 10.0.1.1 on gi1/0/12,      [ospf1 14:39:54]  (0.0.0.1)
```

Since OSPF considers virtual link as the part of the area, R1 routes received from R3 are marked as an intrazone and vice versa.

To view the neighbors, use the following command:

```
esr# show ip ospf neighbors 10
```

To view OSPF routing table, use the following command:

```
esr# show ip ospf 10
```

⚠ In the firewall, you should enable OSPF protocol (89).

5.4 BGP configuration

BGP protocol is designed to exchange subnet reachability information among autonomous systems (AS), i.e. router groups united under a single technical control that uses interdomain routing protocol for defining packet delivery routes to other AS. Transmitted information includes a list of AS that are accessible through this system. Selection of the optimal routes is based on effective rules for the network.

5.4.1 Configuration algorithm

⚠ To establish a BGP session it is necessary to allow TCP port 179 on the firewall.

Step	Description	Command	Keys
1	Configure BGP precedence for the main routing table (optional).	`esr(config)# ip protocols bgp preference <VALUE>`	<VALUE> – protocol precedence, takes values in the range of [1..255]. Default value: BGP (170).

Step	Description	Command	Keys
2	Configure the BGP routing table capacity (not required when using the global routing table).	`esr(config)# ip protocols bgp max-routes <VALUE>`	<VALUE> – amount of BGP routes in the routing table, takes values in the range of: • for ESR-1700 [1..5000000]; • for ESR-1000/1200/1500 [1..3000000]; • for ESR-20/21/100/200 [1..2000000]; • for ESR-10/12V(F)/14VF [1..800000]. The default value for the global routing table: • for ESR-1700 (5000000); • for ESR-1000/1200/1500 (3000000); • for ESR-20/21/100/200 (2000000); • for ESR-10/12V/12VF/14VF (800000). Default value for VRF: 0.
		`esr(config)# ipv6 protocols bgp max-routes <VALUE>`	
		`esr(config-vrf)# ip protocols bgp max-routes <VALUE>`	
		`esr(config-vrf)# ipv6 protocols bgp max-routes <VALUE>`	
3	Enable the output of BGP neighbor state information (optional).	`esr(config)# router bgp log-neighbor-changes`	
		`esr(config)# ipv6 router bgp log-neighbor-changes`	
4	Enable ECMP and define the maximum amount of equal routes to a destination point.	`esr(config)# router bgp maximum-paths <VALUE>`	<VALUE> – amount of valid equal routes to the target, takes the values of [1..16].
3	Select the filtering method for the information transmitted between routers. (Mandatory when configuring eBGP to announce subnets)		
3.1.1	If you select the route-map-based filtering method, create a list of rules that will be used to filter the advertised and received IP routes in the future.	`esr(config)# route-map <NAME>`	<NAME> – configured routing rule name, set by the string of up to 31 characters.

Step	Description	Command	Keys
3.1.2	Create rule	`(config-route-map)# rule <ORDER>`	<ORDER> – rule number, takes values of [1..10000].

3.1.3	Define the list of subnets affected by the rule.	`esr(config-route-map-rule)#match ip address { <ADDR/LEN> | object-group <OBJ-GRP-NETNAME> } [ { eq <LEN> | le <LEN> | ge <LEN 1> [ le <LEN 2> ] } ]`
		
		`esr(config-route-map-rule)#match ipv6 address { <IPV6-ADDR/LEN> | object-group <OBJ-GRP-NETNAME> } [ { eq <LEN> | le <LEN> | ge <LEN 1> [ le <LEN 2> ] } ]`
			<ADDR/LEN> – IP address and subnet mask, in the format of:
			
			AAA.BBB.CCC.DDD/EE – network IP address with prefix mask, where AAA-DDD take values of [0..255] and EE takes values of [1..32];
			
			<IPV6-ADDR/LEN> – IPv6 address and subnet mask, in the format of:
			
			X:X:X:X::X/EE, where each X part takes values in hexadecimal format [0..FFFF] and EE takes values of [1..128];
			
			<OBJ-GRP-NETNAME> – IP addresses profile name, set by the string of up to 31 characters*;
			
			<LEN>, <LEN 1>, <LEN 2> – prefix length, may take values [1..32] in prefix IP lists for IPv4 and [1..128] for IPv6;
			
			• **eq** – when specifying the command, the prefix length mast match the specified one;
			• **le** – when specifying the command, the prefix length mast be less than or match the specified one;
			• **ge** – when specifying the command, the prefix length mast be more than or match the specified one;
			• **ge** <LEN 1> **le** <LEN 2> – When specifying a command, the prefix length must be greater than or equal to <LEN> but less than or equal to <LEN1>.
			
			* When using object-group filtering, they must be created in advance.

3.1.4	Permit or deny action for the specified subnets in the rule.	`esr(config-route-map-rule)# action {deny | permit}`	

Step	Description	Command	Keys
3.2.1	If you select the prefix-list-based filtering method, create a list of IP networks that will be used to filter the advertised and received IP routes in the future.	`esr(config)# ip prefix-list <NAME>` `esr(config)# ipv6 prefix-list <NAME>`	<NAME> – name of a subnet list being configured, set by the string of up to 31 characters.

3.2.2	Permit or deny the prefixes lists.	`esr(config-pl)# permit { <ADDR/LEN> | object-group <OBJ-GRP-NETNAME>} [ { eq <LEN> | le <LEN> | ge <LEN 1> [ le <LEN 2> ] } ]`
		`esr(config-pl)# deny {<ADDR/LEN> | object-group <OBJ-GRP-NETNAME>} [ { eq <LEN> | le <LEN> | ge <LEN 1> [ le <LEN 2> ] } ]`
		`esr(config-ipv6-pl)# permit { <IPV6-ADDR/LEN> | object-group <OBJ-GRP-NETNAME>} [ { eq <LEN> | le <LEN> | ge <LEN 1> [ le <LEN 2> ] } ]`
		`esr(config-ipv6-pl)# deny {<IPV6-ADDR/LEN> | object-group <OBJ-GRP-NETNAME> } [ { eq <LEN> | le <LEN> | ge <LEN 1> [ le <LEN 2> ] } ]`
			<ADDR/LEN> – IP address and subnet mask, in the format of.
			
			AAA.BBB.CCC.DDD/EE – network IP address with prefix mask, where AAA-DDD take values of [0..255] and EE takes values of [1..32];
			
			<IPV6-ADDR/LEN> – IPv6 address and subnet mask, in the format of:
			
			X:X:X:X::X/EE, where each X part takes values in hexadecimal format [0..FFFF] and EE takes values of [1..128];
			
			<OBJ-GRP-NETNAME> – IP addresses profile name, set by the string of up to 31 characters*;
			
			<LEN>, <LEN 1>, <LEN 2> – prefix length, may take values [1..32] in prefix IP lists for IPv4 and [1..128] for IPv6;
			
			• **eq** – when specifying the command, the prefix length mast match the specified one;
			• **le** – when specifying the command, the prefix length mast be less than or match the specified one;
			• **ge** – when specifying the command, the prefix length mast be more than or match the specified one;
			• **ge** <LEN 1> **le** <LEN 2> – When specifying a command, the prefix length must be greater than or equal to <LEN> but less than or equal to <LEN1>.
			
			* When using object-group filtering, they must be created in advance.

Step	Description	Command	Keys
4	Add BGP process to the system and switch to the BGP process parameters configuration mode.	`esr(config)# router bgp <AS>`	<AS> – stand alone system number, takes values of [1..4294967295].
5	Set the router identifier.	`esr(config-bgp)# router-id <ID>`	<ID> – router identifier, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
6	Set the Route-Reflector identifier of the cluster to which the router BGP process belongs. (If necessary)	`esr(config-bgp)# cluster-id <ID>`	<ID> – Route-Reflector cluster identifier, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
7	Enable generation and sending of a default route, if the default route is in the FIB routing table. (optionally)	`esr(config-bgp)# default-information-originate`	
8	Set the time interval after which the connection with the opposing party is checked. (Optional)	`esr(config-bgp-af)# timers keepalive <TIME>`	<TIME> – time in seconds, takes values of [1..65535]. Default value: 60 seconds.
9	Set time interval after which the opposing party is considered to be unavailable. (Optional)	`esr(config-bgp-af)# timers holdtime <TIME>`	<TIME> – time in seconds, takes values of [1..65535]. Default value: 180 seconds.
10	Set the time of minimum and maximum delay during which it is prohibited to establish a connection in order to prevent frequent disconnections (Optional)	`esr(config-bgp-af)# timers error-wait <TIME1> <TIME2>`	<TIME1> – minimum delay time in seconds, takes values of [1..65535]. <TIME2> – maximum delay time in seconds, takes values of [1..65535].
11	Define the global algorithm of neighbor authentication (if necessary).	`esr(config-bgp)# authentication algorithm <ALGORITHM>`	<ALGORITHM> – encryption algorithm: md5 – password is encrypted by md5 algorithm. Default value: Encryption is not used
12	Set a global password for authentication with neighbors. (Used in conjunction with «authentication algorithm»)	`esr(config-bgp)# authentication key ascii-text { <CLEAR-TEXT> | encrypted <ENCRYPTED-TEXT> }`	<CLEAR-TEXT> – password, set by the string of 8 to 16 characters; <ENCRYPTED-TEXT> – encrypted password of 8 to 16 bytes (from 16 to 32 characters) in hexadecimal format (0xYYYY ...) or (YYYY ...).

Step	Description	Command	Keys
13	Enable BGP process.	`esr(config-bgp)# enable`	
14	Define the type of configured routing information and switch to this configuration mode.	`esr(config-bgp)# address-family { ipv4 | ipv6 } unicast`	• **ipv4** – IPv4 family; • **ipv6** – IPv6 family;
15	Enable route advertising by BGP process obtained alternatively (if necessary).	`esr(config-bgp-af)# redistribute static [ route-map <NAME> ]`	<NAME> – name of the route map that will be used for advertised static routes filtration and modification, set by the string of up to 31 characters.
		`esr(config-bgp-af)# redistribute connected [ route-map <NAME> ]`	<NAME> – name of the route map that will be used for filtration and modification of advertised directly connected subnets, set by the string of up to 31 characters.
		`esr(config-bgp-af)# redistribute rip [ route-map <NAME> ]`	<NAME> – name of the route map that will be used for advertised RIP routes filtration and modification, set by the string of up to 31 characters.
		`esr(config-bgp-af)# redistribute ospf <ID> <ROUTE-TYPE 1> [<ROUTE-TYPE 2>] [<ROUTE-TYPE 3>] [<ROUTE-TYPE 4>] [ route-map <NAME> ]`	<ID> – process number, takes values of {1..65535}; <ROUTE-TYPE> – route type: • **intra-area** – OSPF process routes advertising within a zone; • **inter-area** – OSPF process routes advertising between zones; • **external1** – OSPF format 1 external routes advertising; • **external2** – OSPF format 2 external routes advertising; <NAME> – name of the route map that will be used for advertised OSFP routes filtration and modification, set by the string of up to 31 characters.

Step	Description	Command	Keys
		`esr(config-bgp-af)# redistribute bgp <AS> [ route-map <NAME> ]`	<AS> – stand alone system number, takes values of [1..4294967295]. <NAME> – name of the route map that will be used for advertised BGP routes filtration and modification, set by the string of up to 31 characters.
16	Enable subnets advertising.	`esr(config-bgp-af)# network <ADDR/LEN>`	<ADDR/LEN> – subnet address, set in one of the following formats: AAA.BBB.CCC.DDD/EE – network IP address with prefix mask, where AAA-DDD take values of [0..255] and EE takes values of [1..32]; X:X:X:X::X/EE – IPv6 address and mask of a subnet, where each X part takes values in hexadecimal format [0..FFFF] and EE takes values of [1..128].
17	Exit global BGP process route information advertisement configuration mode	`esr(config-bgp-af)# exit`	
18	Add BGP neighbor and switch to the BGP process parameters configuration mode.	`esr(config-bgp)# neighbor <ADDR>|<IPV6-ADDR>`	<ADDR> – neighbor's IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <IPV6-ADDR> – client IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF].
19	Specify neighbor description (optionally).	`esr(config-bgp-neighbor)# description <DESCRIPTION>`	<DESCRIPTION> – neighbor description, set by the string of up to 255 characters.
20	Set the time interval after which the connection with the opposing party is checked. (optionally).	`esr(config-bgp-neighbor)# timers keepalive <TIME>`	<TIME> – time in seconds, takes values of [1..65535]. Default value: 60 seconds.
21	Set time interval after which the opposing party is considered to be unavailable (optionally).	`esr(config-bgp-neighbor)# timers holdtime <TIME>`	<TIME> – time in seconds, takes values of [1..65535]. Default value: 180 seconds.

Step	Description	Command	Keys
22	Set the time of minimum and maximum delay during which it is prohibited to establish a connection in order to prevent frequent disconnections (optionally).	`esr(config-bgp-af)# timers error-wait <TIME1> <TIME2>`	<TIME1> – minimum delay time in seconds, takes values of [1..65535]. <TIME2> – maximum delay time in seconds, takes values of [1..65535]. Default value: 60 and 300 seconds
23	Set the number of BGP neighbor stand alone system.	`esr(config-bgp-neighbor)# remote-as <AS>`	<AS> – stand alone system number, takes values of [1..4294967295].
24	Allow connections to neighbors that are located not in directly connected subnets (optional)	`esr(config-bgp-neighbor)# ebgp-multihop <NUM>`	<NUM> – maximum amount of hops when installing EBGP (used for TTL).
25	Specify BGP neighbor as a Route-Reflector client. (optional)	`esr(config-bgp-neighbor)# route-reflector-client`	
26	Set IP/IPv6 router address that will be used as source IP/IPv6 address in transmitted BGP route information updates. (optionally)	`esr(config-bgp-neighbor)# update-source { <ADDR> | <IPV6-ADDR> }`	<ADDR> – source IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <IPV6-ADDR> – source IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF].
27	Enable the mode in which the reception of routes in the BGP attribute, AS Path of which includes the numbers of process stand alone system, is allowed. (optionally)	`esr(config-bgp-neighbor)# allow-local-as <NUMBER>`	<NUMBER> – threshold amount of instances of autonomous system number in the AS Path attribute at which the route will be accepted, the range of acceptable values [1..10].
28	Enable the BFD protocol on the configured BGP neighbor. (optional, used in conjunction with the update-source parameter)	`esr(config-bgp-neighbor)# bfd-enable`	
29	Specify neighbor authentication algorithm (optionally).	`esr(config-bgp-neighbor)# authentication algorithm <ALGORITHM>`	<ALGORITHM> – encryption algorithm: md5 – password is encrypted by md5 algorithm.

Step	Description	Command	Keys
30	Set the password for neighbour authentication (optionally).	`esr(config-bgp-neighbor)# authentication key ascii-text { <CLEAR-TEXT> | encrypted <ENCRYPTED-TEXT> }`	<CLEAR-TEXT> – password, set by the string of 8 to 16 characters; <ENCRYPTED-TEXT> – encrypted password of 8 to 16 bytes (from 16 to 32 characters) in hexadecimal format (0xYYYY ...) or (YYYY ...).
31	Make neighborhood active	`esr(config-bgp-neighbor)# enable`	
32	Define the type of neighbor configured routing information and switch to this configuration mode.	`esr(config-bgp-neighbor)# address-family { ipv4 | ipv6 | vpnv4 } unicast`	• **ipv4** – IPv4 family; • **ipv6** – IPv6 family; • **vpnv4** – VPNv4 family;
33	If prefix list filtering mode is selected, add subnet filtering in incoming or outgoing updates (Mandatory when configuring eBGP for subnet advertisement).	`esr(config-bgp-neighbor-af)# prefix-list <PREFIX-LIST-NAME> { in | out }`	<PREFIX-LIST-NAME> – name of a subnet list being configured, set by the string of up to 31 characters. • **in** – incoming routes filtering; • **out** – outgoing routes filtering.
34	Set the mode in which the default route is always sent to the BGP neighbor in the update along with other routes. (optional, none for vpnv4)	`esr(config-bgp-neighbor-af)# default-originate`	
35	Set the mode in which all updates are sent to BGP neighbor with the IP address of a local router outgoing interface as the next-hop. (optional, none for vpnv4)	`esr(config-bgp-neighbor-af)# next-hop-self`	
36	Define the precedence of the routes received from a neighbor. (optional)	`esr(config-bgp-neighbor-af)# preference <VALUE>`	<VALUE> – neighbor routes precedence, takes values in the range of [1..255]. Default value: 170.

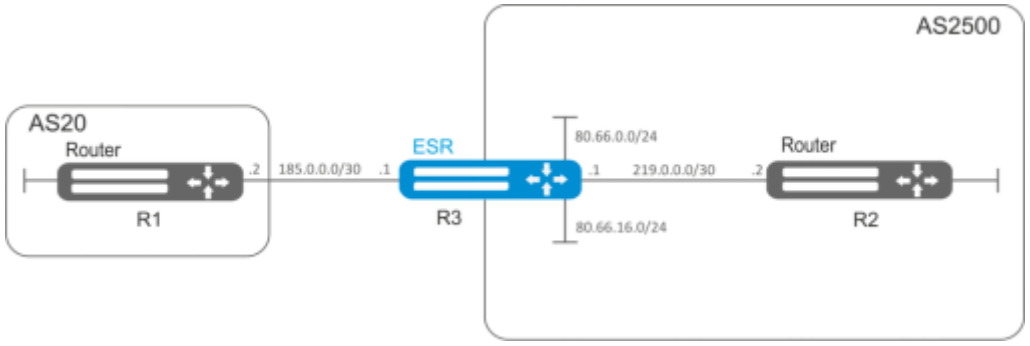
Step	Description	Command	Keys
37	Set the mode in which private numbers of autonomous systems are removed from the AS Path routes BGP attribute before sending an update (in accordance with RFC 6996). (optional, none for vpnv4)	`esr(config-bgp-neighbor-af)# remove-private-as [ { all | nearest | replace } ]`	• **all** – remove all private AS number from AS-path; • **nearest** – replace the nearest private AS in the AS-path with a nearby public AS; • **replace** – replace all private AS numbers with the number of the current BGP process. Default value: all.
38	Enable routing information exchange	`esr(config-bgp-neighbor-af)# enable`	

It often happens, especially when configuring iBGP, that in one bgp process you need to configure several bgp neighbor with the same parameters. To avoid configuration redundancy, it is recommended to use bgp peer-group in which you can describe common parameters and it is easy to identify the bgp peer-group membership in the bgp neighbor configuration.

5.4.2 Configuration example

Objective:

Configure BGP on the R3 router with the following parameters:



- own subnets: 80.66.0.0/24, 80.66.16.0/24;
- advertising of directly connected subnets;
- proprietary AS 2500;
- first neighbouring – subnet 219.0.0.0/30, proprietary IP address 219.0.0.1, neighbour IP address 219.0.0.2, AS2500;
- second neighbouring – subnet 185.0.0.0/30, proprietary IP address 185.0.0.1, neighbour IP address 185.0.0.2, AS20.

Solution:

Configure required network interfaces:

```
esr-R3(config)# interface gigabitethernet 1/0/1
esr-R3(config-if-gi)# ip address 185.0.0.1/30
esr-R3(config-if-gi)# exit
esr-R3(config)# interface gigabitethernet 1/0/2
esr-R3(config-if-gi)# ip address 219.0.0.1/30
esr-R3(config-if-gi)# exit
esr-R3(config)# interface gigabitethernet 1/0/3
esr-R3(config-if-gi)# ip address 80.66.0.1/24
esr-R3(config-if-gi)# exit
esr-R3(config)# interface gigabitethernet 1/0/4
esr-R3(config-if-gi)# ip address 80.66.16.1/24
esr-R3(config-if-gi)# exit
```

Configure the firewall to receive BGP traffic from the WAN security zone

```
esr-R3(config)# object-group service og_bgp
esr-R3(config-object-group-service)# port-range 179
esr-R3(config-object-group-service)# exit
esr-R3(config)# security zone wan
esr-R3(config-zone)# exit
esr-R3(config)# security zone-pair wan self
esr-R3(config-zone-pair)# rule 100
esr-R3(config-zone-pair-rule)# match protocol tcp
esr-R3(config-zone-pair-rule)# match destination-port og_bgp
esr-R3(config-zone-pair-rule)# action permit
esr-R3(config-zone-pair-rule)# enable
esr-R3(config-zone-pair-rule)# exit
esr-R3(config-zone-pair)# exit
```

Specify that the interfaces belong to the security zone

```
esr-R3(config)# interface gigabitethernet 1/0/1
esr-R3(config-if-gi)# security-zone wan
esr-R3(config-if-gi)# exit
esr-R3(config)# interface gigabitethernet 1/0/2
esr-R3(config-if-gi)# security-zone wan
esr-R3(config-if-gi)# exit
```

Create a route-map, which will be used later when configuring enabling advertising to routers from another AS

```
esr-R3(config)# route-map bgp-general
esr-R3(config-route-map)# rule 1
esr-R3(config-route-map-rule)# match ip address 80.66.0.0/24
esr-R3(config-route-map-rule)# match ip address 80.66.16.0/24
esr-R3(config-route-map-rule)# action permit
esr-R3(config-route-map-rule)# exit
esr-R3(config-route-map)# exit
```

Create BGP process for AS 2500 and enter process parameters' configuration mode:

```
esr(config)# router bgp 2500
```

Configure advertising of directly connected subnets:

```
esr-R3(config-bgp)# address-family ipv4 unicast
esr-R3(config-bgp-af)# redistribute connected
esr-R3(config-bgp-af)# exit
```

Create neighborhood with R2 router via iBGP

```
esr-R3(config-bgp)# neighbor 219.0.0.2
esr-R3(config-bgp-neighbor)# remote-as 2500
esr-R3(config-bgp-neighbor)# enable
```

Enable ipv4 route exchange

```
esr-R3(config-bgp-neighbor)# address-family ipv4 unicast
esr-R3(config-bgp-neighbor-af)# enable
esr-R3(config-bgp-neighbor-af)# exit
esr-R3(config-bgp-neighbor)# exit
```

Create a neighborhood with the R1 router via eBGP

```
esr-R3(config-bgp)# neighbor 185.0.0.2
esr-R3(config-bgp-neighbor)# remote-as 20
esr-R3(config-bgp-neighbor)# enable
```

Enable the exchange of ipv4 routes, permitting the necessary routes for advertising by means of a previously prepared route-map

```
esr-R3(config-bgp-neighbor)# address-family ipv4 unicast
esr-R3(config-bgp-neighbor-af)# route-map bgp-general out
esr-R3(config-bgp-neighbor-af)# enable
esr-R3(config-bgp-neighbor-af)# exit
esr-R3(config-bgp-neighbor)# exit
```

Enable protocol operation

```
esr-R3(config-bgp)# enable
esr-R3(config-bgp)# exit
```

To view BGP peers information, use the following command:

```
esr# show ip bgp 2500 neighbors
```

To view BGP routing table, use the following command:

```
esr# show ip bgp
```

5.5 BFD configuration

BFD (Bidirectional Forwarding Detection) is a protocol operating over other protocols and allowing to reduce the problem detection time to 50 msec. BFD is two-party protocol, it requires the configuration of both routers (both routers generate BFD packets and respond to each other).

5.5.1 Configuration algorithm

Step	Description	Command	Keys
1	Enable BFD for OSFP on the interface	`esr(config-if-gi)# ip ospf bfd-enable`	

Step	Description	Command	Keys
2	Enable BFD for BGP neighbor on the interface	`esr(config-bgp-neighbor)# bfd-enable`	
3	Set the interval after which the BFD message is sent to the neighbor. Globally (optionally)	`esr(config)# ip bfd idle-tx-interval <TIMEOUT>`	<TIMEOUT> – interval after which the BFD packet should be sent, takes values in milliseconds in the range of [200..65535] for ESR-1000/1200/1500/1700 and [300..65535] for ESR-10/12V(F)/14VF/20/21/100/200 By default, 1 second
4	Enable the logging of BFD protocol state changes (optionally)	`esr(config)# ip bfd log-adjacency-changes`	
5	Set the minimum interval after which the neighbor should generate BFD message. Globally (optionally)	`esr(config)# ip bfd min-rx-interval <TIMEOUT>`	<TIMEOUT> – interval after which the BFD message should be sent by the neighbor, takes values in milliseconds in the range of [200..65535] for ESR-1000/1200/1500/1700 and [300..65535] for ESR-10/12V(F)/20/21/100/200 By default: • 300 ms on ESR-10/12V(F)/14VF/20/21/100/200 • 200 ms on ESR-1000/1200/1500/1700
6	Set the minimum interval after which the BFD message is sent to the neighbor. Globally (optionally)	`esr(config)# ip bfd min-tx-interval <TIMEOUT>`	<TIMEOUT> – interval after which the BFD message should be sent by the neighbor, takes values in milliseconds in the range of [200..65535] for ESR-1000/1200/1500/1700 and [300..65535] for ESR-10/12V(F)/20/21/100/200 By default: • 300 ms on ESR-10/12V(F)/14VF/20/21/100/200 • 200 ms on ESR-1000/1200/1500/1700

Step	Description	Command	Keys
7	Set the amount of dropped packets, at which the BFD neighbor is considered to be unavailable. Globally	`esr(config)# ip bfd multiplier <COUNT>`	<COUNT> – amount of dropped packets, at which the neighbor is considered to be unavailable, takes values in the range of [1..100]. Default: 5
8	Put BFD mechanism with the specified IP address into operation.	`esr(config)# ip bfd neighbor <ADDR> [ { interface <IF> | tunnel <TUN> } ] [local-address <ADDR> [multihop]] [vrf <VRF>]`	<ADDR> – gateway IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <IF> – interface or interface group; <TUN> – tunnel type and number. <VRF> – VRF name, set by the string of up to 31 characters. multihop – key for setting TTL=255, for BFD mechanism operation through the routed network.
9	Switch BFD session to the passive mode, so that BFD messages will not be sent until the messages from BFD neighbor are received. Globally (optional)	`esr(config)# ip bfd passive`	
10	Set the interval after which the BFD message is sent to the neighbor. On the interface (optionally)	`esr(config-if-gi)# ip bfd idle-tx-interval <TIMEOUT>`	<TIMEOUT> – interval after which the BFD packet should be sent, takes values in milliseconds in the range of [200..65535] for ESR-1000/1200/1500/1700 and [300..65535] for ESR-10/12V(F)/14VF/20/21/100/200 Default: 1 second

Step	Description	Command	Keys
11	Set the minimum interval after which the neighbor should generate BFD message. On the interface (optionally)	`esr(config-if-gi)# ip bfd min-rx-interval <TIMEOUT>`	<TIMEOUT> – interval after which the BFD message should be sent by the neighbor, takes values in milliseconds in the range of [200..65535] for ESR-1000/1200/1500/1700 and [300..65535] for ESR-10/12V(F)/ 20/21/100/200 By default: • 300 ms on ESR-10/12V(F)/ 14VF/20/21/100/200 • 200 ms on ESR-1000/1200/1500/1700
12	Set the minimum interval after which the BFD message is sent to the neighbor. On the interface (optionally)	`esr(config-if-gi)# ip bfd min-tx-interval <TIMEOUT>`	<TIMEOUT> – interval after which the BFD message should be sent by the neighbor, takes values in milliseconds in the range of [200..65535] for ESR-1000/1200/1500/1700 and [300..65535] for ESR-10/12V(F)/ 20/21/100/200 By default: • 300 ms on ESR-10/12V(F)/ 14VF/20/21/100/200 • 200 ms on ESR-1000/1200/1500/1700
13	Set the amount of dropped packets, at which the BFD neighbor is considered to be unavailable. On the interface (optional)	`esr(config-if-gi)# ip bfd multiplier <COUNT>`	<COUNT> – amount of dropped packets, at which the neighbor is considered to be unavailable, takes values in the range of [1..100]. Default: 5
14	Switch BFD session to the passive mode, so that BFD messages will not be sent until the messages from BFD neighbor are received. On the interface (optionally)	`esr(config-if-gi)# ip bfd passive`	

5.5.2 Configuration example of BFD with BGP

Objective:

Configure eBGP between ESR R1 and R2 and enable BFD.

Solution

1. R1 configuration
   Preconfigure Gi1/0/1 interface:

```
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)# ip firewall disable
esr(config-if-gi)# ip address 10.0.0.1/24
```

   Configure eBGP with BFD:

```
esr(config)# router bgp 100
esr(config-bgp)# address-family ipv4
esr(config-bgp-af)# neighbor 10.0.0.2
esr(config-bgp-neighbor)# remote-as 200
esr(config-bgp-neighbor)# update-source 10.0.0.1
esr(config-bgp-neighbor)# bfd-enable
esr(config-bgp-neighbor)# enable
esr(config-bgp-neighbor)# ex
esr(config-bgp-af)# enable
esr(config-bgp-af)# exit
```

2. R2 configuration
   Preconfigure Gi1/0/1 interface:

```
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)# ip firewall disable
esr(config-if-gi)# ip address 10.0.0.2/24
```

   Configure eBGP with BFD:

```
esr(config)# router bgp 200
esr(config-bgp)# address-family ipv4
esr(config-bgp-af)# neighbor 10.0.0.1
esr(config-bgp-neighbor)# remote-as 100
esr(config-bgp-neighbor)# update-source 10.0.0.2
esr(config-bgp-neighbor)# bfd-enable
esr(config-bgp-neighbor)# enable
esr(config-bgp-neighbor)# ex
esr(config-bgp-af)# enable
esr(config-bgp-af)# exit
```

5.6 PBR routing policy configuration

5.6.1 Configuration algorithm of Route-map for BGP

Route-maps may serve as filters processing routing information when it is received from or sent to the neighbouring device. Processing may include filtering based on various route criteria and setting attributes (MED, AS-PATH, community, LocalPreference, etc.) for the respective routes.

Also, Route-map may assign routes based on access control lists (ACL).

Step	Description	Command	Keys
1	Create a route map for IP routes filtration and modification.	`esr(config)# route-map <NAME>`	<NAME> – router map name, set by the string of up to 31 characters.
2	Create a route map rule.	`esr(config-route-map)# rule <ORDER>`	<ORDER> – rule number, takes values of [1..10000].
3	Specify the action that should be applied for routing information.	`esr(config-route-map-rule)# action <ACT>`	<ACT> – allocated action: • **permit** – routing information reception or advertising is permitted; • **deny** – denied.
4	Set BGPAS-Path attribute value in the route for which the rule should work (optionally).	`esr(config-route-map-rule)# match as-path [begin | end | contain] <AS-PATH>`	<AS-PATH> – list of stand alone system numbers, defined as AS,AS,AS, takes values of [1..4294967295]. Optional parameters: • **begin** – attribute value begins with the specified AS numbers; • **end** – attribute value ends with the specified AS numbers; • **contain** – attribute value includes the specified AS numbers list.
5	Set BGPCommunity attribute value for which the rule should work (optionally).	`esr(config-route-map-rule)# match community <COMMUNITY-LIST>`	<COMMUNITY-LIST> – community list, defined as AS:N,AS:N, takes values of [1..4294967295]. You can specify up to 64 community.

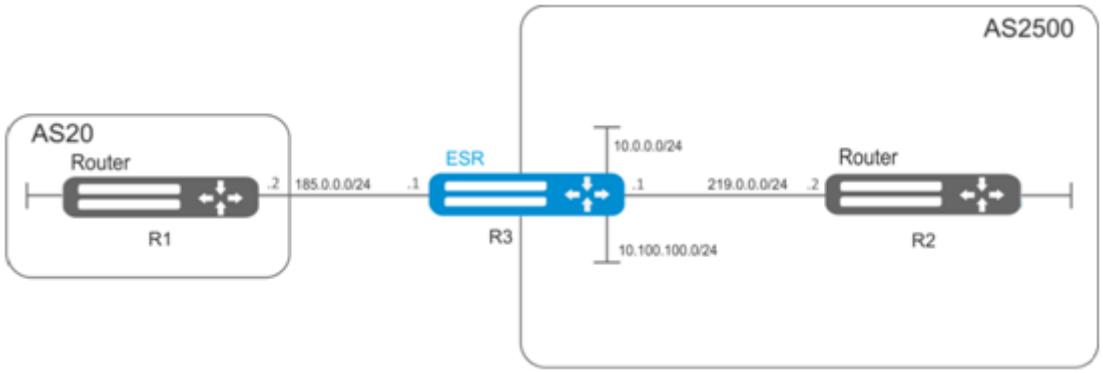
Step	Description	Command	Keys
6	BGPExtendedCommunity attribute value for which the rule should work (optionally).	`esr(config-route-map-rule)# match extcommunity <EXTCOMMUNITY-LIST>`	<EXTCOMMUNITY-LIST> – extcommunity list, defined as KIND:AS:N, KIND:AS:N, where KIND – extcommunity type: • **rt**(Route Target); • **ro** (Route Origin); N – extcommunity number, takes values of [1..65535].
7	Set IP addresses profile including destination subnet values in the route (optionally).	`esr(config-route-map-rule)# match ip address object-group <OBJ-GROUP- NETWORK -NAME>`	<OBJ-GROUP-NETWORK-NAME> – name of the IP addresses profile that includes destination subnets prefixes, set by the string of up to 31 characters.
		`esr(config-route-map-rule)# match ipv6 address object-group <OBJ-GROUP- NETWORK -NAME>`	
8	Set IP addresses profile that includes BGPNext-Hop attribute value in the route for which the rule should work (optionally).	`esr(config-route-map-rule)# match ip next-hop object-group <OBJ-GROUP- NETWORK -NAME>`	<OBJ-GROUP-NETWORK-NAME> – name of the IP addresses profile that includes destination subnets prefixes, set by the string of up to 31 characters.
		`esr(config-route-map-rule)# match ipv6 next-hop object-group <OBJ-GROUP- NETWORK -NAME>`	
9	Set the profile that includes IP addresses of the router having advertised the route for which the rule should work (optionally).	`esr(config-route-map-rule)# match ip route-source object-group <OBJ-GROUP- NETWORK -NAME>`	<OBJ-GROUP-NETWORK-NAME> – name of the IP addresses profile that includes destination subnets prefixes, set by the string of up to 31 characters.
		`esr(config-route-map-rule)# match ipv6 route-source object-group <OBJ-GROUP- NETWORK -NAME>`	
10	Specify ACL group for which the rule should work.	`esr(config-route-map-rule)# match access-group <NAME>`	<NAME> – access control list name, set by the string of up to 31 characters.

Step	Description	Command	Keys
11	Set BGP MED attribute value in the route for which the rule should work (optionally).	`esr(config-route-map-rule)# match metric bgp <METRIC>`	<METRIC> – BGP MED attribute value, takes values in the range of [0..4294967295].
12	Set OSPF Metric attribute value in the route for which the rule should work.	`esr(config-route-map-rule)# match metric ospf <TYPE> <METRIC>`	<TYPE> – OSPF Metric attribute type, takes values type-1 and type-2; <METRIC> – OSPF Metric attribute value, takes values in the range of [0..65535].
13	Set RIP Metric attribute value in the route for which the rule should work.	`esr(config-route-map-rule)# match metric rip <METRIC>`	<METRIC> – RIP Metric attribute value, takes values in the range of [0..16].
14	Set OSPF Tag attribute value in the route for which the rule should work.	`esr(config-route-map-rule)# match tag ospf <TAG>`	<TAG> – OSPF Tag attribute value, takes values in the range of [0..4294967295].
15	Set RIP Tag attribute value in the route for which the rule should work.	`esr(config-route-map-rule)# match tag rip <TAG>`	<RIP> – RIP Tag attribute value, takes values in the range of [0..65535].
16	Set BGP AS-Path attribute value that will be added to the beginning of AS-Path list (optionally).	`esr(config-route-map-rule)# action set as-path prepend <AS-PATH> {track <TRACK-ID>}`	<AS-PATH> – stand alone systems number list that will be added to the current value in the route. Set as AS, AS, AS, takes values of [1..4294967295]. <TCACK-ID> – vrrp-tracking identifier that provides the specified action execution. Changes in the range of [1..60].
17	Set BGP Community attribute value that will be specified in the route (optionally).	`esr(config-route-map-rule)# action set community {COMMUNITY-LIST> | no-advertise | no-export }`	<COMMUNITY-LIST> – community list, defined as AS:N,AS:N, where each part takes values of [1..65535]. • **no-advertise** – routes transmitted with the given community should not be advertised to other BGP neighbors; • **no-export** – routes transmitted with the given community should not be advertised to eBGP neighbors but can be advertised to external neighbors in the confederation.

Step	Description	Command	Keys
18	Set BGP ExtCommunity attribute value that will be specified in the route (optionally).	`esr(config-route-map-rule)# action set extcommunity <EXTCOMMUNITY-LIST>`	<EXTCOMMUNITY-LIST> – extcommunity list, defined as KIND:AS:N, KIND:AS:N, where KIND – extcommunity type: • **rt** (Route Target); • **ro** (Route Origin); N – extcommunity number, takes values of [1..65535].
19	Specify BGP Next-Hop attribute that will be set in the route when advertising (optionally).	`esr(config-route-map-rule)# action set ip bgp-next-hop <ADDR>`	<ADDR> – gateway IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
		`esr(config-route-map-rule)# action set ipv6 bgp-next-hop <IPV6-ADDR>`	<IPV6-ADDR> – gateway IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF].
20	Specify Next-Hop value that will be set in the route received by BGP (optionally).	`esr(config-route-map-rule)# action set ip next-hop {NEXTHOP> | blackhole | unreachable | prohibit}`	<NEXTHOP> – gateway IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; • **blackhole** – packets to this subnet will be removed without sending notifications to a sender; • **unreachable** – packets to this subnet will be removed, a sender will receive in response ICMP Destination unreachable (Host unreachable, code 1); • **prohibit** – when specifying the command, the packets to this subnet will be removed by the device, a sender will receive in response ICMP Destination unreachable (Communication administratively prohibited, code 13);
		`esr(config-route-map-rule)# action set ipv6 next-hop <IPV6-NEXTHOP>`	<IPV6-ADDR> – gateway IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF].

Step	Description	Command	Keys
21	Specify BGP Local Preference attribute value that will be set in the route (optionally).	`esr(config-route-map-rule)# action set local-preference <PREFERENCE>`	<PREFERENCE> – BGP Local Preference attribute value, takes values in the range of [0..255].
22	Specify BGP Origin attribute value that will be set in the route (optionally).	`esr(config-route-map-rule)# action set origin <ORIGIN>`	<ORIGIN> – BGP Origin attribute value: • **egp** – route is learnt by EGP; • **igp** – route is received inside the initial AS; • **incomplete** – route is learnt in another way.
23	Specify BGP MED value that will be set in the route (optionally).	`esr(config-route-map-rule)# action set metric bgp <METRIC>`	<METRIC> – BGP MED attribute value, takes values in the range of [0..4294967295].
24	Add filtration and modification of routes in incoming or outgoing directions.	`esr(config-bgp-neighbor)# route-map <NAME><DIRECTION>` `esr(config-ipv6-bgp-neighbor)# route-map <NAME><DIRECTION>`	<NAME> – name of the route map having been configured; <DIRECTION> – direction: • **in** – filtration and modification of received routes; • **out** – filtration and modification of advertised routes.

5.6.2 Configuration example 1. Route-map for BGP



Objective:

Assign community for routing information coming from AS 20:

First, do the following:

- Configure BGP with AS 2500 on ESR router;
- Establish neighbouring with AS20.

Solution:

Create a policy:

```
esr# configure
esr(config)# route-map from-as20
```

Create rule 1:

```
esr(config-route-map)# rule 1
```

If AS PATH contains AS 20, assign community 20:2020 to it and exit:

```
esr(config-route-map-rule)# match as-path contain 20
esr(config-route-map-rule)# action set community 20:2020
esr(config-route-map-rule)# exit
esr(config-route-map)# exit
```

In AS 2500 BGP process, enter neighbour parameter configuration:

```
esr(config)# router bgp 2500
esr(config-bgp)# address-family ipv4
esr(config-bgp-af)# neighbor 185.0.0.2
```

Map the policy to routing information:

```
esr(config-bgp-neighbor)# route-map from-as20 in
```

5.6.3 Configuration example 2. Route-map for BGP

Objective:

For the whole transmitted routing information (from community 2500:25), assign MED equal to 240 and define EGP routing information source:

First:

Configure BGP with AS 2500 on ESR

Solution:

Create a policy:

```
esr(config)# route-map to-as20
```

Create rule:

```
esr(config-route-map)# rule 1
```

If community contains 2500:25, assign MED 240 and Origin EGP to it:

```
esr(config-route-map-rule)# match community 2500:25
esr(config-route-map-rule)# action set metric bgp 240
esr(config-route-map-rule)# action set origin egp
esr(config-route-map-rule)# exit
esr(config-route-map)# exit
```

In AS 2500 BGP process, enter neighbour parameter configuration:

```
esr(config)# router bgp 2500
esr(config-bgp)# address-family ipv4
esr(config-bgp-af)# neighbor 185.0.0.2
```

Map the policy to routing information being advertised:

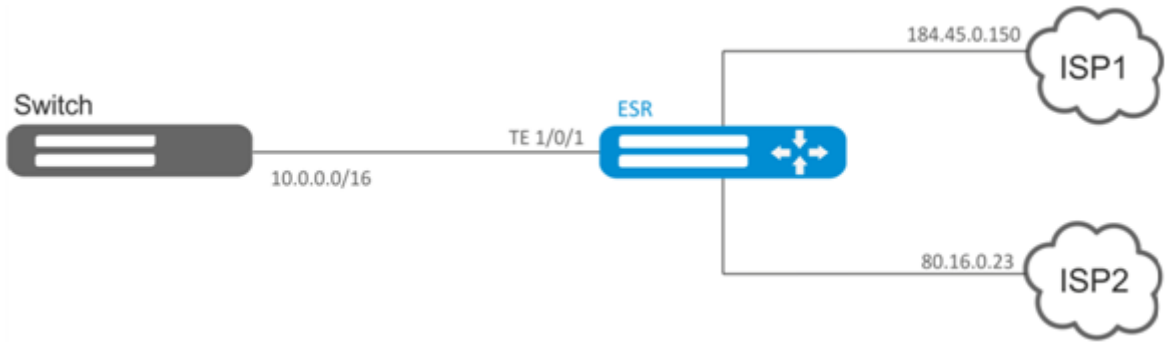
```
esr(config-bgp-neighbor)# route-map to-as20 out
esr(config-bgp-neighbor)# exit
esr(config-bgp)# exit
esr(config)# exit
```

5.6.4 Route-map based on access control lists (Policy-based routing) configuration algorithm

Step	Description	Command	Keys
1	Create a route map for IP routes filtration and modification.	`esr(config)# route-map <NAME>`	<NAME> – router map name, set by the string of up to 31 characters.
2	Create a route map rule	`esr(c onfig-route-map)# rule <ORDER>`	<ORDER> – rule number, takes values of [1..10000].
3	Specify the action that should be applied for routing information.	`esr(config-route-map-rule)# action <ACT>`	<ACT> – allocated action: • **permit** – routing information reception or advertising is permitted; • **deny** – denied.
4	Set ACL for which the rule should work (optionally).	`esr(config-route-map-rule)# match ip access-group <NAME>`	<NAME> – access control list name, set by the string of up to 31 characters.

Step	Description	Command	Keys
5	Set Next-Hop for the packets that meet the requirements of the specified ACL (optionally).	`esr(config-route-map-rule)# action set ip next-hop verify-availability <NEXTHOP><METRIC>`	<NEXTHOP> – gateway IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <METRIC> – route metric, takes values of [0..255].
6	Specify ACL-based routing policy.	`esr(config-if-gi)# ip policy route-map <NAME>`	<NAME> – configured routing policy name, set by the string of up to 31 characters.

5.6.5 Route-map based on access control lists (Policy-based routing) configuration example



Objective:

Distribute traffic between Internet service providers based on user subnets.

First, assign IP address to interfaces.

Route traffic from addresses 10.0.20.0/24 through ISP1 (184.45.0.150), and traffic from addresses 10.0.30.0/24 – through ISP2 (80.16.0.23). You should monitor availability of ISP addresses (ISP connection operational capability), and if one the connections goes down, redirect all the traffic from malfunctioning connection to the operational one.

Solution:

Create ACL:

```
esr# configure
esr(config)# ip access-list extended sub20
esr(config-acl)# rule 1
esr(config-acl-rule)# match source-address 10.0.20.0 255.255.255.0
esr(config-acl-rule)# match destination-address any
esr(config-acl-rule)# match protocol any
esr(config-acl-rule)# action permit
esr(config-acl-rule)# enable
esr(config-acl-rule)# exit
esr(config-acl)# exit
esr(config)# ip access-list extended sub30
esr(config-acl)# rule 1
esr(config-acl-rule)# match source-address 10.0.30.0 255.255.255.0
esr(config-acl-rule)# match destination-address any
esr(config-acl-rule)# match protocol any
esr(config-acl-rule)# action permit
esr(config-acl-rule)# enable
esr(config-acl-rule)# exit
esr(config-acl)# exit
```

Create a policy:

```
esr(config)# route-map PBR
```

Create rule 1:

```
esr(config-route-map)# rule 1
```

Specify ACL as a filter:

```
esr(config-route-map-rule)# match ip access-group sub20
```

Specify nexthop for sub20:

```
esr(config-route-map-rule)# action set ip next-hop verify-availability 184.45.0.150 10
esr(config-route-map-rule)# action set ip next-hop verify-availability 80.16.0.23 30
esr(config-route-map-rule)# exit
esr(config-route-map)# exit
```

Rule 1 should provide traffic routing from the network 10.0.20.0/24 to address 184.45.0.150, and in case of its failure, to address 80.16.0.23. Gateway precedence is defined by metrics values – 10 and 30.

Create rule 2:

```
esr(config-route-map)# rule 2
```

Specify ACL as a filter:

```
esr(config-route-map-rule)# match ip access-group sub30
```

Specify nexthop for sub30 and exit:

```
esr(config-route-map-rule)# action set ip next-hop verify-availability 80.16.0.23 10
esr(config-route-map-rule)# action set ip next-hop verify-availability 184.45.0.150 30
esr(config-route-map-rule)# exit
esr(config-route-map)# exit
```

Rule 2 should provide traffic routing from the network 10.0.30.0/24 to address 80.16.0.23, and in case of its failure, to address 184.45.0.150. Precedence is defined by metrics values.

Proceed to TE 1/0/1 interface:

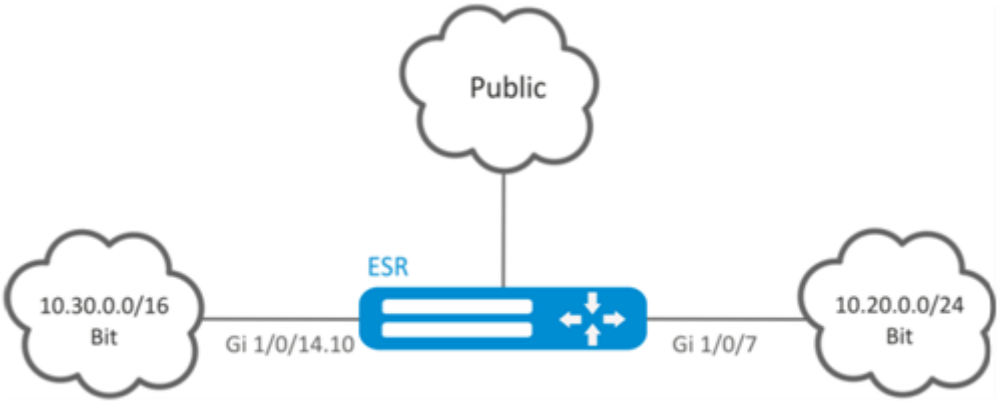
```
esr(config)# interface tengigabitethernet 1/0/1
```

Map the policy the respective interface:

```
esr(config-if-te)# ip policy route-map PBR
```

5.7 VRF Lite configuration

VRF (Virtual Routing and Forwarding) is a technology designed for isolation of routing information that belongs to different classes (e.g., routes of a specific client).



5.7.1 Configuration algorithm

Step	Description	Command	Keys
1	Create VRF instance and switch to the VRF instance parameters configuration mode.	`esr(config)# ip vrf <VRF>`	<VRF> – VRF instance name, set by the string of up to 31 characters.
2	Assign the description of the configured VRF instance.	`esr(config-vrf)# description <DESCRIPTION>`	<DESCRIPTION> – VRF instance description, set by the string of up to 255 characters.

Step	Description	Command	Keys
3	Set the capacity of routing tables in configured VRF for IPv4/IPv6 (optionally).	`esr(config-vrf)# ip protocols <PROTOCOL> max-routes <VALUE>` `esr(config-vrf)#ipv6 protocols <PROTOCOL> max-routes <VALUE>`	<PROTOCOL> – protocol type, takes the following values: ospf, bgp; <VALUE> – amount of routes in the routing table, takes values in the range of: OSPF ESR-1000/1200/1500/1700 [1..500000], ESR-20/21/100/200 [1..300000], ESR-10/12V(F)/14VF [1..30000] BGP ESR-1000/1200/1500/1700 [1..2800000], ESR-20/21/100/200 [1..1500000], ESR-10/12V(F)/ 14VF [1..800000]. Default value: 0
4	Enable and configure dynamic traffic routing protocols (Static/OSPF/BGP/ IS-IS) in VRF instance (optional). See the related sections: Static routes configuration, OSPF configuration, and BGP configuration.		
5	In the configuration mode of physical/ logical interface, tunnel, DNAT/SNAT rule, DAS server or SNMPv3 user, specify the name of VRF instance for which the mode will be used (optionally).	`esr(config-snat-ruleset)# ip vrf forwarding <VRF>`	<VRF> – VRF instance name, set by the string of up to 31 characters.
6	Configure LT tunnel to transmit traffic to global mode or to other VRFs (if required).		See section LT tunnel configuration

5.7.2 Configuration example

Objective:

ESR series router features 2 connected networks that should be isolated from other networks.

Solution:

Create VRF:

```
esr(config)# ip vrf bit
esr(config-vrf)# exit
```

Create a security zone:

```
esr(config)# security zone vrf-sec
esr(config-zone)# ip vrf forwarding bit
esr(config-zone)# exit
```

Create rule for a pair of zones and allow all TCP/UDP traffic:

```
esr(config)# security zone-pair vrf-sec vrf-sec
esr(config-zone-pair)# rule 1
esr(config-zone-rule)# match source-address any
esr(config-zone-rule)# match destination-address any
esr(config-zone-rule)# match protocol udp
esr(config-zone-rule)# match source-port any
esr(config-zone-rule)# match destination-port any
esr(config-zone-rule)# action permit
esr(config-zone-rule)# enable
esr(config-zone-rule)# exit
esr(config-zone-pair)# rule 2
esr(config-zone-rule)# match source-address any
esr(config-zone-rule)# match destination-address any
esr(config-zone-rule)# match protocol tcp
esr(config-zone-rule)# match source-port any
esr(config-zone-rule)# match destination-port any
esr(config-zone-rule)# action permit
esr(config-zone-rule)# enable
esr(config-zone-rule)# exit
```

Create interface mapping, assign IP addresses, specify an inherence to a security zone:

```
esr(config)# interface gigabitethernet 1/0/7
esr(config-if-gi)# ip vrf forwarding bit
esr(config-if-gi)# ip address 10.20.0.1/24
esr(config-if-gi)# security-zone vrf-sec
esr(config-if-gi)# exit
esr(config)# interface gigabitethernet 1/0/14.10
esr(config-subif)# ip vrf forwarding bit
esr(config-subif)# ip address 10.30.0.1/16
esr(config-subif)# security-zone vrf-sec
esr(config-subif)# exit
esr(config)# exit
```

To view information on interfaces mapped to VRF, use the following command:

```
esr# show ip vrf
```

To view VRF routing table, use the following command:

```
esr# show ip route vrf bit
```

5.8 MultiWAN configuration

MultiWAN technology establishes a fail-safe connection with redundancy of links from multiple providers and solves the problem involving traffic balancing between redundant links.

5.8.1 Configuration algorithm

Step	Description	Command	Keys
1	Configure interfaces through which MultiWAN will operate: set ip addresses and specify security zone.		
2	Write static routes through WAN (if required).	`esr(config)# ip route <SUBNET> wan load-balance rule <ID> [<METRIC>]`	<ID> – identifier of the rule being created (see item 2). <METRIC> – route metric, takes values of [0..255].
3	Create WAN rule and switch to the rule parameters configuration mode.	`esr(config)# wan load-balance rule <ID>`	<ID> – identifier of the rule being created, takes values in the range of [1..50].
4	Specify interfaces or tunnels which are gateways in the route created by MultiWAN service.	`esr(config-wan-rule)# outbound { interface <IF> | tunnel <TUN> } [WEIGHT]`	<IF>– interface name; <TUN> – tunnel name; [WEIGHT] – tunnel or interface weight, defined in the range of [1..255]. If the value is equal 2, than 2 times more traffic will be transmit via the given interface than via the interface with the default value. A route with the highest weight will be active in the redundancy mode. Default value: 1
5	Describe the rules (optionally).	`esr(config-wan-rule)# description <DESCRIPTION>`	<DESCRIPTION> – wan rule description, set by the string of up to 255 characters.
6	You can use this command to switch from the balancing mode to the redundancy mode.	`esr(config-wan-rule)# failover`	
7	Enable wan rule.	`esr(config-wan-rule)# enable`	
8	Create a list of IP addresses to check the connection integrity and perform the switching to the list parameters configuration mode.	`esr(config)# wan load-balance target-list <NAME>`	<NAME> – list name, set by the string of up to 31 characters.

Step	Description	Command	Keys
9	Specify the check target and switch to the target parameters configuration mode.	`esr(config-target-list)# target <ID>`	<ID> – target identifier, set in the range of [1..50]. If the “all” parameter value is used when removing, all targets for the configured target list will be removed.
10	Describe target (optionally).	`esr(config-wan-target)# description <DESCRIPTION>`	<DESCRIPTION> – target description, set by the string of up to 255 characters.
11	Specify the standby time via ICMP (optionally).	`esr(config-wan-target)# resp-time <TIME>`	<TIME> – timeout, takes value in seconds [1..30].
12	Specify IP address of the check.	`esr(config-wan-target)# ip address <ADDR>`	<ADDR> – destination IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
		`esr(config-wan-target)# ipv6 address <IPV6-ADDR>`	<IPV6-ADDR> – destination IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF].
13	Enable the target check.	`esr(config-wan-target)# enable`	
`Commands for 14-17 items should be applied on interfaces/tunnels in MultiWAN`			
14	Enable WAN mode on the interface for IPv4/IPv6 stack.	`esr(config-if-gi)# wan load-balance enable`	
		`esr(config-if-gi)# ipv6 wan load-balance enable`	
15	Set the amount of ineffective attempts to check the connection, after which, if there is not response from the opposing side, the connection is considered to be inactive (optionally).	`esr(config-if-gi)# wan load-balance failure-count <VALUE>`	<VALUE> – number of attempts, takes values in the range of [1..10]. Default value: 1
		`esr(config-if-gi)# ipv6 wan load-balance failure-count <VALUE>`	
16	Set the amount of successful attempts to check the connection, after which, if successful, the connection is considered to be active again (optional).	`esr(config-if-gi)# wan load-balance success-count <VALUE>`	<VALUE> – number of attempts, takes values in the range of [1..10]. Default value: 1
		`esr(config-if-gi)# ipv6 wan load-balance success-count <VALUE>`	

Step	Description	Command	Keys
17	Set a neighbour's IP address that will be indicated as one of the gateways in a static route created by MultiWAN service.	`esr(config-if-gi)# wan load-balance nexthop { <IP> | dhcp enable | tunnel enable }`	<IP> – destination IP address (gateway), defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]. dhcp enable – if on the interface an IP address is obtained through a DHCP client, the gateway from the DHCP server is used. tunnel enable – use as nexthop – destination p-t-p address. Applicable for the interfaced being connected that operate via ppp.
		`esr(config-if-gi)# ipv6 wan load-balance nexthop { <IPV6> }`	<IPV6> – destination IPv6 address (gateway), defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF].
18	This command will be checking the IP addresses from the integrity check list. If all (default)/at least one (using the chack-all key) of the tested hosts is unavailable, the gateway is considered unavailable.	`esr(config-if-gi)# wan load-balance target-list { check-all | <NAME> }`	<NAME> – run check on the basis of a certain target list (specified in item 7). check-all – run check on the basis of all targets in the list.
		`esr(config-if-gi)# ipv6 wan load-balance target-list { check-all | <NAME> }`	
19	Write static routes through WAN.	`esr(config)# ip route <SUBNET> wan load-balance rule <ID> [<METRIC>]`	<ID> – identifier of the rule being created (see item 2). <METRIC> – route metric, takes values of [0..255].
		`esr(config)# ipv6 route <SUBNET> wan load-balance rule <ID> [<METRIC>]`	

5.8.2 Configuration example

Objective:

Configure route to the server (108.16.0.1/28) with the load balancing option.

Solution:

First, do the following:

- Configure zones for te1/0/1 and te1/0/2 interfaces.
- Specify IP addresses for te1/0/1 and te1/0/2 interfaces.

Main configuration step:

Configure routing:

```
esr(config)# ip route 108.16.0.0/28 wan load-balance rule 1
```

Create WAN rule:

```
esr(config)# wan load-balance rule 1
```

Specify affected interfaces:

```
esr(config-wan-rule)# outbound interface tengigabitethernet 1/0/2
esr(config-wan-rule)# outbound interface tengigabitethernet 1/0/1
```

Enable the created balancing rule and exit the rule configuration mode:

```
esr(config-wan-rule)# enable
esr(config-wan-rule)# exit
```

Create a list for the connection integrity check:

```
esr(config)# wan load-balance target-list google
```

Create integrity check target:

```
esr(config-target-list)# target 1
```

Specify address to be checked, enable check for the specified address and exit:

```
esr(config-wan-target)# ip address 8.8.8.8
esr(config-wan-target)# enable
esr(config-wan-target)# exit
```

Configure interfaces. In te1/0/1 interface configuration mode, specify nexthop:

```
esr(config)# interface tengigabitethernet 1/0/1
esr(config-if)# wan load-balance nexthop 203.0.0.1
```

In te1/0/1 interface configuration mode, specify a list of targets for connection check:

```
esr(config-if)# wan load-balance target-list google
```

In te1/0/1 interface configuration mode, enable WAN mode and exit:

```
esr(config-if)# wan load-balance enable
esr(config-if)# exit
```

In te1/0/2 interface configuration mode, specify nexthop:

```
esr(config)# interface tengigabitethernet 1/0/2
esr(config-if)# wan load-balance nexthop 65.6.0.1
```

In te1/0/2 interface configuration mode, specify a list of targets for connection check:

```
esr(config-if)# wan load-balance target-list google
```

In te1/0/2 interface configuration mode, enable WAN mode and exit:

```
esr(config-if)# wan load-balance enable
esr(config-if)# exit
```

To switch into redundancy mode, configure the following:

Proceed to WAN rule configuration mode:

```
esr(config)# wan load-balance rule 1
```

MultiWAN function may also work in redundancy mode when traffic is directed to the active interface with the highest weight. To enable this mode, use the following command:

```
esr(config-wan-rule)# failover
```

5.9 IS-IS configuration

IS-IS – ISO standardized dynamic routing protocol based on link-state. It provides fast convergence and excellent scalability, makes economical use of network bandwidth, and uses the Dijkstra Algorithm to calculate the best routes. A distinctive feature of the IS-IS protocol is to work on top of the data link layer of the OSI model, so it is not binded to a specific network layer protocol.

5.9.1 Configuration algorithm

Step	Description	Command	Keys
1	Create an IS-IS process and switch to the parameters configuration mode of this process.	`esr(config)# router isis <ID> [vrf <VRF>]`	<ID> – process number, takes values of [1..65535]; <VRF> – VRF instance name, set by the string of up to 31 characters.
2	Set NET address.	`esr(config-isis)# net {<NET>}`	<NET> – NET address, format: ff[.ffff.ffff.ffff.ffff.ffff].ffff.ffff.ffff.00.
3	Enable IS-IS process.	`esr(config-isis)# enable`	
4	Set the authentication algorithm for the L2 layer (optional).	`esr(config-isis)# authentication domain algorithm <ALGORITHM>`	<ALGORITHM> – authentication algorithm: • cleartext – password, transmitted in clear text; • md5 – password is hashed by md5 algorithm.
5	Set the authentication password for the L2 layer (optional).	`esr(config-isis)# authentication domain key ascii-text { <CLEAR-TEXT> | encrypted <ENCRYPTED-TEXT> }`	<CLEAR-TEXT> – password, set by the string of 8 characters; <ENCRYPTED-TEXT> – encrypted password of 8 bytes (16 characters) in hexadecimal format (0xYYYY ...) or (YYYY ...).
6	Set a list of keys for authentication (optional).	`esr(config-isis)# authentication domain key chain <KEYCHAIN>`	<KEYCHAIN> – key list identifier, set by the string of up to 16 characters.
7	Select the authentication algorithm for the L1 layer (optional).	`esr(config-isis)# authentication area algorithm <ALGORITHM>`	<ALGORITHM> – authentication algorithm: • cleartext – password, transmitted in clear text; • md5 – password is hashed by md5 algorithm.
8	Set the authentication password for the L1 layer (optional).	`esr(config-isis)# authentication area key ascii-text { <CLEAR-TEXT> | encrypted <ENCRYPTED-TEXT> }`	<CLEAR-TEXT> – password, set by the string of 8 characters; <ENCRYPTED-TEXT> – encrypted password of 8 bytes (16 characters) in hexadecimal format (0xYYYY ...) or (YYYY ...).

Step	Description	Command	Keys
9	Set a list of keys for authentication (optional).	`esr(config-isis)# authentication area key chain <KEYCHAIN>`	<KEYCHAIN> – key list identifier, set by the string of up to 16 characters.
10	Enable transmission of router name to the LSP (optional).	`esr(config-isis)# hostname dynamic`	
11	Set the IS-IS process operating level (optional).	`esr(config-isis)# is-type {<LEVEL>}`	<LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-1-2 – operate on levels 1 and 2; • level-2-only – operate only on level 2.
12	Set the type of metric to be used in the IS-IS process (optional).	`esr(config-isis)# metric-style { narrow | wide | transition } [<LEVEL>]`	narrow — accepts and generates TLVs (on network reachability) of the old type; wide — accepts and generates TLVs (on network reachability) of the new type; transition — accepts and generates TLVs (on network reachability) of the new and old type; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.
13	Set the route priority for the specified IS-IS process (optional).	`esr(config-isis)# preference {<VALUE>}`	<VALUE> – may take values [1..255].
14	Enable IS-IS operation with IPv4 and/or IPv6 addresses (optional).	`esr(config-isis)# address-family { ipv4 | ipv6 }`	ipv4 – IPv4 family; ipv6 – IPv6 family.

Step	Description	Command	Keys
15	Set the update interval for own LSP (optional).	`esr(config-isis)# lsp-refresh-interval { min | max } <TIME> [ <LEVEL> ]`	min — minimum update/generation interval; max — maximum update/generation interval; <TIME> – time in seconds, takes values of [1..65535]; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.
16	Set the lifetime of own LSP (optional).	`esr(config-isis)# max-lsp-lifetime <TIME> [<LEVEL>]`	<TIME> – time in seconds, takes values of [1..65535]; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.
17	Set a timeout before the next SPF calculation (optional).	`esr(config-isis)# spf-timeout <TIME> [<LEVEL>]`	<TIME> – time in milliseconds, takes values of [1..10000]; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.

Step	Description	Command	Keys
18	Enable advertising of routes received by alternative method (optional).	`esr(config-isis)# redistribute bgp <AS> [ route-map <NAME> ] [is-type <LEVEL>]`	<AS> – stand alone system number, takes values of [1..4294967295]. <NAME> – name of the route map that will be used for advertised routes filtration and modification, set by the string of up to 31 characters; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.
		`esr(config-isis)# redistribute ipv6 bgp <AS> [ route-map <NAME> ] [is-type <LEVEL>]`	
		`esr(config-isis)# redistribute ospf <ID> <ROUTE-TYPE> [ route-map <NAME> ] [is-type <LEVEL>]`	<ID> – process number, takes values of [1..65535]. <ROUTE-TYPE> – route type: • intra-area – OSPF process routes advertising within a zone; • inter-area – OSPF process routes advertising between zones; • external1 – OSPF format 1 external routes advertising; • external2 – OSPF format 2 external routes advertising; <NAME> – name of the route map that will be used for advertised OSFP routes filtration and modification, set by the string of up to 31 characters; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.
		`esr(config-isis)# redistribute ipv6 ospf <ID> <ROUTE-TYPE> [ route-map <NAME> ] [is-type <LEVEL>]`	

Step	Description	Command	Keys
		`esr(config-isis)# redistribute isis <ID> <ROUTE-TYPE> [ route-map <NAME> ] [is-type <LEVEL>]`	<ID> – process number, takes values of [1..65535]. <ROUTE-TYPE> – route type: • level-1 – level 1 routes advertising; • level-2 – level 2 routes advertising; • inter-area – IS-IS process routes advertising between zones; <NAME> – name of the route map that will be used for advertised IS-IS routes filtration and modification, set by the string of up to 31 characters; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.
		`esr(config-isis)# redistribute rip [ route-map <NAME> ] [is-type <LEVEL>]`	<NAME> – name of the route map that will be used for advertised RIP routes filtration and modification, set by the string of up to 31 characters; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.

Step	Description	Command	Keys
		`esr(config-isis)# redistribute static [ route-map <NAME> ] [is-type <LEVEL>]`	<NAME> – name of the route map that will be used for advertised static routes filtration and modification, set by the string of up to 31 characters; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.
		`esr(config-isis)# redistribute connected [ route-map <NAME> ] [is-type <LEVEL>]`	<NAME> – name of the route map that will be used for advertised connected routes filtration and modification, set by the string of up to 31 characters; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.
19	Add subnets filtering in incoming or outgoing updates (optional).	`esr(config-isis)# prefix-list { ipv6 <LIST_NAME> | <LIST_NAME> } {in|out}`	<LIST-NAME> – name of a subnet list being configured, set by the string of up to 31 characters. • in – incoming routes filtration; • out – advertised routes filtration.
20	Add subnets filtering in incoming or outgoing updates (optional).	`esr(config-isis)# route-map <NAME> {in|out}`	NAME> – name of the route map that will be used for advertised routes filtration and modification, set by the string of up to 31 characters.
21	Set a matching of interface to a specified IS-IS process.	`esr(config-if-gi)# isis instance <ID>`	<ID> – process number, takes values of [1..65535].
22	Enable the IS-IS protocol on the interface.	`esr(config-if-gi)# isis enable`	

Step	Description	Command	Keys
23	Enable the use of TLV#8 in hello packets (optional).	`esr(config-if-gi)# isis hello-padding`	
24	Set the priority when selecting DIS (optional).	`esr(config-if-gi)# isis priority <VALUE> [<LEVEL>]`	<VALUE> – number, may take values [0..127]; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.
25	Set the metric value for the interface (optional).	`esr(config-if-gi)# isis metric <VALUE> [<LEVEL>]`	<VALUE> – number, may take values [1..16777215]; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.
26	Set defines which routing layer on the interface the current IS-IS process will run on (optional).	`esr(config-if-gi)# isis circuit-type {<LEVEL>}`	<LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-1-2 – operate on levels 1 and 2; • level-2-only – operate only on level 2.
27	Set the interval for sending hello packets (optional).	`esr(config-if-gi)# isis hello-interval <TIME> [<LEVEL>]`	<TIME> – time in seconds, takes values of [1..65535]; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.

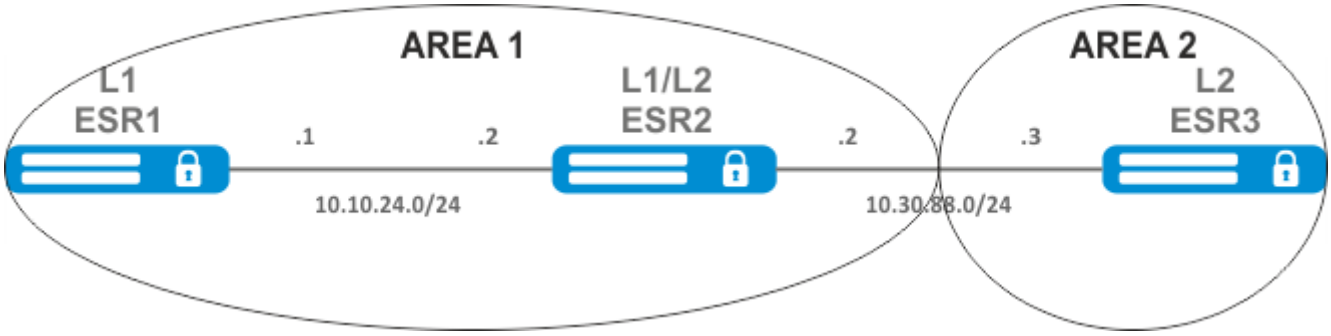
Step	Description	Command	Keys
28	Set the multiplier for calculating and sending Hold Time (optional).	`esr(config-if-gi)# isis hello-multiplier <VALUE> [<LEVEL>]`	<VALUE> – number, may take values [3..1000]; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.
29	Set the interface to point-to-point IS-IS protocol mode (optional).	`esr(config-if-gi)# isis network point-to-point`	
30	Set the interval for generating and sending CSNP (optional).	`esr(config-if-gi)# isis csnp-interval <TIME> [<LEVEL>]`	<TIME> – time in seconds, takes values of [1..65535]; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.
31	Set the interval for generating and sending PSNP (optional).	`esr(config-if-gi)# isis psnp-interval <TIME> [<LEVEL>]`	<TIME> – time in seconds, takes values of [1..65535]; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.
32	Set the interval between LSP transmissions on the Broadcast network (optional).	`esr(config-if-gi)# isis lsp-interval <TIME> [<LEVEL>]`	<TIME> – time in milliseconds, takes values of [1-10000]; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.

Step	Description	Command	Keys
33	Set the LSP re-distribution interval in the PtP network (optional).	`esr(config-if-gi)# isis lsp-retransmit-interval <TIME> [<LEVEL>]`	<TIME> – time in seconds, takes values of [1..65535]; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.
34	Set the authentication algorithm for the hello packets (optional).	`esr(config-if-gi)# isis authentication algorithm <ALGORITHM> [<LEVEL>]`	<ALGORITHM> – authentication algorithm: • cleartext – password, transmitted in clear text; • md5 – password is hashed by md5 algorithm; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.
35	Set the password for hello packet authentication (optionally).	`esr(config-if-gi)# isis authentication key ascii-text { <CLEAR-TEXT> | encrypted <ENCRYPTED-TEXT> } [<LEVEL>]`	<CLEAR-TEXT> – password, set by the string of 8 characters; <ENCRYPTED-TEXT> – encrypted password of 8 bytes (16 characters) in hexadecimal format (0xYYYY ...) or (YYYY ...); <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.
36	Set the key list for hello packet authentication (optionally).	`esr(config-if-gi)# isis authentication key chain <KEYCHAIN> [<LEVEL>]`	<KEYCHAIN> – key list identifier, set by the string of up to 16 characters; <LEVEL> – IS-IS protocol operation level: • level-1 – operate only on level 1; • level-2-only – operate only on level 2.

5.9.2 Configuration example

Objective:

Configure the IS-IS protocol on routers to exchange routing information with neighbors. Router ESR1 will be L1-only, ESR2 will be L1/L2, ESR3 will be L2-only, which will also be in another area.



Solution:

Pre-configure IP addresses on interfaces according to the network structure shown in figure.

Proceed to the ESR1 router configuration. Create IS-IS process with identifier 1 and proceed to the protocol configuration mode:

```
ESR1(config)# router isis 1
```

Set the number of the zone in which the router will operate and its system ID:

```
ESR1(config-isis)# net 49.0001.1111.1111.1111.00
```

Configure the router to operate only on the first layer of the IS-IS protocol:

```
ESR1(config-isis)# is-type level-1
```

Set the operation of the router with a narrow metric on the first level:

```
ESR1(config-isis)# metric-style narrow level-1
```

Enable the IS-IS process on the router

```
ESR1(config-isis)# enable
```

Proceed to the interface configuration. It is necessary to set the number of the IS-IS process which will run on the interface and to enable the protocol itself to run on it:

```
ESR1(config-if-gi)# isis instance 1
ESR1(config-if-gi)# isis enable
```

Proceed to the ESR2 router configuration.

```
ESR2(config)# router isis 2
```

Set the zone number, the same as on ESR1, as well as a unique system identifier:

```
ESR2(config-isis)# net 49.0001.2222.2222.2222.00
```

Set the router to operate with a narrow metric on the first layer and with a wide metric on the second layer, and enable this IS-IS process:

```
ESR2(config-isis)# metric-style narrow level-1
ESR2(config-isis)# metric-style wide level-2
ESR2(config-isis)# enable
```

Configure the interfaces on the router. The configuration will be the same on both interfaces.

```
ESR2(config-if-gi)# isis instance 2
ESR2(config-if-gi)# isis enable
```

Proceed to the ESR3 router configuration.

```
ESR3(config)# router isis 3
ESR3(config-isis)# net 49.0002.3333.3333.3333.00
ESR3(config-isis)# is-type level-2
ESR3(config-isis)# metric-style wide level-2
ESR3(config-isis)# enable
ESR3(config-if-gi)# isis instance 3
ESR3(config-if-gi)# isis enable
```

The neighborhood establishment can be viewed with the show isis neighbors command. Execute it on ESR2:

```
ESR2# show isis neighbors
IS-IS 2
IS-IS Level 1 Neighbors
System ID               Hostname          Interface         State         Holdtime  SNPA
1111.1111.1111  ESR1                    gi1/0/2            Up              25
a8f9.4baa.1d42
IS-IS Level 2 Neighbors
System ID              Hostname          Interface         State         Holdtime  SNPA
3333.3333.3333  ESR3                   gi1/0/1            Up              8
a8f9.4bab.813a
```

6 MPLS technology management

6.1 LDP configuration

LDP is a label distribution protocol. To find the neighbors hello messages are sent to the multicast address 224.0.0.2. When exchanging hello messages, routers learn each other's transport addresses. A router with a bigger address initializes the TCP session. After checking the parameters, the LDP session is considered established.

ESR routers support the following LDP operation modes:

- Tag information exchange mode — Downstream Unsolicited;
- Mechanism for controlling the distribution of tags — Independent Label Distribution Control;
- Label retention mode — Liberal Label Retention;

On interfaces where LDP and MPLS switching are enabled, the firewall must be disabled.

The current version LDP only works with IPv4 addresses.

6.1.1 Configuration algorithm

Step	Description	Command	Keys
1	In the context of MPLS parameters configuration, specify the interfaces involved in the MPLS switching process	`esr(config-mpls)# forwarding interface { <IF> | <TUN> }`	<IF> – an interface's name, specified in the form described in Section Types and naming order of router interfaces; <TUN> – the name of the tunnel is specified as described in section Types and naming order of router tunnels.
2	Specify the router-id for LDP (not necessary if transport-address is specified).	`esr(config-ldp)# router-id <ID>`	<ID> – router identifier, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
3	In the context of the address family ipv4 settings, specify transport-address (not necessary if router-id is specified).	`esr(config-ldp-af-ipv4)# transport-address <ADDR>`	<ADDR> – defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
3	In the context of the address family ipv4 settings, specify interfaces for enabling LDP process.	`esr(config-ldp-af-ipv4)# interface { <IF> | <TUN> }`	<IF> – an interface's name, specified in the form described in Section Types and naming order of router interfaces; <TUN> – the name of the tunnel is specified as described in section Types and naming order of router tunnels.
4	Enable LDP process.	`esr(config-ldp)# enable`	
5	Enable explicit-null functionality (optional).	`esr(config-ldp)# egress-label-type explicit-null`	
6	In the LDP neighbor configuration mode, set the password with the password command (optional).	`esr(config-ldp-neig)# password {<TEXT> | ENCRYPTED-TEXT>}`	<CLEAR-TEXT> – password, sets by string of [8..16] characters; <ENCRYPTED-TEXT> – encrypted password of [8..16] bytes ([16..32] characters) in hexadecimal format (0xYYYY...) or (YYYY...).

The following functionality is also available as part of the LDP configuration:

- LDP tag filtering configuration (see section LDP tag filtering configuration)
- LDP session parameters configuration (see section Configuring session parameters in LDP)
- tLDP session parameters configuration (see section Configuring session parameters in targeted-LDP)

6.1.2 Configuration example

Objective:

Configure LDP communication between peers.

Solution:

1 ESR pre-configuration:

First, IP addresses must be assigned to the interfaces, the firewall must be disabled and one of the internal routing protocols must be configured

ESR pre-configuration:

```
hostname ESR
router ospf 1
  area 0.0.0.0
    enable
  exit
  enable
exit


interface gigabitethernet 1/0/1
  ip firewall disable
  ip address 10.10.10.1/30
  ip ospf instance 1
  ip ospf
exit


interface loopback 1
  ip address 1.1.1.1/32
  ip ospf instance 1
  ip ospf
exit
```

ESR1 pre-configuration:

```
hostname ESR1
router ospf 1
  area 0.0.0.0
    enable
  exit
  enable
exit


interface gigabitethernet 1/0/1
  ip firewall disable
  ip address 10.10.10.2/30
  ip ospf instance 1
  ip ospf
exit


interface loopback 1
  ip address 4.4.4.4/32
  ip ospf instance 1
  ip ospf
exit
```

2 Configuration on ESR:

ESR

```
ESR# config
ESR(config)# mpls
ESR(config-mpls)# forwarding interface gigabitethernet 1/0/1
ESR(config-mpls)# ldp
ESR(config-ldp)# router-id 1.1.1.1
ESR(config-ldp)# enable
ESR(config-ldp)# address-family ipv4
ESR(config-ldp-af-ipv4)# interface gigabitethernet 1/0/1
ESR(config-ldp-af-ipv4-if)# end
ESR#
```

3 Configuration on ESR1:

ESR1

```
ESR1# configure
ESR1(config)# mpls
ESR1(config-mpls)# forwarding interface gigabitethernet 1/0/1
ESR1(config-mpls)# ldp
ESR1(config-ldp)# router-id 4.4.4.4
ESR1(config-ldp)# enable
ESR1(config-ldp)# address-family ipv4
ESR1(config-ldp-af-ipv4)# interface gigabitethernet 1/0/1
ESR1(config-ldp-af-ipv4-if)# end
ESR1#
```

Check:

Enter the following commands at one of the piers:

The output will show the parameters of the neighboring pier obtained from the multicast hello messages.

ESR# show mpls ldp discovery detailed
Local LDP ID: 1.1.1.1
Discovery sources:
Interfaces:
gigabitethernet 1/0/1:
Hello interval: 5 seconds
Transport IP address: 1.1.1.1
LDP ID: 4.4.4.4
Source IP address: 10.10.10.2
Transport IP address: 4.4.4.4
Hold time: 15 seconds
Proposed hold time: 90/15 (local/peer) seconds

The LDP session should be in the "Operational" state.

ESR1# show mpls ldp neighbor
Peer LDP ID: 4.4.4.4; Local LDP ID 1.1.1.1
State: **Operational**
TCP connection: 4.4.4.4:40245 - 1.1.1.1:646
Messages sent/received: 10/11
Uptime: 00:00:58
LDP discovery sources:
gigabitethernet 1/0/1

6.2 Configuring session parameters in LDP

By default, hello messages sent out are set to the following values:

Parameter	LDP
Hello interval	5 seconds
Hold timer	15 seconds
Keepalive holdtime	180 seconds

Hold timer is a matching parameter — the smallest is chosen. This example shows that the ESR after matching the Hold timer is 10 seconds.

```
ESR# sh mpls ldp discovery detailed
Local LDP ID: 4.4.4.4
Discovery sources:
  Interfaces:
    gigabitethernet 1/0/4:
      Hello interval: 5 seconds
      Transport IP address: 4.4.4.4
      LDP ID: 1.1.1.1
        Source IP address: 10.10.10.1
        Transport IP address: 1.1.1.1
                    Hold time: 10 seconds
                    Proposed hold time: 15/10 (local/peer) seconds
```

If after matching, the Hello interval is greater than the Hold timer, then the Hello interval will be equal to Hold timer/3.

ESR routers have the ability to flexibly configure Hello holdtime, Hello interval and Keepalive holdtime settings. Let's consider an example of configuring Hello holdtime for an LDP session:

```
ESR# show run mpls
mpls
 ldp
 router-id 4.4.4.4
   discovery hello holdtime 40
  address-family ipv4
   interface gigabitethernet 1/0/4
        discovery hello holdtime 60
  exit
 exit
 enable
exit
```

If the Hello Holdtime and Hello Interval parameters are not specified, the default values are used. If parameters are specified, the priority of values for address-family will be higher than for globally configured values.

```
ESR# show mpls ldp discovery detailed
Local LDP ID: 4.4.4.4
Discovery sources:
  Interfaces:
    gigabitethernet 1/0/4:
      Hello interval: 5 seconds
      Transport IP address: 4.4.4.4
      LDP ID: 1.1.1.1
        Source IP address: 10.10.10.1
        Transport IP address: 1.1.1.1
        Hold time: 15 seconds
                    Proposed hold time: 60 /15 (local/peer) seconds
```

The parameters configured in address-family can be configured for each individual interface participating in the LDP process.

```
ESR# show running-config mpls
mpls
 ldp
  router-id 4.4.4.4
  discovery hello holdtime 50
  discovery hello interval 10
  address-family ipv4
       interface gigabitethernet 1/0/1
          discovery hello holdtime 60
          discovery hello interval 20
   exit
       interface gigabitethernet 1/0/4
          discovery hello holdtime 30
          discovery hello interval 10
   exit
  exit
 enable
exit
```

For a TCP session, Keepalive holdtime is also a matching parameter similar to Hold timer. Keepalive interval is calculated automatically and equals Keepalive holdtime/3. Keepalive holdtime can be set globally as well as for each neighbor. The timer set for a particular neighbor is a higher priority.

```
ESR# show running-config mpls
mpls
 ldp
 router-id 4.4.4.4
   keepalive 30 // установлен в глобальной конфигурации LDP
 neighbor 1.1.1.1
   keepalive 55// установлен в соседа с адресом 1.1.1.1
 exit
exit
```

ESR# sh mpls ldp neighbor 1.1.1.1
Peer LDP ID: 1.1.1.1; Local LDP ID 4.4.4.4
State: Operational
TCP connection: 1.1.1.1:646 - 4.4.4.4:56668
Messages sent/received: 401/401
Uptime: 02:00:24
Peer holdtime: 55
Keepalive interval: 18
LDP discovery sources:

6.2.1 Algorithm for setting Hello holdtime and Hello interval in the global LDP configuration

Step	Description	Command	Keys
1	Configure the LDP (see section LDP configuration)		
2	In the LDP configuration mode, set Hello holdtime	`esr(config-ldp)# discovery hello holdtime <TIME>`	<TIME> — Time in seconds in the range of [3..65535] Default value:15
3	In the LDP configuration mode, set Hello interval	`esr(config-ldp)# discovery hello interval <TIME>`	<TIME> — Time in seconds in the range of [3..65535] Default value: 5

6.2.2 Algorithm for setting Hello holdtime and Hello interval for address family

Step	Description	Command	Keys
1	Configure the LDP (see section LDP configuration)		
2	In the LDP address family configuration mode, set Hello holdtime on the specified interface	`esr(config-ldp-af-ipv4-if)# discovery hello holdtime <TIME>`	<TIME> — Time in seconds in the range of [3..65535] Default value:15
3	In the LDP address family configuration mode, set Hello interval on the specified interface	`esr(config-ldp-af-ipv4-if)# discovery hello interval <TIME>`	<TIME> — Time in seconds in the range of [3..65535] Default value: 5

6.2.3 Algorithm for setting Keepalive holdtime parameter in the global LDP configuration

Step	Description	Command	Keys
1	Configure the LDP (see section LDP configuration)		
2	In the LDP configuration mode, set the Keepalive parameter	`esr(config-ldp)# keepalive <TIME>`	<TIME> — Time in seconds in the range of [3..65535] Default value:180

6.2.4 Algorithm for setting Keepalive holdtime parameter for the specific neighbor

Step	Description	Command	Keys
1	Configure the LDP (see section LDP configuration)		
2	In the neighbor configuration mode, set the Keepalive holdtime parameter	`esr(config-ldp-neig)# keepalive <TIME>`	<TIME> — Time in seconds in the range of [3..65535] Default value:180

6.2.5 Configuration example

Objective:

Override hello holdtime (40 seconds) and hello interval (10 seconds) parameters for the entire LDP process. For the neighbor with address 1.1.1.1 set the Keepalive holdtime to 150 seconds.

Solution:

ESR

```
ESR(config)# mpls
ESR(config-mpls)# ldp
ESR(config-ldp)# discovery hello holdtime 40
ESR(config-ldp)# discovery hello interval 10
ESR(config-ldp)# neighbor 1.1.1.1
ESR(config-ldp-neig)# keepalive 150
```

Check:

To view hello parameters:

ESR

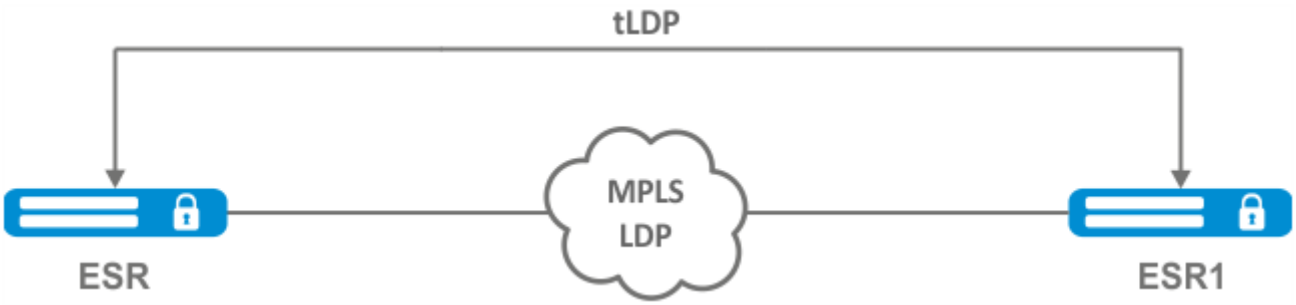
```
ESR# sh mpls ldp discovery detailed
Local LDP ID: 4.4.4.4
Discovery sources:
    Interfaces:
        gigabitethernet 1/0/4:
            Hello interval:       10 seconds
            Transport IP address: 4.4.4.4
            LDP ID:               1.1.1.1
                Source IP address:    10.10.10.1
                Transport IP address: 1.1.1.1
                Hold time:            15 seconds
                Proposed hold time:   40/15 (local/peer) seconds
```

To view parameter of the established TCP session:

ESR

```
ESR# sh mpls ldp neighbor 1.1.1.1
Peer LDP ID: 1.1.1.1; Local LDP ID 4.4.4.4
    State:                  Operational
    TCP connection:         1.1.1.1:646 - 4.4.4.4:45414
    Messages sent/received: 15/15
    Uptime:                 00:06:31
    Peer holdtime:          150
    Keepalive interval:     50
    LDP discovery sources:
```

6.3 Configuring session parameters in targeted-LDP



By default, the targeted LDP session is set to the following values:

Parameters	targeted-LDP
hello interval	5 seconds
Hold timer	45 seconds
Keepalive holdtime	180 seconds

Hold timer is a matching parameter — the smallest is chosen. This example shows that the ESR after matching set 30 seconds:

ESR1# sh mpls ldp discovery detailed
...
Targeted hellos:
1.1.1.1 -> 4.4.4.4:
Hello interval: 2 seconds
Transport IP address: 1.1.1.1
LDP ID: 4.4.4.4
Source IP address: 4.4.4.4
Transport IP address: 4.4.4.4
Hold time: 30 seconds
Proposed hold time: 30/45 (local/peer) seconds

If after matching, the Hello interval is greater than the Hold timer, then the Hello interval will be equal to Hold timer/3.

ESR routers have the possibility to flexibly configure Hello holdtime, Hello interval and Keepalive holdtime parameters: the parameters can be set for the entire LDP process, as well as for the corresponding neighbor.

Example output for the LDP process:

```
ESR# sh running-config mpls
mpls
 ldp
  router-id 1.1.1.1
     keepalive 160
     discovery targeted-hello holdtime 30
     discovery targeted-hello interval 10
 exit
exit
```

Example output for a targeted-LDP session for a particular neighbor:

```
ESR# sh running-config mpls
mpls
 ldp
  router-id 1.1.1.1
  neighbor 4.4.4.4
   keepalive 160
   targeted
   discovery targeted-hello holdtime 30
   discovery targeted-hello interval 45
  exit
 exit
exit
```

If parameters are set for both the LDP process and a specific neighbor, the priority will be the settings set for the neighbor.

```
ESR# sh running-config mpls
mpls
 ldp
  router-id 1.1.1.1
  keepalive  160
  discovery hello holdtime 90
  discovery targeted-hello interval 30
  neighbor 4.4.4.4
   keepalive 140
   targeted
   discovery targeted-hello holdtime 45
   discovery targeted-hello interval 15
  exit
 exit
exit
```

ESR# show mpls ldp discovery detailed
...
Targeted hellos:
1.1.1.1 -> 4.4.4.4:
Hello interval: 15 seconds
Transport IP address: 1.1.1.1
LDP ID: 4.4.4.4
Source IP address: 4.4.4.4
Transport IP address: 4.4.4.4
Hold time: 45 seconds
Proposed hold time: 45/45 (local/peer) seconds

ESR# show mpls ldp neighbor 4.4.4.4
Peer LDP ID: 4.4.4.4; Local LDP ID 1.1.1.1
State: Operational
TCP connection: 4.4.4.4:51861 - 1.1.1.1:646
Messages sent/received: 10/10
Uptime: 00:00:09
Peer holdtime: 140
Keepalive interval: 46
LDP discovery sources:
1.1.1.1 -> 4.4.4.4:

6.3.1 Algorithm for setting Hello holdtime, Hello interval and Keepalive holdtime for the LDP process

1	Configure the LDP (see section LDP configuration)		
2	In the LDP configuration mode, set Hello holdtime	`esr(config-ldp)# discovery targeted-hello holdtime <TIME>`	<TIME> — Time in seconds in the range of [3..65535] Default value: 45
3	In the LDP configuration mode, set Hello interval	`esr(config-ldp)# discovery targeted- hello interval <TIME>`	<TIME> — Time in seconds in the range of [1..65535] Default value: 5
4	In the LDP configuration mode, set Keepalive holdtime	`esr(config-ldp)# keepalive <TIME>`	<TIME> — Time in seconds in the range of [3..65535] Default value: 180

6.3.2 Algorithm for setting Hello holdtime, Hello interval and Keepalive holdtime for the specific neighbor

1	Configure the LDP (see section LDP configuration)		
2	В режиме конфигурации LDP-соседа задать Hello holdtime	`esr(config-ldp-neig)# discovery targeted-hello holdtime <TIME>`	<TIME> — Time in seconds in the range of [3..65535] Default value: 45
3	In the LDP neighbor configuration mode, set Hello interval	`esr(config-ldp-neig)# discovery targeted- hello interval <TIME>`	<TIME> — Time in seconds in the range of [1..65535] Default value: 5

4	In the LDP neighbor configuration mode, set Keepalive holdtime	`esr(config-ldp-neig)# keepalive <TIME>`	<TIME> — Time in seconds in the range of [3..65535] Default value: 180

6.3.3 Configuration example

Objective:

Override hello holdtime (120 seconds) and hello interval (30 seconds) parameters for the entire targeted-LDP process. For the neighbor with address 4.4.4.4 set the Keepalive holdtime to 150 seconds.

Solution:

ESR

```
ESR(config)# mpls
ESR(config-mpls)# ldp
ESR(config-ldp)# discovery targeted-hello holdtime 40
ESR(config-ldp)# discovery targeted-hello interval 10
ESR(config-ldp)# neighbor 4.4.4.4
ESR(config-ldp-neig)# keepalive 150
```

Check:

To view hello parameters of the targeted-LDP session:

ESR

```
ESR1# sh mpls ldp discovery detailed
...
    Targeted hellos:
         1.1.1.1 -> 4.4.4.4:
            Hello interval:       10 seconds
            Transport IP address: 1.1.1.1
            LDP ID:               4.4.4.4
                Source IP address:    4.4.4.4
                Transport IP address: 4.4.4.4
                Hold time:            40 seconds
                Proposed hold time:   40/45 (local/peer) seconds
```

To view parameter of the established TCP session:

ESR

```
ESR# sh mpls ldp neighbor 4.4.4.4
Peer LDP ID: 4.4.4.4; Local LDP ID 1.1.1.1
    State:                  Operational
    TCP connection:         4.4.4.4:34879 - 1.1.1.1:646
    Messages sent/received: 11/11
    Uptime:                 00:01:05
    Peer holdtime:          150
    Keepalive interval:     50
    LDP discovery sources:
         1.1.1.1 -> 4.4.4.4:
            Hello interval: 10 seconds
            Holdtime:       40 seconds
  ...
```

6.4 LDP tag filtering configuration

By default, routers allocate a separate label to each FEC. There are scenarios when it is necessary to allocate MPLS tags only for certain FECs.

6.4.1 Configuration algorithm

Step	Description	Command	Keys
1	Configure the LDP (see section LDP configuration)		
2	Create network type object-group	`esr(config)# object-group network <NAME>`	<NAME> – name of a subnet list being configured, set by the string of up to 31 characters.
3	Describe the subnets for which labels will be assigned	`esr(config-object-group-network)# ip prefix <ADDR/LEN>`	<ADDR/LEN> – IP address and subnet mask, defined as AAA.BBB.CCC.DDD/EE where each part AAA–DDD takes values of [0..255] and EE takes values of [1..32];
4	In the context of the LDP configuration, apply the created object-group	`esr(config-ldp)# advertise-labels <NAME>`	<NAME> – name of a subnet list being configured, set by the string of up to 31 characters.

ⓘ Tags will be allocated ONLY to the subnets described in the object-group, regardless of how they were learned (connected, local, IGP, etc.).

ⓘ Prefixes must be described in the object-group.

ⓘ This functionality is supported for IPv4.

6.4.2 Configuration example

Objective:

Assign mpls tags only to FEC 10.10.0.0/24

Solution:

On ESR_A and ESR_B create an object-group ADV_LABELS of type network and add a subnet 10.10.0.0/24 to it. On ESR_B we also add 192.168.2.0/24.

ESR_A

```
esr(config)# object-group network ADV_LABELS
esr(config-object-group-network)# ip prefix 10.10.0.0/24
```

ESR_B

```
esr(config)# object-group network ADV_LABELS
esr(config-object-group-network)# ip prefix 10.10.0.0/24
esr(config-object-group-network)# ip prefix 192.168.2.0/24
```

Apply the created object-group on both routers.

ESR_A и ESR_B

```
esr(config)# mpls
esr(config-ldp)# ldp
esr(config-ldp)# advertise-labels ADV_LABELS
```

Check:

On ESR_B make sure that the label is assigned to addresses from the subnet 10.10.0.0/24

```
esr# sh mpls ldp bindings 10.10.0.1/32
10.10.0.1/32
local label: exp-null
remote label: 75 lsr: 172.16.0.1
```

And not assigned to 192.168.2.0/24

```
esr# sh mpls ldp bindings 192.168.2.0/24
192.168.2.0/24:
local label: --
remote label: imp-null lsr: 172.16.0.1
```

6.5 L2VPN Martini mode configuration

L2VPN allows you to organize ethernet frames transmission through the MPLS domain. Allocation and distribution of tunnel labels, in this mode, is carried out by means of the LDP. In the implementation of L2VPN can be divided into two cases:

1. P2P — "point-to-point" tunnel
2. VPLS — "point-to-multipoint" tunnel

In both cases, a virtual channel (pseudo-wire) is created to transmit ethernet frames between routers. To negotiate pseudo-wire parameters, as well as to allocate and transfer tunnel labels between routers, an LDP session is established in the targeted mode.

6.5.1 L2VPN VPWS configuration algorithm

Step	Description	Command	Keys
1	Configure the LDP (see section LDP configuration)		
2	Create pw-class in the system and switch to the pw-class configuration mode.	`esr(config-l2vpn)# pw-class <WORD>`	`<WORD> - Имя pw-class длинной [1..31] символов.`
3	Add a description for pw-class (optional).	`esr(config-l2vpn-pw-class)# description <LINE>`	<LINE> - Описание. Задается в виде строки длинной [1..255] символов
4	Set the MTU value for the pseudo-wire included in the pw-class (optional).	`esr(config-l2vpn-pw-class)# encapsulation mpls mtu <MTU>`	<MTU> - значение MTU, принимает значение в диапазоне [552..10000] Значение по умолчанию: 1500.
5	Disable status-tlv messaging (optional).	`esr(config-l2vpn-pw-class)# encapsulation mpls status-tlv disable`	Значение по умолчанию: status-tlv enable
6	Create p2p-class in the system and switch to the p2p-class configuration mode.	`esr(config-l2vpn)# p2p <NAME>`	<NAME> - Имя p2p сервиса, задается строкой до 31 символа.

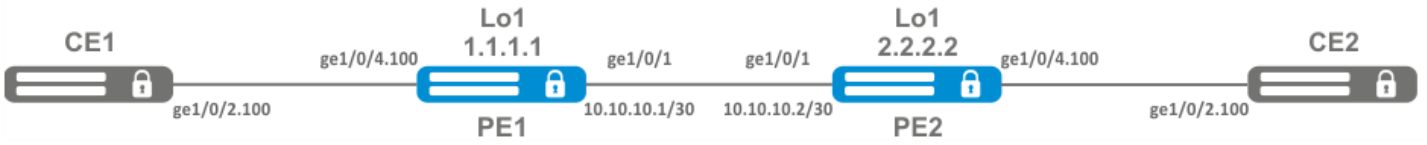
Step	Description	Command	Keys
7	Specify Attached Circuit interface.	`esr(config-l2vpn-p2p)# interface { <IF> | <TUN> }`	<IF> – an interface's name, specified in the form described in Section Types and naming order of router interfaces; <TUN> – the name of the tunnel is specified as described in section Types and naming order of router tunnels.
8	Enable p2p tunnel.	`esr(config-l2vpn-p2p)# enable`	
9	Specify transport mode (optional).	`esr(config-l2vpn-p2p)# transport-mode { ethenet | vlan }`	<ethernet> - Режим при котором при входе в pseudo-wire из заголовка удаляется 802.1Q тэг ; <vlan> - Режим при котором 802.1Q тэг может быть сохранен при передаче через pseudo-wire. Значение по умолчанию: ethernet
10	Create a pseudo-wire and switch to its parameters configuration mode	`esr(config-l2vpn-p2p)# pw <PW_ID> <LSR_ID>`	<PW_ID> - идентификатор psewdowire, задается в виде числа в диапазоне [1..4294967295] <LSR_ID> - идентификатор LSR до которого строится pseudo-wire, задаётся в виде AAA.BBB.CCC.DDD, где каждая часть принимает значения [0..255]
11	Add a description for pseudo-wire (optional).	`esr(config-l2vpn-pw)# description <LINE>`	<LINE> - Описание. Задается в виде строки длинной [1..255] символов
12	Set pw-class for pseudo-wire.	`esr(config-l2vpn-pw)# pw-class <WORD>`	`<WORD> - Имя pw-class длинной [1..31] символов.`
13	Set the LSR address to which the pseudo-wire is set (Optional if the neighbor address is the same as the LSR_ID).	`esr(config-l2vpn-pw)# neighbor-address <ADDR>`	<ADDR> – IP-адрес маршрутизатора, задаётся в виде AAA.BBB.CCC.DDD, где каждая часть принимает значения [0..255].
14	Enable pseudo-wire.	`esr(config-l2vpn-pw)# enable`	

Step	Description	Command	Keys
	If it is necessary to change the default settings for a targeted LDP session, see section Configuring session parameters in targeted-LDP.		

6.5.2 L2VPN VPWS configuration example

Objective:

Configure l2vpn so that ge1/0/2.100 interface of the CE1 router and ge1/0/2.100 interface of the CE2 router operate within the same broadcast domain.



Solution:

Pre-requisite:

- Enable Jumbo frames support with the "system jumbo-frames" command (the device must be rebooted for the changes to take effect);
- Configure IP addresses on interfaces according to the network structure shown in the figure above;
- Organize the exchange of routes between PE1 and PE2 using IGP (OSPF, IS-IS, RIP).

On the PE1 router create a sub-interface from which traffic from CE1 will be received:

```
PE1# configure
PE1(config)# interface gigabitethernet 1/0/4.100
PE1(config-subif)# exit
```

Set the MTU value on the interface towards PE2 to 9600 to avoid MTU overrun after encapsulating the MPLS header and disable the firewall:

```
PE1#(config)# interface gigabitethernet 1/0/1
PE1(config-if-gi)# mtu 9600
PE1(config-if-gi)# ip firewall disable
PE1(config-if-gi)# exit
```

Allow packets with an mpls header to be received on the interface towards the mpls network (in this example, the interface towards PE2):

```
PE1(config)# mpls
PE1(config-mpls)# forwarding interface gigabitethernet 1/0/1
```

Configure the LDP protocol and enable neighbor detection on the interface towards PE2:

```
PE1(config-mpls)# ldp
PE1(config-ldp)# router-id 1.1.1.1
PE1(config-ldp)# address-family ipv4
PE1(config-ldp-af-ipv4)# interface gigabitethernet 1/0/1
PE1(config-ldp-af-ipv4-if)# exit
PE1(config-ldp-af-ipv4)# transport-address 1.1.1.1
PE1(config-ldp-af-ipv4)# exit
PE1(config-ldp)# enable
PE1(config-ldp)# exit
```

Create a pw-class on the basis of which the virtual channel (pw) will be created later. Since, in this example, the default parameters will be applied to pw, it will be sufficient to specify the class name:

```
PE1(config-mpls)# l2vpn
PE1(config-l2vpn)# pw-class for_p2p_VLAN100
PE1(config-l2vpn-pw-class)# exit
```

Create a new l2vpn of type p2p and add pw to router PE3, take the pw identifier as VID for convenience (in this case = 100):

```
PE1(config-l2vpn)# p2p to_PE2_VLAN100
PE1(config-l2vpn-p2p)# interface gigabitethernet 1/0/4.100
PE1(config-l2vpn-p2p)# pw 100 3.3.3.3
PE1(config-l2vpn-pw)# pw-class for_p2p_VLAN100
PE1(config-l2vpn-pw)# enable
PE1(config-l2vpn-pw)# exit
PE1(config-l2vpn-p2p)# enable
PE1(config-l2vpn-p2p)# end
```

Apply the configuration:

```
PE1# commit
PE1# confirm
```

Configure the PE2 router in the same way as PE1:

```
PE2# configure
PE2(config)# interface gigabitethernet 1/0/4.100
PE2(config-subif)# exit
PE2#(config)# interface gigabitethernet 1/0/1
PE2(config-if-gi)# mtu 9600
PE1(config-if-gi)# ip firewall disable
PE1(config-if-gi)# exit
PE2(config)# mpls
PE2(config-mpls)# forwarding interface gigabitethernet 1/0/1
PE2(config-mpls)# ldp
PE2(config-ldp)# router-id 2.2.2.2
PE2(config-ldp)# address-family ipv4
PE2(config-ldp-af-ipv4)# interface gigabitethernet 1/0/1
PE2(config-ldp-af-ipv4-if)# exit
PE2(config-ldp-af-ipv4)# transport-address 2.2.2.2
PE2(config-ldp-af-ipv4)# exit
PE2(config-ldp)# enable
PE2(config-ldp)# exit
PE2(config-mpls)# l2vpn
PE2(config-l2vpn)# pw-class for_p2p_VLAN100
PE2(config-l2vpn-pw-class)# exit
PE2(config-l2vpn)# p2p to_PE1_VLAN100
PE2(config-l2vpn-p2p)# interface gigabitethernet 1/0/4.100
PE2(config-l2vpn-p2p)# pw 100 1.1.1.1
PE2(config-l2vpn-pw)# pw-class for_p2p_VLAN100
PE2(config-l2vpn-pw)# enable
PE2(config-l2vpn-pw)# exit
PE2(config-l2vpn-p2p)# enable
PE2(config-l2vpn-p2p)# end
PE2# commit
PE2# confirm
```

Make sure that the LDP neighborhood is established and display the virtual channel status (pseudowire) between PE1 and PE2

```
PE2# show mpls ldp neighbor
Peer LDP ID: 1.1.1.1; Local LDP ID 2.2.2.2
    State: Operational
    TCP connection: 1.1.1.1:646 - 2.2.2.2:34625
    Messages sent/received: 12/12
    Uptime: 00:03:50
    LDP discovery sources:
        2.2.2.2 -> 1.1.1.1
```

```
PE2# show mpls l2vpn pseudowire
Neighbor                                PW ID           Type          Status
--------------------------------------- ----------      ----------    ------
1.1.1.1                                   100           Ethernet        Up
```

The LDP neighborhood is established, pseudowire has moved to 'UP' status. The l2vpn p2p type configuration is now complete.

6.5.3 L2VPN VPLS configuration algorithm

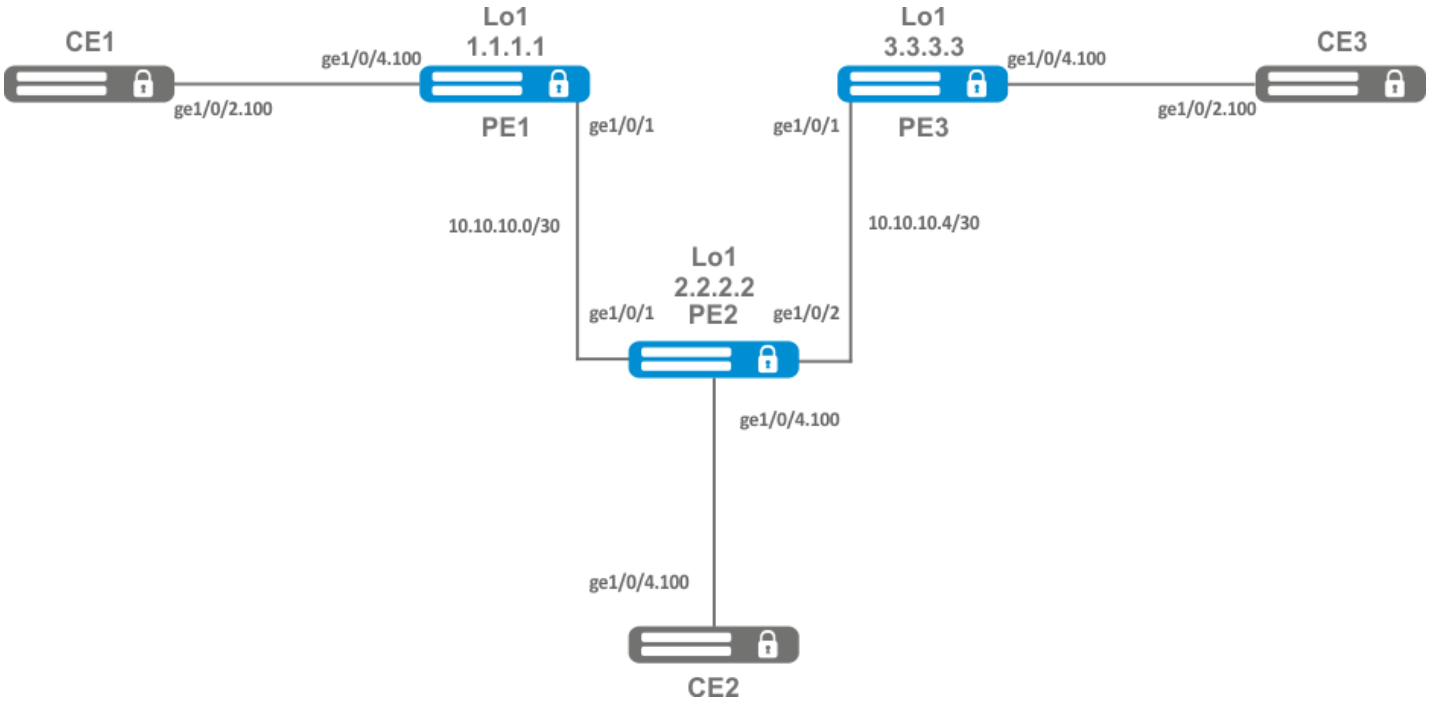
Step	Description	Command	Keys
1	Configure the LDP (see section LDP configuration)		
2	Create a network bridge in the system without specifying an ip address (see section Bridge configuration).		
3	Create pw-class in the system and switch to the pw-class configuration mode.	`esr(config-l2vpn)# pw-class <WORD>`	<WORD> — pw-class name [1..31] characters long.
4	Add a description for pw-class (optional).	`esr(config-l2vpn-pw-class)# description <LINE>`	<LINE> — description. Set by the string [1..255] characters long.
5	Set the MTU value for the pseudo-wire included in the pw-class (optional).	`esr(config-l2vpn-pw-class)# encapsulation mpls mtu <MTU>`	<MTU> — MTU value, takes values in the range of [552..10000] Default value: 1500.
6	Disable status-tlv messaging (optional).	`esr(config-l2vpn-pw-class)# encapsulation mpls status-tlv disable`	Default value: status-tlv enable
7	Create vpls domain in the system and switch to the vpls domain configuration mode.	`esr(config-l2vpn)# vpls <NAME>`	<NAME> — name of the p2p service, set by the string of up to 31 characters.
8	Enable vpls tunnel.	`esr(config-l2vpn-vpls)# enable`	
9	Add bridge domain.	esr (config-l2vpn-vpls)# bridge-group <ID>	<ID> — bridge domain identifier, specified in the range [1..250]
10	Specify transport mode (optional).	`esr(config-l2vpn-vpls)# transport-mode { ethenet | vlan }`	<ethernet> — mode in which the 802.1Q tag is removed from the header when entering pseudo-wire; <vlan> — mode in which the 802.1Q tag can be saved when transmitted over pseudo-wire. Default value: ethernet
11	Create a pseudo-wire and switch to its parameters configuration mode.	`esr(config-l2vpn-vpls)# pw <PW_ID> <LSR_ID>`	<PW_ID> — psewdowire identifier, specified in the range [1..4294967295] <LSR_ID> — identifier of LSR to which pseudo-wire is built, specified as AAA.BBB.CCC.DDD, where each part takes values [0..255]

Step	Description	Command	Keys
12	Add a description for pseudo-wire (optional).	`esr(config-l2vpn-pw)# description <LINE>`	<LINE> — description. Set by the string [1..255] characters long.
13	Set pw-class for pseudo-wire.	`esr(config-l2vpn-pw)# pw-class <WORD>`	`<WORD> – pw-class name [1..31] characters long.`
14	Set the LSR address to which the pseudo-wire is set (Optional if the neighbor address is the same as the LSR_ID).	`esr(config-l2vpn-pw)# neighbor-address <ADDR>`	<ADDR> – router IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
15	Enable pseudo-wire.	`esr(config-l2vpn-pw)# enable`	
16	If the topology of the VPLS domain to be created requires more than one pseudo-wire, repeat steps 10 to 14.		
17	If it is necessary to change the default settings for a targeted LDP session, see section Configuring session parameters in targeted-LDP.		

6.5.4 L2VPN VPLS configuration example

Objective:

Configure l2vpn so that CE1,CE2,CE3 routers have L2 connectivity through the gi1/0/2.100 and gi1/0/4(CE2) interfaces.



Solution:

Pre-requisite:

- Enable Jumbo frames support with the "system jumbo-frames" command (the device must be rebooted for the changes to take effect);
- Configure IP addresses on interfaces according to the network structure shown in the figure above;
- Organize the exchange of routes between PE1, PE2 and PE3 using IGP (OSPF, IS-IS);

On router PE1, create a bridge group and enable it:

```
PE1# configure
PE1(config)# bridge 10
PE1(config-bridge)# enable
PE1(config-bridge)# exit
```

On the Interface to the CE1 side, include it in the created bridge group:

```
PE1(config)# interface gigabitethernet 1/0/4.100
PE1(config-subif)# bridge-group 10
PE1(config-subif)# exit
```

Set the MTU value on the interface towards PE2 to 9600 to avoid MTU overrun after encapsulating the MPLS header and disable the firewall

```
PE1#(config)# interface gigabitethernet 1/0/1
PE1(config-if-gi)# mtu 9600
PE1(config-if-gi)# ip firewall disable
PE1(config-if-gi)# exit
```

Allow packets with an mpls header to be received on the interface towards the mpls network (in this example, the interface towards PE2):

```
PE1(config)# mpls
PE1(config-mpls)# forwarding interface gigabitethernet 1/0/1
```

Configure the LDP protocol and enable neighbor detection on the interface towards PE2:

```
PE1(config-mpls)# ldp
PE1(config-ldp)# router-id 1.1.1.1
PE1(config-ldp)# address-family ipv4
PE1(config-ldp-af-ipv4)# interface gigabitethernet 1/0/1
PE1(config-ldp-af-ipv4-if)# exit
PE1(config-ldp-af-ipv4)# transport-address 1.1.1.1
PE1(config-ldp-af-ipv4)# exit
PE1(config-ldp)# enable
PE1(config-ldp)# exit
```

Create a pw-class on the basis of which the virtual channels (pw) will be created later. Since, in this example, the default parameters will be applied to pw, it will be sufficient to specify the class name:

```
PE1(config-mpls)# l2vpn
PE1(config-l2vpn)# pw-class for_vpls1
PE1(config-l2vpn-pw-class)# exit
```

Create a new l2vpn of vpls type and add pw to routers PE2 and PE3, take the pw identifier as VID for convenience (in this case = 100):

```
PE1(config-l2vpn)# vpls vpls1
PE1(config-l2vpn-vpls)# bridge-group 10
PE1(config-l2vpn-vpls)# pw 100 2.2.2.2
PE1(config-l2vpn-pw)# pw-class for_vpls1
PE1(config-l2vpn-pw)# enable
PE1(config-l2vpn-pw)# exit
PE1(config-l2vpn-vpls)# pw 100 3.3.3.3
PE1(config-l2vpn-pw)# pw-class for_vpls1
PE1(config-l2vpn-pw)# enable
PE1(config-l2vpn-pw)# exit
PE1(config-l2vpn-vpls)# enable
PE1(config-l2vpn-vpls)# end
```

Apply the created configuration:

```
PE1# commit
PE1# confirm
```

Configure PE2 and PE3 routers in the same way as PE1:

```
PE2# configure
PE2(config)# bridge 10
PE2(config-bridge)# enable
PE2(config-bridge)# exit
PE2(config)# interface gigabitethernet 1/0/4.100
PE2(config-subif)# bridge-group 10
PE2(config-subif)# exit
PE2(config)# interface gigabitethernet 1/0/2
PE2(config-if-gi)# mtu 9600
PE2(config-if-gi)# ip firewall disable
PE2(config-if-gi)# exit
PE2(config)# mpls
PE2(config-mpls)# forwarding interface gigabitethernet 1/0/1
PE2(config-mpls)# forwarding interface gigabitethernet 1/0/2
PE2(config-mpls)# ldp
PE2(config-ldp)# enable
PE2(config-ldp)# router-id 2.2.2.2
PE2(config-ldp)# address-family ipv4
PE2(config-ldp-af-ipv4)# transport-address 2.2.2.2
PE2(config-ldp-af-ipv4)# interface gigabitethernet 1/0/1
PE2(config-ldp-af-ipv4-if)# exit
PE2(config-ldp-af-ipv4)# interface gigabitethernet 1/0/2
PE2(config-ldp-af-ipv4-if)# exit
```

```
PE2(config-ldp-af-ipv4)# exit
PE2(config-ldp)# exit
PE2(config-mpls)# l2vpn
PE2(config-l2vpn)# pw-class for_vpls1
PE2(config-l2vpn-pw-class)# exit
PE2(config-l2vpn)# vpls vpls1
PE2(config-l2vpn-vpls)# enable
PE2(config-l2vpn-vpls)# bridge-group 10
PE2(config-l2vpn-vpls)# pw 100 1.1.1.1
PE2(config-l2vpn-pw)# pw-class for_vpls1
PE2(config-l2vpn-pw)# enable
PE2(config-l2vpn-pw)# exit
PE2(config-l2vpn-vpls)# pw 100 3.3.3.3
PE2(config-l2vpn-pw)# pw-class for_vpls1
PE2(config-l2vpn-pw)# enable
PE2(config-l2vpn-pw)# end
PE2# commit
PE2# confirm
PE3(config)# bridge 10
PE3(config-bridge)# enable
PE3(config-bridge)# exit
PE3(config)# interface gigabitethernet 1/0/4.100
PE3(config-subif)# bridge-group 10
PE3(config-subif)# exit
PE3(config)# interface gigabitethernet 1/0/1
PE3(config-if-gi)# mtu 9600
PE3(config-if-gi)# ip firewall disable
PE3(config-if-gi)# exit
PE3(config)# mpls
PE3(config-mpls)# forwarding interface gigabitethernet 1/0/1
PE3(config-mpls)# exit
PE3(config)# mpls
PE3(config-mpls)# ldp
PE3(config-ldp)# enable
PE3(config-ldp)# router-id 3.3.3.3
PE3(config-ldp)# address-family ipv4
PE3(config-ldp-af-ipv4)# interface gigabitethernet 1/0/1
PE3(config-ldp-af-ipv4-if)# exit
PE3(config-ldp-af-ipv4)# transport-address 3.3.3.3
PE3(config-ldp-af-ipv4)# exit
PE3(config-ldp)# exit
PE3(config-mpls)# l2vpn
PE3(config-l2vpn)# pw-class for_vpls
PE3(config-l2vpn-pw-class)# exit
PE3(config-l2vpn)# vpls vpls1
PE3(config-l2vpn-vpls)# enable
PE3(config-l2vpn-vpls)# bridge-group 10
PE3(config-l2vpn-vpls)# pw 100 2.2.2.2
PE3(config-l2vpn-pw)# pw-class for_vpls
PE3(config-l2vpn-pw)# enable
PE3(config-l2vpn-pw)# exit
PE3(config-l2vpn-vpls)# pw 100 1.1.1.1
PE3(config-l2vpn-pw)# pw-class for_vpls
PE3(config-l2vpn-pw)# enable
PE3(config-l2vpn-pw)# end
PE3# commit
PE3# confirm
```

Make sure that the LDP neighborhood is established and display the virtual channel status (pseudowire) between PE1, PE2 and PE3

```
PE3# show mpls ldp neighbor
Peer LDP ID: 1.1.1.1; Local LDP ID 3.3.3.3
    State: Operational
    TCP connection: 1.1.1.1:646 - 3.3.3.3:45979
    Messages sent/received: 22/22
    Uptime: 00:13:16
    LDP discovery sources:
        3.3.3.3 -> 1.1.1.1
Peer LDP ID: 2.2.2.2; Local LDP ID 3.3.3.3
    State: Operational
    TCP connection: 2.2.2.2:646 - 3.3.3.3:59627
    Messages sent/received: 22/22
    Uptime: 00:13:20
    LDP discovery sources:
        3.3.3.3 -> 2.2.2.2
        gigabitethernet 1/0/1
```

```
PE3# show mpls l2vpn pseudowire
Neighbor                                    PW ID    Type          Status
------------------------------------- ----------      ----------       ------
1.1.1.1                                       100        Ethernet     Up
2.2.2.2                                       100        Ethernet     Up
```

The LDP neighborhood is established, pseudowire has moved to 'UP' status. The l2vpn configuration is now complete.

6.6 L2VPN Kompella mode configuration

Unlike Martini mode, where all operation is done by the LDP, in this mode the LDP does only operate with transport labels. Autodetection (not typical of LDP signaling), and the construction of a pseudowire connection is entrusted to BGP.

6.6.1 L2VPN VPLS configuration algorithm

Step	Description	Command	Keys
1	Configure the LDP (see section LDP configuration)		
2	Create a network bridge in the system without specifying an ip address (see section Bridge configuration).		
3	Create vpls domain in the system and switch to the vpls domain configuration mode.	`esr(config-l2vpn)# vpls <NAME>`	<NAME> — name of the p2p service, set by the string of up to 31 characters.
4	Enable vpls tunnel.	`esr(config-l2vpn-vpls)# enable`	

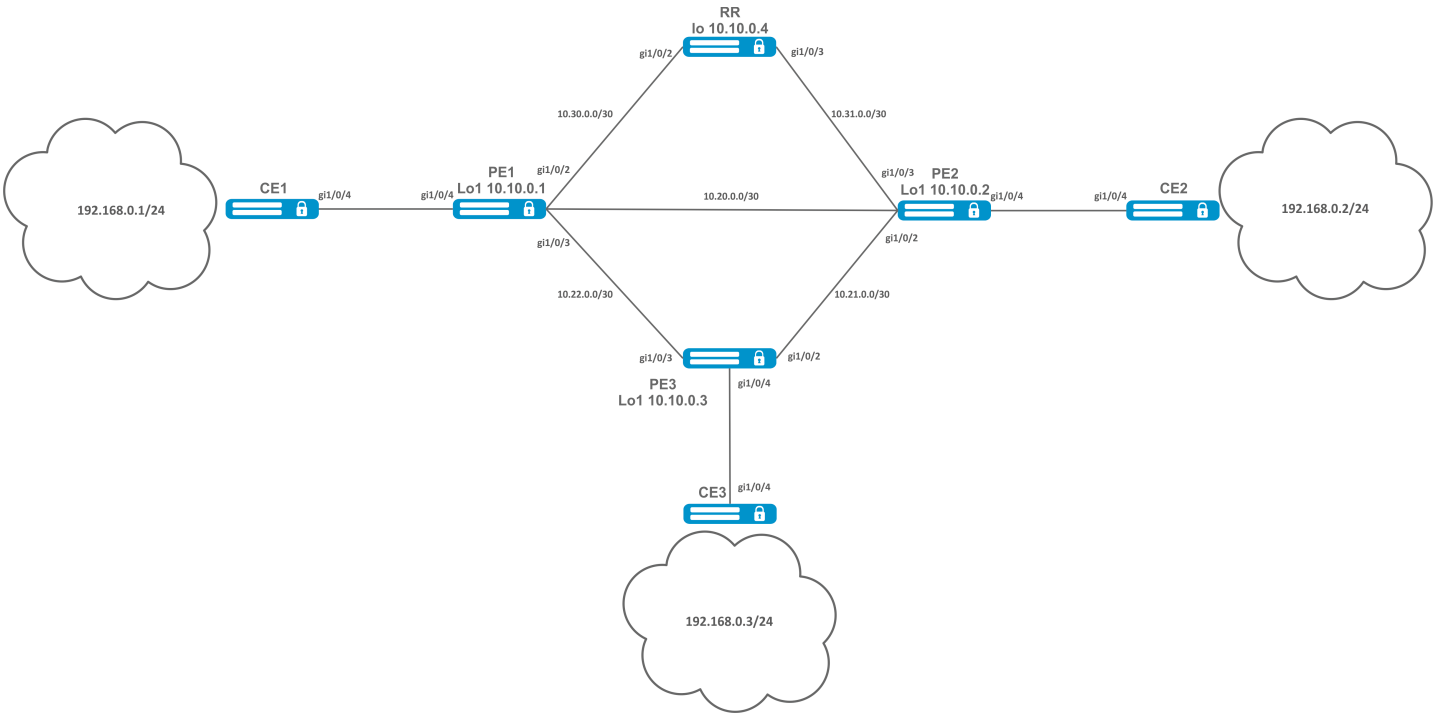
Step	Description	Command	Keys
5	Add bridge domain.	`esr(config-l2vpn-vpls)# bridge-group <ID>`	<ID> — bridge domain identifier, specified in the range [1..250].
6	Switch to the autodiscovery bgp configuration context.	`esr(config-l2vpn-vpls)# autodiscovery bgp`	
7	Specify route distinguisher for the given VPLS instance.	`esr(config-bgp)# rd <RD>`	<RD> – Route distinguisher value, specified in one of the following forms: • <ASN>:<nn> — where <ASN> may take values [1..65535], nn may take values [1..65535]; • <ADDR>:<nn> — where <ADDR> specified as AAA.BBB.CCC.DDD/EE, AAA-DDD may take values [0..255], nn may take values [1..65535]; • <4ASN>:<nn> — where <4ASN> may take values [1..4294967295], nn may take values [1..65535];
8	Specify route target import for the given VPLS instance.	`esr(config-bgp)# route-target import <RT>`	<RT> – Route-target value, specified in one of the following forms: • <ASN>:<nn> — where <ASN> may take values [1..65535], nn may take values [1..65535]; • <ADDR>:<nn> — where <ADDR> specified as AAA.BBB.CCC.DDD/EE, AAA-DDD may take values [0..255], nn may take values [1..65535]; • <4ASN>:<nn> — where <4ASN> may take values [1..4294967295], nn may take values [1..65535];

Step	Description	Command	Keys
9	Specify route target export for the given VPLS instance.	`esr(config-bgp)# route-target export <RT>`	<RT> – Route-target value, specified in one of the following forms: • <ASN>:<nn> — where <ASN> may take values [1..65535], nn may take values [1..65535]; • <ADDR>:<nn> — where <ADDR> specified as AAA.BBB.CCC.DDD/EE, AAA-DDD may take values [0..255], nn may take values [1..65535]; • <4ASN>:<nn> — where <4ASN> may take values [1..4294967295], nn may take values [1..65535];
10	Specify ve id.	`esr(config-bgp)# ve id <ID>`	<ID> — VPLS instance identifier, specified in the range [1..16384].
11	Specify vpn id.	esr (config-bgp)# vpn id <ID>	<ID> — VPN identifier, specified in the range [1..4294967295]
12	Specify ve range (optional).	esr (config-bgp)# ve range <RANGE>	<RANGE> — range of VPLS border device identifiers [8..100].
13	Specify mtu (optional).	esr (config-bgp)# mtu <VALUE>	<VALUE> — MTU value [552..10000].
14	Enable ignoring encapsulation type (optional).	esr(config-bgp)# ignore encapsulation-mismatch	
15	Enable ignoring MTU values (optional).	esr(config-bgp)# ignore mtu-mismatch	
16	In the context of address-family l2vpn vpls BGP configuration, enable extended attribute transfer.	`esr(config-bgp-neighbor-af)# send-community extended`	

6.6.2 L2VPN VPLS configuration example

Objective:

Configure L2VPN service: all CE devices must work within the same broadcast domain.



Solution:

Pre-requisite:

- Enable Jumbo frames support with the "system jumbo-frames" command (the device must be rebooted for the changes to take effect);
- Configure IP addresses on interfaces according to the network structure shown in the figure above;
- Organize the exchange of routes between PE1, PE2, PE3 and RR using IGP (OSPF, IS-IS).

First, configure the RR router:

Pre-configuration

```
hostname RR
system jumbo-frames
router ospf 1
area 0.0.0.0
enable
exit
enable
exit
interface gigabitethernet 1/0/2
mtu 9500
ip firewall disable
ip address 10.30.0.2/30
ip ospf instance 1
ip ospf
exit
interface gigabitethernet 1/0/3
mtu 9500
ip firewall disable
ip address 10.31.0.2/30
ip ospf instance 1
ip ospf
exit
interface loopback 1
ip address 10.10.0.4/32
ip ospf instance 1
ip ospf
exit
mpls
ldp
router-id 10.10.0.4
address-family ipv4
interface gigabitethernet 1/0/2
exit
interface gigabitethernet 1/0/3
exit
exit
enable
exit
forwarding interface gigabitethernet 1/0/2
forwarding interface gigabitethernet 1/0/3
exit
```

Configure the BGP Route Reflector for the address family l2vpn:

```
RR(config)# router bgp 65500
RR(config-bgp)#   router-id 10.10.0.4
RR(config-bgp)#   neighbor 10.10.0.1
RR(config-bgp-neighbor)#     remote-as 65500
RR(config-bgp-neighbor)#     route-reflector-client
RR(config-bgp-neighbor)#     update-source 10.10.0.4
RR(config-bgp-neighbor)#     address-family l2vpn vpls
RR(config-bgp-neighbor-af)#       send-community extended
RR(config-bgp-neighbor-af)#       enable
RR(config-bgp-neighbor-af)#     exit
RR(config-bgp-neighbor)#     enable
RR(config-bgp-neighbor)#   exit
RR(config-bgp)#   neighbor 10.10.0.2
RR(config-bgp-neighbor)#     remote-as 65500
RR(config-bgp-neighbor)#     route-reflector-client
RR(config-bgp-neighbor)#     update-source 10.10.0.4
RR(config-bgp-neighbor)#     address-family l2vpn vpls
RR(config-bgp-neighbor-af)#       send-community extended
RR(config-bgp-neighbor-af)#       enable
RR(config-bgp-neighbor-af)#     exit
RR(config-bgp-neighbor)#     enable
RR(config-bgp-neighbor)#   exit
RR(config-bgp)#   neighbor 10.10.0.3
RR(config-bgp-neighbor)#     remote-as 65500
RR(config-bgp-neighbor)#     route-reflector-client
RR(config-bgp-neighbor)#     update-source 10.10.0.4
RR(config-bgp-neighbor)#     address-family l2vpn vpls
RR(config-bgp-neighbor-af)#       send-community extended
RR(config-bgp-neighbor-af)#       enable
RR(config-bgp-neighbor-af)#     exit
RR(config-bgp-neighbor)#     enable
RR(config-bgp-neighbor)#   exit
RR(config-bgp)#   enable
```

Next, configure BGP on the PE routers:

Pre-configuration
hostname PE1
system jumbo-frames
router ospf 1
area 0.0.0.0
enable
exit
enable
exit
interface gigabitethernet 1/0/1
mtu 9500

Pre-configuration

```
ip firewall disable
ip address 10.20.0.1/30
ip ospf instance 1
ip ospfexit
interface gigabitethernet 1/0/2
mtu 9500
ip firewall disable
ip address 10.30.0.1/30
ip ospf instance 1
ip ospf
exitinterface gigabitethernet 1/0/3
mtu 9500
ip firewall disable
ip address 10.22.0.1/30
ip ospf instance 1
ip ospf
exit
interface loopback 1
ip address 10.10.0.1/32
ip ospf instance 1
ip ospf
exit
mpls
ldp
router-id 10.10.0.1
address-family ipv4
interface gigabitethernet 1/0/1
exit
interface gigabitethernet 1/0/2
exit
interface gigabitethernet 1/0/3
exit
exit
enable
exit
forwarding interface gigabitethernet 1/0/1
forwarding interface gigabitethernet 1/0/2
forwarding interface gigabitethernet 1/0/3
exit
```

BGP configuration:

```
PE1(config)# router bgp 65500
PE1(config-bgp)#   neighbor 10.10.0.4
PE2(config-bgp)#   router-id 10.10.0.1
PE1(config-bgp-neighbor)#     remote-as 65500
PE1(config-bgp-neighbor)#     update-source 10.10.0.1
PE1(config-bgp-neighbor)#     address-family l2vpn vpls
PE1(config-bgp-neighbor-af)#       send-community extended
PE1(config-bgp-neighbor-af)#       enable
PE1(config-bgp-neighbor-af)#     exit
PE1(config-bgp-neighbor)#     enable
PE1(config-bgp-neighbor)#   exit
PE1(config-bgp)#   enable
PE1(config-bgp)# exit
```

Check that the BGP session with RR is successfully established:

PE1# sh ip bgp neighbors
BGP neighbor is 10.10.0.4
BGP state: Established
Neighbor address: 10.10.0.4
Neighbor AS: 65500
Neighbor ID: 10.10.0.4
Neighbor caps: refresh enhanced-refresh restart-aware AS4
Session: internal multihop AS4
Source address: 10.10.0.1
Weight: 0
Hold timer: 110/180
Keepalive timer: 21/60
Uptime: 7375 s

Configuration of BGP on PE2:

Pre-configuration
hostname PE2
system jumbo-frames
router ospf 1
area 0.0.0.0
enable
exit
enable
exit

Pre-configuration

```
interface gigabitethernet 1/0/1
mtu 9500
ip firewall disable
ip address 10.20.0.2/30
ip ospf instance 1
ip ospf
exit
interface gigabitethernet 1/0/2
mtu 9500
ip firewall disable
ip address 10.21.0.1/30
ip ospf instance 1
ip ospf
exit
interface gigabitethernet 1/0/3
mtu 9500
ip firewall disable
ip address 10.31.0.1/30
ip ospf instance 1
ip ospf
exit
interface loopback 1
ip address 10.10.0.2/32
ip ospf instance 1
ip ospf
exit
mpls
ldp
router-id 10.10.0.2
address-family ipv4
interface gigabitethernet 1/0/1
exit
interface gigabitethernet 1/0/2
exit
interface gigabitethernet 1/0/3
exit
exit
enable
exit
forwarding interface gigabitethernet 1/0/1
forwarding interface gigabitethernet 1/0/2
forwarding interface gigabitethernet 1/0/3
exit
```

```
PE2(config)# router bgp 65500
PE2(config-bgp)#   router-id 10.10.0.2
PE2(config-bgp)#   neighbor 10.10.0.4
PE2(config-bgp-neighbor)#     remote-as 65500
PE2(config-bgp-neighbor)#     update-source 10.10.0.2
PE2(config-bgp-neighbor)#     address-family l2vpn vpls
PE2(config-bgp-neighbor-af)#       send-community extended
PE2(config-bgp-neighbor-af)#       enable
PE2(config-bgp-neighbor-af)#     exit
PE2(config-bgp-neighbor)#     enable
PE2(config-bgp-neighbor)#   exit
PE2(config-bgp)#   enable
PE2(config-bgp)# exit
```

Check that the session with RR is successfully established:

PE2# sh ip bgp neighbors
BGP neighbor is 10.10.0.4
BGP state: Established
Neighbor address: 10.10.0.4
Neighbor AS: 65500
Neighbor ID: 10.10.0.4
Neighbor caps: refresh enhanced-refresh restart-aware AS4
Session: internal multihop AS4
Source address: 10.10.0.2
Weight: 0
Hold timer: 113/180
Keepalive timer: 56/60
Uptime: 47 s

Configuration of BGP on PE3:

Pre-configuration

```
hostname PE3
system jumbo-frames
router ospf 1
area 0.0.0.0
enable
exit
enable
exit
interface gigabitethernet 1/0/2
mtu 9500
ip firewall disable
ip address 10.21.0.2/30
ip ospf instance 1
ip ospf
exit
interface gigabitethernet 1/0/3
mtu 9500
ip firewall disable
ip address 10.22.0.2/30
ip ospf instance 1
ip ospf
exit
interface loopback 1
ip address 10.10.0.3/24
ip ospf instance 1
ip ospf
exit
mpls
ldp
router-id 10.10.0.3
address-family ipv4
interface gigabitethernet 1/0/2
exit
interface gigabitethernet 1/0/3
exit
exit
enable
exit
forwarding interface gigabitethernet 1/0/2
forwarding interface gigabitethernet 1/0/3
exit
```

```
PE3(config)# router bgp 65500
PE3(config-bgp)#   router-id 10.10.0.3
PE3(config-bgp)#   neighbor 10.10.0.4
PE3(config-bgp-neighbor)#     remote-as 65500
PE3(config-bgp-neighbor)#     update-source 10.10.0.3
PE3(config-bgp-neighbor)#     address-family l2vpn vpls
PE3(config-bgp-neighbor-af)#       send-community extended
PE3(config-bgp-neighbor-af)#       enable
PE3(config-bgp-neighbor-af)#     exit
PE3(config-bgp-neighbor)#     enable
PE3(config-bgp-neighbor)#   exit
PE3(config-bgp)#   enable
PE3(config-bgp)# exit
```

Check that the BGP session is successfully established:

PE3# sh ip bgp neighbors
BGP neighbor is 10.10.0.4
BGP state: Established
Neighbor address: 10.10.0.4
Neighbor AS: 65500
Neighbor ID: 10.10.0.4
Neighbor caps: refresh enhanced-refresh restart-aware AS4
Session: internal multihop AS4
Source address: 10.10.0.3
Weight: 0
Hold timer: 141/180
Keepalive timer: 27/60
Uptime: 77 s

The next step is to create a bridge domain on each PE router, and include an interface (Attachment circuit, AC) that looks towards CE:

PE1:

```
PE1(config)# bridge 1
PE1(config-bridge)# enable
PE1(config-bridge)# exit
PE1(config)# interface gigabitethernet 1/0/4
PE1(config-if-gi)# mode switchport
PE1(config-if-gi)# bridge-group 1
```

Check that the interface is included into the bridge domain:

```
PE1# sh interfaces bridge
Bridges      Interfaces
----------   ------------------------------------------------------------
bridge 1     gi1/0/4

PE1# sh interfaces status bridge 1
Interface 'bridge 1' status information:
 Description:          --
 Operational state:    Up
 Administrative state: Up
 Supports broadcast:   Yes
 Supports multicast:   Yes
 MTU:                  1500
 MAC address:          a8:f9:4b:ac:4d:15
 Last change:          4 minutes and 22 seconds
 Mode:                 Routerport
```

PE2:

```
PE2(config)# bridge 1
PE2(config-bridge)# enable
PE2(config-bridge)# exit
PE2(config)# interface gigabitethernet 1/0/4
PE2(config-if-gi)# mode switchport
PE2(config-if-gi)# bridge-group 1
```

```
PE2# sh interfaces bridge 1
Bridges      Interfaces
----------   ------------------------------------------------------------
bridge 1     gi1/0/4

PE2# sh interfaces status bridge 1
Interface 'bridge 1' status information:
 Description:          --
 Operational state:    Up
 Administrative state: Up
 Supports broadcast:   Yes
 Supports multicast:   Yes
 MTU:                  1500
 MAC address:          a8:f9:4b:ad:f2:45
 Last change:          10 seconds
 Mode:                 routerport
```

PE3:

```
PE3(config)# bridge 1
PE3(config-bridge)# enable
PE3(config-bridge)# exit
PE3(config)# interface gigabitethernet 1/0/4
PE3(config-if-gi)# mode switchport
PE3(config-if-gi)# bridge-group 1
```

```
PE3# sh interfaces bridge
Bridges      Interfaces
----------   ------------------------------------------------------------
bridge 1     gi1/0/4
PE3# sh interfaces status bridge
Interface            Admin   Link    MTU      MAC address          Last change
Mode
                     state   state
------------------   -----   -----   ------   ------------------   -------------------------
----------
bridge 1             Up      Up      1500     a8:f9:4b:ac:df:f0    1 minute and 21 seconds
Routerport

PE3# sh interfaces status bridge 1
Interface 'bridge 1' status information:
 Description:          --
 Operational state:    Up
 Administrative state: Up
 Supports broadcast:   Yes
 Supports multicast:   Yes
 MTU:                  1500
 MAC address:          a8:f9:4b:ac:df:f0
 Last change:          1 minute and 24 seconds
 Mode:                 Routerport
```

Next, perform the VPLS configuration:

PE1:

Switch to the L2VPN configuration context and include the previously created bridge domain.

```
PE1(config)# mpls
PE1(config-mpls)# l2vpn
PE1(config-l2vpn)# vpls l2vpn
PE1(config-l2vpn-vpls)# bridge-group 1
```

Specify RD, RT, VE-ID, VPN-ID according to the network scheme and activate the service:

In some cases you can skip entering such parameters as RD and RT: if you specify only VPN ID, they will be formed as follows: < AS number> : <vpn-id>.
For example, we have an AS 65550 autonomous system number, vpn-id is 10, then the following parameters will be generated:
RD - 65550: 10.
RT import/export - 65550:10.

```
PE1(config-bgp)# rd 65500:100
PE1(config-bgp)# route-target import 65500:100
PE1(config-bgp)# route-target export 65500:100
PE1(config-bgp)# ve id 1
PE1(config-bgp)# vpn id 1
PE1(config-bgp)# exit
PE1(config-l2vpn-vpls)# enable
```

After activating the service, check that route information appeared in the l2vpn table, and it is advertised on RR:

```
PE1# sh ip bgp l2vpn vpls all
Status codes: * - valid, > - best, i - internal, S - stale
Origin codes: i - IGP, e - EGP, ? - incomplete

Codes Route Distinguisher   VID   VBO   VBS   Next hop        Metric     LocPrf     Weight Path
----- --------------------- ----- ----- ----- --------------- ---------- ---------- ------
--------------------
*>    65500:100             1     1     10    --              --         --         --


PE1# sh ip bgp l2vpn vpls all neighbor 10.10.0.4 advertise-routes
Origin codes: i - IGP, e - EGP, ? - incomplete

Route Distinguisher   VID   VBO   VBS   Next hop        Metric     LocPrf     Path
--------------------- ----- ----- ----- --------------- ---------- ----------
----------------------
65500:100             1     1     10    10.10.0.1       --         100        i


* Подробный вывод анонсируемого маршрута *

PE1# sh ip bgp l2vpn vpls all neighbor 10.10.0.4 advertise-routes  ve-id 1 block
-offset 1
BGP routing table entry for 65500:100 VE ID 1 VE Block Offset 1
    VE Block Size:      10
    Label Base:         86
    Next hop:           10.10.0.1
    AS path:            --
    Origin:             IGP
    Local preference:   100
    Extended Community: RT:65500:100
    Layer2-info:        encaps (VPLS), control flags(0x00), MTU (1500)
```

Proceed to the PE2 configuration:

```
PE2(config-mpls)# l2vpn
PE2(config-l2vpn)# vpls l2vpn
PE2(config-l2vpn-vpls)# bridge-group 1
PE2(config-l2vpn-vpls)# autodiscovery bgp
PE2(config-bgp)# rd 65500:100
```

```
PE2(config-bgp)# route-target export 65500:100
PE2(config-bgp)# route-target import  65500:100
PE2(config-bgp)# vpn id 2
PE2(config-bgp)# ve id 2
PE2(config-bgp)# exit
PE2(config-l2vpn-vpls)# enable
```

Check that PE2 is advertising the route information on RR:

```
PE2# sh ip bgp l2vpn vpls all  neighbor 10.10.0.4 advertise-routes
Origin codes: i - IGP, e - EGP, ? - incomplete

Route Distinguisher   VID   VBO   VBS   Next hop        Metric     LocPrf     Path
--------------------- ----- ----- ----- --------------- ---------- ----------
----------------------
65500:100             2     1     10    10.10.0.2       --         100        i
```

In the l2vpn table you can see its routes as well as routes from PE1:

```
PE2# sh ip bgp l2vpn vpls all
Status codes: * - valid, > - best, i - internal, S - stale
Origin codes: i - IGP, e - EGP, ? - incomplete

Codes Route Distinguisher   VID   VBO   VBS   Next hop        Metric     LocPrf     Weight Path
----- --------------------- ----- ----- ----- --------------- ---------- ---------- ------
--------------------
*>    65500:100             2     1     10    --              --         --         --
*>i   65500:100             1     1     10    10.10.0.1       --         100        0      i
```

The calculated service marks can be viewed as follows:
1) PE2# sh mpls l2vpn bindings
Neighbor: 10.10.0.1, PW ID: 2, VE ID: 1
Local label: 45
Encasulation Type: VPLS
Control flags: 0x00
MTU: 1500
Remote label: 87
Encasulation Type: VPLS
Control flags: 0x00
MTU: 1500
2) PE2# sh mpls forwarding-table

Local label	Outgoing label	Prefix or tunnel ID	Outgoing Interface	Next Hop
45	**87**	PW ID 2	--	10.10.0.1

Check the service state:

```
PE2# sh mpls l2vpn vpls l2vpn
VPLS: l2vpn
    bridge 1:
        MTU:    1500
        Status: Up
    ACs:
      gigabitethernet 1/0/4:
        MTU:    1500
        Status: Up
    PWs:
      PW ID 2, Neighbor 10.10.0.1:
        MTU:         1500
        Last change: 00:21:33
        Status:      Up
```

Proceed to the PE3 configuration:

```
PE3#    config
PE3(config)# mpls
PE3(config-mpls)# l2vpn
PE3(config-l2vpn)# vpls l2vpn
PE3(config-l2vpn-vpls)# bridge-group 1
PE3(config-l2vpn-vpls)# autodiscovery bgp
PE3(config-bgp)# rd 65500:100
PE3(config-bgp)# route-target export 65500:100
PE3(config-bgp)# route-target import  65500:100
PE3(config-bgp)# ve id 3
PE3(config-bgp)# vpn id 3
PE3(config-bgp)# exit
PE3(config-l2vpn-vpls)# enable
```

Check the routing information in PE3:

```
PE3# sh ip bgp l2vpn vpls all
Status codes: * - valid, > - best, i - internal, S - stale
Origin codes: i - IGP, e - EGP, ? - incomplete

Codes Route Distinguisher   VID   VBO   VBS   Next hop        Metric     LocPrf     Weight Path
----- --------------------- ----- ----- ----- --------------- ---------- ---------- ------
-------------------
*>    65500:100             3     1     10    --              --         --         --
*>i   65500:100             2     1     10    10.10.0.2       --         100        0      i
*>i   65500:100             1     1     10    10.10.0.1       --         100        0      i
```

Check that PE3 is advertising the route information on RR:

```
PE3# sh ip bgp l2vpn vpls all neighbor 10.10.0.4 advertise-routes
Origin codes: i - IGP, e - EGP, ? - incomplete

Route Distinguisher   VID   VBO   VBS   Next hop        Metric     LocPrf     Path
--------------------- ----- ----- ----- --------------- ---------- ----------
----------------------
65500:100             3     1     10    10.10.0.3       --         100        i
```

Check that the pseudowire is built before both PEs and is in the "UP" status:

```
PE3# sh mpls l2vpn vpls l2vpn
VPLS: l2vpn
    bridge 1:
        MTU:    1500
        Status: Up
    ACs:
      gigabitethernet 1/0/4:
        MTU:    1500
        Status: Up
    PWs:
      PW ID 3, Neighbor 10.10.0.2:
        MTU:         1500
        Last change: 00:06:08
        Status:      Up
      PW ID 3, Neighbor 10.10.0.1:
        MTU:         1500
        Last change: 00:06:08
        Status:      Up
```

Check the network availability of client equipment (CE):

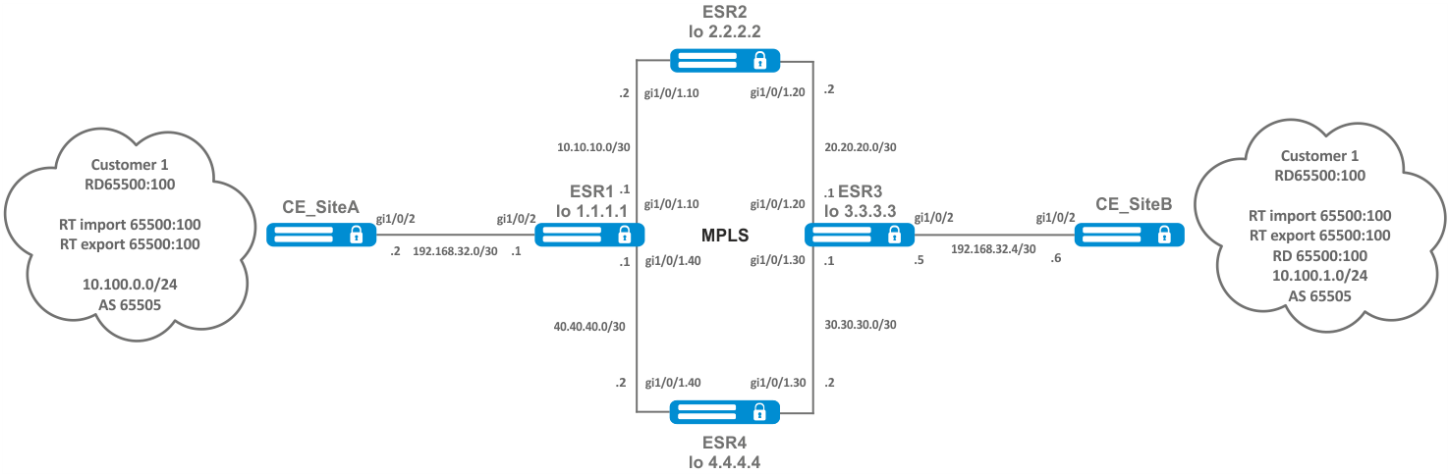
```
CE3# ping 192.168.0.1
PING 192.168.0.1 (192.168.0.1) 56(84) bytes of data.
!!!!!
--- 192.168.0.1 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4004ms
rtt min/avg/max/mdev = 0.173/0.208/0.290/0.045 ms
CE3# ping 192.168.0.2
PING 192.168.0.2 (192.168.0.2) 56(84) bytes of data.
!!!!!
--- 192.168.0.2 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4004ms
rtt min/avg/max/mdev = 0.158/0.204/0.255/0.032 ms

PE3# sh mac address-table bridge 1
VID     MAC Address          Interface                       Type
-----   ------------------   -----------------------------   -------
--      a8:f9:4b:aa:11:08    gigabitethernet 1/0/4           Dynamic
--      a8:f9:4b:aa:11:06    dypseudowire 3_10.10.0.1        Dynamic
--      a8:f9:4b:aa:11:07    dypseudowire 3_10.10.0.2        Dynamic
3 valid mac entries
```

L2VPN service configuration is now complete.

6.7 L3VPN configuration

L3VPN service allows to combine distributed client IP networks, and ensure the transfer of traffic between them within a single VRF.

⚠ The current implementation of MP-BGP only supports VPN–IPv4 routes (AF I= 1, SAFI = 128)



6.7.1 Configuration algorithm

Step	Description	Command	Keys
1	Configure addressing and one of IGP on all P and PE routers		
2	Configure LDP transport tag distribution		
3	Create VRF	`esr(config)# ip vrf <VRF>`	<VRF> – VRF instance name, set by the string of up to 31 characters.
4	Specify route distinguisher for the given VRF	`esr(config-vrf)# rd <RD>`	<RD> — Route distinguisher value, specified in one of the following forms: • <ASN>:<nn> — where <ASN> may take values [1..65535], nn may take values [1..65535]; • <ADDR>:<nn> — where <ADDR> specified as AAA.BBB.CCC.DDD/EE, AAA-DDD may take values [0..255], nn may take values [1..65535]; • <4ASN>:<nn> — where <4ASN> may take values [1..4294967295], nn may take values [1..65535];

Step	Description	Command	Keys
5	Specify route target import for the given VRF	`esr(config-vrf)# route-target import <RT>`	<RT> — Route-target value, specified in one of the following forms: • <ASN>:<nn> — where <ASN> may take values [1..65535], nn may take values [1..65535]; • <ADDR>:<nn> — where <ADDR> specified as AAA.BBB.CCC.DDD/EE, AAA-DDD may take values [0..255], nn may take values [1..65535]; • <4ASN>:<nn> — where <4ASN> may take values [1..4294967295], nn may take values [1..65535];
6	Specify route target export for the given VRF	`esr(config-vrf)# route-target export <RT>`	<RT> — Route-target value, specified in one of the following forms: • <ASN>:<nn> — where <ASN> may take values [1..65535], nn may take values [1..65535]; • <ADDR>:<nn> — where <ADDR> specified as AAA.BBB.CCC.DDD/EE, AAA-DDD may take values [0..255], nn may take values [1..65535]; • <4ASN>:<nn> — where <4ASN> may take values [1..4294967295], nn may take values [1..65535];

Step	Description	Command	Keys

7	Specify the allowed number of routes for this VRF	`esr(config-vrf)# ip protocols <PROTOCOLS> max-routes <VALUE>`	<PROTOCOL> – protocol type, may take following values: rip (only in global mode), ospf, isis, bgp;
			
			<VALUE> – amount of routes in the routing table, takes values in the range of:
			
			• BGP
			  • ESR-1700 [1..5000000];
			  • ESR-1000/1200/1500 [1..3000000];
			  • ESR-20/21/100/200 [1..1500000],
			  • ESR-10/12V/12VF/14VF [1.. 800000].
			• OSPF and IS-IS
			  • ESR-1000/1200/1500/1700 [1..500000];
			  • ESR-20/21/100/200 [1..300000];
			  • ESR-10/12V/12VF/14VF [1..30000].

8	In the context of address-family VPNv4 BGP configuration, enable extended attribute transfer	`esr(config-bgp-neighbor-af)# send-community extended`	

6.7.2 Configuration example

Objective:

Configure L3VPN based on MPLS technology between ESR1 and ESR3. The final result of the configuration is the appearance of connectivity between nodes connected to the VRF on different routers in the network (i.e. the union of VRFs on different routers via MPLS transport). In this case, transfer of MPLS service tags for L3VPN service via MP-BGP and transfer of transport tags to reach nexthop addresses of received BGP routes must be provided.

Solution:

1 Configuring addressing and enabling IGP on routers

ESR1

```
router ospf log-adjacency-changes
router ospf 1
  router-id 1.1.1.1
  area 0.0.0.0
    enable
  exit
  enable
exit

interface loopback 1
  ip address 1.1.1.1/32
  ip ospf instance 1
  ip ospf
exit

interface gigabitethernet 1/0/1.10
  ip firewall disable
  ip address 10.10.10.1/30
  ip ospf instance 1
  ip ospf
exit

interface gigabitethernet 1/0/1.40
  ip firewall disable
  ip address 40.40.40.1/30
  ip ospf instance 1
  ip ospf
exit

system jumbo-frames
```

ESR2

```
router ospf log-adjacency-changes
router ospf 1
  router-id 2.2.2.2
  area 0.0.0.0
    enable
  exit
  enable
exit

interface loopback 1
  ip address 2.2.2.2/32
  ip ospf instance 1
  ip ospf
exit

interface gigabitethernet 1/0/1.10
  ip firewall disable
  ip address 10.10.10.2/30
  ip ospf instance 1
  ip ospf
exit

interface gigabitethernet 1/0/1.20
  ip firewall disable
  ip address 20.20.20.2/30
  ip ospf instance 1
  ip ospf
exit

system jumbo-frames
```

ESR3

```
router ospf log-adjacency-changes
  router ospf 1
  router-id 3.3.3.3
  area 0.0.0.0
    enable
  exit
  enable
exit

interface loopback 1
  ip address 3.3.3.3/32
  ip ospf instance 1
  ip ospf
exit

interface gigabitethernet 1/0/1.20
  ip firewall disable
  ip address 20.20.20.1/30
  ip ospf instance 1
  ip ospf
exit

interface gigabitethernet 1/0/1.30
  ip firewall disable
  ip address 30.30.30.1/30
  ip ospf instance 1
  ip ospf
exit

system jumbo-frames
```

ESR4

```
router ospf log-adjacency-changes
router ospf 1
  router-id 4.4.4.4
  area 0.0.0.0
    enable
  exit
  enable
exit

interface loopback 1
  ip address 4.4.4.4/32
  ip ospf instance 1
  ip ospf
exit

interface gigabitethernet 1/0/1.40
  ip firewall disable
  ip address 40.40.40.2/30
  ip ospf instance 1
  ip ospf
exit

interface gigabitethernet 1/0/1.30
  ip firewall disable
  ip address 30.30.30.2/30
  ip ospf instance 1
  ip ospf
exit

system jumbo-frames
```

It is necessary to make sure that the protocol is running on every router.

```
ESR1# show ip ospf neighbors

  Router ID        Pri  State          DTime  Interface      Router IP
  ---------        ---  -----          -----  -------------  ---------
  2.2.2.2          128  Full/BDR       00:39  gi1/0/1.10     10.10.10.2
  4.4.4.4          128  Full/BDR       00:32  gi1/0/1.40     40.40.40.2
```

```
  ESR1# show ip ospf
  O       40.40.40.0/30      [150/10]          dev gi1/0/1.40
                    [ospf1 1970-01-08]  (1.1.1.1)
  O     * 30.30.30.0/30      [150/20]          via 40.40.40.2 on gi1/0/1.40
       [ospf1 1970-01-08]  (3.3.3.3)
  O       1.1.1.1/32              [150/0]             dev lo1      [ospf1 1970-01-08]
   (1.1.1.1)
  O     * 4.4.4.4/32             [150/10]          via 40.40.40.2 on gi1/0/1.40
       [ospf1 1970-01-08]  (4.4.4.4)
  O     * 20.20.20.0/30      [150/20]          via 10.10.10.2 on gi1/0/1.10
       [ospf1 22:05:45]  (3.3.3.3)
  O       10.10.10.0/30      [150/10]          dev gi1/0/1.10
                    [ospf1 22:05:33]  (1.1.1.1)
  O     * 3.3.3.3/32             [150/20]          multipath
                         [ospf1 22:05:45]  (3.3.3.3)
                                     via 40.40.40.2 on gi1/0/1.40 weight 1
  O     * 2.2.2.2/32             [150/10]          via 10.10.10.2 on gi1/0/1.10
       [ospf1 22:05:45]  (2.2.2.2)
```

2 LDP configuration:

ESR1

```
mpls
  ldp
    address-family ipv4
      transport-address 1.1.1.1
      interface gigabitethernet 1/0/1.10
      exit
      interface gigabitethernet 1/0/1.40
      exit
    exit
    enable
  exit
  forwarding interface gigabitethernet 1/0/1.10
  forwarding interface gigabitethernet 1/0/1.40
exit
```

ESR2

```
mpls
  ldp
    address-family ipv4
      transport-address 2.2.2.2
      interface gigabitethernet 1/0/1.10
      exit
      interface gigabitethernet 1/0/1.20
      exit
    exit
    enable
  exit
  forwarding interface gigabitethernet 1/0/1.10
  forwarding interface gigabitethernet 1/0/1.20
exit
```

ESR3

```
mpls
  ldp
    address-family ipv4
      transport-address 3.3.3.3
      interface gigabitethernet 1/0/1.20
      exit
      interface gigabitethernet 1/0/1.30
      exit
    exit
    enable
  exit
  forwarding interface gigabitethernet 1/0/1.20
  forwarding interface gigabitethernet 1/0/1.30
exit
```

ESR4

```
mpls
  ldp
    address-family ipv4
      transport-address 4.4.4.4
      interface gigabitethernet 1/0/1.30
      exit
      interface gigabitethernet 1/0/1.40
      exit
    exit
    enable
  exit
  forwarding interface gigabitethernet 1/0/1.30
  forwarding interface gigabitethernet 1/0/1.40
exit
```

One of the following commands can be used to check the LDP convergence:

```
ESR1# show mpls ldp neighbor
Peer LDP ID: 2.2.2.2; Local LDP ID 1.1.1.1
    State: Operational
    TCP connection: 2.2.2.2:33933 - 1.1.1.1:646
    Messages sent/received: 1059/1070
    Uptime: 17:32:07
    LDP discovery sources:
        gigabitethernet 1/0/1.10
Peer LDP ID: 4.4.4.4; Local LDP ID 1.1.1.1
    State: Operational
    TCP connection: 4.4.4.4:40894 - 1.1.1.1:646
    Messages sent/received: 1376/1386
    Uptime: 22:38:38
    LDP discovery sources:
        gigabitethernet 1/0/1.40
```

3 MP-BGP configuration

Create VRF on ESR1 and ESR3, respectively. Specify RD, rt-export/import in accordance with our scheme.

Without specifying RD and RT attributes the route information will not get into the VPNv4 table.

ESR1

```
ESR1(config)# ip vrf Customer1
ESR1(config-vrf)# ip protocols bgp max-routes 1000
ESR1(config-vrf)# rd 65500:100
ESR1(config-vrf)# route-target import 65500:100
ESR1(config-vrf)# route-target export 65500:100
```

ESR3

```
ESR3(config)# ip vrf Customer1
ESR3(config-vrf)# ip protocols bgp max-routes 1000
ESR3(config-vrf)# rd 65500:100
ESR3(config-vrf)# route-target export 65500:100
ESR3(config-vrf)# route-target import 65500:100
ESR3(config-vrf)# exit
```

Configure iBGP between ESR1 and ESR3. Enable extended community sending on both devices.

ESR1

```
ESR1(config)# router bgp log-neighbor-changes
ESR1(config)# router bgp 65500
ESR1(config-bgp)# router-id 1.1.1.1
ESR1(config-bgp)# enable
ESR1(config-bgp)# neighbor 3.3.3.3
ESR1(config-bgp-neighbor)# remote-as 65500
ESR1(config-bgp-neighbor)# update-source 1.1.1.1
ESR1(config-bgp-neighbor)# enable
ESR1(config-bgp-neighbor)# address-family ipv4 unicast
ESR1(config-bgp-neighbor-af)# enable
ESR1(config-bgp-neighbor-af)# exit
ESR1(config-bgp-neighbor)# address-family vpnv4 unicast
ESR1(config-bgp-neighbor-af)# send-community extended
ESR1(config-bgp-neighbor-af)# enable
```

ESR3

```
ESR3(config)# router bgp log-neighbor-changes
ESR3(config)# router bgp 65500
ESR3(config-bgp)# router-id 3.3.3.3
ESR3(config-bgp)# enable
ESR3(config-bgp)# neighbor 1.1.1.1
ESR3(config-bgp-neighbor)# remote-as 65500
ESR3(config-bgp-neighbor)# update-source 3.3.3.3
ESR3(config-bgp-neighbor)# enable
ESR3(config-bgp-neighbor)# address-family ipv4 unicast
ESR3(config-bgp-neighbor-af)# enable
ESR3(config-bgp-neighbor-af)# exit
ESR3(config-bgp-neighbor)# address-family vpnv4 unicast
ESR3(config-bgp-neighbor-af)# send-community extended
ESR3(config-bgp-neighbor-af)# enable
```

It is necessary to make sure that BGP session is successfully established.

```
ESR1# show ip bgp neighbors
BGP neighbor is 3.3.3.3
    BGP state: Established
    Neighbor address: 3.3.3.3
    Neighbor AS: 65500
    Neighbor ID: 3.3.3.3
    Neighbor caps: refresh enhanced-refresh restart-aware AS4
    Session: internal multihop AS4
    Source address: 1.1.1.1
    Weight: 0
    Hold timer: 126/180
    Keepalive timer: 40/60
    Address family ipv4 unicast:
    Default originate: No
    Default information originate: No
    Uptime: 88495 s
```

4 PE-CE routing configuration

Customer1 advertises a BGP(AS65505) subnet 10.100.0.0/24. Configure eBGP session between CE_SiteA and PE.

> By default: the route advertising is prohibited for EBGP, you should configure an allow rule; for IBGP route advertising is allowed.

CE_SiteA

Configure the corresponding interfaces. Also create a route-map in which we specify the subnets allowed to be advertised.

CE _SiteA

```
interface gigabitethernet 1/0/2
  ip firewall disable
  ip address 192.168.32.2/30
exit

interface loopback 1
  ip address 10.100.0.1/24
exit

route-map OUTPUT
  rule 1
    match ip address 10.100.0.0/24
    action permit
```

Configure eBGP between ESR1 and CE_SiteA.

CE_SiteA

```
router bgp log-neighbor-changes
router bgp 65505
  router-id 192.168.32.1
  neighbor 192.168.32.1
    remote-as 65500
    allow-local-as 1
    update-source 192.168.32.2
    address-family ipv4 unicast
      route-map OUTPUT out
      enable
    exit
    enable
  exit
  address-family ipv4 unicast
    network 10.100.0.0/24
    exit
  enable
```

ESR1

Configure interface to the CE direction. Also create a route-map in which we specify the subnets allowed to be advertised.

ESR1

```
interface gigabitethernet 1/0/2
  ip vrf forwarding Customer1
  description "Customer1"
  ip firewall disable
  ip address 192.168.32.1/30

Создаем route-map

route-map OUTPUT
  rule 1
    action permit
```

Configure eBGP between ESR1 and CE_SiteA.

ESR1

```
router bgp 65500
  vrf Customer1
    router-id 192.168.32.1
    neighbor 192.168.32.2
    remote-as 65505
    update-source 192.168.32.1
    address-family ipv4 unicast
```

Allow BGP routes to be transmitted to the peer.

ESR1

```
route-map OUTPUT out
  enable
exit
enable
exit
```

Allow forwarding routes from VRF to the VPNv4 unicast table

ESR1

```
address-family ipv4 unicast
redistribute connected
redistribute bgp 65500
exit
enable
exit
```

The following commands can be used to check the accepted and announced routes:

```
ESR1# show ip bgp 65500 vrf Customer1 neighbors 192.168.32.2 advertise-routes
Status codes: u - unicast, b - broadcast, m - multicast, a - anycast
              * - valid, > - best
Origin codes: i - IGP, e - EGP, ? - incomplete


     Network              Next Hop             Metric  LocPrf      Weight Path

*> u 10.100.1.0/24        192.168.32.1                 100                 65500 i
*> u 192.168.32.4/30      192.168.32.1                 100                 65500 i
```

Display the announced routes for a specific peer. The route information is displayed after the filtering is applied.

```
ESR1# show ip bgp 65500 vrf Customer1 neighbors 192.168.32.2 routes
Status codes: u - unicast, b - broadcast, m - multicast, a - anycast
              * - valid, > - best
Origin codes: i - IGP, e - EGP, ? - incomplete


     Network              Next Hop             Metric  LocPrf      Weight Path

*> u 10.100.0.0/24        192.168.32.2                 100         0      65505
```

Outputs the received route information from a specific peer. The route information is displayed after the filtering is applied.

CE_SiteB

Configure the corresponding interfaces.

CE_SiteB

```
interface gigabitethernet 1/0/2
ip firewall disable
ip address 192.168.32.6/30
exit

interface loopback 1
ip address 10.100.1.1/24
exit

route-map OUTPUT
rule 1
match ip address 10.100.1.0/24
action permit
```

Configure eBGP between ESR3 and CE_SiteB.

CE_SiteB

```
router bgp 65505
router-id 192.168.32.6
neighbor 192.168.32.5
remote-as 65500
allow-local-as 1
update-source 192.168.32.6
address-family ipv4 unicast
route-map OUTPUT out
enable
exit
enable
exit
address-family ipv4 unicast
network 10.100.1.0/24
exit
enable
```

ESR3

Configure interface to the CE direction.

ESR3

```
interface gigabitethernet 1/0/2
ip vrf forwarding Customer1
description "Customer1"
ip firewall disable
ip address 192.168.32.5/30
```

Create a route-map in which we specify the subnets allowed to be advertised.

ESR3

```
route-map OUTPUT
rule 1
action permit
```

Configure eBGP between ESR3 and CE_SiteB.

ESR3

```
router bgp 65500
vrf Customer1
router-id 192.168.32.5
neighbor 192.168.32.6
remote-as 65505
update-source 192.168.32.5
address-family ipv4 unicast
```

Allow BGP routes to be transmitted to the peer.

ESR3

```
route-map OUTPUT out
enable
exit
enable
exit
```

Allow route forwarding from VRF to VPNV4 for address-family IPv4.

ESR3

```
address-family ipv4 unicast
redistribute connected
redistribute bgp 65500
exit
enable
exit
```

You can use one of the following commands to view the VPNv4 table:

```
ESR1# show ip bgp vpnv4 unicast all
Status codes: * - valid, > - best, i - internal, S - stale
Origin codes: i - IGP, e - EGP, ? - incomplete


Codes Route Distinguisher   IP Prefix          Next hop        Metric     Label
  LocPrf     Weight Path
----- --------------------- ------------------ --------------- ---------- -------
---------- ------ -----------------
*>    65500:100             10.100.0.0/24      --              --         23      --
        --     ?
*>i   65500:100             192.168.32.4/30    3.3.3.3         --         84
     100        0      i
*>i   65500:100             10.100.1.0/24      3.3.3.3         --         84
     100        0      i
```

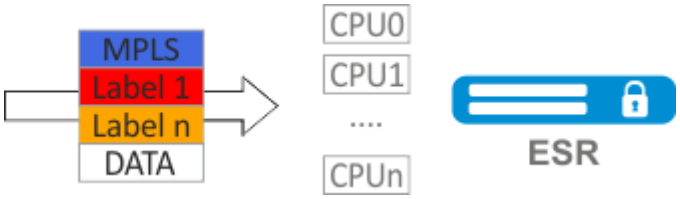
Outputs all accepted VPNv4 routes after applying filtering.

6.8 MPLS traffic balancing

ESR routers have a multi-core architecture. One of the first links in processing incoming traffic is the load balancer daemon (lbd), which performs two main functions:

1) Distributes the load evenly among all router CPUs.

2) Detects abnormal situations with high load on some CPUs, and redistributes processing from these CPUs to less loaded ones.



By default, lbd uses only MPLS tags to calculate the hash and then distribute the load to the different CPUs. This behavior is not always an advantage, especially when there are "large" homogeneous streams of MPLS traffic. Additional functionality can be included to add entropy to the hash:

cpu load-balance mpls passenger ip
Enables the possibility to "look beyond" the MPLS header to find the IP header, and add ip-src and ip-dst to the hash calculation.

cpu load-balance mpls passenger ip-over-ethernet-pseudowire-with-cw
cpu load-balance mpls passenger ip-over-ethernet-pseudowire-without-cw
Allows to explicitly specify whether Control Word functionality is used when building L2VPN. Allows to prevent an error occurring when a package with Control Word present can be mistakenly recognized as a package without Control Word.

6.8.1 Configuration example

Objective:

Enable L2VPN traffic balancing without using Control Word functionality.

Solution:

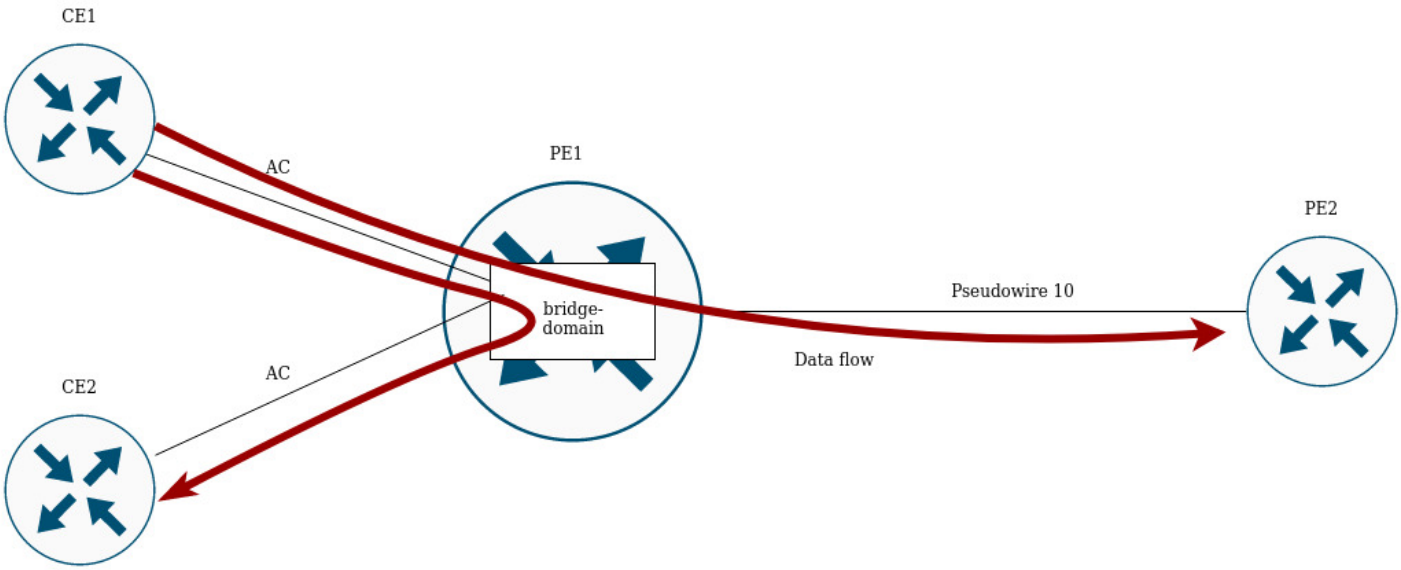
ESR

```
ESR(config)# system cpu load-balance mpls passenger ip
ESR(config)# system cpu load-balance mpls passenger ipoe-pw-without-cw
```

6.9 Operation with the bridge domain within MPLS

To organize L2VPN service, you need to configure a bridge domain on the device, create the required AC, PW (LDP-signaling) and include all the necessary elements in this bridge domain.

For point-to-point, a bridge domain is created automatically.



Traffic is switched between elements of the bridge domain based on the listed rules:

1. A MAC address table is automatically created for each bridge domain, similar to Ethernet switches. Ethernet frames are switched based on analysis of the destination MAC address (DST MAC).
2. Frames with a known DST MAC will be sent to the appropriate AC/PW.
3. Frames with unknown DST MAC, broadcast- and multicast-frames (so called BUM traffic, "Broadcast,Unknown unicast and Multicast") will be sent to all elements of the bridge domain, except for the element (AC or PW) from which you entered the bridge domain.
4. Switching takes into account the DST MAC in the frames, but does not take into account the VLAN tags present on the frames — thus, switching within a bridge domain is not "VLAN-aware".

⚠ In the current implementation, the bridge domain does not allow traffic of data link layer protocols such as STP, LLDP, CDP, etc.

The bridge domain can operate in two transport modes: ethernet or vlan. Transport mode sets the rules for handling traffic to and from the bridge domain.

In LDP signaling, ethernet mode (Raw mode, type 5) is used by default. A transport mode can be set for each individual VPLS instance.

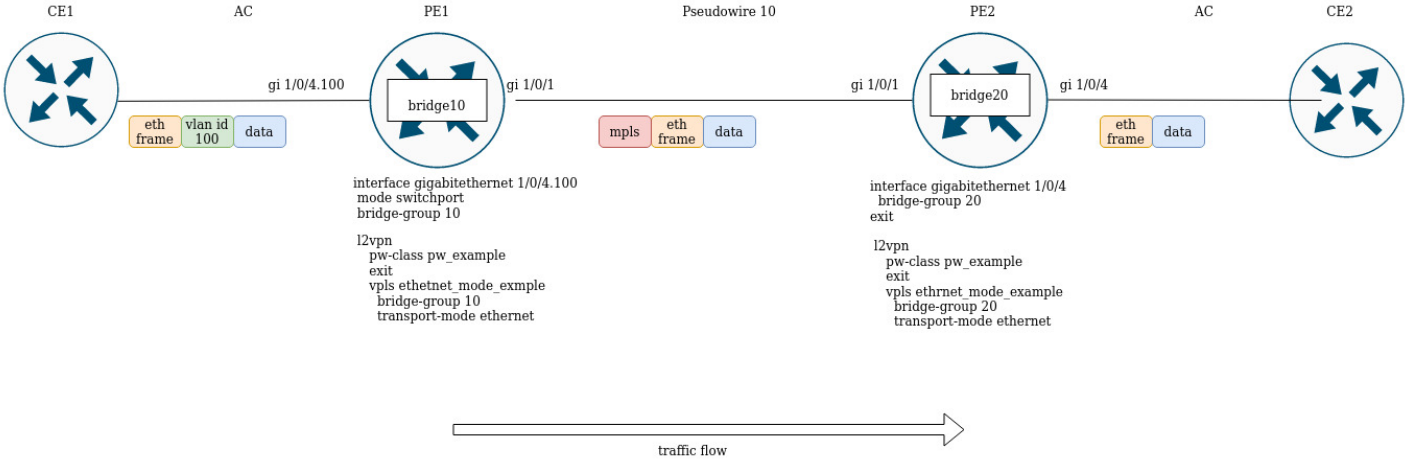
In BGP signaling, the bridge domain only operate in ethernet mode.

```
PE1# config
PE1(config)# mpls
PE1(config-mpls)# l2vpn
PE1(config-l2vpn)# vpls MARTINI_br
PE1(config-l2vpn-vpls)# transport-mode vlan

PE1# sh mpls l2vpn pseudowire
Neighbor                                PW ID      Sig Type       Status
--------------------------------------- ---------- --- ---------- ------
10.10.0.2                               200        LDP Eth Tagged Up
```

⚠ In LDP signaling, the transport mode is matched between PEs during pseudowire creation, so it must match on both PEs.

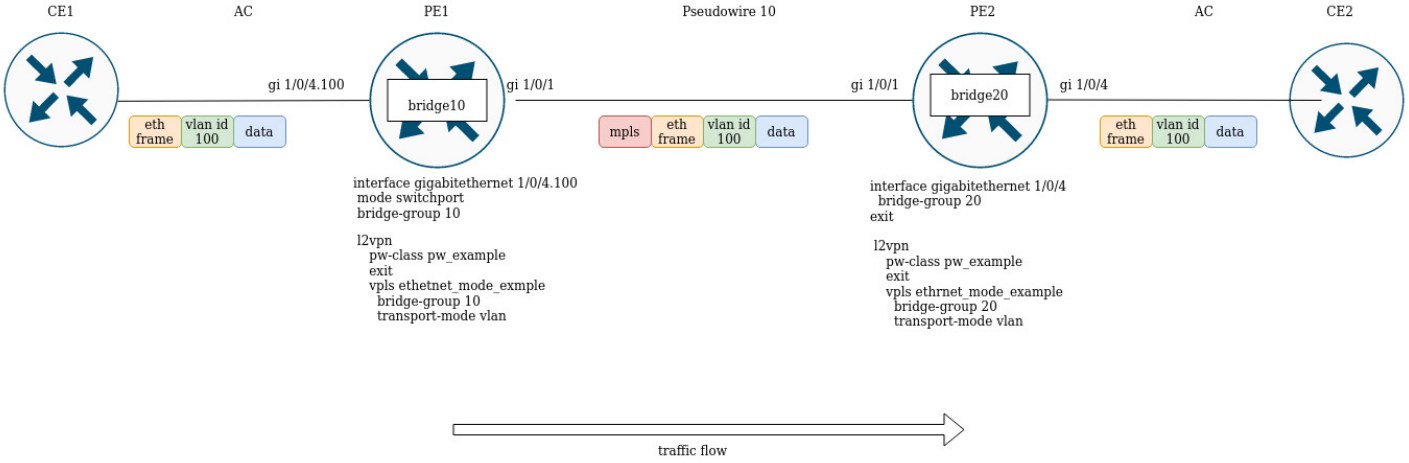
Consider the rules of traffic processing:

1. Ethernet (Raw) mode:
   - If AC is a subinterface, the vlan tag is removed before putting it in the bridge. Upon leaving the bridge, the vlan tag is restored.
   - If AC is an interface, then tagged and untagged traffic flows in both directions without modification.



Suppose PE1 and PE2 are configured in ethernet mode (Figure 2). On the PE1 side, gigabitethernet 1/0/4.100 subinterface is included in the bridge domain, so the vlan tag (vlan id 100) from incoming traffic will be removed before being placed in Pseudowire 10 (respectively, restored when traffic to the AC side). On the other side the AC on PE2, is an interface, which means that traffic will pass through without modification in either direction.

2. Vlan (Tagged) mode:
   - If AC is a subinterface, the vlan tag is saved before putting it in the bridge. The vlan tag can be saved or overwritten depending on the configuration when you exit the bridge.
   - If AC is an interface, traffic modification does not occur in either direction.



6.10 Assignment of MTU when operating with MPLS

It is very important to correctly configure the MTU parameter on the interfaces through which a packet is transmitted. This is true for the installation of the pseudowire and for the transmission of service traffic.

First of all, the MTU value is involved in signaling when constructing a pseudowire in both LDP-signaling and BGP-signaling. In LDP-signaling, the MTU is set within the pw — class setting:

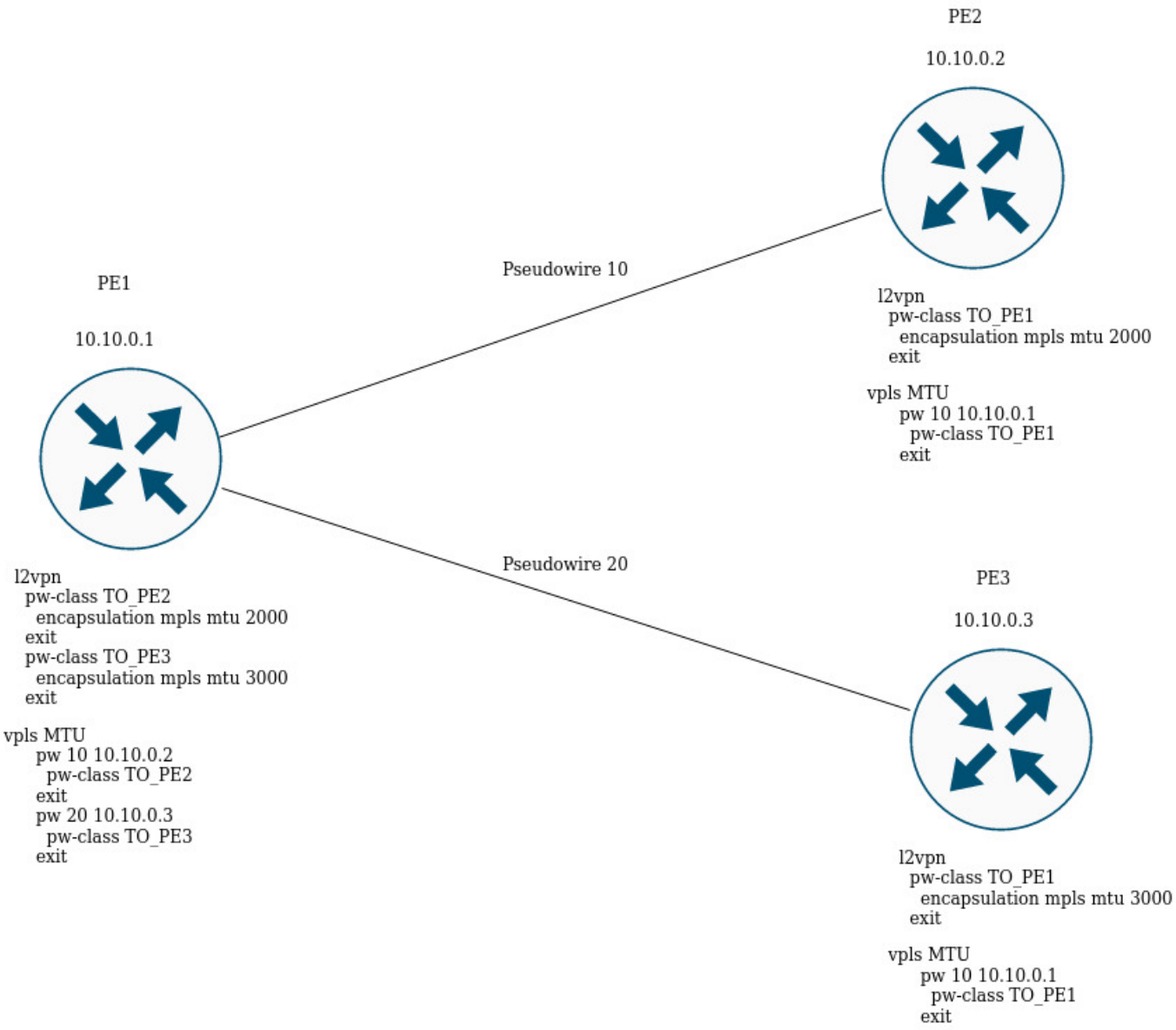
For signaling (LDP, BGP) the default MTU value is 1500.

The MTU values involved in signaling do not affect the actual packet size passing through the pseudowire.

LDP-signaling. Configuration of MTU for matching

```
PE2(config)# mpls
PE2(config-mpls)# l2vpn
PE2(config-l2vpn)# pw-class MTU_example
PE2(config-l2vpn-pw-class)# encapsulation mpls mtu 9000
PE2(config-l2vpn-pw-class)# exit
PE2(config-mpls)# l2vpn
PE2(config-l2vpn)# vpls MTU_Example_PW
PE2(config-l2vpn-vpls)# pw 200 10.10.0.1
PE2(config-l2vpn-pw)# pw-class
PE2(config-l2vpn-pw)# pw-class MTU_example

*View created pw-class*
PE2#  sh mpls l2vpn pw-class
PW-class                         Neighbor    PW ID      Status Status-tlv MTU
-------------------------------- ----------- ---------- ------ ---------- ------
MTU_example                       10.10.0.1  200         Up     Enable     9000


PE2# sh mpls l2vpn vpls  MTU_Example_PW
VPLS:  MTU_Example_PW
...
    PWs:
      PW ID 2, Neighbor 10.10.0.1:
        MTU:         9000
        Last change: 01:27:42
        Status:      Up

*The MTU 9000 is selected for the PW 2 alarm of this VPLS*
```

Consider the example:



In the figure above, PE1 raises two pseudowires: Pseudowire 10 to PE2, and Pseudowire 20 to PE3 respectively. For signaling with PE2 the MTU will be set to 2000 (pw-class TO_PE2), for PE3 the MTU will be 3000 (pw-class TO_PE3).

For BGP-signaling the MTU parameter can also be specified:

BGP-signaling. Configuration of MTU for matching

```
PE1(config)# mpls
PE1(config-mpls)# l2vpn
PE1(config-l2vpn)# vpls l2vpn_MTU
PE1(config-l2vpn-vpls)# autodiscovery bgp
PE1(config-bgp)# mtu 1500

PE2# sh mpls l2vpn vpls  l2vpn_MTU
VPLS: l2vpn_MTU
...
    PWs:
      PW ID 2, Neighbor 10.10.0.1:
        MTU:          1500
        Last change: 01:27:42
        Status:       Up

*The MTU 1500 will be selected for signaling all pseudowires of this VPLS*
```

If the MTU value is different when matching, the status of the pseudowire will be "DOWN", "Reason : MTU mismatch".

```
PE1(config-l2vpn)# vpls l2vpn_MTU
PE1(config-l2vpn-vpls)# autodiscovery bgp
PE1(config-bgp)# mtu 2000

PE2# sh mpls l2vpn vpls l2vpn_MTU
...
    PWs:
      PW ID 2, Neighbor 10.10.0.1:
        MTU:          2000
        Last change: 00:00:10
        Status:       Down
        Reason:       MTU mismatch
```

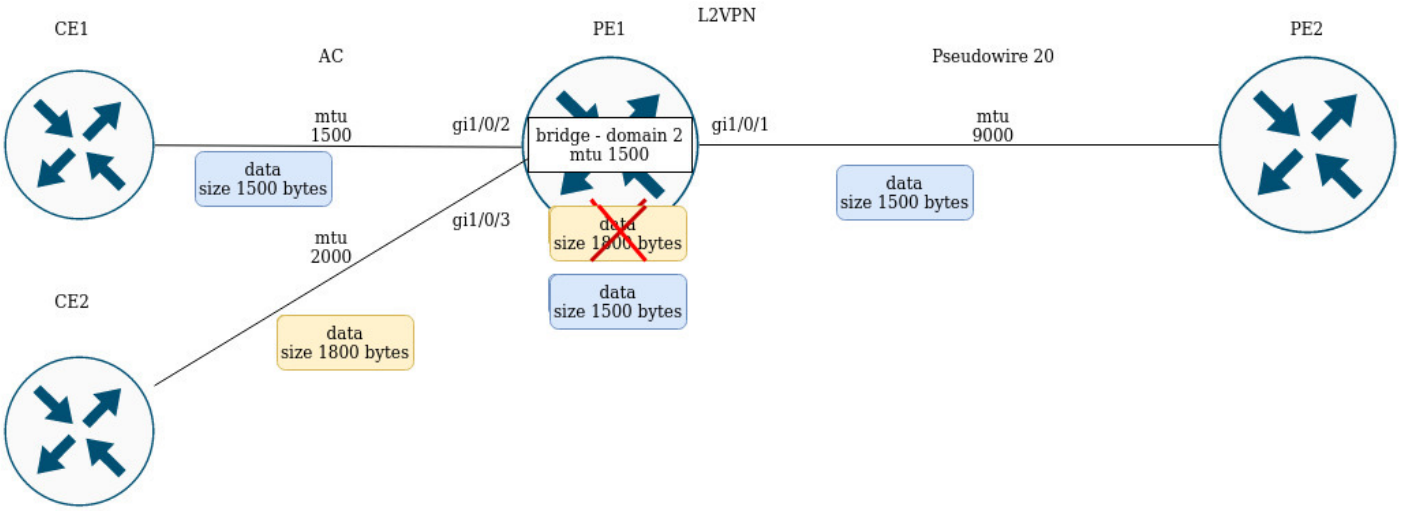
⚠ When configuring VPLS (BGP-signaling), you can disable MTU checking when creating pseudowires:
PE1(config)# mpls
PE1(config-mpls)# l2vpn
PE1(config-l2vpn)# vpls l2vpn _MTU
PE1(config-l2vpn-vpls)# autodiscovery bgp
PE1(config-bgp)# ignore mtu-mismatch
Now, when matching, the MTU value will be ignored.

By default, the bridge domain has an MTU of 1500 bytes. It is worth noting that bridge-domain automatically selects the lowest MTU value based on its own MTU and the MTU of the interfaces included in the bridge-domain.

```
*E.g., we have a bridge domain 100, which includes interfaces gi1/0/1 with MTU value 2000, and
gi1/0/2 with MTU value 3000*
CE3(config)# bridge 100
CE3(config-bridge)# enable
CE3(config-bridge)# exit
CE3(config)# interface gigabitethernet 1/0/1
CE3(config-if-gi)# mtu 2000
CE3(config-if-gi)# bridge-group 100
CE3(config-if-gi)# exit
CE3(config)# interface gigabitethernet 1/0/2
CE3(config-if-gi)# mtu 3000
CE3(config-if-gi)# bridge-group 100
CE3(config-if-gi)# do com

* The MTU of the bridge domain will be 1500, since the bridge itself has a default MTU of 1500
 (the default value), which has become the lowest:
 MTU bridge 100 = 1500  <-- The lowest MTU value
 MTU gi1/0/1  = 2000
 MTU gi1/0/2 = 3000
*


CE3# sh interfaces bridge
Bridges      Interfaces
----------   ------------------------------------------------------------
bridge 100   gi1/0/1-2

CE3# sh interfaces status bridge 100
Interface 'bridge 100' status information:
 Description:          --
 Operational state:    UP
 Administrative state: Up
 Supports broadcast:   Yes
 Supports multicast:   Yes
 MTU:                  1500
 MAC address:          a8:f9:4b:aa:11:00
 Last change:          1 minute and 46 seconds
 Mode:                 Routerport

*Change the MTU on the bridge domain itself:*

CE3(config)# bridge 100
CE3(config-bridge)# mtu 6000
CE3(config-bridge)# do com

* The MTU of the bridge domain became 2000 bytes, because gi1/0/2 has the lowest MTU:
 MTU bridge 100 = 6000
 MTU gi1/0/1  = 2000 <-- The lowest MTU value
 MTU gi1/0/2 = 3000
*

CE3# sh interfaces bridge
Bridges      Interfaces
----------   ------------------------------------------------------------
bridge 100   gi1/0/1-2

CE3# sh interfaces status bridge 100
Interface 'bridge 100' status information:
```

```
Description:          --
Operational state:    Up
Administrative state: Up
Supports broadcast:   Yes
Supports multicast:   Yes
MTU:                  2000
MAC address:          a8:f9:4b:aa:11:00
Last change:          6 minutes and 42 seconds
Mode:                 Routerport
```

Consider the example of traffic passing through the L2VPN service:

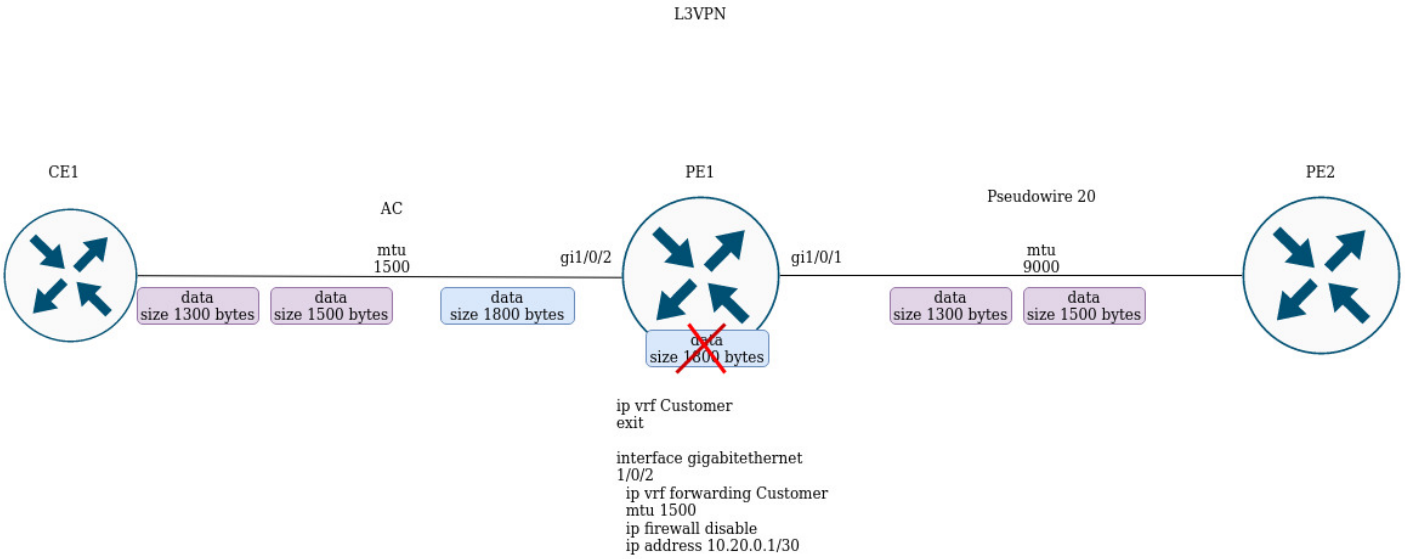


PE1 has the following MTU values on the interfaces:

```
PE1# sh interfaces status
Interface            Admin   Link    MTU      MAC address          Last change
Mode
                     state   state
-------------------  -----   -----   ------   ------------------   -------------------------
----------
gi1/0/1              Up      Up      9000     a8:f9:4b:ac:4d:16    5 hours, 25 minutes and 2
Routerport
                                                                  seconds
gi1/0/2              Up      Up      1500     a8:f9:4b:ac:4d:17    4 days, 4 hours, 49
Switchport
                                                                  minutes and 40 seconds
gi1/0/3              Up      Up      1800     a8:f9:4b:ac:4d:18    4 days, 1 hour, 49
Switchport
                                                                  minutes and 38 seconds
bridge 2             Up      Up      1500     a8:f9:4b:ac:4d:15    1 day, 1 hour, 27 minutes
Routerport
                                                                  and 28 seconds
```

CE1 sends packets of 1500 bytes, CE2 sends packets of 1800 bytes respectively. Since the MTU of the bridge domain is less than the MTU of the packet from CE2, the packet from CE2 will be discarded before reaching the bridge domain. The same will be true if the MTU of the interface facing the mpls-core (gi1/0/1) is less than the MTU of the packets coming from CE (taking into account the mpls header).

Similar behavior when passing traffic in the L3VPN service:



If CE1 sends a packet with a higher MTU than on the interface facing the client (gi1/0/2) or towards the mpls-core (gi1/0/1), the packet will be discarded.

7 Security management

7.1 AAA configuration

AAA (Authentication, Authorization, Accounting) is used for description of access provisioning and control.

- Authentication is a matching of a person (request) for the existing account in the security system. Performed by the login and password.
- Authorization (authorization, privilege verification, access level verification) is a matching of the existing account in the system (passed authentication) and specific privileges.
- Accounting is a monitoring of user connection or changes made by the user.

7.2 Local authentication configuration algorithm

Step	Description	Command	Keys
1	Set local as authentication method.	`esr(config)# aaa authentication login { default | <NAME> } <METHOD 1> [ <METHOD 2> ] [ <METHOD 3> ] [ <METHOD 4> ]`	<NAME> – list name, set by the string of up to 31 characters. Authentication methods: • local – authentication by local user base; • tacacs – authentication by TACACS server list; • radius – authentication by RADIUS server list; • ldap – authentication by LDAP server list.
2	Set enable as authentication method of user privileges elevation.	`esr(config)# aaa authentication enable <NAME><METHOD 1> [ <METHOD 2> ] [ <METHOD 3> ] [ <METHOD 4> ]`	<NAME> – list name, set by the string of up to 31 characters. Authentication methods: • local – authentication by local user base; • tacacs – authentication by TACACS server list; • radius – authentication by RADIUS server list; • ldap – authentication by LDAP server list.
3	Set the method for iterating over authentication methods (optional).	`esr(config)# aaa authentication mode <MODE>`	<MODE> – options of iterating over methods: • chain – if the server returned FAIL, proceed to the following authentication method in the chain; • break – if the server returned FAIL, abandon authentication attempts. If the server is unavailable, continue authentication attempts by the following methods in the chain. Default value: chain.

Step	Description	Command	Keys
4	Specify the number of failed authentication attempts to block the user login and time of the lock (optional)	`esr(config)# aaa authentication attempts max-fail <COUNT> <TIME>`	<COUNT> – amount of failed authentication attempts after which a user is blocked, takes the values of [1..65535]; <TIME> – user blocking time in minutes, takes the values of [1..65535]. Default value: <COUNT> – 5; <TIME> – 300
5	Enable request for change the default password for the 'admin' user (optional)	`esr(config)# security passwords default-expired`	
6	Enable the inhibit mode on the use of previously set local user passwords (optional)	`esr(config)# security passwords history <COUNT>`	<COUNT> – number of passwords saved in the router memory. Takes values in the range of [1..15]. Default value: 0
7	Set the lifetime of local user password (optional)	`esr(config)# security passwords lifetime <TIME>`	<TIME> – password lifetime in days. Takes values in the range of [1..365]. Default: The lifetime of local user password is unlimited.
8	Set a limit on the minimum length of local user password and ENABLE password (optional)	`esr(config)# security passwords min-length <NUM>`	<NUM> – minimum number of characters in the password. Takes values in the range of [8..128]. Default value: 0
9	Set a limit on the maximum length of local user password and ENABLE password (optional)	`esr(config)# security passwords max-length <NUM>`	<NUM> – maximum number of characters in the password. Takes values in the range of [8..128]. Default value: no limit.
10	Set the minimum number of character types that must be present in the local user password and ENABLE password (optional)	`esr(config)# security passwords symbol-types <COUNT>`	<COUNT> – minimum number of character types in the password. Takes values in the range of [1..4]. Default value: 1

Step	Description	Command	Keys
11	Set the minimum number of lower case letters in the local user password and ENABLE password (optional)	`esr(config)# security passwords lower-case <COUNT>`	<COUNT> – minimum number of lower case letters in the local user password and ENABLE password. Takes values in the range of [0..128]. Default value: 0
12	Set the minimum number of upper case letters in the local user password and ENABLE password (optional)	`esr(config)# security passwords upper-case <COUNT>`	<COUNT> – minimum number of upper case letters in the password. Takes values in the range of [0..128]. Default value: 0
13	Set the minimum number of digits in the local user password and ENABLE password (optional)	`esr(config)# security passwords numeric-count <COUNT>`	<COUNT> – minimum number of digits in the password. Takes values in the range of [0..128]. Default value: 0
14	Set the minimum number of special characters in the local user password and ENABLE password (optional)	`esr(config)# security passwords special-case <COUNT>`	<COUNT> – minimum number of special characters in the password. Takes values in the range of [0..128]. Default value: 0
15	Add user in the local database and switch to the user parameters configuration mode	`esr(config)# username <NAME>`	<NAME> – user name, set by the string of up to 31 characters.
16	Set user password	`esr(config-user)# password { <CLEAR-TEXT> | encrypted <HASH_SHA512> }`	<CLEAR-TEXT> – password, set by the string of 8 to 32 characters, takes the value of [0-9a-fA-F]; <HASH_SHA512> – hash password via sha512 algorithm, set by the string of 110 characters.
17	Set user privileges level	`esr(config-user)# privilege <PRIV>`	<PRIV> – required privilege level. Takes values in the range of [1..15].

18	Switch to the corresponding terminal configuration mode	`esr(config)# line console`
		or
		`esr(config)# line telnet`
		or
		`esr(config)# line ssh`	

Step	Description	Command	Keys
19	Activate user login authentication list	`esr(config-line-ssh)# login authentication <NAME>`	<NAME> – list name, set by the string of up to 31 characters.
20	Activate authentication list of user privileges elevation	`esr(config-line-ssh)# enable authentication <NAME>`	<NAME> – list name, set by the string of up to 31 characters.
21	Set the interval after which the idle session will be terminated	`esr(config-line-ssh)# exec-timeout <SEC>`	<SEC> – time interval in minutes, takes values of [1..65535].

7.2.1 AAA configuration algorithm via RADIUS

Step	Description	Command	Keys
1	Set the DSCP code global value for the use in IP headers of RADIUS server egress packets (optional).	`esr(config)# radius-server dscp <DSCP>`	<DSCP> – DSCP code value, takes values in the range of [0..63]. Default value: 63.
2	Set the global number of iterative queries to the last active RADIUS server (optional).	`esr(config)# radius-server retransmit <COUNT>`	<COUNT> – amount of iterative requests to RADIUS server, takes values of [1..10]. Default value: 1.
3	Set the global value of the interval after which the router assumes that the RADIUS server is not available (optional).	`esr(config)# radius-server timeout <SEC>`	<SEC> – time interval in seconds, takes values of [1..30]. Default value: 3 seconds.
4	Add RADIUS server to the list of used servers and switch to its configuration mode.	`esr(config)# radius-server host { <IP-ADDR> | <IPV6-ADDR> } [ vrf <VRF> ]` `esr(config-radius-server)#`	<IP-ADDR> – RADIUS server IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <IPV6-ADDR> – RADIUS server IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF] <VRF> – VRF instance name, set by the string of up to 31 characters.

Step	Description	Command	Keys
5	Specify the number of failed authentication attempts to block the user login and time of the lock (optional).	`aaa authentication attempts max-fail <COUNT> <TIME>`	<COUNT> – amount of failed authentication attempts after which a user is blocked, takes the values of [1..65535]; <TIME> – user blocking time in seconds, takes the values of [1..65535]. Default value: <COUNT> – 5; <TIME> – 300
6	Set the password for authentication on remote RADIUS server.	`esr(config-radius-server)# key ascii-text { <TEXT> | encrypted <ENCRYPTED-TEXT> }`	<TEXT> – string [8..16] ASCII characters; <ENCRYPTED-TEXT> – encrypted password, [8..16] bytes size, set by the string of [16..32] characters.
7	Prioritize the use of a remote RADIUS server (optional).	`esr(config-radius-server)# priority <PRIORITY>`	<PRIORITY> – remote server priority, takes values in the range of [1..65535]. The lower value, the higher the priority of server is. Default value: 1.
8	Set the interval after which the router assumes that the RADIUS server is not available (optional).	`esr(config-radius-server)# timeout <SEC>`	<SEC> – time interval in seconds, takes values of [1..30]. Default value: global timer value is used.
9	Set IPv4/IPv6 address that will be used as source IPv4/IPv6 address in transmitted RADIUS packets.	`esr(config-radius-server)# source-address { <ADDR> | <IPV6-ADDR> }`	<ADDR> – source IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <IPV6-ADDR> – source IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF].

Step	Description	Command	Keys
10	Set radius as authentication method.	`esr(config)# aaa authentication login { default | <NAME> } <METHOD 1> [ <METHOD 2> ] [ <METHOD 3> ] [ <METHOD 4> ]`	<NAME> – list name, set by the string of up to 31 characters. Authentication methods: • local – authentication by local user base; • tacacs – authentication by TACACS server list; • radius – authentication by RADIUS server list; • ldap – authentication by LDAP server list.
11	Set radius as authentication method of user privileges elevation.	`esr(config)# aaa authentication enable <NAME><METHOD 1> [ <METHOD 2> ] [ <METHOD 3> ] [ <METHOD 4> ]`	<NAME> – list name, set by the string of up to 31 characters; • default – default list name. <METHOD> – authentication methods: • enable – authentication by enable passwords; • tacacs – authentication by TACACS; • radius – authentication by RADIUS; • ldap – authentication by LDAP.
12	Set the method for iterating over authentication methods (optional).	`esr(config)# aaa authentication mode <MODE>`	<MODE> – options of iterating over methods: • chain – if the server returned FAIL, proceed to the following authentication method in the chain; • break – if the server returned FAIL, abandon authentication attempts. If the server is unavailable, continue authentication attempts by the following methods in the chain. Default value: chain.

Step	Description	Command	Keys
13	Configure radius in the list of user session accounting methods (optional).	`esr(config)# aaa accounting login start-stop <METHOD 1> [ <METHOD 2> ]`	<METHOD> – accounting methods: • tacacs – session accounting by TACACS; • radius – session accounting by RADIUS.
14	Switch to the corresponding terminal configuration mode.	`esr(config)# line <TYPE>`	<TYPE> – console type: • console – local console; • ssh – secure remote console.
15	Activate user login authentication list.	`esr(config-line-console)# login authentication <NAME>`	<NAME> – list name, set by the string of up to 31 characters. Created in step 8.
16	Activate authentication list of user privileges elevation.	`esr(config-line-console)# enable authentication <NAME>`	<NAME> – list name, set by the string of up to 31 characters. Created in step 9.

7.2.2 AAA configuration algorithm via TACACS

Step	Description	Command	Keys
1	Set the DSCP code global value for the use in IP headers of TACACS server egress packets (optional).	`esr(config)# tacacs-server dscp <DSCP>`	<DSCP> – DSCP code value, takes values in the range of [0..63]. Default value: 63.
2	Set the global value of the interval after which the router assumes that the TACACS server is not available (optional).	`esr(config)# tacacs-server timeout <SEC>`	<SEC> – time interval in seconds, takes values of [1..30]. Default value: 3 seconds.
3	Add TACACS server to the list of used servers and switch to its configuration mode.	`esr(config)# tacacs-server host { <IP-ADDR> | <IPV6-ADDR> } [ vrf <VRF> ]` `esr(config- tacacs-server)#`	<IP-ADDR> – TACACS server IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255] <IPV6-ADDR> – TACACS server IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF] <VRF> – VRF instance name, set by the string of up to 31 characters.

Step	Description	Command	Keys
4	Specify the number of failed authentication attempts to block the user login and time of the lock (optional)	`aaa authentication attempts max-fail <COUNT> <TIME>`	<COUNT> – amount of failed authentication attempts after which a user is blocked, takes the values of [1..65535]; <TIME> – user blocking time in minutes, takes the values of [1..65535]. Default value: <COUNT> – 5; <TIME> – 300
5	Set the password for authentication on remote TACACS server.	`esr(config-tacacs-server)# key ascii-text { <TEXT> | encrypted <ENCRYPTED-TEXT> }`	<TEXT> – string [8..16] ASCII characters; <ENCRYPTED-TEXT> – encrypted password, [8..16] bytes size, set by the string of [16..32] characters.
6	Set the port number to communicate with remote TACACS server (optional).	`esr(config-tacacs-server)# port <PORT>`	<PORT> – number of TCP port to exchange data with a remote server, takes values of [1..65535]. Default value: 49 for TACACS server.
7	Prioritize the use of a remote TACACS server (optional).	`esr(config-tacacs-server)# priority <PRIORITY>`	<PRIORITY> – remote server priority, takes values in the range of [1..65535]. The lower value, the higher the priority of server is. Default value: 1.
8	Set IPv4/IPv6 address that will be used as source IPv4/IPv6 address in transmitted TACACS packets.	`esr(config-radius-tacacs)# source-address { <ADDR> | <IPV6-ADDR> }`	<ADDR> – source IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255];

Step	Description	Command	Keys
9	Set TACACS as authentication method of user privileges elevation.	`esr(config)# aaa authentication enable <NAME><METHOD 1> [ <METHOD 2> ] [ <METHOD 3> ] [ <METHOD 4> ]`	<NAME> – list name, set by the string of up to 31 characters; • default – default list name. <METHOD> – authentication methods: • enable – authentication by enable passwords; • tacacs – authentication by TACACS; • radius – authentication by RADIUS; • ldap – authentication by LDAP.
10	Set the method for iterating over authentication methods (optional).	`esr(config)# aaa authentication mode <MODE>`	<MODE> – options of iterating over methods: • chain – if the server returned FAIL, proceed to the following authentication method in the chain; • break – if the server returned FAIL, abandon authentication attempts. If the server is unavailable, continue authentication attempts by the following methods in the chain. Default value: chain.
11	Configure the list of CLI commands accounting methods (optional).	`esr(config)# aaa accounting commands stop-only tacacs`	
12	Configure tacacs in the list of user session accounting methods (optional).	`esr(config)# aaa accounting login start-stop <METHOD 1> [ <METHOD 2> ]`	<METHOD> – accounting methods: • tacacs – session accounting by TACACS; • radius – session accounting by RADIUS.
13	Switch to the corresponding terminal configuration mode.	`esr(config)# line <TYPE>`	<TYPE> – console type: • console – local console; • ssh – secure remote console.
14	Activate user login authentication list.	`esr(config-line-console)# login authentication <NAME>`	<NAME> – list name, set by the string of up to 31 characters. Created in step 7.

Step	Description	Command	Keys
15	Activate authentication list of user privileges elevation.	`esr(config-line-console)# enable authentication <NAME>`	<NAME> – list name, set by the string of up to 31 characters. Created in step 8.

7.2.3 AAA configuration algorithm via LDAP

Step	Description	Command	Keys
1	Specify basic DN (Distinguished name) which will be used when searching for users.	`esr(config)# ldap-server base-dn <NAME>`	<NAME> – basic DN, set by the string of up to 255 characters.
2	Set the interval after which the router assumes that the LDAP server is not available (optional).	`esr(config)# ldap-server bind timeout <SEC>`	<SEC> – time interval in seconds, takes values of [1..30]. Default value: 3 seconds.
3	Specify the DN (Distinguished name) of a user with administrator rights, under which authorization will take place on the LDAP server when searching for users.	`esr(config)# ldap-server bind authenticate root-dn <NAME>`	<NAME> – DN of a user with administration rights, set by the string of up to 255 characters.
4	Specify the password of a user with administrator rights, under which authorization will take place on the LDAP server when searching for users.	`esr(config)# ldap-server bind authenticate root-password ascii-text { <TEXT> | encrypted <ENCRYPTED-TEXT> }`	<TEXT> – string [8..16] ASCII characters; <ENCRYPTED-TEXT> – encrypted password, [8..16] bytes size, set by the string of [16..32] characters.
5	Specify a class name of the objects among which it is necessary to search for users on LDAP server (optional).	`esr(config)# ldap-server search filter user-object-class <NAME>`	<NAME> – object class name, set by the string of up to 127 characters. Default value: posixAccount.
6	Specify the user search scope in LDAP server tree (optional).	`esr(config)# ldap-server search scope <SCOPE>`	<SCOPE> – user search scope on LDAP server, takes the following values: • onelevel – search through the objects on the level following a basic DN tree in LDAP server tree; • subtree – search through all objects of basic DN subtree in LDAP server tree. Default value: subtree.

Step	Description	Command	Keys
7	Specify the interval after which the device assumes that LDAP server has not found users entries satisfying the search condition (optional).	`esr(config)# ldap-server search timeout <SEC>`	<SEC> – time interval in seconds, takes values of [0..30] Default value: 0 – device is waiting for search completion and response from LDAP server.
8	Specify an attribute name of the object which is compared with the name of the desired user on LDAP server (optional).	`esr(config)# ldap-server naming-attribute <NAME>`	<NAME> – object attribute name, set by the string of up to 127 characters. Default value: uid.
9	Specify the object attribute name which is compared with the name of a desired user on LDAP server (optional).	`esr(config)# ldap-server privilege-level-attribute <NAME>`	<NAME> – object attribute name, set by the string of up to 127 characters. Default value: priv-lvl
10	Set the DSCP code global value for the use in IP headers of LDAP server egress packets (optional).	`esr(config)# ldap-server dscp <DSCP>`	<DSCP> – DSCP code value, takes values in the range of [0..63]. Default value: 63
11	Add LDAP server to the list of used servers and switch to its configuration mode.	`esr(config)# ldap -server host { <IP-ADDR> | <IPV6-ADDR> } [ vrf <VRF> ]` `esr(config- ldap -server)#`	<IP-ADDR> – LDAP server IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255] <IPV6-ADDR> – LDAP server IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF] <VRF> – VRF instance name, set by the string of up to 31 characters.
12	Specify the number of failed authentication attempts to block the user login and time of the lock (optional)	`aaa authentication attempts max-fail <COUNT> <TIME>`	<COUNT> – amount of failed authentication attempts after which a user is blocked, takes the values of [1..65535]; <TIME> – user blocking time in minutes, takes the values of [1..65535]. Default value: <COUNT> – 5; <TIME> – 300

Step	Description	Command	Keys
13	Set the port number to communicate with remote LDAP server (optional).	`esr(config-ldap-server)# port <PORT>`	<PORT> – number of TCP port to exchange data with a remote server, takes values of [1..65535]. Default value: 389 for LDAP server.
14	Prioritize the use of a remote LDAP server (optional).	`esr(config-ldap-server)# priority <PRIORITY>`	<PRIORITY> – remote server priority, takes values in the range of [1..65535]. The lower value, the higher the priority of server is. Default value: 1.
15	Set IPv4/IPv6 address that will be used as source IPv4/IPv6 address in transmitted LDAP packets.	`esr(config-ldap-server)# source-address { <ADDR> | <IPV6-ADDR> }`	<ADDR> – source IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <IPV6-ADDR> – source IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF].
16	Set LDAP as authentication method.	`esr(config)# aaa authentication login { default | <NAME> } <METHOD 1> [ <METHOD 2> ] [ <METHOD 3> ] [ <METHOD 4> ]`	<NAME> – list name, set by the string of up to 31 characters. Authentication methods: • local – authentication by local user base; • tacacs – authentication by TACACS server list; • radius – authentication by RADIUS server list; • ldap – authentication by LDAP server list.

Step	Description	Command	Keys
17	Set LDAP as authentication method of user privileges elevation.	`esr(config)# aaa authentication enable <NAME> <METHOD 1> [ <METHOD 2> ] [ <METHOD 3> ] [ <METHOD 4> ]`	<NAME> – list name, set by the string of up to 31 characters; • default – default list name. <METHOD> – authentication methods: • enable – authentication by enable passwords; • tacacs – authentication by TACACS; • radius – authentication by RADIUS; • ldap – authentication by LDAP.
18	Set the method for iterating over authentication methods.	`esr(config)# aaa authentication mode <MODE>`	<MODE> – options of iterating over methods: • chain – if the server returned FAIL, proceed to the following authentication method in the chain; • break – if the server returned FAIL, abandon authentication attempts. If the server is unavailable, continue authentication attempts by the following methods in the chain. Default value: chain.
19	Switch to the corresponding terminal configuration mode.	`esr(config)# line <TYPE>`	<TYPE> – console type: • console – local console; • ssh – secure remote console.
20	Activate user login authentication list.	`esr(config-line-console)# login authentication <NAME>`	<NAME> – list name, set by the string of up to 31 characters. Created in step 14.
21	Activate authentication list of user privileges elevation.	`esr(config-line-console)# enable authentication <NAME>`	<NAME> – list name, set by the string of up to 31 characters. Created in step 15.

7.2.4 Example of authentication configuration using telnet via RADIUS server

Objective:

Configure authentication for users being connected via Telnet and RADIUS (192.168.16.1/24).

Solution:

Configure connection to RADIUS server and specify the key (password):

```
esr# configure
esr(config)# radius-server host 192.168.16.1
esr(config-radius-server)# key ascii-text encrypted 8CB5107EA7005AFF
esr(config-radius-server)# exit
```

Create authentication profile:

```
esr(config)# aaa authentication login log radius
```

Specify authentication mode used for Telnet protocol connection:

```
esr(config)# line telnet
esr(config-line-telnet)# login authentication log
esr(config-line-telnet)# exit
esr(config)# exit
```

To view the information on RADIUS server connection settings, use the following command:

```
esr# show aaa radius-servers
```

To view the authentication profiles, use the following command:

```
esr# show aaa authentication
```

7.3 Command privilege configuration

Command privilege configuration is a flexible tool that allows you to assign baseline user privilege level (1–15) to a command set. In future, you may specify privilege level during user creation which will define a command set available to them.

- *Levels 1-9* enable all monitoring commands (show …);
- *Levels 10-14* enable all commands except for device reboot, user management and other specific commands;
- *Level 15* enables all monitoring commands.

7.3.1 Configuration algorithm

To change minimum privilege level required for CLI command execution, use the following command:

```
esr(config)# privilege <COMMAND-MODE> level <PRIV><COMMAND>
```

<COMMAND-MODE> – command mode;

<PRIV> – required command subtree privilege level, takes value in the range of [1..15];

<COMMAND> – command subtree, set by the string of up to 255 characters.

7.3.2 Example of command privilege configuration

Objective:

Transfer all interface information display commands to the privilege level 10 except for 'show interfaces bridges' command. Transfer 'show interfaces bridges' command to the privilege level 3.

Solution:

In configuration mode, identify commands enabled for operation under privilege level 10 and privilege level 3:

```
esr(config)# privilege root level 3 "show interfaces bridge"
esr(config)# privilege root level 10 "show interfaces"
```

7.4 Configuration of logging and protection against network attacks

7.4.1 Configuration algorithm

Step	Description	Command	Keys
1	Enable protection against ICMP flood attacks.	`esr(config)# ip firewall screen dos-defense icmp-threshold { <NUM> }`	<NUM> – amount of ICMP packets per second, set in the range of [1..10000]
2	Enable protection against land attacks.	`esr(config)# firewall screen dos-defense land`	
3	Enable the limitation on amount of simultaneous sessions based on the destination address	`esr(config)# ip firewall screen dos-defense limit-session-destination { <NUM> }`	<NUM> – limitation on amount of IP sessions, set in the range of [1..10000].
4	Enable the limitation on the amount of simultaneous sessions, based on the source address, that mitigates DoS attacks.	`esr(config)# ip firewall screen dos-defense limit-session-source { <NUM> }`	<NUM> – limitation on amount of IP sessions, set in the range of [1..10000].

Step	Description	Command	Keys
5	Enable protection against SYN flood attacks.	`esr(config)# ip firewall screen dos-defense syn-flood { <NUM> } [src-dsr]`	<NUM> – maximum amount of TCP packets with the set SYN flag per second, set in the range of [1..10000]. src-dst – limitation on the amount of TCP packets with the SYN flag set, based on the source and destination addresses.
6	Enable protection against UDP flood attacks.	`esr(config)# ip firewall screen dos-defense udp-threshold { <NUM> }`	<NUM> – maximum amount of UDP packets per second, set in the range of [1..10000].
7	.Enable protection against winnuke attacks.	`esr(config)# ip firewall screen dos-defense winnuke`	
8	Enable the blocking of TCP packets with the FIN flag set and the ACK flag not set.	`esr(config)# ip firewall screen spy-blocking fin-no-ack`	
9	Enable the blocking of various type ICMP packets.	`esr(config)# ip firewall screen spy-blocking icmp-type`	<TYPE> – ICMP type, may take the following values: • destination-unreachable • echo-request • reserved • source-quench • time-exceeded
10	Enable the protection against IP-sweep attacks.	`esr(config)# ip firewall screen spy-blocking ip-sweep { <NUM> }`	<NUM> – ip sweep attack detection time, set in milliseconds [1..1000000].
11	Enable protection against port scan attacks.	`esr(config)# ip firewall screen spy-blocking port-scan { <threshold> } [ <TIME> ]`	<threshold> – interval in milliseconds during which the port scan attack will be recorded [1..1000000]. <TIME> – blocking time in milliseconds [1..1000000].
12	Enable the protection against IP spoofing attacks.	`esr(config)# ip firewall screen spy-blocking spoofing`	

Step	Description	Command	Keys
13	Enable the blocking of TCP packets, with the SYN and FIN flags set.	`esr(config)# ip firewall screen spy-blocking syn-fin`	
14	Enable the blocking of TCP packets, with all flags or with the set of flags: FIN, PSH, URG. The given command provides the protection against XMAS attack	`esr(config)# ip firewall screen spy-blocking tcp-all-flag`	
15	Enable the blocking of TCP packets, with the zero “flags” field.	`esr(config)# ip firewall screen spy-blocking tcp-no-flag`	
16	Enable the blocking of fragmented ICMP packets.	`esr(config)# ip firewall screen suspicious-packets icmp-fragment`	
17	Enable the blocking of fragmented IP packets.	`esr(config)# ip firewall screen suspicious-packets ip-fragment`	
18	Enable the blocking of ICMP packets more than 1024 bytes.	`esr(config)# ip firewall screen suspicious-packets icmp-fragment`	
19	Enable the blocking of fragmented TCP packets, with the SYN flag.	`esr(config)# ip firewall screen suspicious-packets syn-fragment`	
20	Enable the blocking of fragmented UDP packets.	`esr(config)# ip firewall screen suspicious-packets udp-fragment`	
21	Enable the blocking of packets, with the protocol ID contained in IP header equal to 137 and more.	`esr(config)# ip firewall screen suspicious-packets unknown-protocols`	
22	Set the frequency of notification (via SNMP, syslog and in CLI) of detected and blocked network attacks.	`esr(config)# ip firewall logging interval <NUM>`	<NUM> – time interval in seconds [30 .. 2147483647]

Step	Description	Command	Keys
23	Enable more detailed message output about detected and blocked network attacks in the CLI.	`esr(config)# logging firewall screen detailed`	
24	Enable mechanism of DoS attacks detection and logging via CLI, syslog and SNMP.	`esr(config)# logging firewall screen dos-defense <ATACK_TYPE>`	<ATACK_TYPE> – DoS attack type, takes the following values: icmp-threshold, land, limit-session-destination, limit-session-source, syn-flood, udp-threshold, winnuke.
25	Enable mechanism of espionage activity detection and logging via CLI, syslog and SNMP.	`esr(config)# logging firewall screen spy-blocking { <ATACK_TYPE> | icmp-type <ICMP_TYPE> }`	<ATACK_TYPE> – espionage activity type, takes the following values: fin-no-ack, ip-sweep, port-scan, spoofing, syn-fin, tcp-all-flag, tcp-no-flag. <ICMP_TYPE> – ICMP type, takes the following values: destination-unreachable, echo-request, reserved, source-quench, time-exceeded.
26	Enable mechanism of specialized packets detection and logging via CLI, syslog and SNMP.	`esr(config)# logging firewall screen suspicious-packets <PACKET_TYPE>`	<PACKET_TYPE> – specialized packets type, takes the following values: icmp-fragment, ip-fragment, large-icmp, syn-fragment, udp-fragment, unknown-protocols.

7.4.2 Description of attack protection mechanisms

Command	Description
ip firewall screen dos-defense icmp-threshold	The given command enables the protection against ICMP flood attacks. When the protection is enabled, the amount of all types ICMP packets per second for one destination address is limited. The attack leads to the host reboot and its failure due to the necessity to process each query and respond to it.
firewall screen dos-defense land	The given command enables the protection against land attacks. When the protection is enabled, the packets with the same source and destination IP addresses and with SYN flag in TCP header are blocked. The attack leads to the host reboot and its failure due to the necessity to process each TCP SYN packet and the attempts of the host to establish a TCP session with itself.
ip firewall screen dos-defense limit-session-destination	When the host IP sessions table is overfilled, the host is unable to establish new sessions and it drops the requests (this may happen during various attacks: SYN flood, UDP flood, ICMP flood, etc.). The command enables the limitation on the amount of simultaneous sessions, based on the source address, that mitigates DoS attacks.

Command	Description
ip firewall screen dos-defense limit-session-source	When the host IP sessions table is overfilled, the host is unable to establish new sessions and it drops the requests (this may happen during various DoS attacks: SYN flood, UDP flood, ICMP flood, etc.). The command enables the limitation on the amount of simultaneous sessions, based on the source address, that mitigates DoS attacks.
ip firewall screen dos-defense syn-flood	The given command enables the protection against SYN flood attacks. When the protection is enabled, the amount of TCP packets with the SYN flag set per second for one destination address is limited. The attack leads to the host reboot and its failure due to the necessity to process each TCP SYN packet and the attempts to establish a TCP session.
ip firewall screen dos-defense udp-threshold	The given command enables the protection against UDP flood attacks. When the protection is enabled, the amount of UDP packets per second for one destination address is limited. The attack lead to the host reboot and its failure due to the massive UDP traffic.
ip firewall screen dos-defense winnuke	The given command enables the protection against winnuke attacks. When the protection is enabled, TCP packets with the URG flag set and 139 destination port are blocked. The attack leads to the older Windows versions (up to 95 version) failure.
ip firewall screen spy-blocking fin-no-ack	The given command enables the blocking of TCP packets with the FIN flag set and the ACK flag not set. These packets are specialized and it is possible to determine a victim operational system by the respond.
ip firewall screen spy-blocking icmp-type destination-unreachable	The given command enables the blocking of all 3 type ICMP packets (destination-unreachable) including the packets generated by the router itself. The protection prevents an attacker from learning about network topology and hosts availability
ip firewall screen spy-blocking icmp-type echo-request	The given command enables the blocking of all 8 type ICMP packets (echo-request) including the packets generated by the router itself. The protection prevents an attacker from learning about network topology and hosts availability
ip firewall screen spy-blocking icmp-type reserved	The given command enables the blocking of all 2 and 7 type ICMP packets (reserved) including the packets generated by the router itself. The protection prevents an attacker from learning about network topology and hosts availability
ip firewall screen spy-blocking icmp-type source-quench	The given command enables the blocking of all 4 type ICMP packets (source quench) including the packets generated by the router itself. The protection prevents an attacker from learning about network topology and hosts availability

Command	Description
ip firewall screen spy-blocking icmp-type time-exceeded	The given command enables the blocking of all 11 type ICMP packets (time exceeded) including the packets generated by the router itself. The protection prevents an attacker from learning about network topology and hosts availability
ip firewall screen spy-blocking ip-sweep	The given command enables the protection against IP-sweep attacks. When the protection is enabled, if more than 10 ICMP queries from one source arrive within the specified interval, the first 10 queries are dropped by the router and 11th with the following ones are discarded for the remaining interval time. The protection prevents an attacker from learning about network topology and hosts availability.
ip firewall screen spy-blocking port-scan	The given command enables the protection against port scan attacks. If more than 10 TCP packets with the SYN flag arrive to several TCP ports and or more than 10 UDP packets arrive ti several UDP ports of one source within the first specified interval (<threshold>), then this behaviour is recorded as port scan attack and all the following packets of that type are blocked for the second specified time interval (<TIME>). An attacker will not be able to scan the device open ports quickly.
ip firewall screen spy-blocking spoofing	The given command enables the protection against ip spoofing attacks. When the protection is enabled, the router checks packets for matching the source address and routing table entries, and in case of mismatch the packet is dropped. For example, if a packet with source address 10.0.0.1/24 arrives to the Gi1/0/1 interface and the given subnet is located after the Gi1/0/2 interface in the routing table, it is considered that the source address has been replaced. Protects from network intrusions with replaced source IP addresses.
ip firewall screen spy-blocking syn-fin	The given command enables the blocking of TCP packets, with the SYN and FIN flags set. These packets are specialized and it is possible to determine a victim operational system by the respond.
ip firewall screen spy-blocking tcp-all-flag	This command enables the blocking of TCP packets, with all flags or with the set of flags: FIN, PSH, URG. The protection against XMAS attack is provided.
ip firewall screen spy-blocking tcp-no-flag	This command enables the blocking of TCP packets with the zero 'flags' field. These packets are specialized and it is possible to determine a victim operational system by the respond.
ip firewall screen suspicious-packets icmp-fragment	The given command enables the blocking of fragmented ICMP packets. ICMP packets are usually small and there is no need to fragment them.
ip firewall screen suspicious-packets ip-fragment	The given command enables the blocking of fragmented packets.
ip firewall screen suspicious-packets large-icmp	The given command enables the blocking of ICMP packets more than 1024 bytes.

Command	Description
ip firewall screen suspicious-packets syn-fragment	This command enables the blocking of fragmented TCP packets with the SYN flag. TCP packets with the SYN flag are usually small and there is no need to fragment them. The protection prevents concentration of fragmented packets in a buffer.
ip firewall screen suspicious-packets udp-fragment	The given command enables the blocking of fragmented UDP packets.
ip firewall screen suspicious-packets unknown-protocols	The given command enables the blocking of packets, with the protocol ID contained in IP header equal to 137 and more.

7.4.3 Configuration example of logging and protection against network attacks

Objective:

Protect LAN and ESR router from land, syn-flood, ICMP flood network attacks and configure the notification of attacks by SNMP to SNMP server 192.168.0.10

Solution:

You should first configure interfaces and firewall (firewall configuration or its absence will not influence on the operation of network attacks protection):

```
esr(config)# security zone LAN
esr(config-zone)# exit
esr(config)# security zone WAN
esr(config-zone)# exit
esr(config)# security zone-pair LAN WAN
esr(config-zone-pair)# rule 100
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# ex
esr(config-zone-pair)# exit
esr(config)# security zone-pair WAN LAN
esr(config-zone-pair)# rule 100
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)# exit
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)# security-zone LAN
esr(config-if-gi)# ip address 192.168.0.1/24
esr(config-if-gi)# exit
esr(config)# interface gigabitethernet 1/0/2
esr(config-if-gi)# security-zone WAN
esr(config-if-gi)# ip address 10.0.0.1/24
esr(config-if-gi)# exit
```

Enable the protection against land, syn-flood, ICMP flood attacks:

```
esr(config)# ip firewall screen dos-defense land
esr(config)# ip firewall screen dos-defense syn-flood 100 src-dst
esr(config)# ip firewall screen dos-defense icmp-threshold 100
```

Configure the logging of detected attacks:

```
esr(config)# ip firewall logging screen dos-defense land
esr(config)# ip firewall logging screen dos-defense syn-flood
esr(config)# ip firewall logging screen dos-defense icmp-threshold
```

Configure SNMP server to which the traps will be sent:

```
esr(config)# snmp-server
esr(config)# snmp-server host 192.168.0.10
```

To view the statistics on recorded network attacks, use the following command:

```
esr# show ip firewall screen counters
```

7.5 Firewall configuration

Firewall is a package of hardware or software tools that allows for control and filtering of transmitted network packets in accordance with the defined rules.

7.5.1 Configuration algorithm

Step	Description	Command	Keys
1	Create security zones.	`esr(config)# security zone <zone-name1>` `esr(config)# security zone <zone-name2>`	<zone-name> – up to 12 characters.
2	Specify a security zone description.	`esr(config-zone)# description <description>`	<description> – up to 255 characters..
3	Specify VRF instance, in which the given security zone will operate (optional).	`esr(config- zone )# ip vrf forwarding <VRF>`	<VRF> – VRF name, set by the string of up to 31 characters.
4	Enable session counters for NAT and Firewall (optional, may reduce the performance).	`esr(config)# ip firewall sessions counters`	
5	Disable filtration of packets for which it was not possible to determine belonging to any known connection and which are not the beginning of a new connection (optional, may reduce the performance).	`esr(config)# ip firewall sessions allow-unknown`	
6	Select firewall operation mode (optional)	`esr(config)# ip firewall mode <MODE>`	<MODE> – firewall operation mode, may take the following values: stateful, stateless. Default value: stateful
7	Determine the session lifetime for unsupported protocols (optional).	`esr(config)# ip firewall sessions generic-timeout <TIME>`	<TIME> – session lifetime for unsupported protocols, takes values in seconds [1..8553600]. Default value: 60 seconds.
8	Determine ICMP session lifetime after which it is considered to be outdated (optional).	`esr(config)# ip firewall sessions icmp-timeout <TIME>`	<TIME> – ICMP session lifetime, takes values in seconds [1..8553600]. Default value: 30 seconds.

Step	Description	Command	Keys
9	Determine ICMPv6 session lifetime after which it is considered to be outdated (optional).	`esr(config)# ip firewall sessions icmpv6-timeout <TIME>`	<TIME> – ICMP session lifetime, takes values in seconds [1..8553600]. Default value: 30 seconds.
10	Determine the size of outstanding sessions table (optional).	`esr(config)# ip firewall sessions max-expect <COUNT>`	<COUNT> – table size, takes values of [1..8553600]. Default value: 256.
11	Determine the size of trackable sessions table (optional).	`esr(config)# ip firewall sessions max-tracking <COUNT>`	<COUNT> – table size, takes values of [1..8553600]. Default value: 512000.
12	Determine the lifetime of TCP session in “connection is being established” state after which it is considered to be outdated (optional).	`esr(config)# ip firewall sessions tcp-connect-timeout <TIME>`	<TIME> – lifetime of TCP session in “connection is being established” state, takes values in seconds [1..8553600]. Default value: 60 seconds.
13	Determine the lifetime of TCP session in 'connection is being closed' state after which it is considered to be outdated (optional).	`esr(config)# ip firewall sessions tcp-disconnect-timeout <TIME>`	<TIME> – lifetime of TCP session in “connection is being closed” state, takes values in seconds [1..8553600]. Default value: 30 seconds.
14	Determine the lifetime of TCP session in “connection is being established” state after which it is considered to be outdated (optional).	`esr(config)# ip firewall sessions tcp-established-timeout <TIME>`	<TIME> – lifetime of TCP session in “connection is being established” state, takes values in seconds [1..8553600]. Default value: 120 seconds.
15	Determine the timeout after which the closed TCP session is actually deleted from the table of trackable sessions (optional).	`esr(config)# ip firewall sessions tcp-latecome-timeout <TIME>`	<TIME> – timeout, takes value in seconds [1..8553600]. Default value: 120 seconds.

Step	Description	Command	Keys
16	Enable application-level session tracking for certain protocols (optional).	`esr(config)# ip firewall sessions tracking`	<PROTOCOL> - application-level protocol [ftp, h323, pptp, netbios-ns, tftp] sessions of which should be tracked. <OBJECT-GROUP-SERVICE> – sip session TCP/UDP ports' profile name, set by the string of up to 31 characters. If a group is not specified, sip sessions monitoring will be performed for 5060 port. Instead of a certain protocol you can use the "all" key that enables application-level session tracking for all available protocols. By default - disabled for all protocols.
17	Determine the lifetime of UDP session in "connection is confirmed" state after which it is considered to be outdated (optional).	`esr(config)# ip firewall sessions udp-assured-timeout <TIME>`	<TIME> – lifetime of UDP session in "connection is confirmed" state, takes values in seconds [1..8553600]. Default value: 180 seconds.
18	Determine the lifetime of UDP session in 'connection is not confirmed' state after which it is considered to be outdated.	`esr(config)# ip firewall sessions udp-wait-timeout <TIME>`	<TIME> – lifetime of UDP session in "connection is not confirmed" state, takes values in seconds [1..8553600]. Default value: 30 seconds.
19	Create IP addresses lists which will be used during filtration.	`esr(config)# object-group network <obj-group-name>`	<obj-group-name> – up to 31 characters.
20	Specify IP addresses list description (optional).	`esr(config-object-group-network)# description <description>`	<description> – profile description, set by the string of up to 255 characters.
21	Add necessary IPv4/IPv6 addresses to the list.	`esr(config-object-group-network)# ip prefix <ADDR/LEN>`	<ADDR/LEN> – subnet, defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32].

Step	Description	Command	Keys
		`esr(config-object-group-network)# ip address-range <FROM-ADDR>-<TO-ADDR>`	<FROM-ADDR> – range starting IP address; <TO-ADDR> – range ending IP address, optional parameter; If the parameter is not specified, a single IP address is set by the command. The addresses are defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
		`esr(config-object-group-network)# ipv6 prefix <IPV6-ADDR/LEN>`	<IPV6-ADDR/LEN> – IP address and mask of a subnet, defined as X:X:X:X::X/EE where each X part takes values in hexadecimal format [0..FFFF] and EE takes values of [1..128].
		`esr(config-object-group-network)# ipv6 address-range <FROM-ADDR>-<TO-ADDR>`	<FROM-ADDR> – range starting IPv6 address; <TO-ADDR> – range ending IPv6 address, optional parameter. If the parameter is not specified, a single IPv6 address is set by the command. The addresses are defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF].
22	Create services lists which will be used during filtration.	`esr(config)# object-group service <obj-group-name>`	<obj-group-name> – service profile name, set by the string of up to 31 characters.
23	Specify services list description (optional).	`esr(config-object-group-service)# description <description>`	<description> – profile description, set by the string of up to 255 characters.
24	Add necessary services (tcp/udp ports) to the list.	`esr(config-object-group-service)# port-range <port>`	<port> – takes values in the range of [1..65535]. You can specify several ports separated by commas “,” or you can specify the range of ports with “-”.
25	Create applications lists which will be used in DPI mechanism.	`esr(config)# object-group application <NAME>`	<NAME> – application profile name, set by the string of up to 31 characters.

Step	Description	Command	Keys
26	Specify applications list description (optional).	`esr(config-object-group-application)# description <description>`	<description> – profile description, set by the string of up to 255 characters.
27	Add necessary applications to the lists.	`esr(config-object-group-application)# application < APPLICATION >`	<APPLICATION> – specifies the application covered by the given profile
28	Add interfaces (physical, logical, E1/Multilink and connected), remote-access server (l2tp, openvpn, pptp) or tunnels (gre, ip4ip4, l2tp, lt, pppoe, pptp) into security zones (optional).	`esr(config-if-gi)# security-zone <zone-name>`	<zone-name> – up to 12 characters.
	Disable Firewall functions on the network interface (physical, logical, E1/Multilink and connected), remote-access server (l2tp, openvpn, pptp) or tunnels (gre, ip4ip4, l2tp, lt, pppoe, pptp) (optional).	`esr(config-if-gi)# ip firewall disable`	
29	Create an interzone interaction rule set.	`esr(config)# security zone-pair <src-zone-name1> <dst-zone-name2>`	<src-zone-name> – up to 12 characters. <dst-zone-name> – up to 12 characters.
30	Create an interzone interaction rule set.	`esr(config-zone-pair)# rule <rule-number>`	<rule-number> – 1..10000.
31	Specify rule description (optional).	`esr(config-zone-rule)# description <description>`	<description> – up to 255 characters..
32	Specify the given rule force.	`esr(config-zone-rule)# action <action> [ log ]`	<action> – permit/deny/reject/ netflow-sample/sflow-sample log – activation key for logging of sessions established according to the given rule.
33	Set name or number of IP for which the rule should work (optional).	`esr(config-zone-rule)# match [not] protocol <protocol-type>`	<protocol-type> – protocol type, takes the following values: esp, icmp, ah, eigrp, ospf, igmp, ipip, tcp, pim, udp, vrrp, rdp, l2tp, gre. When specifying the “any” value, the rule will work for any protocols.

Step	Description	Command	Keys
		`esr(config-zone-rule)# match [not] protocol-id <protocol-id>`	<protocol-id> – IP identification number, takes values of [0x00-0xFF].
34	Specify the profile of transmitter IP addresses for which the rule should work (optional).	`esr(config-zone-rule)# match [not] source-address <OBJ-GROUP-NETWORK-NAME>`	<OBJ-GROUP-NETWORK-NAME> – IP addresses profile name, set by the string of up to 31 characters. When specifying the “any” value, the rule will work for any sender/recipient IP address.
35	Set the profile of destination IP addresses for which the rule should work (optional).	`esr(config-zone-rule)# match [not] destination-address <OBJ-GROUP-NETWORK-NAME>`	
36	Set source MAC address for which the rule should work (optional).	`esr(config-zone-rule)# match [not] source-mac <mac-addr>`	<mac-addr> – defined as XX:XX:XX:XX:XX:XX where each part takes the values of [00..FF].
37	Set sender MAC address for which the rule should work (optional).	`esr(config-zone-rule)# match [not] destination-mac <mac-addr>`	
38	Set TCP/UDP ports profile for which the rule should work (if the protocol is specified).	`esr(config-zone-rule)# match [not] source-port <PORT-SET-NAME>`	<PORT-SET-NAME> – set by the string of up to 31 characters. When specifying the “any” value, the rule will work for any sender/recipient TCP/UDP port.
39	Set the destination TCP/UDP ports profile for which the rule should work (if the protocol is specified).	`esr(config-zone-rule)# match [not] destination-port <PORT-SET-NAME>`	
40	Specify the type and code of ICMP messages for which the rule should work (if ICMP is selected as protocol) (optional).	`esr(config-zone-rule)# match [not] icmp <ICMP_TYPE> <ICMP_CODE>`	<ICMP_TYPE> – ICMP message type, takes values of [0..255]. <ICMP_CODE> – ICMP message code, takes values of [0..255]. When specifying the “any” value, the rule will work for any ICMP message code.
41	Set the limitation under which the rule will only work for traffic modified by the IP address and destination ports translation service.	`esr(config-zone-rule)# match [not] destination-nat`	
42	Set the maximum packet rate (optional, available only for zone-pair any self and zone-pair <zone-name> any).	`esr(config-zone-pair-rule)# rate-limit pps <rate-pps>`	<rate-pps> – maximum amount of packets that can be transmitted. Takes values in the range of [1..10000].

Step	Description	Command	Keys
43	Set the filtration only for fragmented IP packets (optional, available only for zone-pair any self and zone-pair <zone-name> any).	`esr(config-zone-pair-rule)# match [not] fragment`	
44	Set the filtration only for IP packets including ip-option (optional, available only for zone-pair any self and zone-pair <zone-name> any).	`esr(config-zone-pair-rule)# match [not] ip-option`	
45	Create an interzone interaction rule.	`esr(config-zone-rule)# enable`	
46	Enable filtering and session tracking mode while packets are transmitted between one Bridge group participants (optional, available only for ESR-1000/1200/1500/1700)	`esr(config-bridge)# ports firewall enable`	

[1] When using the not key, the rule will work for values which are not included in a specified profile.

Each “match” command may contain “not” key. When using the key, packets that do not meet the given requirement will fall under the rule.

You can obtain more detail information about firewall configuration in “CLI command reference guide”.

7.5.2 Firewall configuration example

Objective:

Enable message passage via ICMP between R1, R2 and ESR router.

Solution:

Create a security zone for each ESR network:

```
esr# configure
esr(config)# security zone LAN
esr(config-zone)# exit
esr(config)# security zone WAN
esr(config-zone)# exit
```

Configure network interfaces and identify their inherence to security zones:

```
esr(config)# interface gi1/0/2
esr(config-if-gi)# ip address 192.168.12.2/24
esr(config-if-gi)# security-zone LAN
esr(config-if-gi)# exit
esr(config)# interface gi1/0/3
esr(config-if-gi)# ip address 192.168.23.2/24
esr(config-if-gi)# security-zone WAN
esr(config-if-gi)# exit
```

For definition of rules for security zones, create 'LAN' address profile that includes addresses which are allowed to access WAN network and 'WAN' network address profile.

```
esr(config)# object-group network WAN
esr(config-object-group-network)# ip address-range 192.168.23.2
esr(config-object-group-network)# exit
esr(config)# object-group network LAN
esr(config-object-group-network)# ip address-range 192.168.12.2
esr(config-object-group-network)# exit
esr(config)# object-group network LAN_GATEWAY
esr(config-object-group-network)# ip address-range 192.168.12.1
esr(config-object-group-network)# exit
esr(config)# object-group network WAN_GATEWAY
esr(config-object-group-network)# ip address-range 192.168.23.3
esr(config-object-group-network)# exit
```

To transfer traffic from 'LAN' zone into 'WAN' zone, create a pair of zones and add a rule allowing ICMP traffic transfer from R1 to R2. Rules are applied with the *enable* command:

```
esr(config)# security zone-pair LAN WAN
esr(config-zone-pair)# rule 1
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol icmp
esr(config-zone-pair-rule)# match destination-address WAN_GATEWAY
esr(config-zone-pair-rule)# match source-address LAN_GATEWAY
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair-pair)# exit
```

To transfer traffic from 'WAN' zone into 'LAN' zone, create a pair of zones and add a rule allowing ICMP traffic transfer from R2 to R1. Rules are applied with the *enable* command:

```
esr(config)# security zone-pair WAN LAN
esr(config-zone-pair)# rule 1
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol icmp
esr(config-zone-pair-rule)# match destination-address LAN_GATEWAY
esr(config-zone-pair-rule)# match source-address WAN_GATEWAY
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)# exit
```

Router always has a security zone named 'self'. When the traffic recipient is the router itself, i.e. traffic is not transit, pass 'self' zone as a parameter. Create a pair of zones for traffic coming from 'WAN' zone into 'self' zone. In order the router could response to the ICMP requests from 'WAN' zone, add a rule allowing ICMP traffic transfer from R2 to ESR router:

```
esr(config)# security zone-pair WAN self
esr(config-zone-pair)# rule 1
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol icmp
esr(config-zone-pair-rule)# match destination-address WAN
esr(config-zone-pair-rule)# match source-address WAN_GATEWAY
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)# exit
```

Create a pair of zones for traffic coming from 'LAN' zone into 'self' zone. In order the router could response to the ICMP requests from 'LAN' zone, add a rule allowing ICMP traffic transfer from R1 to ESR:

```
esr(config)# security zone-pair LAN self
esr(config-zone-pair)# rule 1
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol icmp
esr(config-zone-pair-rule)# match destination-address LAN
esr(config-zone-pair-rule)# match source-address LAN_GATEWAY
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)# exit
esr(config)# exit
```

To view port membership in zones, use the following command:

```
esr# show security zone
```

To view zone pairs and their configuration, use the following commands:

```
esr# show security zone-pair
esr# show security zone-pair configuration
```

To view active sessions, use the following commands:

```
esr# show ip firewall sessions
```

7.5.3 Configuration example of application filtering (DPI)

⚠ The use of application filtering mechanism reduces by several times the router performance because of the need to check each packet. The performance decreases with an increase in amount of the selected for filtration applications.

Objective:

Block access to such resources as youtube, bittorrent and facebook.

Solution:

Create a security zone for each ESR network:

```
esr# configure
esr(config)# security zone LAN
esr(config-zone)# exit
esr(config)# security zone WAN
esr(config-zone)# exit
```

Configure network interfaces and identify their inherence to security zones:

```
esr(config)# interface gi1/0/1
esr(config-if-gi)# ip address 10.0.0.1/24
esr(config-if-gi)# security-zone WAN
esr(config-if-gi)# exit
esr(config)# interface gi1/0/2
esr(config-if-te)# ip address 192.168.0.1/24
esr(config-if-te)# security-zone LAN
esr(config-if-te)# exit
```

To configure security zones rules, you should create profile of the applications that should be blocked.

```
esr(config)# object-group application APP
esr(config-object-group-application)# application youtube
esr(config-object-group-application)# application bittorrent
esr(config-object-group-application)# application facebook
esr(config-object-group-application)# exit
```

To set the rules of traffic passing from “WAN” zone to “LAN” zone, create a couple of zones and add a rule prohibiting the application traffic from passing and a rule allowing the rest of traffic to pass. Rules are applied with the *enable* command:

```
esr(config)# security zone-pair WAN LAN
esr(config-zone-pair)# rule 1
esr(config-zone-pair-rule)# action deny
esr(config-zone-pair-rule)# match application APP
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)# rule 2
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair-pair)# exit
```

To set the rules of traffic passing from “LAN” zone to “WAN” zone, create a couple of zones and add a rule allowing all traffic to pass. Rules are applied with the *enable* command:

```
esr(config)# security zone-pair LAN WAN
esr(config-zone-pair)# rule 1
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair-pair)# exit
```

To view port membership in zones, use the following command:

```
esr# show security zone
```

To view zone pairs and their configuration, use the following commands:

```
esr# show security zone-pair
esr# show security zone-pair configuration
```

To view active sessions, use the following commands:

```
esr# show ip firewall sessions
```

7.6 Access list (ACL) configuration

Access Control List or ACL is a list that contains rules defining traffic transmission through the interface.

7.6.1 Configuration algorithm

Step	Description	Command	Keys
1	Create access control list and switch to its configuration mode.	`esr(config)# ip access-list extended <NAME>`	<NAME> – access control list name, set by the string of up to 31 characters.

Step	Description	Command	Keys
2	Specify the description of a configurable access control list (optional).	`esr(config-acl)# description <DESCRIPTION>`	<DESCRIPTION> – access control list description, set by the string of up to 255 characters.
3	Create a rule and switch to its configuration mode. The rules are proceeded by the router in number ascending order.	`esr(config-acl)# rule <ORDER>`	<ORDER> – rule number, takes values of [1..4094].
4	Specify the action that should be applied for the traffic meeting the given requirements.	`esr(config-acl-rule)# action <ACT>`	<ACT> – allocated action: • permit – traffic transfer is permitted; • deny – traffic transfer is denied.
5	Set name of protocol for which the rule should work (optional).	`esr(config-acl-rule)# match protocol <TYPE>`	<TYPE> – protocol type, takes the following values: esp, icmp, ah, eigrp, ospf, igmp, ipip, tcp, pim, udp, vrrp, rdp, l2tp, gre. When specifying the “any” value, the rule will work for any protocols.
		`esr(config-acl-rule)# match protocol-id <ID>`	<ID> – IP identification number, takes values of [0x00-0xFF].
6	Set sender IP addresses for which the rule should work (optional).	`esr(config-acl-rule)# match source-address { <ADDR> <MASK> | any }`	<ADDR> – sender IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <MASK> – IP address mask, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]. Mask bits, set to zero, specify IP address bits excluded from the comparison when searching. When specifying the “any” value, the rule will work for any sender/recipient IP address.
7	Set destination IP addresses for which the rule should work (optional).	`esr(config-acl-rule)# match destination-address { <ADDR> <MASK> | any }`	
8	Set sender MAC addresses for which the rule should work (optional).	`esr(config-acl-rule)# match source-mac <ADDR><WILDCARD>`	<ADDR> – sender MAC address, defined as XX:XX:XX:XX:XX:XX where each part takes the values of [00..FF]. <WILDCARD> – MAC address mask, defined as XX:XX:XX:XX:XX:XX where each part takes the values of [00..FF]. Mask bits, set to zero, specify MAC address bits excluded from the comparison when searching.
9	Set destination MAC addresses for which the rule should work (optional).	`esr(config-acl-rule)# match destination-mac <ADDR><WILDCARD>`	

Step	Description	Command	Keys
10	Set the number of sender TCP/ UDP ports for which the rule should work (if the protocol is specified).	`esr(config-acl-rule)# match source-port { <PORT> | any }`	<PORT> – number of sender TCP/UDP port, takes values of [1..65535]. When specifying the “any” value, the rule will work for any sender TCP/UDP port.
11	Set the destination TCP/UDP ports number for which the rule should work (if the protocol is specified).	`esr(config-acl-rule)# match destination-port { <PORT> | any }`	
12	Set priority 802.1p value for which the rule should work (optional).	`esr(config-acl-rule)# match c os <COS>`	<COS> – priority 802.1p value, takes values of [0..7].
13	Set DSCP code value for which the rule should work (optional). Can not be used with IP Precedence.	`esr(config-acl-rule)# match dscp <DSCP>`	<DSCP> – DSCP code value, takes values in the range of [0..63].
14	Set IP Precedence code for which the rule should work (optional). Can not be used with DSCP.	`esr(config-acl-rule)# match ip-precedence <IPP>`	<IPP> – IP Precedence code value, takes values in the range of [0..7].
15	Set VLAN ID for which the rule should work (optional).	`esr(config-acl-rule)# match vlan <VID>`	<VID> – VLAN ID, takes values of [1..4094].
16	Activate a rule.	`esr(config-acl-rule)# enable`	
17	Specify access control list for the configured interface to filtrate incoming traffic.	`esr(config-if-gi)# service-acl input <NAME>`	<NAME> – access control list name, set by the string of up to 31 characters.

Also the access lists can be used to organize QoS policy.

7.6.2 Access list configuration example

Objective:

Allow traffic transmission from 192.168.20.0/24 subnet only.

Solution:

Configure access control list for filtering by a subnet:

```
esr# configure
esr(config)# ip access-list extended white
esr(config-acl)# rule 1
esr(config-acl-rule)# action permit
esr(config-acl-rule)# match source-address 192.168.20.0 255.255.255.0
esr(config-acl-rule)# enable
esr(config-acl-rule)# exit
esr(config-acl)# exit
```

Apply access list to Gi1/0/19 interface for inbound traffic:

```
esr(config)# interface gigabitethernet 1/0/19
esr(config-if-gi)# service-acl input white
```

To view the detailed information on access control list, use the following command:

```
esr# show ip access-list white
```

7.7 IPS/IDS configuration

IPS/IDS (*Intrusion Prevention System/Intrusion Detection System*) – a network and computer security software system that detects intrusions or security breaches and automatically protecting from them.

The system is based on signature traffic analysis. Signatures for IPS/IDS systems are commonly called rules. ESR devices allow you to download current rules from open sources on the Internet or from a corporate server. Using the CLI, you can also create your own specific rules.

By default, ESR devices have a basic set of rules from EmergingThreats designed for testing and verifying system health.

7.7.1 Base configuration algorithm

Step	Description	Command	Keys
1	Create IPS/IDS security policy.	`esr(config)# security ips policy <NAME>`	<NAME> – security policy name, set by the string of up to 32 characters
2	Specify policy description (optional).	`esr(config-ips-policy)# description <DESCRIPTION>`	<DESCRIPTION> – description, set by the string of up to 255 characters.
3	Specify the IP address profile that IPS/IDS will protect.	`esr(config-ips-policy)# protect network-group <OBJ-GROUP-NETWORK_NAME>`	<OBJ-GROUP-NETWORK-NAME> – protected IP addresses profile name, set by the string of up to 32 characters.
4	Specify the profile of IP addresses that are external for IPS/IDS (optional).	`esr(config-ips-policy)# external network-group <OBJ-GROUP-NETWORK_NAME>`	<OBJ-GROUP-NETWORK-NAME> – external IP addresses profile name, set by the string of up to 32 characters.

Step	Description	Command	Keys
5	Switch to the IPS/IDS configuration mode.	`esr(config)# security ips`	
6	Assign IPS/IDS security policy.	`esr(config-ips)# policy <NAME>`	<NAME> – security policy name, set by the string of up to 32 characters
7	Use all ESR rosiurces for IPS/IDS. (optional).	`esr(config-ips)# perfomance max`	By default, half of the available processor cores are allocated for IPS/IDS.
8	Set USB drive for recording logs in EVE format (optional).	`esr(config-ips)# logging storage-device <DEVICE_NAME>`	<DEVICE_NAME> USB storage device name.
9	Enable IPS/IDS.	`esr(config-ips )# enable`	
10	Enable IPS/IDS on the interface.	`esr(config-if-gi)# service-ips enable`	

7.7.2 Configuration algorithm for IPS/IDS rules autoupdate from external sources

Step	Description	Command	Keys
1	Switch to the autoupdate configuration mode	`esr(config-ips)# auto-upgrade`	
2	Specify a name and enter the configuration mode of the user update server.	`esr(config-ips-auto-upgrade)# user-server <WORD>`	<WORD> – server name, set by the string of up to 32 characters.
3	Specify the description of the user update server (optional).	`esr(config-ips-upgrade-user-server)# description <DESCRIPTION>`	<DESCRIPTION> – description, set by the string of up to 255 characters.
4	Specify URL.	`esr(config-ips-upgrade-user-server)# url <URL>`	<URL> – text field containing URL link of 8-255 characters length. As an URL-links can be specified: • rule file with the .rule extension; • rule classifier file named classification.config; • directory on the server containing rule files and/or rule classifier file.

Step	Description	Command	Keys
5	Set the frequency for update checking (optional).	`esr(config-ips-upgrade-user-server)# upgrade interval <HOURS>`	<HOURS> – update interval in hours, from 1 to 240. Default value: 24 hours

7.7.3 Recommended open rule update source

https://sslbl.abuse.ch/	SSL Blacklist contains lists of 'bad' SSL certificates, i.e. certificates in respect of which the fact of their use by malware and botnets has been established. The lists contain SHA1 fingerprints of public keys from SSL certificates.
https://feodotracker.abuse.ch/	Feodo Tracker – list of management servers for the Feodo Trojan. Feodo (also known as Cridex or Bugat) is used by cybercriminals to steal sensitive information in the field of electronic banking (credit card information, logins/passwords) from users' computers. Currently, there are four versions of the Trojan (versions A, B, C and D), mainly distinguished by the infrastructure of control servers.
https://rules.emergingthreats.net/open/suricata/rules/botcc.rules	These rules describe well-known botnets and control servers. Sources: Shadowserver.org, Zeus Tracker, Palevo Tracker, Feodo Tracker, Ransomware Tracker.
https://rules.emergingthreats.net/open/suricata/rules/ciarmy.rules	These rules describe malicious hosts by the classification of the www.cinsarmy.com project.
https://rules.emergingthreats.net/open/suricata/rules/compromised.rules	These rules describe well-known compromised and malicious hosts. Ыщгксуы: Daniel Gerzo's BruteForceBlocker, The OpenBL, Emerging Threats Sandnet, SidReporter Projects.
https://rules.emergingthreats.net/open/suricata/rules/drop.rules	These rules describe spammer hosts/networks by the classification of the www.spamhaus.org project.
https://rules.emergingthreats.net/open/suricata/rules/dshield.rules	These rules describe malicious hosts by the classification of the www.dshield.org project.
https://rules.emergingthreats.net/open/suricata/rules/emerging-activex.rules	These rules contain signatures for using ActiveX content.
https://rules.emergingthreats.net/open/suricata/rules/emerging-attack_response.rules	Rules that detect host behavior after successful attacks.
https://rules.emergingthreats.net/open/suricata/rules/emerging-chat.rules	These rules describe signs of accessing popular chat rooms.

https://rules.emergingthreats.net/open/suricata/rules/emerging-current_events.rules	Temporary rules awaiting possible inclusion in permanent rule lists.
https://rules.emergingthreats.net/open/suricata/rules/emerging-dns.rules	These rules contain signatures of vulnerabilities in the DNS protocol, signs of the use of DNS by malware, and incorrect use of the DNS protocol.
https://rules.emergingthreats.net/open/suricata/rules/emerging-dos.rules	These rules contain DOS attack signatures.
https://rules.emergingthreats.net/open/suricata/rules/emerging-exploit.rules	These rules contain exploit signatures.
https://rules.emergingthreats.net/open/suricata/rules/emerging-ftp.rules	These rules contain signatures of vulnerabilities in the FTP protocol, signs of incorrect use of the FTP protocol.
https://rules.emergingthreats.net/open/suricata/rules/emerging-games.rules	These rules describe the signs of reference to popular game sites: World of Warcraft, Starcraft, etc.
https://rules.emergingthreats.net/open/suricata/rules/emerging-icmp.rules	These rules contain signatures of incorrect use of the ICMP protocol.
https://rules.emergingthreats.net/open/suricata/rules/emerging-icmp_info.rules	These rules contain signatures of ICMP information messages.
https://rules.emergingthreats.net/open/suricata/rules/emerging-imap.rules	These rules contain signatures of vulnerabilities in the IMAP protocol, signs of incorrect use of the IMAP protocol.
https://rules.emergingthreats.net/open/suricata/rules/emerging-inappropriate.rules	These rules describe signs of accessing unwanted resources.
https://rules.emergingthreats.net/open/suricata/rules/emerging-info.rules	These rules contain different vulnerabilities signatures.
https://rules.emergingthreats.net/open/suricata/rules/emerging-malware.rules	These rules contain signatures of malware that uses the HTTP protocol in their work.
https://rules.emergingthreats.net/open/suricata/rules/emerging-misc.rules	These rules contain different vulnerabilities signatures.
https://rules.emergingthreats.net/open/suricata/rules/emerging-mobile_malware.rules	These rules contain malware signatures for mobile platforms.
https://rules.emergingthreats.net/open/suricata/rules/emerging-netbios.rules	These rules contain signatures of vulnerabilities in the NetBIOS protocol, signs of incorrect use of the NetBIOS protocol.
https://rules.emergingthreats.net/open/suricata/rules/emerging-p2p.rules	These rules describe signs of access to P2P networks (Bittorrent, Gnutella, Limewire).

https://rules.emergingthreats.net/open/suricata/rules/emerging-policy.rules	These rules describe unwanted network activity (access to MySpace, Ebay).
https://rules.emergingthreats.net/open/suricata/rules/emerging-poprules	These rules contain signatures of vulnerabilities in the POP3 protocol, signs of incorrect use of the POP3 protocol.
https://rules.emergingthreats.net/open/suricata/rules/emerging-rpc.rules	These rules contain signatures of vulnerabilities in the RPC protocol, signs of incorrect use of the RPC protocol.
https://rules.emergingthreats.net/open/suricata/rules/emerging-scada.rules	These rules contain vulnerability signatures for SCADA systems.
https://rules.emergingthreats.net/open/suricata/rules/emerging-scan.rules	These rules describe signs of activity associated with network scanning (Nessus, Nikto, portscanning).
https://rules.emergingthreats.net/open/suricata/rules/emerging-shellcode.rules	These rules describe signs of activity associated with attempts to gain shell access as a result of exploits.
https://rules.emergingthreats.net/open/suricata/rules/emerging-smtp.rules	These rules contain signatures of vulnerabilities in the SMTP protocol, signs of incorrect use of the SMTP protocol.
https://rules.emergingthreats.net/open/suricata/rules/emerging-sql.rules	These rules contain vulnerability signatures for SQL DBMS.
https://rules.emergingthreats.net/open/suricata/rules/emerging-telnet.rules	These rules contain signatures of vulnerabilities in the telnet protocol, signs of incorrect use of the telnet protocol.
https://rules.emergingthreats.net/open/suricata/rules/emerging-tftp.rules	These rules contain signatures of vulnerabilities in the TFTP protocol, signs of incorrect use of the TFTP protocol.
https://rules.emergingthreats.net/open/suricata/rules/emerging-trojan.rules	These rules contain signs of network activity of Trojans.
https://rules.emergingthreats.net/open/suricata/rules/emerging-user_agents.rules	These rules contain signs of suspicious and potentially dangerous HTTP clients (identified by the values in the User-Agent HTTP header).
https://rules.emergingthreats.net/open/suricata/rules/emerging-l.rules	These rules contain vulnerability signatures for VOIP protocol.
https://rules.emergingthreats.net/open/suricata/rules/emerging-web_client.rules	These rules contain vulnerability signatures for WEB clients.
https://rules.emergingthreats.net/open/suricata/rules/emerging-web_server.rules	These rules contain vulnerability signatures for WEB servers.
https://rules.emergingthreats.net/open/suricata/rules/emerging-web_specific_apps.rules	These rules contain vulnerability exploitation signatures for WEB applications.

https://rules.emergingthreats.net/open/suricata/rules/emerging-worm.rules	These rules describe signs of network worm activity.

7.7.4 IPS/IDS configuration example with auto-update rules

Objective:

Organize LAN protection with auto-update rules from open sources.

192.168.1.0/24 – LAN

Solution:

Create a profile of addresses of LAN which we will protect:

```
esr(config)# object-group network LAN
esr(config-object-group-network)# ip prefix 192.168.1.0/24
esr(config-object-group-network)# exit
```

Configure the DNS client on the ESR to allow the names of the IPS/IDS rule update sources:

```
esr(config)# domain lookup enable
esr(config)# domain name-server 8.8.8.8
```

Create IPS/IDS security policy:

```
esr(config)# security ips policy OFFICE
esr(config-ips-policy)# description "My Policy"
esr(config-ips-policy)# protect network-group LAN
```

Allow IPS/IDS operation on the bridge 1 LAN interface:

```
esr(config)# bridge 1
esr(config-bridge)# service-ips enable
```

Configure IPS/IDS parameters:

```
esr(config)# security ips
esr(config-ips)# logging storage-device usb://DATA
esr(config-ips)# policy OFFICE
esr(config-ips)# enable
```

The device will be used only as a security gateway, for this allocate the IPS/IDS service all available resources:

```
esr(config-ips)# perfomance max
```

Configure auto-update rules from EmergingThreats.net, etnetera.cz and Abuse.ch sites

```
esr(config-ips)# auto-upgrade
esr(config-auto-upgrade)# user-server ET-Open
esr(config-ips-upgrade-user-server)# description «emerging threats open rules»
esr(config-ips-upgrade-user-server)# url https://rules.emergingthreats.net/open/suricata-4.0/
rules/
esr(config-ips-upgrade-user-server)# exit
esr(config-auto-upgrade)# user-server Aggressive
esr(config-ips-upgrade-user-server)# description «Etnetera aggressive IP blacklist»
esr(config-ips-upgrade-user-server)# url https://security.etnetera.cz/feeds/
etn_aggressive.rules
esr(config-ips-upgrade-user-server)# upgrade interval 4
esr(config-ips-upgrade-user-server)# exit
esr(config-auto-upgrade)# user-server SSL-BlackList
esr(config-ips-upgrade-user-server)# description «Abuse.ch SSL Blacklist»
esr(config-ips-upgrade-user-server)# url https://sslbl.abuse.ch/blacklist/sslblacklist.rules
esr(config-ips-upgrade-user-server)# upgrade interval 4
esr(config-ips-upgrade-user-server)# exit
esr(config-auto-upgrade)# user-server C2-Botnet
esr(config-ips-upgrade-user-server)# description «Abuse.ch Botnet C2 IP Blacklist»
esr(config-ips-upgrade-user-server)# url https://sslbl.abuse.ch/blacklist/sslipblacklist.rules
esr(config-ips-upgrade-user-server)# upgrade interval 4
esr(config-ips-upgrade-user-server)# exit
```

7.7.5 Basic user rules configuration algorithm

Step	Description	Command	Keys
1	Specify a name and enter the configuration mode of the set of user rules.	`esr(config)# security ips-category user-defined <WORD>`	<WORD> – user rule set name, set by the string of up to 32 characters.
2	Define a description of a set of user rules (optional).	`esr(config-ips-category)# description <DESCRIPTION>`	<DESCRIPTION> – description, set by the string of up to 255 characters.
3	Create a rule and switch to its configuration mode.	`esr(config-ips-category)# rule <ORDER>`	<ORDER> – rule number, takes values of [1..512].
4	Specify the rule description. (optional)	`esr(config-ips-category-rule)# description <DESCRIPTION>`	<DESCRIPTION> – description, set by the string of up to 255 characters.

Step	Description	Command	Keys
5	Specify the given rule force.	`esr(config-ips-category-rule)# action { alert | reject | pass | drop }`	• alert – traffic is allowed and the IPS/IDS service generates a message; • reject – traffic is prohibited. If it is TCP traffic, a TCP-RESET packet is sent to the sender and recepient, for the rest of the traffic type, an ICMP-ERROR packet is sent. IPS/IDS service generates a message; • pass – traffic transfer is permitted; • drop – traffic is prohibited and the IPS/IDS service generates a message.
6	Set name of IP protocol for which the rule should work.	`esr(config-ips-category-rule)# protocol <PROTOCOL>`	<PROTOCOL> – take values: any/ip/icmp/http/tcp/udp When specifying the 'any' value, the rule will work for any protocols
7	Set sender IP addresses for which the rule should work.	`esr(config-ips-category-rule)# source-address {ip <ADDR> | ip-prefix <ADDR/LEN> | object-group <OBJ_GR_NAME> | policy-object-group { protect | external } | any }`	<ADDR> – sender IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <ADDR/LEN> – sender IP subnet, defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and LEN takes values of [1..32]. <OBJ_GR_NAME> – name of IP addresses profile that contains sender IP address, set by the string of up to 31 characters. • protect – sets sender addresses, protect addresses defined in IPS/IDS policy; • external – sets external addresses defined in IPS/IDS policy as sender addresses. When specifying the 'any' value, the rule will be triggered for any source IP address.

Step	Description	Command	Keys
8	Set the profile of source TCP/UDP ports for which the rule should work. For protocol icmp value, source-port can only be any.	`esr(config-ips-category-rule)# source-port {any | <PORT> | object-group <OBJ-GR-NAME> }`	<PORT> – number of sender TCP/UDP port, takes values of [1..65535]. <OBJ_GR_NAME> – sender TCP/UDP ports profile name, set by the string of up to 31 characters. When specifying the “any” value, the rule will work for any sender TCP/UDP port.
9	Set destination IP addresses for which the rule should work.	`esr(config-ips-category-rule)# destination-address {ip <ADDR> | ip-prefix <ADDR/LEN> | object-group <OBJ_GR_NAME> | policy-object-group { protect | external } | any }`	<<ADDR> – recepient IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <ADDR/LEN> – recepient IP subnet, defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and LEN takes values of [1..32]. <OBJ_GR_NAME> – name of IP addresses profile that contains recepient IP address, set by the string of up to 31 characters. • protect – sets recepient addresses, protect addresses defined in IPS/IDS policy; • external – sets external addresses defined in IPS/IDS policy as recepient addresses. When specifying the “any” value, the rule will work for any sender IP address.
10	Set the profile of destination TCP/UDP ports for which the rule should work. For protocol icmp value, destination-port can only be any.	`esr(config-ips-category-rule)# destination-port {any | <PORT> | object-group <OBJ-GR-NAME> }`	<PORT> – number of destination TCP/UDP port, takes values of [1..65535]. <OBJ_GR_NAME> – recepient TCP/UDP ports profile name, set by the string of up to 31 characters. When specifying the 'any' value, the rule will be triggered for any source TCP/UDP port.
11	Set traffic direction for which the rule should trigger.	`esr(config-ips-category-rule)# direction { one-way | round-trip }`	• one-way – traffic is transmitted in one direction. • round-trip – traffic is transmitted in both directions.

Step	Description	Command	Keys
12	Define the message that IPS/IDS will record to the log when this rule will trigger.	`esr(config-ips-category-rule)# meta log-message <MESSAGE>`	<MESSAGE> – text message specified by a string of up to 129 characters.

Step	Description	Command	Keys
13	Define the traffic classification which will record to the log when this rule will work (optional)	`esr(config-ips-category-rule)# meta classification-type { not-suspicious | unknown | bad-unknown | attempted-recon | successful-recon-limited | successful-recon-largescale | attempted-dos | successful-dos | attempted-user | unsuccessful-user | successful-user | attempted-admin | successful-admin | rpc-portmap-decode | shellcode-detect | string-detect | suspicious-filename-detect | suspicious-login | system-call-detect | tcp-connection | trojan-activity | unusual-client-port-connection | network-scan | denial-of-service | non-standard-protocol | protocol-command-decode | web-application-activity | web-application-attack | misc-activity | misc-attack | icmp-event | inappropriate-content | policy-violation | default-login-attempt }`	• not-suspicious – not suspicious traffic; • unknown – unknown traffic. • bad-unknown – potentially bad traffic. • attempted-recon – information leak attempt. • successful-recon-limited – information leak. • successful-recon-largescale – large-scale information leak. • attempted-dos – denial of service attempt. • successful-dos – denial of service. • attempted-user – attempt to obtain user privileges. • unsuccessful-user – unsuccessful attempt to obtain user privileges. • successful-user – successful attempt to obtain user privileges. • successful-admin – successful attempt to obtain admin privileges. • successful-admin – successful attempt to obtain admin privileges. • rpc-portmap-decode – RPC request decoding. • shellcode-detect – executable code detected. • string-detect – suspicious string detected. • suspicious-filename-detect – suspicious filename was detected. • suspicious-login – attempt to log in using a suspicious username was deteceted. • system-call-detect – system call was detected. • tcp-connection – TCP connection was detected. • trojan-activity – network Trojan was detected. • unusual-client-port-connection – the client used an unusual port.

Step	Description	Command	Keys
			• network-scan – network scan was detected. • denial-of-service – denial of service attack was detected. • non-standard-protocol – custom protocol or event was detected. • protocol-command-decode – encryption attempt was detected. • web-application-activity – access to a potentially vulnerable web application. • web-application-attack – attack on web application. • misc-activity – other activity. • misc-attack – other attacks. • icmp-event – general ICMP event. • inappropriate-content – inappropriate content was detected. • policy-violation – potential breach of corporate privacy. • default-login-attempt – login attempt using a standard login/password.
14	Set DSCP code value for which the rule should work (optional).	`esr(config-ips-category-rule)# ip dscp <DSCP>`	<DSCP> – DSCP code value, takes values in the range of [0..63].
15	Set the packet lifetime (TTL) value for which the rule will work (optional).	`esr(config-ips-category-rule)# ip ttl <TTL>`	<TTL> – TTL value, takes values in the range of [1..255].
16	Set number of IP protocol for which the rule should work Applicable only for protocol any value (optional).	`esr(config-ips-category-rule)# ip protocol-id <ID>`	<ID> – IP identification number, takes values of [1..255].

Step	Description	Command	Keys
17	Set ICMP CODE value for which the rule should work Applicable only for protocol icmp value (optional).	`esr(config-ips-category-rule)# ip icmp code <CODE>`	<CODE> – ICMP CODE value, takes a value in the range [0..255].
		`esr(config-ips-category-rule)# ip icmp code comparison-operator { greater-than | less-than }`	Comparison operator for ip icmp code value: • greater-than – greater than.. • less-than – less than..
18	Set ICMP ID value for which the rule should work Applicable only for protocol icmp value (optional).	`esr(config-ips-category-rule)# ip icmp id <ID>`	<ID> – ICMP ID value, takes a value in the range [0..65535].
19	Set ICMP Sequence-ID value for which the rule should work Applicable only for protocol icmp value (optional).	`esr(config-ips-category-rule)# ip icmp sequence-id <SEQ-ID>`	<SEQ-ID> – ICMP Sequence-ID value, takes a value in the range [0..4294967295].
20	Set ICMP TYPE value for which the rule should work Applicable only for protocol icmp value (optional).	`esr(config-ips-category-rule)# ip icmp type <TYPE>`	<TYPE> – ICMP TYPE value, takes a value in the range [0..255].
		`esr(config-ips-category-rule)# ip icmp type comparison-operator { greater-than | less-than }`	Comparison operator for ip icmp type value: • greater-than – greater than.. • less-than – less than..
21	Set TCP Acknowledgement-Number value for which the rule should work Applicable only for protocol tcp value (optional).	`esr(config-ips-category-rule)# ip tcp acknowledgment-number <ACK-NUM>`	<ACK-NUM> – TCP Acknowledgement-Number value, takes a value in the range [0..4294967295].

Step	Description	Command	Keys
22	Set TCP Sequence-ID value for which the rule should work Applicable only for protocol tcp value (optional).	`esr(config-ips-category-rule)# ip tcp sequence-id <SEQ-ID>`	<SEQ-ID> – TCP Sequence-ID value, takes a value in the range [0..4294967295].
23	Set TCP Window-Size value for which the rule should work Applicable only for protocol tcp value (optional).	`esr(config-ips-category-rule)# ip tcp window-size <SIZE>`	<SIZE> – TCP Window-Size value, takes a value in the range [0..65535].
24	Set HTTP protocol keywords for which the rule will trigger. Applicable only for protocol http value. (optional).	`esr(config-ips-category-rule)# ip http { accept | accept-enc | accept-lang | client-body | connection | content-type | cookie | file-data | header | header-names | host | method | protocol | referer | request-line | response-line | server-body | start | start-code | start-msg | uri | user-agent }`	See the Suricata 4.X documentation for the meaning of the keywords. https://suricata.readthedocs.io/en/suricata-4.1.4/rules/http-keywords.html
25	Set HTTP protocol URI LEN keyword value for which the rule will trigger. Applicable only for protocol http value (optional).	`esr(config-ips-category-rule)# ip http urilen <LEN>`	<LEN> – takes values in the range of [0.. 65535].
		`esr(config-ips-category-rule)# ip http urilen comparison-operator { greater-than | less-than }`	Comparison operator for ip http urilen value: • greater-than – greater than.. • less-than – less than..
26	Set the value of the content of packages (Payload content) for which the rule will work (optional).	`esr(config-ips-category-rule)# payload content <CONTENT>`	<CONTENT> – text message specified by a string of up to 1024 characters.

Step	Description	Command	Keys
27	Do not distinguish between uppercase and lowercase letters in the description of package contents. Only applicable in conjunction with the payload content command. (optional).	`esr(config-ips-category-rule)# payload no-case`	
28	Set how many bytes from the beginning of the contents of the packet will be checked. Only applicable in conjunction with the payload content command (optional).	`esr(config-ips-category-rule)# payload depth <DEPTH>`	<DEPTH> – the number of bytes from the beginning of the packet contents, takes a value in the range [1 .. 65535]. By default, the entire contents of the package are checked.
29	Set the number of offset bytes from the beginning of the contents of the packet to check Only applicable in conjunction with the payload content command (optional).	`esr(config-ips-category-rule)# payload offset <OFFSET>`	<OFFSET> – the number of offset bytes from the beginning of the packet contents, takes a value in the range [1 .. 65535]. By default, it is checked from the beginning of the content.
30	Set the size of the contents of packets for which the rule will trigger (optional).	`esr(config-ips-category-rule)# payload data-size <SIZE>`	<SIZE> – packet content size, takes values in the range of [0.. 65535].
		`esr(config-ips-category-rule)# payload data-size comparison-operator { greater-than | less-than }`	Comparison operator for payload data-size value: • greater-than – greater than.. • less-than – less then.
31	Specify the threshold number of packets at which the rule will work (optional).	`esr(config-ips-category-rule)# threshold count <COUNT>`	<COUNT> – number of packets, takes values in the range of [1.. 65535].

Step	Description	Command	Keys
32	Specify the time interval for which the threshold number of packets is considered (Mandatory if threshold count is enabled)	`esr(config-ips-category-rule)# threshold second <SECOND>`	<SECOND> – time interval in seconds, takes values in the range of [1.. 65535].
33	Specify at the sender or recipient address thresholds will be considered. (Mandatory if threshold count is enabled)	`esr(config-ips-category-rule)# threshold track { by-src | by-dst }`	• by-src – read threshold value for packets with the same IP sender. • by-dst – read threshold value for packets with the same IP recipient.
34	Specify threshold handling method.	`esr(config-ips-category-rule)# threshold type {threshold | limit | both }`	• threshold – display a message every time a threshold is reached. • limit – issue a message no more than <COUNT> times per time interval <SECOND>. • both – threshold and limit combination. A message will be generated if during the <SECOND> time interval there were <COUNT> or more packets matching the rule conditions, and the message will be sent only once during the <SECOND> time interval.
35	Activate a rule.	`esr(config-ips-category-rule)# enable`	

7.7.6 Basic user rules configuration example

Objective:

Write a rule to protect a server with IP 192.168.1.10 from a DOS attack by large ICMP packets.

Solution:

Create a set of user rules:

```
esr(config)# security ips-category user-defined USER
```

Create a rule to protect against attack:

```
esr(config-ips-category)# rule 10
esr(config-ips-category-rule)# description «Big ICMP DoS»
```

Drop packets:

```
esr(config-ips-category-rule)# action drop
```

Configure attack message:

```
esr(config-ips-category-rule)# meta log-message «Big ICMP DoS»
esr(config-ips-category-rule)# meta classification-type successful-dos
```

Specify protocol type for the rule:

```
esr(config-ips-category-rule)# protocol icmp
```

Since we specified the icmp protocol, we need to specify any as the port of the sender and recipient:

```
esr(config-ips-category-rule)# source-port any
esr(config-ips-category-rule)# destination-port any
```

We will indicate our server as the recipient address:

```
esr(config-ips-category-rule)# destination-address ip 192.168.1.10
```

Attacker can send packets from any address:

```
esr(config-ips-category-rule)# source-address any
```

Set traffic direction:

```
esr(config-ips-category-rule)# direction one-way
```

The rule will trigger on packets larger than 1024 bytes:

```
esr(config-ips-category-rule)# payload data-size 1024
esr(config-ips-category-rule)# payload data-size comparison-operator greate r-than
```

The rule will trigger if the load on the server exceeds 3 Mbps, while an attack message will be generated not more than once a minute:

```
3 Mbps = 3145728 bps
1KB packet = 8192 bits
3145728/8192 = 384 packet per second
384 * 60 = 23040 packets per minute
```

```
esr(config-ips-category-rule)# threshold count 23040
esr(config-ips-category-rule)# threshold second 60
esr(config-ips-category-rule)# threshold track by-dst
esr(config-ips-category-rule)# threshold type both
```

7.7.7 Extended user rules configuration algorithm

Step	Description	Command	Keys
1	Specify a name and enter the configuration mode of the set of user rules.	`esr(config)# security ips-category user-defined <WORD>`	<WORD> – user rule set name, set by the string of up to 32 characters.
2	Define a description of a set of user rules (optional).	`esr(config-ips-category)# description <DESCRIPTION>`	<DESCRIPTION> – description, set by the string of up to 255 characters.
3	Create extended rule and switch to its configuration mode.	`esr(config-ips-category)# rule-advanced <SID>`	<SID> – rule number, takes values of [1..4294967295].
4	Specify the rule description (optional).	`esr(config-ips-category-rule-advanced)# description <DESCRIPTION>`	<DESCRIPTION> – description, set by the string of up to 255 characters.
5	Specify the given rule force.	`esr(config-ips-category-rule-advanced)# rule-text <LINE>`	<CONTENT> – text message in SNORT 2.X/Suricata 4.X format, specified by a string of up to 1024 characters. *When writing rules, the symbol " needs to be replaced with the symbol '*
6	Activate a rule.	`esr(config-ips-category-rule-advanced)# enable`	

7.7.8 Extended user rules configuration example

Objective:

Write a rule detecting attack like Slowloris.

Solution:

Create a set of user rules:

```
esr(config)# security ips-category user-defined ADV
```

Create an extended rule:

```
esr(config-ips-category)# rule-advanced 1
esr(config-ips-category-rule-advanced)# description «Slow Loris rule 1»
esr(config-ips-category-rule-advanced)# rule-text "alert tcp any any -> any 80 (msg:'Possible
Slowloris Attack Detected';
flow:to_server,established; content:'X-a|3a|'; distance:0; pcre:'/\d\d\d\d/'; distance:0;
content:'|0d 0a|'; sid:10000001;)"
```

Create another extended rule that works on a similar algorithm to determine which rule will be more effective:

```
esr(config-ips-category)# rule-advanced 2
esr(config-ips-category-rule-advanced)# description «Slow Loris rule 2»
esr(config-ips-category-rule-advanced)# rule-text «alert tcp $EXTERNAL_NET any -> $HOME_NET
$HTTP_PORTS (msg:'SlowLoris.py DoS attempt'; flow:established,to_server,no_stream; content:'X-
a:'; dsize:<15; detection_filter:track by_dst, count 3, seconds 30; classtype:denial-of-
service; sid: 10000002; rev:1; )
```

7.8 Eltex Distribution Manager interaction configuration

EDM (Eltex Distribution Manager) is a service for distributing licensed content to devices via commercial subscription.

Using Kaspersky Lab's security infrastructure, including the Kaspersky Security Network cloud-based "collective intelligence" with Kaspersky SafeStream II support, the ESR service router is able to detect malware in all types of traffic (web, email, P2P, instant messaging services, etc.). As a result, users are protected from the most dangerous cyber threats, including zero-day threats, encryption programs, infected sites and other types.
IPS on ESR devices can use the following sets of rules provided by Kaspersky SafeStream II:

- IP address Reputation Data – a set of IP addresses with contextual information that reports suspicious and malicious hosts;
- URLs of malicious links – a set of URLs corresponding to dangerous links and websites;
- URLs of phishing links – a set of URLs recognized by Kaspersky Lab as phishing. Masked and unmasked entries are available;
- URLs of botnet command servers – a set of URLs of botnet command servers and associated malicious objects;
- URLs of encryptors – set of encryptor URLs;
- Hashes of malicious objects – a set of file hashes that covers the most dangerous and common, as well as the newest malicious programs;
- Hashes of malicious objects for mobile devices – a set of file hashes to detect malicious objects infecting mobile devices;
- P-SMS Trojan data – a set of Trojan hashes with contextual information to detect SMS Trojans calling from cell phones to paid numbers, as well as allow the attacker to intercept SMS messages, respond to them and delete them;
- URLs of botnet command servers for mobile devices – a set of URLs with contextual information to identify botnet command servers using mobile devices;
- URLs of websites used to host malicious programs that infect Internet of Things (IoT) devices.

EDM Server software is provided to operate under a group license, allowing the new ESR service router to be automatically enabled under an existing license. Thus, the user of the system can manage the allocation of licenses to ESR devices within his organization. EDM Server software can be installed on multiple hosts to provide scalability and fault tolerance.

7.8.1 Base configuration algorithm

Step	Description	Command	Keys
1	Go to the content provider configuration.	`esr (config)# content-provider`	
2	Specify edm server IP address.	`esr (config-content-provider)# host address <A.B.C.D | WORD | X:X:X:X::X>`	<IP-ADDR> – IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <IPV6-ADDR> – RADIUS server IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF]. WORD(1-31) - DNS name of the server.
3	Set the port to connect to the edm server.	`esr (config-content-provider)# host port <PORT>`	<PORT> – number of sender TCP/UDP port, takes values of [1..65535].
4	Set the type and partition of the external device to create a crypto store.	`esr (config-content-provider)# storage-device <DEVICE>`	<DEVICE> – label and partition name on the external storage in the format of usb://Partion_name:/ mmc://Partion_name:/
5	Set the time to reboot the device after receiving the certificate.	`esr (config-content-provider)# reboot immediately | [time <HH:MM:SS>]`	Restart the device after receiving the certificate. time <HH:MM:SS> – The time at which esr will reboot <hours:minutes:seconds>.
6	Enable content provider.	`enable`	
7	Set the interval for accessing the edm server in hours.	`esr (config-content-provider)# upgrade interval <1-240>`	
8	Specify description (optional).	`esr (config-content-provider)# description edm`	LINE(1-255) String describing server

9	Create IP addresses lists which will be used during filtration.	`esr (config)# object-group network <WORD>`
		
		`esr (config-object-group-network)# ip prefix <ADDR/LEN>`
			<WORD> – server name, set by the string of up to 32 characters.
			
			<ADDR/LEN> – subnet, defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32].

Step	Description	Command	Keys
10	Enable service-ips on interface.	`esr (config)# interface gigabitethernet 1/0/X` `esr (config-if-gi)# service-ips enable`	
11	Create IPS/IDS security policy.	`esr (config)# security ips policy WORD(1-31)`	WORD(1-31)
12	Specify the IP address profile that IPS/IDS will protect.	`esr(config-ips-policy)# protect network-group <OBJ-GROUP-NETWORK_NAME>`	<OBJ-GROUP-NETWORK-NAME> – protected IP addresses profile name, set by the string of up to 32 characters.
13	Enter the vendor configuration section.	`esr (config-ips-policy)# vendor kaspersky`	

Step	Description	Command	Keys
14	Connect the desired category.	`esr (config-ips-vendor)# category WORD(1-64)`	Phishing URL Data Feed – Phishing URL data streams Malicious URL Data Feed – Malicious URL data streams Botnet C&C URL Data Feed – Botnet C&C URL data streams Malicious Hash Data Feed – Malicious Hashes data streams Mobile Malicious Hash Data Feed – mobile Malicious Hashes data streams IP Reputation Data Feed – IP address data streams Mobile Botnet Data Feed – mobile Botnet data streams P-SMS Trojan Data Feed – P-SMS Trojan data stream Ransomware URL Data Feed – Ransomware URL data stream Botnet C&C URL Exact Data Feed – Botnet C&C URL Exact data stream Phishing URL Exact Data Feed – Phishing URL Exact data stream Malicious URL Exact Data Feed – Malicious URL Exact data stream Iot URL Data Feed – IoT URL data stream

Step	Description	Command	Keys
15	Specify rule type.	`esr (config-ips-vendor-category)# rules action <ACTION>`	<ACTION> - drop | reject | alert | pass – actions to be applied to packages. • alert – traffic is allowed and the IPS/IDS service generates a message; • reject – traffic is prohibited. If it is TCP traffic, a TCP-RESET packet is sent to the sender and recepient, for the rest of the traffic type, an ICMP-ERROR packet is sent. IPS/IDS service generates a message; • pass – traffic transfer is permitted; • drop – traffic is prohibited and the IPS/IDS service generates a message.
16	Set the number of downloadable rules.	`esr (config-ips-vendor-category)# rules count <number>`	<number>
17	Enable category	`enable`	
18	Switch to the IPS/IDS configuration mode.	`esr (config)# security ips`	
19	Assign IPS/IDS security policy.	`esr(config-ips)# policy <NAME>`	<NAME> – security policy name, set by the string of up to 32 characters.
20	Use all ESR rosiurces for IPS/IDS (optional).	`esr(config-ips)# perfomance max`	
21	Set USB drive for recording logs in EVE format (optional).	`esr(config-ips)# logging storage-device <DEVICE_NAME>`	<DEVICE> – label and partition name on the external storage in the format of usb://Partion_name:/ mmc://Partion_name:/
22	Enable IPS/IDS.	`esr(config- ips )# enable`	

7.8.2 Configuration example:

Set the content-provider parameters – this is the address of the Eltex server. There must be network reachability between the content-provider server and the router.

```
content-provider
  host address edm.eltex-co.ru
  host port 8098
  upgrade interval 1
  storage-device mmc://TEST:/
  reboot immediately
  enable
exit
```

After rebooting the device, you can start configuring the IPS service.

Specify the IP address profile that IPS/IDS will protect:

```
object-group network objectgroup0
  ip prefix 192.168.30.0/24
exit
```

Enable IPS on the interface:

```
interface gigabitethernet 1/0/1
  service-ips enable
exit
```

Configure security policy:

```
security ips policy policy0
  protect network-group objectgroup0
  vendor kaspersky
    category MaliciousURLsDF
      rules action alert
      rules count 100
      enable
    exit
    category MobileBotnetCAndCDF
      rules action alert
      rules count 1000
      enable
    exit
    category APTIPDF
      rules action alert
      rules count 1000
      enable
    exit
```

```
    category APTURLsDF
      rules action alert
      rules count 1000
      enable
    exit
    category BotnetCAndCURLsDF
      rules action alert
      rules count 1000
      enable
    exit
    category IPReputationDF
      rules action alert
      rules count 1000
      enable
    exit
    category IoTURLsDF
      rules action alert
      rules count 1000
      enable
    exit
    category MaliciousHashDF
      rules action alert
      rules count 1
      enable
    exit
    category MobileMaliciousHashDF
      rules action alert
      rules count 1
      enable
    exit
    category PSMSTrojanDF
      rules action alert
      rules count 1
      enable
    exit
    category PhishingURLsDF
      rules action alert
      rules count 1000
      enable
    exit
    category RansomwareURLsDF
      rules action alert
      rules count 1000
      enable
    exit
  exit
exit
```

Assign an IPS policy to the service and enable it:

```
security ips
  performance max
  policy policy0
  enable
exit
```

You can use the following two commands to view information about downloaded content for IPS/IDS:

show security ips content-provider:

```
esr-20# show security ips content-provider
 Server: content-provider
                Last MD5 of received files:        c60bd0f10716d3f48e18f24828337135
                Next update: 30 October 2020 00:37:06
```

With this command you can find out if the content provider has downloaded rules from the EDM server (based on the presence of the md5 checksum) and when the next update is scheduled for the device.

show security ips counters:

```
esr-20# show security ips counters
TCP flows processed :     191
Alerts generated :        0
Blocked by ips engine :   7
Accepted by ips engine :  51483
```

Shows the traffic passed through IPS/IDS and the actions that were applied to the traffic, as well as the number of IPS/IDS rule triggers.

8 Redundancy management

8.1 VRRP configuration

VRRP (Virtual Router Redundancy Protocol) is a network protocol designed for increased availability of routers, acting as a default gateway. This is performed by aggregation of a router group into a single virtual router and assigning a shared IP address, that will be used as a default gateway for computers in the network.

8.1.1 Configuration algorithm

Step	Description	Command	Keys
1	Switch to the interface/tunnel/ network bridge configuration mode for which it is necessary to configure VRRP	`esr(config)# interface <IF-TYPE><IF-NUM>`	<IF-TYPE> – interface type; <IF-NUM> – F/S/P – F frame (1), S – slot (0), P – port.
		`esr(config)# tunnel <TUN-TYPE><TUN-NUM>`	<TUN-TYPE> – tunnel type; <TUN-NUM> – tunnel number.
		`esr(config)# bridge <BR-NUM>`	<BR-NUM> – bridge number.
2	Configure the required parameters on the interface/tunnel/network bridge including IP address		
3	Enable VRRP process on IP interface.	`esr(config-if-gi)# vrrp`	
		`esr(config-if-gi)# ipv6 vrrp`	
4	Set virtual IP address of VRRP router.	`esr(config-if-gi)# vrrp ip <ADDR/LEN>`	<ADDR/LEN> – virtual IP address, defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32]. You can specify several IP addresses separated by commas. Up to 4 IP addresses can be assigned to the interface.

Step	Description	Command	Keys
		`esr(config-if-gi)# ipv6 vrrp ip <IPV6-ADDR>`	<IPV6-ADDR> – virtual IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF]. You can specify up to 8 IPv6 addresses separated by commas.
5	Set the VRRP router identifier.	`esr(config-if-gi)# vrrp id <VRID>`	<VRID> – VRRP router identifier, takes values in the range of [1..255].
		`esr(config-if-gi)# ipv6 vrrp id <VRID>`	
6	Set the VRRP router priority.	`esr(config-if-gi)# vrrp priority <PR>`	<PR> – VRRP router priority, takes values in the range of [1..254]. Default value: 100.
		`esr(config-if-gi)# ipv6 vrrp priority <PR>`	
7	Identify the VRRP router's inherence to a group. The group provides with an opportunity to synchronize several VRRP processes, so if in one of the processes there is a change of master, then in another process the roles will also be changed.	`esr(config-if-gi)# vrrp group <GRID>`	<GRID> – VRRP router group identifier, takes values in the range of [1..32].
		`esr(config-if-gi)# ipv6 vrrp group <GRID>`	
8	Set the IP address that will be used as a source IP address for VRRP messages.	`esr(config-if-gi)# vrrp source-ip <IP>`	<ADDR> – sender IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255];
		`esr(config-if-gi)# ipv6 vrrp source-ip <IPV6>`	<IPV6> – source IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF].
9	Set the interval between sending VRRP messages	`esr(config-if-gi)# vrrp timers advertise <TIME>`	<TIME> – time in seconds, takes values of [1..40]. Default value: 1 second.
		`esr(config-if-gi)# ipv6 vrrp timers advertise <TIME>`	
10	Set the interval after which GratuituousARP messages are sent when switching the router to the Master status.	`esr(config-if-gi)# vrrp timers garp delay <TIME>`	<TIME> – time in seconds, takes values of [1..60]. Default value: 5 seconds.

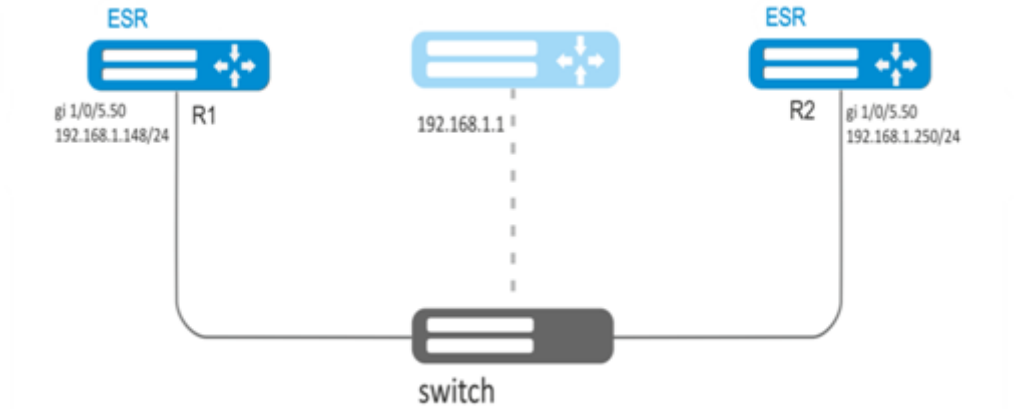
Step	Description	Command	Keys
11	Set the amount of GratuituousARP messages that will be sent when switching the router to the Master status.	`esr(config-if-gi)# vrrp timers garp repeat <COUNT>`	<COUNT> – amount of messages, takes values of [1..60]. Default value: 5.
12	Set the interval after which GratuituousARP messages will be sent periodically while the router is in the Master status.	`esr(config-if-gi)# vrrp timers garp refresh <TIME>`	<TIME> – time in seconds, takes values of [1..65535]. Default value: Periodic sending is disabled.
13	Set the amount of GratuituousARP messages that will be sent with the garprefresh period while the router is in the Master status.	`esr(config-if-gi)# vrrp timers garp refresh-repeat <COUNT>`	<COUNT> – amount of messages, takes values of [1..60]. Default value: 1.
14	Specify whether the higher priority Backup router would try to take the Master role from the current lower priority Master router.	`esr(config-if-gi)# vrrp preemption disable`	
		`esr(config-if-gi)# ipv6 vrrp preemption disable`	
15	Set the time interval after which the higher priority Backup route will try to take the Master role from the current lower priority Master router.	`esr(config-if-gi)# vrrp preemption delay <TIME>`	<TIME> – timeout, takes value in seconds [1..1000]. Default value: 0
		`esr(config-if-gi)# ipv6 vrrp preemption delay <TIME>`	
16	Set the password for neighbour authentication.	`esr(config-if-gi)# vrrp authentication key ascii-text { <CLEAR-TEXT> | encrypted <ENCRYPTED-TEXT> }`	<CLEAR-TEXT> – password, set by the string of 8 to 16 characters; <ENCRYPTED-TEXT> – encrypted password of 8 to 16 bytes (from 16 to 32 characters) in hexadecimal format (0xYYYY ...) or (YYYY ...).
17	Define authentication algorithm.	`esr(config-if-gi)# vrrp authentication algorithm <ALGORITHM>`	<ALGORITHM> – authentication algorithm: • **cleartext** – password, transmitted in clear text; • **md5** – password is hashed by md5 algorithm.
18	Specify VRRP version.	`esr(config-if-gi)# vrrp version <VERSION>`	<VERSION> – VRRP version: 2, 3.

Step	Description	Command	Keys
19	Set the mode when vrrp IP address remains in the UP status regardless of the status of the interface itself. (optionally)	`esr(config-if-gi)# vrrp force-up`	
20	Specify the delay between the assignment of MASTER status to ipv6 vrrp and the start of ND messages distribution.	`esr(config-if-gi)# ipv6 vrrp timers nd delay <TIME>`	<TIME> – time in seconds, takes values of [1..60]. Default value: 5
21	Specify the period of ND protocol information update for ipv6 vrrp in MASTER status.	`esr(config-if-gi)# ipv6 vrrp timers nd refresh <TIME>`	<TIME> – time in seconds, takes values of [1..65535]. Default value: 5
22	Specify the amount of ND messages sent in the update period for ipv6 vrrp in MASTER status.	`esr(config-if-gi)# ipv6 vrrp timers nd refresh-repeat <NUM>`	<NUM> – amount, takes values of [1..60]. Default value: 0
23	Specify the amount of ND packets sendings after setting ipv6 vrrp to the MASTER status.	`esr(config-if-gi)# ipv6 vrrp timers nd repeat <NUM>`	<NUM> – amount, takes values of [1..60]. Default value: 1

8.1.2 Configuration example 1

Objective:

Establish LAN virtual gateway in VLAN 50 using VRRP. IP address 192.168.1.1 is used as a local virtual gateway.



Solution:

First, do the following:

- create a correspond sub interface;

- configure a zone for the sub-interface;
- specify IP address for the sub-interface.

Main configuration step:

Configure R1 router.

Configure VRRP in the created sub-interface. Specify unique VRRP identifier:

```
R1(config)#interface gi 1/0/5.50
R1(config-subif)# vrrp id 10
```

Specify virtual gateway IP address 192.168.1.1/24:

```
R1(config-subif)# vrrp ip 192.168.1.1
```

Enable VRRP**:**

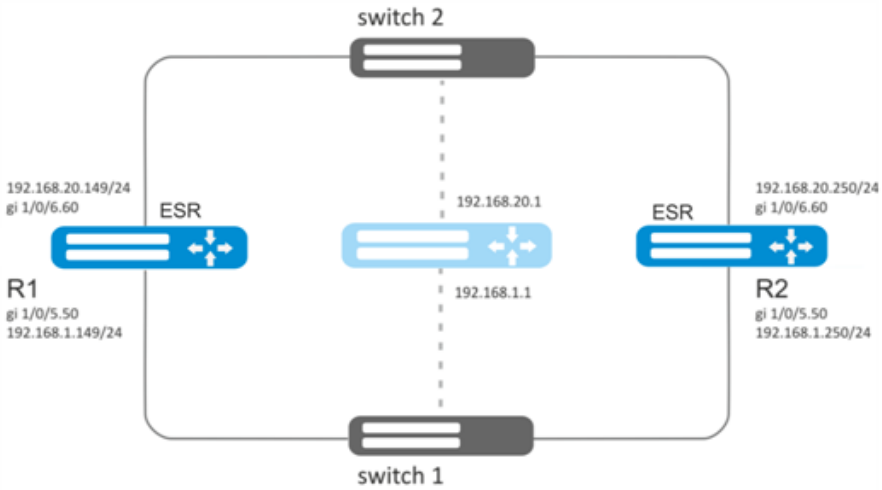
```
R1(config-subif)# vrrp
R1(config-subif)# exit
```

Configure R2 in the same manner.

8.1.3 Configuration example 2

Objective:

Establish virtual gateways for 192.168.20.0/24 subnet in VLAN 50 and 192.168.1.0/24 in VLAN 60 using VRRP with Master sync feature. To do this, you have to group VRRP processes. IP addresses 192.168.1.1 and 192.168.20.1 are used as virtual gateways.



Solution:

First, do the following:

- create correspond sub interfaces;
- configure a zone for the sub-interfaces;
- specify IP addresses for the sub-interfaces.

Main configuration step:

Configure R1 router.

Configure VRRP for 192.168.1.0/24 subnet in the created sub-interface.

Specify unique VRRP identifier:

```
R1(config-sub)#interface gi 1/0/5.50
R1(config-subif)# vrrp id 10
```

Specify virtual gateway IP address 192.168.1.1:

```
R1(config-subif)# vrrp ip 192.168.1.1
```

Specify VRRP group identifier:

```
R1(config-subif)# vrrp group 5
```

Enable VRRP:

```
R1(config-subif)# vrrp
R1(config-subif)# exit
```

Configure VRRP for 192.168.20.0/24 subnet in the created sub-interface.

Specify unique VRRP identifier:

```
R1(config-sub)#interface gi 1/0/6.60
R1(config-subif)# vrrp id 20
```

Specify virtual gateway IP address 192.168.1.20:

```
R1(config-subif)# vrrp ip 192.168.20.1
```

Specify VRRP group identifier:

```
R1(config-subif)# vrrp group 5
```

Enable VRRP:

```
R1(config-subif)# vrrp
R1(config-subif)# exit
```

Configure R2 in the same manner.

⚠ In addition to tunnel creation, you should enable VRRP protocol (112) in the firewall.

8.2 VRRP tracking configuration

VRRP tracking is a mechanism, which allows activating static routes, depending on VRRP state.

8.2.1 Configuration algorithm

Step	Description	Command	Keys
1	Configure VRRP according to the section «VRRP configuration algorithm».		
2	Add Tracking object to the system and switch to the Tracking object parameters configuration mode.	`esr(config)#tracking <ID>`	<ID> – Tracking object number, takes values of [1..60].
3	Specify a rule for keeping track of VRRP process status.	`esr(config-tracking)# vrrp <VRID> [not] state { master | backup | fault }`	<VRID> – trackable VRRP router identifier, takes values in the range of [1..255].
4	Enable Tracking object.	`esr(config-tracking)#enable`	

Step	Description	Command	Keys
5	Create a static IP route to the specified subnet indicating the Tracking object.	`esr(config)# ip route [ vrf <VRF> ] <SUBNET> { <NEXTHOP> [ resolve ] | interface <IF> | tunnel <TUN> | wan load-balance rule <RULE> | blackhole | unreachable | prohibit } [ <METRIC> ] [ track <TRACK-ID> ]`	<VRF> – VRF name, set by the string of up to 31 characters. <SUBNET> – destination address, can be specified in the following formats: AAA.BBB.CCC.DDD – host IP address, where each part takes values of [0..255]. AAA.BBB.CCC.DDD/NN – network IP address with prefix mask, where AAA-DDD take values of [0..255] and NN takes values of [1..32]. <NEXTHOP> – gateway IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; • **resolve** – when specifying this parameter, gateway IP address will be recursively calculated through the routing table. If the recursive calculation fails to find a gateway from a directly connected subnet, then this route will not be installed into the system; <IF> – an IP interface name specified in the form described in Section Types and naming order of router interfaces; <TUN> – the name of the tunnel is specified as described in section Types and naming order of router tunnels; <RULE> – wan rule number, set in the range of [1..50]; • **blackhole** – when specifying the command, the packets to this subnet will be removed by the device without sending notifications to a sender; • **unreachable** – when specifying the command, the packets to this subnet will be removed by the device, a sender will receive in response ICMP Destination unreachable (Host unreachable, code 1);

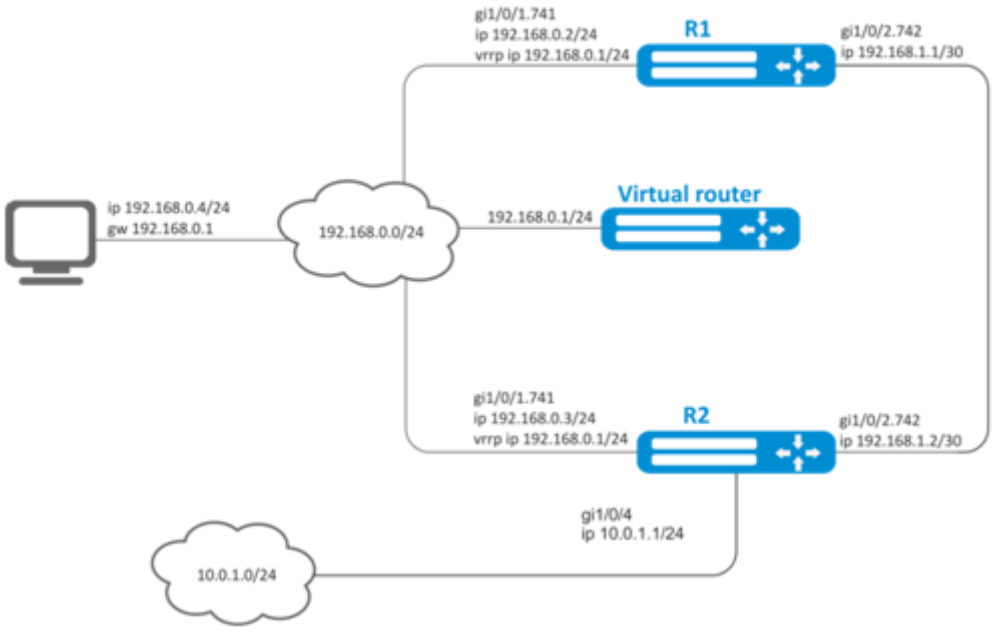
Step	Description	Command	Keys
			• **prohibit** – when specifying the command, the packets to this subnet will be removed by the device, a sender will receive in response ICMP Destination unreachable (Communication administratively prohibited, code 13); <METRIC> – route metric, takes values of [0..255]; <TRACK-ID> – Tracking object identifier. If the router is bound to the Tracking object, it will appear in the system only after meeting all requirements specified in the object.
6	Configure IP address, the availability of which is checked by sending pings. It is necessary to allow ICMP on the Firewall.	`esr(config-bridge)# vrrp track-ip <AAA.BBB.CCC.DDD>`	AAA.BBB.CCC.DDD – host IP address, where each part takes values of [0..255].
7	The interval at which pings are sent.	`esr(config-bridge)# vrrp track-ip <seconds>`	<seconds> – time interval in seconds [3..60]. Default value is 10.
8	The number of pings that are sent when monitoring a remote address.	`esr(config-bridge)# vrrp track-ip packets <packets>`	<packets> – number of packets to be sent [1..5]. Default value: 5

8.2.2 Configuration example

Objective:

Virtual gateway 192.168.0.1/24 is organized for 192.168.0.0/24 subnet, using VRRP protocol and routers R1 and R2. There is a link with a singular subnet 192.168.1.0/30 between R1 and R2 routers. Subnet 10.0.1.0/24 is terminated only on R2 router. PC has IP address - 192.168.0.4/24 and default gateway 192.168.1.1.

When router R1 is in vrrp backup state, traffic from PC will be transmitted without any additional settings. When router R1 is in vrrp master state, additional route is necessary for subnet 10.0.1.0/24 through interface 192.168.1.2.



Initial configurations of the routers:

1 R1 router

```
hostname R1
interface gigabitethernet 1/0/1
  switchport forbidden default-vlan
exit
interface gigabitethernet 1/0/1.741
  ip firewall disable
  ip address 192.168.0.2/24
  vrrp id 10
  vrrp ip 192.168.0.1/24
  vrrp
exit
interface gigabitethernet 1/0/2
  switchport forbidden default-vlan
exit
interface gigabitethernet 1/0/2.742
  ip firewall disable
  ip address 192.168.1.1/30
exit
```

2 R2 router

```
hostname R2
interface gigabitethernet 1/0/1
  switchport forbidden default-vlan
exit
interface gigabitethernet 1/0/1.741
  ip firewall disable
  ip address 192.168.0.3/24
  vrrp id 10
  vrrp ip 192.168.0.1/24
  vrrp
exit
interface gigabitethernet 1/0/2
  switchport forbidden default-vlan
exit
interface gigabitethernet 1/0/2.742
  ip firewall disable
  ip address 192.168.1.2/30
exit
interface gigabitethernet 1/0/4
  ip firewall disable
  ip address 10.0.1.1/24
exit
```

Solution:

There is no need in any changes in router R2, since subnet 10.0.1.0/24 is terminated on it and as soon as router R2 is vrrp master, packets will be transmitted to corresponding interface. As soon as R1 becomes vrrp master, route for packets must be created with destination IP address from network 10.0.1.0/24.

Create tracking-object with corresponding condition:

```
R1(config)# tracking 1
R1(config-tracking)# vrrp 10 state master
R1(config-tracking)# enable
R1(config-tracking)# exit
```

Create static route to subnet 10.0.1.0/24 through 192.168.1.2, which will work in case of satisfying of tracking 1 condition:

```
R1(config)# ip route 10.0.1.0/24 192.168.1.2 track 1
```

9 Remote access configuration

9.1 Configuring server for remote access to corporate network via PPTP protocol

PPTP (Point-to-Point Tunneling Protocol) is a point-to-point tunneling protocol that allows a computer to establish secure connection with a server by creating a special tunnel in a common unsecured network. PPTP encapsulates PPP frames into IP packets for transmission via global IP network, e.g. the Internet. PPTP may be used for tunnel establishment between two local area networks. PPTP uses an additional TCP connection for tunnel handling.

9.1.1 Configuration algorithm

Step	Description	Command	Keys
1	Create PPTP server profile.	`esr(config)# remote-access pptp <NAME>`	<NAME> – PPTP server profile name, set by the string of up to 31 characters.
2	Specify the description of the configured server (optionally).	`esr(config-pptp-server)# description <DESCRIPTION>`	<DESCRIPTION> – PPTP server description, set by the string of up to 255 characters.

Step	Description	Command	Keys
3	Specify IP address that should be proceeded by PPTP server.	`esr(config-pptp-server)# outside-address { object-group <OBJ-GROUP-NETWORK-NAME> | ip-address <ADDR> | interface { <IF> | <TUN> } }`	<OBJ-GROUP-NETWORK-NAME> – name of the profile having IP address that should listened by PPTP server, set by the string of up to 31 characters; <ADDR> – range starting IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <IF> – router interface type and identifier; <TUN> – router tunnel type and number.
4	IP address of a local gateway.	`esr(config-pptp-server)# local-address { object-group <OBJ-GROUP-NETWORK-NAME > | ip-address <ADDR> }`	<OBJ-GROUP-NETWORK-NAME> – name of the IP addresses profile that includes local gateway IP address, set by the string of up to 31 characters; <ADDR> – range starting IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
5	Specify IP addresses list from which dynamic IP addresses are leased to remote users by PPTP.	`esr(config-pptp-server)# remote-address { object-group <OBJ-GROUP-NETWORK-NAME > | address-range <FROM-ADDR>-<TO-ADDR> }`	<OBJ-GROUP-NETWORK-NAME> – name of the IP addresses profile that includes remote users IP addresses list, set by the string of up to 31 characters; <FROM-ADDR> – range starting IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <TO-ADDR> – range ending IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
6	Select PPTP clients authentication mode.	`esr(config-pptp-server)# authentication mode { local | radius }`	• local – user authentication by local base. • radius – user authentication by RADIUS server base. The router must be configured to interact with a RADIUS-server, see section AAA RADIUS configuration algorithm

Step	Description	Command	Keys
7	Allow necessary authentication methods for remote users	`esr(config-pptp-server)# authentication method <METHOD>`	<METHOD> – authentication method, possible values: [chap, mschap, mschap-v2, eap, pap]. By default only chap is allowed
8	Specify user name (when using local user authentication).	`esr(config-pptp-server) username < NAME >`	<NAME> – user name, set by the string of up to 12 characters.
9	Specify password (when using local user authentication).	`esr(config-pptp-user) password ascii-text { <PASSWORD> | encrypted <PASSWORD> }`	<PASSWORD> – user password, set by the string of up to 32 characters.
10	Activate user (when using local user authentication).	`esr(config-pptp-user) enable`	
11	Include the PPTP server in a security zone and configure interaction rules between zones or disable firewall (see section Firewall configuration).	`esr(config-pptp-server)# security-zone <NAME>`	<NAME> – security zone name, set by the string of up to 31 characters.
12	Enable server.	`esr(config-pptp-server)# enable`	
13	Specify outgoing packets DSCP priority (optionally).	`esr(config-pptp-server)# dscp <DSCP>`	<DSCP> – outgoing packets dscp priority [0..63].
14	Enable MPPE encryption for PPTP connections (optionally).	`esr(config-pptp-server)# encryption mppe`	
15	Specify MTU size (MaximumTransmissionUnit) for the server (optionally). MTU above 1500 will be active only when using the "system jumbo-frames" command.	`esr(config-pptp-server) mtu <MTU>`	<MTU> – MTU value, takes values in the range of [1280..1500]. Default value: 1500.
16	Define the list of DNS servers that will be used by remote users (optionally).	`esr(config-pptp-server)# dns-servers object-group <OBJ-GROUP-NETWORK -NAME >`	<OBJ-GROUP-NETWORK-NAME> – name of the IP addresses profile that includes required DNS servers addresses, set by the string of up to 31 characters.

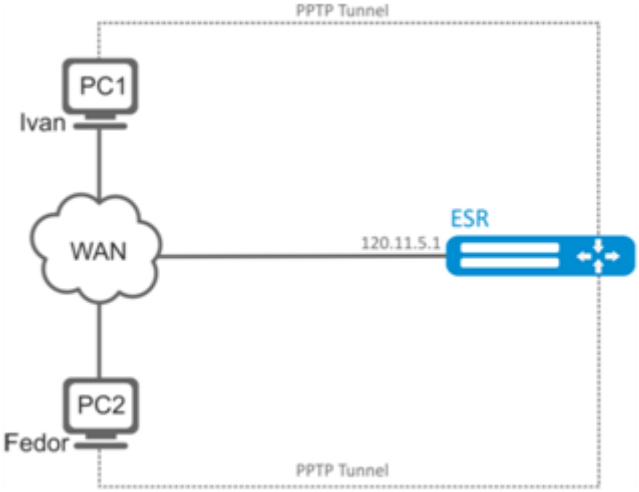
Step	Description	Command	Keys
17	Define the list of WINS servers that will be used by remote users (optionally).	`esr(config-pptp-server)# wins-servers object-group <OBJ-GROUP-NETWORK-NAME >`	<OBJ-GROUP-NETWORK-NAME> – name of the IP addresses profile that includes required WINS servers addresses, set by the string of up to 31 characters.

9.1.2 Configuration example

Objective:

Configure PPTP server on a router.

- PPTP server address: 120.11.5.1;
- Gateway inside the tunnel for connecting clients: 10.10.10.1;
- IP address pool for lease: 10.10.10.5-10.10.10.25;
- DNS servers: 8.8.8.8, 8.8.8.4;
- Accounts for connection: fedor, ivan.



Solution:

Create an address profile that contains an address to be listened by the server:

```
esr# configure
esr(config)# object-group network pptp_outside
esr(config-object-group-network)# ip address-range 120.11.5.1
esr(config-object-group-network)# exit
```

Create address profile that contains local gateway address:

```
esr(config)# object-group network pptp_local
esr(config-object-group-network)# ip address-range 10.10.10.1
esr(config-object-group-network)# exit
```

Create address profile that contains client addresses:

```
esr(config)# object-group network pptp_remote
esr(config-object-group-network)# ip address-range 10.10.10.5-10.10.10.25
esr(config-object-group-network)# exit
```

Create PPTP server and map profiles listed above:

```
esr(config)# remote-access pptp remote-workers
esr(config-pptp)# local-address object-group pptp_local
esr(config-pptp)# remote-address object-group pptp_remote
esr(config-pptp)# outside-address object-group pptp_outside
esr(config-pptp)# dns-servers object-group pptp_dns
```

Select authentication method for PPTP server users:

```
esr(config-pptp)# authentication mode local
```

Specify security zone that user sessions will be related to:

```
esr(config-pptp)# security-zone VPN
```

Create PPTP users *Ivan* and *Fedor* for PPTP server:

```
esr(config-pptp)# username ivan
esr(config-pptp-user)# password ascii-text password1
esr(config-pptp-user)# enable
esr(config-pptp-user)# exit
esr(config-pptp)# username fedor
esr(config-pptp-user)# password ascii-text password2
esr(config-pptp-user)# enable
esr(config-pptp-user)# exit
esr(config-pptp)# exit
```

Enable PPTP server:

```
esr(config-pptp)# enable
```

When a new configuration is applied, the router will listen to 120.11.5.1:1723. To view PPTP server session status, use the following command:

```
esr# show remote-access status pptp server remote-workers
```

To view PPTP server session counters, use the following command:

```
esr# show remote-access counters pptp server remote-workers
```

To clear PPTP server session counters, use the following command:

```
esr# clear remote-access counters pptp server remote-workers
```

To end PPTP server session for user 'fedor', use one of the following commands:

```
esr# clear remote-access session pptp username fedor
esr# clear remote-access session pptp server remote-workers username fedor
```

To view PPTP server configuration, use the following command:

```
esr# show remote-access configuration pptp remote-workers
```

⚠ In addition to PPTP server creation, you should open TCP port 1723 designed for connection handling and enable GRE protocol (47) for the tunnel traffic in the firewall.

9.2 Configuring server for remote access to corporate network via L2TP protocol

L2TP (Layer 2 Tunneling Protocol) is a sophisticated tunneling protocol used to support virtual private networks. L2TP encapsulates PPP frames into IP packets for transmission via global IP network, e.g. the Internet. L2TP may be used for tunnel establishment between two local area networks. L2TP uses an additional UDP connection for tunnel handling. L2TP protocol does not provide data encryption, therefore it is usually combined with an IPsec protocol group that provides security on a packet level.

9.2.1 Configuration algorithm

Step	Description	Command	Keys
1	Create L2TP server profile.	`esr(config)# remote-access l2tp <NAME>`	<NAME> – L2TP server profile name, set by the string of up to 31 characters.

Step	Description	Command	Keys
2	Specify the description of the configured server (optionally).	`esr(config-l2tp-server)# description <DESCRIPTION>`	<DESCRIPTION> – L2TP server description, set by the string of up to 255 characters.
3	Specify IP address that should be listened by L2TP server.	`esr(config-l2tp-server)# outside-address { object-group <NAME> | ip-address <ADDR> | interface { <IF> | <TUN> } }`	<OBJ-GROUP-NETWORK-NAME> – name of the profile having IP address that should be listened by L2TP server, set by the string of up to 31 characters; <ADDR> – range starting IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <IF> – router interface type and identifier; <TUN> – router tunnel type and number.
4	Specify the IP address of the local gateway or disable firewall for the PPTP server	`esr(config-l2tp-server)# local-address { object-group <OBJ-GROUP-NETWORK-NAME> | ip-address <ADDR> }`	<OBJ-GROUP-NETWORK-NAME> – name of the IP addresses profile that includes local gateway IP address, set by the string of up to 31 characters; <ADDR> – range starting IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
5	Specify IP addresses list from which dynamic IP addresses are leased to remote users by L2TP.	`esr(config-l2tp-server)# remote-address { object-group <OBJ-GROUP-NETWORK -NAME > | address-range <FROM-ADDR>-<TO-ADDR> }`	<OBJ-GROUP-NETWORK-NAME> – name of the IP addresses profile that includes remote users IP addresses list, set by the string of up to 31 characters; <FROM-ADDR> – range starting IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <TO-ADDR> – range ending IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].

Step	Description	Command	Keys
6	Select L2TP clients authentication mode.	`esr(config-l2tp-server)# authentication mode { local | radius }`	• local – user authentication by local base. • radius – user authentication by RADIUS server base. The router must be configured to interact with a RADIUS-server, see section AAA RADIUS configuration algorithm
7	Allow necessary authentication methods for remote users	`esr(config-l2tp-server)# authentication method <METHOD>`	<METHOD> – authentication method, possible values: [chap, mschap, mschap-v2, eap, pap]. By default only chap is allowed.
8	Include the L2TP server in a security zone and configure interaction rules between zones (see section Firewall configuration).	`esr(config-l2tp-server)# security-zone <NAME>`	<NAME> – security zone name, set by the string of up to 31 characters.
9	Specify user name (when using local authentication base).	`esr(config-l2tp-server) username < NAME >`	<NAME> – user name, set by the string of up to 12 characters.
10	Specify user password (when using local authentication base).	`esr(config-l2tp-user) password ascii-text { <PASSWORD> | encrypted <PASSWORD> }`	<PASSWORD> – user password, set by the string of up to 32 characters.
11	Enable user (when using local authentication base).	`esr(config-l2tp-user) enable`	
12	Select a key authentication method for IKE connection (optional).	`esr(config-l2tp-server)# ipsec authentication method pre-shared-key`	

Step	Description	Command	Keys
13	Specify a shared secret authentication key that should be the same for both parties of the tunnel.	`esr(config-l2tp-server)# ipsec authentication pre-shared-key { ascii-text { <TEXT> | encrypted <ENCRYPTED-TEXT> } | hexadecimal {<HEX> | encrypted <ENCRYPTED-HEX> } }`	<TEXT> – string [1..64] ASCII characters; <HEX> – number, [1..32] bytes size, set by the string of [2..128] characters in hexadecimal format (0xYYYY ...) or (YYYY ...). <ENCRYPTED-TEXT> – encrypted password, [1..32] bytes size, set by the string of [2..128] characters. <ENCRYPTED-TEXT> – encrypted number, [2..64] bytes size, set by the string of [2..256] characters.
14	Enable server.	`esr(config-l2tp-server)# enable`	
15	Specify outgoing packets DSCP priority.	`esr(config-l2tp-server)# dscp <DSCP>`	<DSCP> – outgoing packets dscp priority [0..63].
16	Specify MTU size (MaximumTransmissionUnit) for the server (optionally). MTU above 1500 will be active only when using the "system jumbo-frames" command.	`esr(config-l2tp-server) mtu <MTU>`	<MTU> – MTU value, takes values in the range of [1280..1500]. Default value: 1500.
17	Define the list of DNS servers that will be used by remote users (optionally).	`esr(config-l2tp-server)# dns-servers object-group <OBJ-GROUP-NETWORK -NAME >`	<OBJ-GROUP-NETWORK-NAME> – name of the IP addresses profile that includes required DNS servers addresses, set by the string of up to 31 characters.
18	Define the list of WINS servers that will be used by remote users (optionally).	`esr(config-l2tp-server)# wins-servers object-group <OBJ-GROUP-NETWORK -NAME >`	<OBJ-GROUP-NETWORK-NAME> – name of the IP addresses profile that includes required WINS servers addresses, set by the string of up to 31 characters.

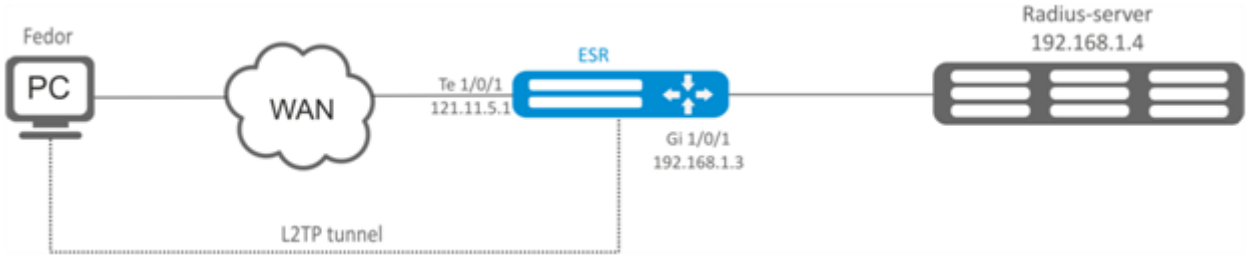
9.2.2 Configuration example

Objective:

Configure L2TP server on a router for remote user connection to LAN. Authentication is performed on RADIUS server.

- L2TP server address: 120.11.5.1;
- Gateway inside the tunnel: 10.10.10.1;
- Radius server address: 192.168.1.4;

For IPsec, key authentication method is used: key–'password'.



Solution:

First, do the following:

- Configure RADIUS server connection;
- Configure zones for te1/0/1 and gi1/0/1 interfaces.
- Specify IP addresses for te1/0/1 and te1/0/1 interfaces.

Create address profile that contains local gateway address:

```
esr(config)# object-group network l2tp_local
esr(config-object-group-network)# ip address-range 10.10.10.1
esr(config-object-group-network)# exit
```

Create address profile that contains DNS servers:

```
esr(config)# object-group network pptp_dns
esr(config-object-group-network)# ip address-range 8.8.8.8
esr(config-object-group-network)# ip address-range 8.8.4.4
esr(config-object-group-network)# exit
```

Create L2TP server and map profiles listed above:

```
esr(config)# remote-access l2tp remote-workers
esr(config-l2tp)# local-address ip-address 10.10.10.1
esr(config-l2tp)# remote-address address-range 10.10.10.5-10.10.10.15
esr(config-l2tp)# outside-address ip-address 120.11.5.1
esr(config-l2tp)# dns-server object-group l2tp_dns
```

Select authentication method for L2TP server users:

```
esr(config-l2tp)# authentication mode radius
```

Specify security zone that user sessions will be related to:

```
esr(config-l2tp)# security-zone VPN
```

Specify authentication method for IKE phase 1 and define an authentication key.

```
esr(config-l2tp)# ipsec authentication method psk
esr(config-l2tp)# ipsec authentication pre-shared-key ascii-text password
```

Enable L2TP server:

```
esr(config-l2tp)# enable
```

When a new configuration is applied, the router will listen to IP address 120.11.5.1 and port 1701. To view L2TP server session status, use the following command:

```
esr# show remote-access status l2tp server remote-workers
```

To view L2TP server session counters, use the following command:

```
esr# show remote-access counters l2tp server remote-workers
```

To clear L2TP server session counters, use the following command:

```
esr# clear remote-access counters l2tp server remote-workers
```

To end L2TP server session for user 'fedor', use one of the following commands:

```
esr# clear remote-access session l2tp username fedor
esr# clear remote-access session l2tp server remote-workers username fedor
```

To view L2TP server configuration, use the following command:

```
esr# show remote-access configuration l2tp remote-workers
```

⚠ In addition to L2TP server creation, you should open UDP port 500, 1701, 4500 designed for connection handling and enable ESP (50) and GRE protocol (47) for the tunnel traffic in the firewall.

9.3 Configuring server for remote access to corporate network via OpenVPN protocol

OpenVPN is a sophisticated tool based on SSL that implements Virtual Private Networks (VPN), enables remote access and solves many different tasks related to data transmission security.

9.3.1 Configuration algorithm

Step	Description	Command	Keys
1	Create OpenVPN server profile.	`esr(config)# remote-access openvpn <NAME>`	<NAME> – OpenVPN server profile name, set by the string of up to 31 characters.
2	Specify the description of the configured server (optionally).	`esr(config-openvpn-server)# description <DESCRIPTION>`	<DESCRIPTION> – OpenVPN server description, set by the string of up to 255 characters.

Step	Description	Command	Keys
3	Define the subnet from which IP addresses are leased to users. (only for tunnel ip)	`esr(config-openvpn-server)# network <ADDR/LEN>`	<ADDR/LEN> – subnet address, set in the following format: AAA.BBB.CCC.DDD/EE – network IP address with prefix mask, where AAA-DDD take values of [0..255] and EE takes values of [1..32].
4	Specify an encapsulated protocol.	`esr(config-openvpn-server)# protocol <PROTOCOL>`	<PROTOCOL> – encapsulation type, possible values: • TCP encapsulation in TCP segments; • UDP encapsulation in UDP datagrams.
5	Define type of connection with a private network via OpenVPN server.	`esr(config-openvpn-server)# tunnel <TYPE>`	<TYPE> – encapsulation protocol, takes the following values: • ip – point-to-point connection; • ethernet – L2 domain connection.
6	Specify IP addresses list from which dynamic IP addresses are leased to remote users in L2 mode by OpenVPN server. (only for tunnel ethernet)	`esr(config-openvpn-server)# address-range <FROM-ADDR>-<TO-ADDR>`	<FROM-ADDR> – range starting IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <TO-ADDR> – range ending IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
7	Include client connections via OpenVPN in L2 domain (only for tunnel ethernet).	`esr(config-openvpn-server)# bridge-group <BRIDGE-ID>`	<BRIDGE-ID> – bridge identifying number.

Step	Description	Command	Keys
8	Specify certificates and keys.	`esr(config-openvpn-server)# certificate <CERTIFICATE-TYPE> <NAME>`	<CERTIFICATE-TYPE> – certificate or key type, may take the following values: • ca – Certificate Authority; • crl – Certificate Revocation List; • dh – Diffie-Hellman key; • server - crt – public server certificate; • server - key – private server key; • ta – HMAC key. <NAME> – certificate or key name, set by the string of up to 31 characters.
9	Select encryption algorithm used when data transmission.	`esr(config-openvpn-server)# encryption algorithm <ALGORITHM>`	<ALGORITHM> – encryption protocol identifier, may take values: 3des,blowfish128, aes128.
10	Include the OpenVPN server in a security zone and configure interaction rules between zones (see section Firewall configuration).	`esr(config-openvpn-server)# security-zone <NAME>`	<NAME> – security zone name, set by the string of up to 31 characters.
11	Define the additional parameters for a specified OpenVPN server user (when using a local base for user authentication).	`esr(config-openvpn-server)# username < NAME >`	<NAME> – user name, set by the string of up to 31 characters.
12	Define a subnet for the specified user of the OpenVPN server.	`esr(config-openvpn-user)# subnet <ADDR/LEN>`	<ADDR/LEN> – subnet address, set in the following format: AAA.BBB.CCC.DDD/NN – network IP address with prefix mask, where AAA-DDD take values of [0..255] and EE takes values of [1..32].
13	Define a static ip address for the specified OpenVPN server user	`esr(config-openvpn-user)# ip address <ADDR>`	<ADDR> – address set in the following format: AAA.BBB.CCC.DDD – IP address of the subnet where AAA-DDD are set to [0..255].
14	Enable OpenVPN server profile.	`esr(config-openvpn-server)# enable`	
15	Enable data transmission blocking between clients (optionally).	`esr(config-openvpn-server)# client-isolation`	

Step	Description	Command	Keys
16	Set the maximum amount of simultaneous user sessions (optionally).	`esr(config-openvpn-server)# client-max <VALUE>`	<VALUE> – maximum amount of users, takes values of [1..65535].
17	The mechanism of transmitted data compression between clients and the OpenVPN server is enabled (optionally).	`esr(config-openvpn-server)# compression`	
18	Define the list of DNS servers that will be used by remote users (optionally).	`esr(config-openvpn-server)# dns-server <ADDR>`	<ADDR> – DNS server IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
19	Specify TCP/UDP port that will be listened by OpenVPN server (optionally).	`esr(config-openvpn-server)# port <PORT>`	<PORT> – TCP/UDP port, takes values of [1..65535]. Default value: 1194
20	Enable the default route advertising for OpenVPN connections, which leads to the replacement of the default route on the client side (optionally).	`esr(config-openvpn-server)# redirect-gateway`	
21	Enable the advertising of specified subnets, the gateway is OpenVPN server IP address (optionally).	`esr(config-openvpn-server)# route <ADDR/LEN>`	<ADDR/LEN> – subnet address, set in the following format: AAA.BBB.CCC.DDD/EE – network IP address with prefix mask, where AAA-DDD take values of [0..255] and EE takes values of [1..32].
22	Set time interval after which the opposing party is considered to be unavailable (optionally).	`esr(config-openvpn-server)# timers holdtime <TIME>`	<TIME> – time in seconds, takes values of [1..65535]. Default value: 120
23	Set the time interval after which the connection with the opposing party is checked (optionally).	`esr(config-openvpn-server)# timers keepalive <TIME>`	<TIME> – time in seconds, takes values of [1..65535]. Default value: 10
24	Allow multiple users with the same certificate to connect to the OpenVPN server.	`esr(config-openvpn-server)# duplicate-cn`	

Step	Description	Command	Keys
25	Define the list of WINS servers that will be used by remote users (optionally).	`esr(config-openvpn-server)# wins-server <ADDR>`	<ADDR> – WINS server IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
26	Change the authentication algorithm for OpenVPN clients (optional).	`esr(config-openvpn-server)# authentication algorithm <ALGORITHM>`	<ALGORITHM> – authentication algorithm: • 8-128 bits key size: md4, rsa-md4, md5, rsa-md5, mdc2, rsa-mdc2 • 8-160 bits key size: sha, sha1, rsa-sha, rsa-sha1, rsa-sha1-2, dsa, dsa-sha, dsa-sha1, dsa-sha1-old, ripemd160, rsa-ripemd160, ecdsa-with-sha1 • 8-224 bits key size: sha-224, rsa-sha-224 • 8-256 bits key size: sha-256, rsa-sha-256 • 8-384 bits key size: sha-384, rsa-sha-384 • 8-512 bits key size: sha-512, rsa-sha-512, whirlpool Default value: sha

9.3.2 Configuration example

Objective:

Configure Open VPN server in L3 mode on a router for remote user connection to LAN.

- OpenVPN server subnet: 10.10.100.0/24;
- Mode: L3;
- Authentication based on certificates.

Solution:

First, do the following:

- Prepare certificates and keys:
  - CA certificate
  - OpenVPN server key and certificate

    - Diffie-Hellman and HMAC key for TLS
- Configure zone for te1/0/1 interface
- Specify IP address for te1/0/1 interface

Import certificates and keys via tftp:

```
esr# copy tftp://192.168.16.10:/ca.crt certificate:ca/ca.crt
esr# copy tftp://192.168.16.10:/dh.pem certificate:dh/dh.pem
esr# copy tftp://192.168.16.10:/server.key certificate:server-key/server.key
esr# copy tftp://192.168.16.10:/server.crt certificate:server-crt/server.crt
esr# copy tftp://192.168.16.10:/ta.key certificate:ta/ta.key
```

Create OpenVPN server and a subnet for its operation:

```
esr(config)# remote-access openvpn AP
esr(config-openvpn)# network 10.10.100.0/24
```

Specify L3 connection type and encapsulation protocol.

```
esr(config-openvpn)# tunnel ip
esr(config-openvpn)# protocol tcp
```

Announce LAN subnets that will be available via OpenVPN connection and define DNS server

```
esr(config-)# route 10.10.0.0/20
esr(config-openvpn)# dns-server 10.10.1.1
```

Specify previously imported certificates and keys that will be used with OpenVPN server:

```
esr(config-openvpn)# certificate ca ca.crt
esr(config-openvpn)# certificate dh dh.pem
esr(config-openvpn)# certificate server-key server.key
esr(config-openvpn)# certificate server-crt server.crt
esr(config-openvpn)# certificate ta ta.key
```

Specify security zone that user sessions will be related to:

```
esr(config-openvpn)# security-zone VPN
```

Select aes128 encryption algorithm:

```
esr(config-openvpn)# encryption algorithm aes128
```

Enable OpenVPN server:

```
esr(config-openvpn)# enable
```

When a new configuration is applied, the router will listen to port 1194 (used by default).

To view OpenVPN server session status, use the following command:

```
esr# show remote-access status openvpn server AP
```

To view OpenVPN server session counters, use the following command:

```
esr# show remote-access counters openvpn server AP
```

To clear OpenVPN server session counters, use the following command:

```
esr# clear remote-access counters openvpn server AP
```

To end OpenVPN server session for user 'fedor', use one of the following commands:

```
esr# clear remote-access session openvpn username fedor
esr# clear remote-access session openvpn server AP username fedor
```

To view OpenVPN server configuration, use the following command:

```
esr# show remote-access configuration openvpn AP
```

⚠ In addition to OpenVPN server creation, you should open TCP port 1194 in the firewall.

9.4 Configuring remote access client via PPPoE

PPPoE is a tunneling protocol that allows encapsulating IP PPP over Ethernet connections and has PPP connection software capabilities, which allows using it to establish virtual connections to a neighbouring Ethernet device or a point-to-point connection that is used to transmit IP packets, and also works with PPP features. This allows applying conventional PPP-oriented software to configure the connection that uses not serial communication link but packet-oriented network (for example, Ethernet) to organize a classical connection with login and password for Internet connections. In addition, IP address on the opposite side of connection is assigned only when PPPoE connection is open, allowing the dynamic reuse of IP addresses.

9.4.1 Configuration algorithm

Step	Description	Command	Keys
1	Create a PPPoE tunnel and switch to its configuration mode.	`esr(config)# tunnel pppoe <PPPoE>`	<PPPoE> – tunnel sequence number from 1 to 10.
2	Specify the description of the configured client (optionally).	`esr(config-pppoe)# description <DESCRIPTION>`	<DESCRIPTION> – PPPoE server description, set by the string of up to 255 characters.
3	Specify the name of the VRF instance that will use the PPPoE client. (optional)	`esr(config-pppoe)# ip vrf forwarding <VRF>`	<VRF> – VRF name, set by the string of up to 31 characters.

Step	Description	Command	Keys
4	Specify the interface through which the PPPoE connection will be established.	`esr(config-pppoe)# interface <IF>`	<IF> – interface or interface group.
5	Specify user name and password for connection to PPPoE server	`esr(config-pppoe)# username <NAME> password ascii-text { <CLEAR-TEXT> | encrypted <ENCRYPTED-TEXT> }`	<NAME> – user name, set by the string of up to 31 characters; <CLEAR-TEXT> – password, set by the string of 8 to 16 characters; <ENCRYPTED-TEXT> – encrypted password, set by the string of [16..128] characters.
6	Include the PPPoE tunnel in a security zone and configure interaction rules between zones (see section Firewall configuration).	`esr(config-pppoe)# security-zone <NAME>`	<NAME> – security zone name, set by the string of up to 31 characters.
7	Enable a configured profile.	`esr(config-pppoe)# enable`	
8	Specify authentication method (optionally).	`esr(config-pppoe)# authentication method <METHOD>`	<METHOD> – authentication method, possible values: chap, mschap, mschap-v2, eap, pap Default value: chap
9	Enable the opt-out of receiving the default route from PPPoE server (optionally).	`esr(config-pppoe)# ignore-default-route`	
10	Specify the time interval during which the statistics on the load is averaged (optionally).	`esr(config-pppoe)# load-average <TIME>`	<TIME> – time interval in seconds from 5 to 150 (5 seconds by default)
11	Specify MTU size (MaximumTransmissionUnit) for PPPoE tunnel. MTU above 1500 will be active only when using the 'system jumbo-frames' command (optionally).	`esr(config-pppoe)# mtu <MTU>`	<MTU> – MTU value, takes values in the range of: • for ESR-10/12V(F)/14VF – [1280..9600]; • for ESR-20/21 – [1280..9500]; • for ESR-100/200/1000/1200/1500/1700 [1280..10000]. Default value: 1500.

Step	Description	Command	Keys
12	Change the number of failed data-link tests before breaking the session (optional).	`esr(config-pppoe)# ppp failure-count <NUM>`	<NUM> – the number of failed data-link tests, specified in the range [1..100]. Default value: 10
13	Change the time interval in seconds after which the router sends a keepalive message (optional).	`esr(config-pppoe)# ppp timeout keepalive <TIME>`	<TIME> – time in seconds, takes values of [1..32767]. Default value: 10
14	Override the MSS (Maximum segment size) field in incoming TCP packets (optional).	`esr(config-pppoe)# ip tcp adjust-mss <MSS>`	<MSS> – MSS value, takes values in the range of [500..1460]. Default value: 1460
15	Enable recording of the current tunnel usage statistics (optional).	`esr(config-pppoe)# history statistics`	

It is also possible to configure the PPPoE client:

- QoS in basic or advanced mode (see section QoS management);
- proxy (see section HTTP/HTTPS traffic proxying);
- Traffic monitoring (see sections Netflow configuration and sFlow configuration);

9.4.2 Configuration example

Objective:

Configure PPPoE client on the router.

- Accounts for connection – tester;
- Account passwords – password;
- The connection should be established from the gigabitethernet 1/0/7 interface.

Solution:

Pre-configure PPPoE server with the accounts.

Enter the PPPoE client configuration mode and disable the firewall:

```
esr# configure
esr(config)# tunnel pppoe 1
esr(config-pppoe)# ip firewall disable
```

Specify user name and password for connection to PPPoE server:

```
esr(config-pppoe)# username tester password ascii-text password
```

Specify the interface through which the PPPoE connection will be established:

```
esr(config-pppoe)# interface gigabitethernet 1/0/7
esr(config- pppoe)# enable
```

To view the tunnel status, use the following command:

```
esr# show tunnels configuration pppoe 1
```

To view PPPoE client session counters, use the following command:

```
esr# show tunnels counters pppoe 1
```

9.5 Configuring remote access client via PPTP

PPTP (Point-to-Point Tunneling Protocol) is a point-to-point tunneling protocol that allows establishing secure connection with a server by creating a special tunnel in a common unsecured network. PPTP encapsulates PPP frames into IP packets for transmission via global IP network, e.g. the Internet. PPTP may be used for tunnel establishment between two local area networks. PPTP uses an additional TCP connection for tunnel handling.

9.5.1 Configuration algorithm

Step	Description	Command	Keys
1	Create a PPTP tunnel and switch to its configuration mode.	`esr(config)# tunnel pptp <INDEX>`	<INDEX> – tunnel identifier, set in the range of: [1..10].
2	Specify the description of the configured tunnel (optionally).	`esr(config-pptp)# description <DESCRIPTION>`	<DESCRIPTION> – tunnel description, set by the string of up to 255 characters.
3	Specify VRF instance, in which the given PPTP tunnel will operate (optionally).	`esr(config-pptp)# ip vrf forwarding <VRF>`	<VRF> – VRF name, set by the string of up to 31 characters.

Step	Description	Command	Keys
4	Include the PPTP tunnel in a security zone and configure interaction rules between zones or disable firewall (see section Firewall configuration).	`esr(config-pptp)# security-zone <NAME>`	<NAME> – security zone name, set by the string of up to 31 characters.
		`esr(config-pptp)# ip firewall disable`	
5	Set remote IP address for tunnel installation.	`esr(config-pptp)# remote address <ADDR>`	<ADDR> – local gateway IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
6	Specify MTU size (MaximumTransmissionUnit) for the tunnel (optionally).	`esr(config-pptp)# mtu <MTU>`	<MTU> – MTU value, takes values in the range of: • for ESR-10/12V(F)/14VF – [552..9600]; • for ESR-20/21 – [552..9500]; • for ESR-100/200/1000/1200/1500/1700 [552..10000]. Default value: 1500.
7	Specify the user and set an encrypted or unencrypted password to authenticate the remote party.	`esr(config-pptp)# username <NAME> password ascii-text { <WORD> | encrypted <HEX> }`	<NAME> – user name, set by the string of up to 31 characters. <WORD> – unencrypted password, set by the string of [8..64] characters, may include [0-9a-fA-F] characters. <HEX> – encrypted password, set by the string of [16..128] characters.
8	Enable the tunnel	`esr(config-pptp)# enable`	
9	Override the MSS (Maximum segment size) field in incoming TCP packets (optional).	`esr(config-pptp)# ip tcp adjust-mss <MSS>`	<MSS> – MSS value, takes values in the range of [500..1460]. Default value: 1460
10	Ignore the default route via the given PPTP tunnel (optionally)	`esr(config-pptp)# ignore-default-route`	

Step	Description	Command	Keys
11	Specify the time interval during which the statistics on the tunnel load is averaged (optionally).	`esr(config-pptp)# load-average <TIME>`	<TIME> – interval in seconds, takes values of [5..150]. Default value: 5
12	Specify authentication method (optionally).	`esr(config-pptp)# authentication method <METHOD>`	<METHOD> – authentication method, possible values: chap, mschap, mschap-v2, eap, pap Default value: chap
13	Enable recording of the current tunnel usage statistics (optional).	`esr(config-pptp)# history statistics`	
14	Change the time interval in seconds after which the router sends a keepalive message (optional).	`esr(config-pptp)# ppp timeout keepalive <TIME >`	<TIME> – time in seconds, takes values of [1..32767]. Default value: 10
15	Change the number of failed data-link tests before breaking the session (optional).	`esr(config-pptp)# ppp failure-count <NUM>`	<NUM> – the number of failed data-link tests, specified in the range [1..100]. Default value: 10

9.5.2 Configuration example

Objective:

Configure PPTP tunnel on a router:

- PPTP server address: 20.20.0.1;
- account for connection – login: ivan, password: simplepass.

Solution:

Create PPTP tunnel:

```
esr(config)# tunnel pptp 1
```

Specify the account (Ivan user) to connect to the server:

```
esr(config-pptp)# username ivan password ascii-text simplepass
```

Specify the remote gateway:

```
esr(config-pptp)# remote address 20.20.0.1
```

Specify a security zone:

```
esr(config-pptp)# security-zone VPN
```

Enable PPTP tunnel:

```
esr(config-pptp)# enable
```

To view the tunnel status, use the following command:

```
esr# show tunnels status pptp
```

To view sent and received packet counters, use the following command:

```
esr# show tunnels counters pptp
```

To view the tunnel configuration, use the following command:

```
esr# show tunnels configuration pptp
```

9.6 Configuring remote access client via L2TP

L2TP (Layer 2 Tunneling Protocol) is a sophisticated tunneling protocol used to support virtual private networks. L2TP encapsulates PPP frames into IP packets for transmission via global IP network, e.g. the Internet. L2TP may be used for tunnel establishment between two local area networks. L2TP uses an additional UDP connection for tunnel handling. L2TP protocol does not provide data encryption, therefore it is usually combined with an IPsec protocol group that provides security on a packet level.

9.6.1 Configuration algorithm

Step	Description	Command	Keys
1	Create a L2TP tunnel and switch to its configuration mode.	`esr(config)# tunnel l2tp <INDEX>`	<INDEX> – tunnel identifier, set in the range of: [1..10].
2	Specify VRF instance, in which the given L2TP tunnel will operate (optionally).	`esr(config-l2tp)# ip vrf forwarding <VRF>`	<VRF> – VRF name, set by the string of up to 31 characters.

Step	Description	Command	Keys
3	Specify the description of the configured tunnel (optionally).	`esr(config-l2tp)# description <DESCRIPTION>`	<DESCRIPTION> – tunnel description, set by the string of up to 255 characters.
4	Include the L2TP tunnel in a security zone and configure interaction rules between zones or disable firewall (see section Firewall configuration).	`esr(config-l2tp)# security-zone <NAME>`	<NAME> – security zone name, set by the string of up to 31 characters.
		`esr(config-l2tp)# ip firewall disable`	
5	Set remote IP address for tunnel installation.	`esr(config-l2tp)# remote address <ADDR>`	<ADDR> – local gateway IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
6	Specify the user and set an encrypted or unencrypted password to authenticate the remote party.	`esr(config-l2tp)# username <NAME> password ascii-text { <WORD> | encrypted <HEX> }`	<NAME> – user name, set by the string of up to 31 characters. <WORD> – unencrypted password, set by the string of [8..64] characters, may include [0-9a-fA-F] characters. <HEX> – encrypted password, set by the string of [16..128] characters.
7	Select a key authentication method for IKE connection.	`esr(config-l2tp)# ipsec authentication method pre-shared-key`	
8	Specify a shared secret authentication key that should be the same for both parties of the tunnel.	`esr(config-l2tp)# ipsec authentication pre-shared-key { ascii-text { <TEXT> | encrypted <ENCRYPTED-TEXT> } | hexadecimal {<HEX> | encrypted <ENCRYPTED-HEX> } }`	<TEXT> – string [1..64] ASCII characters; <HEX> – number, [1..32] bytes size, set by the string of [2..128] characters in hexadecimal format (0xYYYY ...) or (YYYY ...); <ENCRYPTED-TEXT> – encrypted password, [1..32] bytes size, set by the string of [2..128] characters. <ENCRYPTED-TEXT> – encrypted number, [2..64] bytes size, set by the string of [2..256] characters.
9	Enable the tunnel	`esr(config-l2tp)# enable`	

Step	Description	Command	Keys
10	Specify MTU size (MaximumTransmissionUnit) for the tunnel (optional).	`esr(config-l2tp)# mtu <MTU>`	<MTU> – MTU value, takes values in the range of: • for ESR-10/12V(F)/14VF – [552..9600]; • for ESR-20/21 – [552..9500]; • for ESR-100/200/1000/1200/1500/1700 [552..10000]. Default value: 1500.
11	Ignore the default route via the given L2TP tunnel (optionally)	`esr(config-l2tp)# ignore-default-route`	
12	Specify authentication method (optionally).	`esr(config-l2tp)# authentication method <METHOD>`	<METHOD> – authentication method, possible values: chap, mschap, mschap-v2, eap, pap Default value: chap
13	Specify the time interval during which the statistics on the tunnel load is averaged (optionally).	`esr(config-l2tp)# load-average <TIME>`	<TIME> – interval in seconds, takes values of [5..150]. Default value: 5
14	Change the time interval in seconds after which the router sends a keepalive message (optional).	`esr(config-l2tp)# ppp timeout keepalive <TIME >`	<TIME> – time in seconds, takes values of [1..32767]. Default value: 10
15	Change the number of failed data-link tests before breaking the session (optional).	`esr(config-l2tp)# ppp failure-count <NUM>`	<NUM> – the number of failed data-link tests, specified in the range [1..100]. Default value: 10
It is also possible to configure QoS in basic or advanced mode for the PPPoE client (see section QoS management).			

9.6.2 Configuration example

Objective:

Configure PPTP tunnel on a router:

- PPTP server address: 20.20.0.1;
- account for connection – login: ivan, password: simplepass

Solution:

Create L2TP tunnel:

```
esr(config)# tunnel l2tp 1
```

Specify the account (Ivan user) to connect to the server:

```
esr(config-l2tp)# username ivan password ascii-text simplepass
```

Specify the remote gateway:

```
esr(config-l2tp)# remote address 20.20.0.1
```

Specify a security zone:

```
esr(config-l2tp)# security-zone VPN
```

Specify ipsec authentication method:

```
esr(config-l2tp)# ipsec authentication method pre-shared-key
```

Specify ipsec security key:

```
esr(config-l2tp)# ipsec authentication pre-shared-key ascii-text password
```

Enable L2TP tunnel:

```
esr(config-l2tp)# enable
```

To view the tunnel status, use the following command:

```
esr# show tunnels status l2tp
```

To view sent and received packet counters, use the following command:

```
esr# show tunnels counters l2tp
```

To view the tunnel configuration, use the following command:

```
esr# show tunnels configuration l2tp
```

10 Service management

10.1 DHCP server configuration

Integrated DHCP server of the router allows you to configure LAN device network settings. Router DHCP server is able to send additional options to network devices, for example:

- default-router – IP address of the router used as default gateway;
- domain-name – domain name which will be used by client while solving host names via domain name system (DNS);
- dns-server – list of domain name server addresses for the current network that should be known by the client. Server addresses are listed in descending order of their preference.

10.1.1 Configuration algorithm

Step	Description	Command	Keys
1	Enable IPv4/IPv6 DHCP server.	`esr(config)# ip dhcp-server [vrf <VRF>]`	<VRF> – VRF instance name, set by the string of up to 31 characters, within which the NTP server will operate. Set by the string of up to 31 characters.
		`esr(config)# ipv6 dhcp-server [vrf <VRF>]`	
2	Set the DSCP code value for the use in IP headers of DHCP server egress packets (optionally).	`esr(config)# ip dhcp-server dscp <DSCP>`	<DSCP> – DSCP code value, takes values in the range of [0..63]. Default value: 61.

Step	Description	Command	Keys
3	Create pool of DHCP server IPv4/ IPv6 addresses and switch to its configuration mode.	`esr(config)# ip dhcp-server pool <NAME> [vrf <VRF>]`	<NAME> – IPv4/IPv6 server profile name, set by the string of up to 31 characters. <VRF> – VRF instance name, within which the NTP server will operate. Set by the string of up to 31 characters.
		`esr(config)# ipv6 dhcp-server pool <NAME> [vrf <VRF>]`	
4	Specify IPv4/IPv6 address and mask for the subnet from which IPv4/IPv6 addresses pool will be allocated.	`esr(config-dhcp-server)# network <ADDR/LEN>`	<ADDR/LEN> – IP address and prefix of a subnet, defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32].
		`esr(config-ipv6-dhcp-server)# network <IPV6-ADDR/LEN>`	<IPV6-ADDR/LEN> – IP address and prefix of a subnet, defined as X:X:X:X::X/EE where each X part takes values in hexadecimal format [0..FFFF] and EE takes values of [1..128].
5	Add IPv4/IPv6 addresses range to the address pool of configurable DHCP server.	`esr(config-dhcp-server)# address-range <FROM-ADDR>-<TO-ADDR>`	<FROM-ADDR> – range starting IP address; <TO-ADDR> – range ending IP address; The addresses are defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]. You can specify up to 32 IP addresses separated by commas.
		`esr(config-ipv6-dhcp-server)# address-range <FROM-ADDR>-<TO-ADDR>`	<FROM-ADDR> – range starting IP address; <TO-ADDR> – range ending IP address; The addresses are defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF].

Step	Description	Command	Keys
6	Add IPv4/IPv6 address for a specific physical address to the address pool of configurable DHCP server (optionally).	`esr(config-dhcp-server)# address <ADDR> {mac-address <MAC> | client-identifier <CI>}`	<ADDR> – client IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <MAC> – MAC address of the client, which will be given the IP address, is defined as XX: XX: XX: XX: XX: XX where each part takes the values of [00..FF]. <CI> – client identifier according to DHCPOption61. Can be specified as follows: • HH:HH:HH:HH:HH:HH:HH: – client identifier in hexadecimal format and client MAC address; • STRING – text string from 1 to 64 characters.
		`esr(config-ipv6-dhcp-server)# address <ADDR> mac-address <MAC>`	<IPV6-ADDR> – client IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF]; <MAC> – MAC address of the client, which will be given the IP address, defined as XX: XX: XX: XX: XX: XX where each part takes the values of [00..FF].
7	Specify the list of default gateway IPv4 addresses which will be transmitted by DHCP server to clients through DHCP option 3.	`esr(config-dhcp-server)# default-router <ADDR>`	<ADDR> – default gateway IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; You can specify up to 8 IP addresses separated by commas.
8	Specify network domain DNS name. Domain name is transmitted to clients as part of DHCP option 15 (optionally).	`esr(config-dhcp-server)# domain-name <NAME>`	<NAME> – router domain name, set by the string from 1 to 255 characters.
		`esr(config-ipv6-dhcp-server)# domain-name <NAME>`	
9	Specify DNS server IPv4/IPv6 addresses list. The list is transmitted to clients as part of DHCP option 6 (optionally).	`esr(config-dhcp-server)# dns-server <ADDR>`	<ADDR> – DNS server IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]. You can specify up to 8 IP addresses separated by commas.

Step	Description	Command	Keys
		`esr(config-ipv6-dhcp-server)# dns-server <IPV6-ADDR>`	<IPV6-ADDR> – DNS server IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF]. You can specify up to 8 IP addresses separated by commas.

10	Specify maximum IP addresses lease time (optionally).
	
	If DHCP client requests the lease time that exceeds a maximum value, the time specified by the command will be set.
		`esr(config-dhcp-server)# max-lease-time <TIME>`
		
		`esr(config-ipv6-dhcp-server)# max-lease-time <TIME>`
			<TIME> – maximal IP address lease time, sets in format DD:HH:MM, where:
			• DD – amount of days, takes values of [0..364].
			• HH – amount of hours, takes values of [0..23].
			• MM – amount of minutes, takes the value of [0 ..59].
			Default value: 1 day

11	Specify the lease time for which a client will be given IP address (optionally).
	
	This time will be used if a client did not request the certain lease time.
		`esr(config-dhcp-server)# default-lease-time <TIME>`
		
		`esr(config-ipv6-dhcp-server)# default-lease-time <TIME>`
			<TIME> – maximal IP address lease time, sets in format DD:HH:MM, where:
			• DD – amount of days, takes values of [0..364].
			• HH – amount of hours, takes values of [0..23].
			• MM – amount of minutes, takes the value of [0 ..59].
			Default value: 12 hours.

12	Create supplier class identifier (DHCP Option 60) (optionally).	`esr(config)# ip dhcp-server vendor-class-id <NAME>`
		
		`esr(config)# ipv6 dhcp-server vendor-class-id <NAME>`
			<NAME> – carrier class identifier, set by the string of up to 31 characters.

13	Specify specific supplier information (DHCP Option 43).	`esr(config-dhcp-vendor-id)# vendor-specific-options <HEX>`
		
		`esr(config-ipv6-dhcp-vendor-id)# vendor-specific-options <HEX>`
			<HEX> – vendor-specific information, specified in hexadecimal format up to 128 symbols.

Step	Description	Command	Keys
14	Specify NetBIOS server IP address (DHCP option 44) (optionally).	`esr(config-dhcp-server)# netbios-name-server <ADDR>`	<ADDR> – NetBIOS server IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]. You can set up to 4 IP addresses.
15	Specify tftp server IP address (DHCP option 150) (optionally).	`esr(config-dhcp-server)# tftp-server <ADDR>`	<ADDR> – DNS server IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].

10.1.2 Configuration example

Objective:

Configure DHCP server operation in a local network that belongs to the 'trusted' security zone. Specify IP address pool from 192.168.1.0/24 subnet for distribution to clients. Specify address lease time equal to 1 day. Configure transmission of the default route, domain name and DNS server addresses to clients using DHCP options.

Solution:

Create «trusted» security zone and determine the inherence of the network interfaces being used to zones:

```
esr# configure
esr(config)# security zone trusted
esr(config-zone)# exit
```

Create address pool named «Simple» and add IP address range intended for server clients lease into this pool. Specify parameters of the subnet that the pool belongs to, and the lease time for addresses:

```
esr# configure
esr(config)# ip dhcp-server pool Simple
esr(config-dhcp-server)# network 192.168.1.0/24
esr(config-dhcp-server)# address-range 192.168.1.100-192.168.1.125
esr(config-dhcp-server)# default-lease-time 1:00:00
```

Configure transfer of additional network parameters to clients:

- default route: 192.168.1.1;
- domain name: eltex.loc;
- DNS server list: DNS1: 172.16.0.1, DNS2: 8.8.8.8.

```
esr(config-dhcp-server)# domain-name "eltex.loc"
esr(config-dhcp-server)# default-router 192.168.1.1
esr(config-dhcp-server)# dns-server 172.16.0.1 8.8.8.8
esr(config-dhcp-server)# exit
```

To enable IP address distribution from the configurable pool by DHCP server, IP interface should be created on the router that belongs to the same subnet as the pool addresses.

```
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)# security-zone trusted
esr(config-if-gi)# ip address 192.168.1.1/24
esr(config-if-gi)# exit
```

To enable DHCP message transmission to the server, you should create the respective port profiles including source port 68 and destination port 67 used by DHCP and create the allowing rule in the security policy for UDP packet transmission:

```
esr(config)# object-group service dhcp_server
esr(config-object-group-service)# port-range 67
esr(config-object-group-service)# exit
esr(config)# object-group service dhcp_client
esr(config-object-group-service)# port-range 68
esr(config-object-group-service)# exit
esr(config)# security zone-pair trusted self
esr(config-zone-pair)# rule 30
esr(config-zone-rule)# match protocol udp
esr(config-zone-rule)# match source-port dhcp_client
esr(config-zone-rule)# match destination-port dhcp_server
esr(config-zone-rule)# action permit
esr(config-zone-rule)# enable
esr(config-zone-rule)# exit
esr(config-zone-pair)# exit
```

Enable server operation:

```
esr(config)# ip dhcp-server
esr(config)# exit
```

To view the list of leased addresses, use the following command:

```
esr# show ip dhcp binding
```

To view the configured address pools, use the following commands:

```
esr# show ip dhcp server pool
esr# show ip dhcp server pool Simple
```

⚠ Configuration of settings for IPv6 is performed by analogy to IPv4.

10.2 Destination NAT configuration

Destination NAT (DNAT) function includes destination IP address translation for packets transferred through the network gateway.

DNAT is used for redirection of traffic, coming to a specific 'virtual' address in a public network, to a 'real' server in LAN located behind the network gateway. This function may be used for establishing a public access to servers located within the private network without any public network address.

10.2.1 Configuration algorithm

Step	Description	Command	Keys
1	Switch to the configuration mode of destination address translation service.	`esr(config)# nat destination`	
2	Create a pool of IP addresses and/or TCP/UDP ports with a specific name (optionally).	`esr(config-dnat)# pool <NAME>`	<NAME> – NAT addresses pool name, set by the string of up to 31 characters.
3	Set the internal IP address which will replace a destination IP address.	`esr(config-dnat-pool)# ip address <ADDR>`	<ADDR> – IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
4	Set the internal TCP/UDP port which will replace a destination TCP/UDP port.	`esr(config-dnat-pool)# ip port <PORT>`	<PORT> – TCP/UDP port, takes values of [1..65535].
5	Create a rule group with a specific name.	`esr(config-dnat)# ruleset <NAME>`	<NAME> – rule group name, set by the string of up to 31 characters.
6	Specify VRF instance, in which the given rule group will operate (optionally).	`esr(config-dnat-ruleset)# ip vrf forwarding <VRF>`	<VRF> – VRF name, set by the string of up to 31 characters.
7	Set the rule group scope. The rules will be applied only to traffic coming from a certain zone or interface.	`esr(config-dnat-ruleset)# from { zone <NAME> | interface <IF> | tunnel <TUN> | default }`	<NAME> – isolation zone name; <IF> – device interface name; <TUN> – device tunnel name; default – denotes a group of rules for all traffic, the source of which did not fall under the criteria of other groups of rules.
8	Specify a rule with a certain number. The rules are proceeded in ascending order.	`esr(config-dnat-ruleset)# rule <ORDER>`	<ORDER> – rule number, takes values of [1..10000].
9	Specify the profile of IP addresses {sender | recipient} for which the rule should work.	`esr(config-dnat-rule)# match [not] {source| destination}-address <OBJ-GROUP-NETWORK-NAME>`	<OBJ-GROUP-NETWORK-NAME> – IP addresses profile name, set by the string of up to 31 characters. “Any” value points at any source IP address.

Step	Description	Command	Keys
10	Specify the profile of services (tcp/udp ports) {sender | recipient} for which the rule should work (optionally).	`esr(config-dnat-rule)# match [not] {source|destination}-port <PORT-SET-NAME>`	<PORT-SET-NAME> – port profile name, set by the string of up to 31 characters. “Any” value points at any source TCP/UDP port.
11	Set name or number of IP for which the rule should work (optional).	`esr(config-dnat-rule)# match [not] {protocol <TYPE> | protocol-id <ID> }`	<TYPE> – protocol type, takes the following values: esp, icmp, ah, eigrp, ospf, igmp, ipip, tcp, pim, udp, vrrp, rdp, l2tp, gre. “Any” value points at any protocol type. <ID> – IP identification number, takes values of [0x00-0xFF].
12	Specify the type and code of ICMP messages for which the rule should work (if ICMP is selected as protocol) (optionally).	`esr(config-dnat-rule)# match [not] icmp {<ICMP_TYPE><ICMP_CODE> | <TYPE-NAME>}`	<ICMP_TYPE> – ICMP message type, takes values of [0..255]. <ICMP_CODE> – ICMP message code, takes values of [0..255]. “Any” value points at any message code. <TYPE-NAME> – ICMP message type name.
13	Specify the action “translation of source address and port” for the traffic meeting the requirements of “match” commands.	`esr(config-dnat-rule)# action destination-nat { off | pool <NAME> | netmap <ADDR/LEN> }`	off – translation is disabled; pool<NAME> – name of the pool that contains IP addresses and/or TCP/UDP ports set; netmap <ADDR/LEN> – subnet IP address and mask used during translation. The parameter is defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32].
14	Activate a configured rule.	`esr(config-dnat-rule)# enable`	

[1] When using the *not* key, the rule will work for values which are not included in a specified profile

Each “match” command may contain “not” key. When using the key, packets that do not meet the given requirement will fall under the rule.

You can obtain more detail information about router configuration in “CLI command reference guide”.

10.2.2 Destination NAT configuration example

Objective:

Establish access from the public network, that belongs to the 'UNTRUST' zone, to LAN server in 'TRUST' zone. Server address in LAN – 10.1.1.100. Server should be accessible from outside the network–address 1.2.3.4, access port 80.

Solution:

Create 'UNTRUST' and 'TRUST' security zones. Specify the inherence of the network interfaces being used to zones. Assign IP ‗addresses to interfaces simultaneously.

```
esr# configure
esr(config)# security zone UNTRUST
esr(config-zone)# exit
esr(config)# security zone TRUST
esr(config-zone)# exit
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)#   security-zone TRUST
esr(config-if-gi)#   ip address 10.1.1.1/25
esr(config-if-gi)# exit
esr(config)# interface tengigabitethernet 1/0/1
esr(config-if-te)# ip address 1.2.3.4/29
esr(config-if-te)# security-zone UNTRUST
esr(config-if-te)# exit
```

Create IP address and port profiles required for configuration of the Firewall and DNAT rules.

- NET_UPLINK – public network address profile;
- SERVER_IP – local area network address profile;
- SRV_HTTP – port profile.

```
esr(config)# object-group network NET_UPLINK
esr(config-object-group-network)# ip address 1.2.3.4
esr(config-object-group-network)# exit
```

```
esr(config)# object-group service SRV_HTTP
esr(config-object-group-service)# port 80
esr(config-object-group-service)# exit
```

```
esr(config)# object-group network SERVER_IP
esr(config-object-group-network)# ip address 10.1.1.100
esr(config-object-group-network)# exit
```

Proceed to DNAT configuration mode and create destination address and port pool that will be used for translation of packet addresses coming to address 1.2.3.4 from the external network.

```
esr(config)# nat destination
esr(config-dnat)# pool SERVER_POOL
esr(config-dnat-pool)# ip address 10.1.1.100
esr(config-dnat-pool)# ip port 80
esr(config-dnat-pool)# exit
```

Create 'DNAT' rule set which will be used for address translation. In the set attributes, specify that the rules are applying only to packets coming from the 'UNTRUST' zone. Rule set includes data matching requirements for destination address and port (match destination-address, match destination-port) and for the protocol. Also, the set includes an action that applies to the data that satisfy all of the rules (action destination-nat). The rule set is applied with 'enable' command.

```
esr(config-dnat)# ruleset DNAT
esr(config-dnat-ruleset)# from zone UNTRUST
esr(config-dnat-ruleset)# rule 1
esr(config-dnat-rule)# match destination-address NET_UPLINK
esr(config-dnat-rule)# match protocol tcp
esr(config-dnat-rule)# match destination-port SRV_HTTP
esr(config-dnat-rule)# action destination-nat pool SERVER_POOL
esr(config-dnat-rule)# enable
esr(config-dnat-rule)# exit
esr(config-dnat-ruleset)# exit
esr(config-dnat)# exit
```

To transfer the traffic coming from 'UNTRUST' zone into 'TRUST' zone, create the respective pair of zones. Only DNAT-translated traffic with the destination address matching the 'SERVER_IP' specified in the profile should be transferred.

```
esr(config)# security zone-pair UNTRUST TRUST
esr(config-zone-pair)# rule 1
esr(config-zone-pair-rule)# match destination-address SERVER_IP
esr(config-zone-pair-rule)# match destination-nat
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)# exit
esr(config)# exit
```

Configuration changes will take effect when the configuration is applied:

```
esr# show ip nat destination pools
esr# show ip nat destination rulesets
esr# show ip nat proxy-arp
esr# show ip nat translations
```

10.3 Source NAT configuration

Source NAT (SNAT) function substitutes source address for packets transferred through the network gateway. When packets are transferred from LAN into public network, source address is substituted to one of the gateway public addresses. Additionally, source port substitution may be added to the source address. When packets are transferred back from public network to LAN, address and port are reverted to their original values.

SNAT function enables Internet access for computers located in LAN. At that, there is no need in assigning public IP addresses for these computers.

10.3.1 Configuration algorithm

Step	Description	Command	Keys
1	Switch to the configuration mode of source address translation service.	`esr(config)# nat source`	
2	Create a pool of IP addresses and/or TCP/UDP ports with a specific name (optionally).	`esr(config-snat)# pool <NAME>`	<NAME> – NAT addresses pool name, set by the string of up to 31 characters.
3	Set the range of IP addresses which will replace a source IP address.	`esr(config-snat-pool)# ip address-range <IP>[-<ENDIP>]`	<IP> – IP address of the beginning of the range, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <ENDIP> – IP address of the end of the range, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]. If IP address of the end of the range is not specified, only IP address of the beginning of the range is used as IP address for translation.
4	Specify the range of external TCP/UDP ports which will replace a source TCP/UDP port.	`esr(config-snat-pool)# ip port-range <PORT>[-<ENDPORT>]`	<PORT> – TCP/UDP port of the beginning of range, takes values of [1..65535]. <ENDPORT> – TCP/UDP port of the end of range, takes values of [1..65535]. If TCP/UDP port of the end of the range is not specified, only TCP/UDP port of the beginning of the range is used as TCP/UDP port for translation.
5	Set the internal TCP/UDP port which will replace a source TCP/UDP port.	`esr(config-snat-pool)# ip port <PORT>`	<PORT> – TCP/UDP port, takes values of [1..65535].
6	Enable NAT persistent functions.	`esr(config-snat-pool)# persistent`	

Step	Description	Command	Keys
7	Create a rule group with a specific name.	`esr(config-snat)# ruleset <NAME>`	<NAME> – rule group name, set by the string of up to 31 characters.
8	Specify VRF instance, in which the given rule group will operate (optionally).	`esr(config-snat-ruleset)# ip vrf forwarding <VRF>`	<VRF> – VRF name, set by the string of up to 31 characters.
9	Set the rule group scope. The rules will be applied only to traffic coming to a certain zone or interface.	`esr(config-snat-ruleset)# to { zone <NAME> | interface <IF> tunnel <TUN> | | default }`	<NAME> – isolation zone name; <IF> – device interface name; <TUN> – device tunnel name default – denotes a group of rules for all traffic, the source of which did not fall under the criteria of other groups of rules.
10	Specify a rule with a certain number. The rules are proceeded in ascending order.	`esr(config-snat-ruleset)# rule <ORDER>`	<ORDER> – rule number, takes values of [1..10000].
11	Specify the profile of IP addresses {sender | recipient} for which the rule should work.	`esr(config-snat-rule)# match [not] {source|destination}-address <OBJ-GROUP-NETWORK-NAME>`	<OBJ-GROUP-NETWORK-NAME> – IP addresses profile name, set by the string of up to 31 characters. “Any” value points at any source IP address.
12	Specify the profile of IP addresses {sender| recipient} for which the rule should work (optionally).	`esr(config-snat-rule)# match [not] {source | destination}-port <PORT-SET-NAME>`	<PORT-SET-NAME> – port profile name, set by the string of up to 31 characters. “Any” value points at any source TCP/UDP port.
13	Set name or number of IP for which the rule should work (optional).	`esr(config-snat-rule)# match [not] {protocol|protocol-id} <TYPE>`	<TYPE> – protocol type, takes the following values: esp, icmp, ah, eigrp, ospf, igmp, ipip, tcp, pim, udp, vrrp, rdp, l2tp, gre. “Any” value points at any protocol type. <ID> – IP identification number, takes values of [0x00-0xFF].

Step	Description	Command	Keys
14	Specify the type and code of ICMP messages for which the rule should work (optionally).	`esr(config-snat-rule)# match [not] icmp {<ICMP_TYPE><ICMP_CODE> | <TYPE-NAME>}`	<ICMP_TYPE> – ICMP message type, takes values of [0..255]. <ICMP_CODE> – ICMP message code, takes values of [0..255]. “Any” value points at any message code. <TYPE-NAME> – ICMP message type name
15	Specify the action “translation of source address and port” for the traffic meeting the requirements of “match” command.	`esr(config-snat-rule)# action source-nat { off | pool <NAME> | netmap <ADDR/LEN> [static] | interface [FIRST_PORT - LAST_PORT] }`	off – translation is disabled; pool<NAME> – name of the pool that contains IP addresses and/or TCP/UDP ports set; netmap <ADDR/LEN> – subnet IP address and mask used during translation; static – option for static NAT organization. The parameter is defined as AAA.BBB.CCC.DDD/EE where each part AAA-DDD takes values of [0..255] and EE takes values of [1..32]. interface [FIRST_PORT – LAST_PORT] – specify the translation to the interface IP address. If the range of TCP/UDP ports is additionally specified, the translation will occur only for the sender TCP/UDP ports included in the specified range.
16	Activate a configured rule.	`esr(config-snat-rule)# enable`	

[1] When using the not key, the rule will work for values which are not included in a specified profile

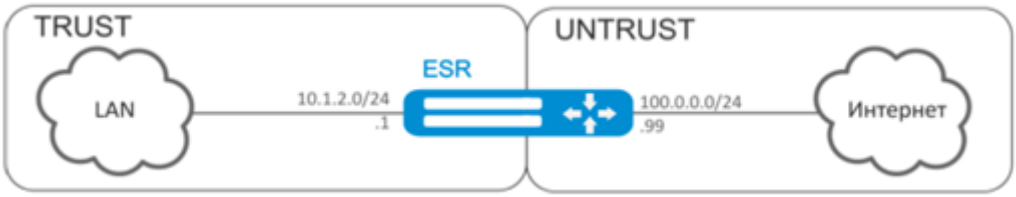
Each “match” command may contain “not” key. When using the key, packets that do not meet the given requirement will fall under the rule.

You can obtain more detail information about router configuration in “CLI command reference guide”.

10.3.2 Configuration example 1

Objective:

Configure access for users in LAN 10.1.2.0/24 to public network using Source NAT function. Specify public network address range for SNAT 100.0.0.100-100.0.0.249.



Solution:

Begin configuration with creation of security zones, configuration of network interfaces and their inherence to security zones. Create 'TRUST' zone for LAN and 'UNTRUST' zone for public network.

```
esr# configure
esr(config)# security zone UNTRUST
esr(config-zone)# exit
esr(config)# security zone TRUST
esr(config-zone)# exit
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)# ip address 10.1.2.1/24
esr(config-if-gi)# security-zone TRUST
esr(config-if-gi)# exit
esr(config)# interface tengigabitethernet 1/0/1
esr(config-if-te)# ip address 100.0.0.99/24
esr(config-if-te)# security-zone UNTRUST
esr(config-if-te)# exit
```

For SNAT function configuration and definition of rules for security zones, create 'LOCAL_NET' LAN address profile that includes addresses which are allowed to access the public network and 'PUBLIC_POOL' public network address profile.

```
esr(config)# object-group network LOCAL_NET
esr(config-object-group-network)# ip address-range 10.1.2.2-10.1.2.254
esr(config-object-group-network)# exit
esr(config)# object-group network PUBLIC_POOL
esr(config-object-group-network)# ip address-range 100.0.0.100-100.0.0.249
esr(config-object-group-network)# exit
```

To transfer traffic from 'TRUST' zone into 'UNTRUST' zone, create a pair of zones and add rules allowing traffic transfer in this direction. Additionally, there is a check in place to ensure that data source address belongs to 'LOCAL_NET' address range in order to limit the access to public network. Rules are applied with the *enable* command.

```
esr(config)# security zone-pair TRUST UNTRUST
esr(config-zone-pair)# rule 1
esr(config-zone-pair-rule)# match source-address LOCAL_NET
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)# exit
```

Configure SNAT service. First step is to create public network address pool for use with SNAT.

```
esr(config)# nat source
esr(config-snat)# pool TRANSLATE_ADDRESS
esr(config-snat-pool)# ip address-range 100.0.0.100-100.0.0.249
esr(config-snat-pool)# exit
```

Second step is to create SNAT rule set. In the set attributes, specify that the rules are applying only to packets transferred to public network–into the 'UNTRUST' zone. Rules include a check which ensures that data source address belongs to 'LOCAL_NET' pool.

```
esr(config-snat)# ruleset SNAT
esr(config-snat-ruleset)# to zone UNTRUST
esr(config-snat-ruleset)# rule 1
esr(config-snat-rule)# match source-address LOCAL_NET
esr(config-snat-rule)# action source-nat pool TRANSLATE_ADDRESS
esr(config-snat-rule)# enable
esr(config-snat-rule)# exit
esr(config-snat-ruleset)# exit
```

In order the router could response to the ARP requests for addresses from the public pool, you should launch ARP Proxy service. ARP Proxy service is configured on the interface that IP address from 'PUBLIC_POOL' public network address profile subnet belongs to.

```
esr(config)# interface tengigabitethernet 1/0/1
esr(config-if-te)# ip nat proxy-arp PUBLIC_POOL
```

To enable public network access for LAN devices, they should be configured for routing–10.1.2.1 should be defined as a gateway address.

On the router, you should create the route for public network. Specify this route as a default using the following command.

```
esr(config)# ip route 0.0.0.0/0 100.0.0.1
esr(config)# exit
```

10.3.3 Configuration example 2

Objective:

Configure access for users in LAN 21.12.2.0/24 to public network using Source NAT function without the firewall. Public network address range for SNAT 200.10.0.100-200.10.0.249.

Solution:

Begin configuration with network interface configuration and disabling the firewall:

```
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)# ip address 21.12.2.1/24
esr(config-if-gi)# ip firewall disable
esr(config-if-gi)# exit
```

```
esr(config)# interface tengigabitethernet 1/0/1
esr(config-if-te)# ip address 200.10.0.1/24
esr(config-if-te)# ip firewall disable
esr(config-if-te)# exit
```

For SNAT function configuration, create 'LOCAL_NET' LAN address profile that includes addresses which are allowed to access the public network and 'PUBLIC_POOL' public network address profile.

```
esr(config)# object-group network LOCAL_NET
esr(config-object-group-network)# ip address-range 21.12.2.2-21.12.2.254
esr(config-object-group-network)# exit

esr(config)# object-group network PUBLIC_POOL
esr(config-object-group-network)# ip address-range 200.10.0.100-200.10.0.249
esr(config-object-group-network)# exit
```

Configure SNAT service.

First step is to create public network address pool for use with SNAT:

```
esr(config)# nat source
esr(config-snat)# pool TRANSLATE_ADDRESS
esr(config-snat-pool)# ip address-range 200.10.0.100-200.10.0.249
esr(config-snat-pool)# exit
```

Second step is to create SNAT rule set. In the set attributes, specify that the rules are applying only to packets transferred to public network through te1/0/1 port. Rules include a check which ensures that data source address belongs to 'LOCAL_NET' pool:

```
esr(config-snat)# ruleset SNAT
esr(config-snat-ruleset)# to interface te1/0/1
esr(config-snat-ruleset)# rule 1
esr(config-snat-rule)# match source-address LOCAL_NET
esr(config-snat-rule)# action source-nat pool TRANSLATE_ADDRESS
esr(config-snat-rule)# enable
esr(config-snat-rule)# exit
esr(config-snat-ruleset)# exit
```

In order the router could response to the ARP requests for addresses from the public pool, you should launch ARP Proxy service. ARP Proxy service is configured on the interface that IP address from 'PUBLIC_POOL' public network address profile subnet belongs to:

```
esr(config)# interface tengigabitethernet 1/0/1
esr(config-if-te)# ip nat proxy-arp PUBLIC_POOL
```

To enable public network access for LAN devices, they should be configured for routing – 21.12.2.1 should be defined as a gateway address.

On the router, you should create the route for public network. Specify this route as a default using the following command:

```
esr(config)# ip route 0.0.0.0/0 200.10.0.254
esr(config)# exit
```

10.4 Static NAT configuration

Static NAT — static NAT sets a unique match between two addresses. In other words, when passing through the router the address is changed to another strictly specified one, one-to-one. The record about this translation is kept indefinitely until NAT reconfiguration is carried out on the router.

10.4.1 Configuration algorithm

Static NAT configuration is carried out by Source NAT means, the configuration algorithm is described in Section Source NAT configuration, configuration algorithm of the manual.

10.4.2 Static NAT configuration example

Objective:

Configure two-way and continuous translation from LAN for the addresses range of 21.12.2.100-21.12.2.150 to the public network 200.10.0.0/24. Public network address range for translation use – 200.10.0.100-200.10.0.150.

Solution:

Begin configuration with network interface configuration and disabling the firewall:

```
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)# ip address 21.12.2.1/24
esr(config-if-gi)# ip firewall disable
esr(config-if-gi)# exit
```

```
esr(config)# interface tengigabitethernet 1/0/1
esr(config-if-te)# ip address 200.10.0.1/24
esr(config-if-te)# ip firewall disable
esr(config-if-te)# exit
```

For Static NAT configuration, create 'LOCAL_NET' LAN address profile, that includes local subnet, and 'PUBLIC_POOL' public network address profile.

```
esr(config)# object-group network LOCAL_NET
esr(config-object-group-network)# ip prefix 21.12.2.0/24
esr(config-object-group-network)# exit
```

```
esr(config)# object-group network PUBLIC_POOL
esr(config-object-group-network)# ip prefix 200.10.0.0/24
esr(config-object-group-network)# exit
```

The range of public network addresses for Static NAT use is specified in “PROXY” profile:

```
esr(config)# object-group network PROXY
esr(config-object-group-network)# ip address-range 200.10.0.100-200.10.0.150
esr(config-object-group-network)# exit
```

Configure Static NAT service in SNAT configuration mode. In the set attributes, specify that the rules are applying only to packets transferred to public network through te1/0/1 port. The rules include data source address test for belonging to “LOCAL_NET” pool and destination addresses test for belonging to “PUBLIC_POOL” pool.

```
esr(config)# nat source
esr(config-snat)# ruleset SNAT
esr(config-snat-ruleset)# to interface te1/0/1
esr(config-snat-ruleset)# rule 1
esr(config-snat-rule)# match source-address LOCAL_NET
esr(config-snat-rule)# match destination-address PUBLIC_POOL
esr(config-snat-rule)# action source-nat netmap 200.10.0.0/24 static
esr(config-snat-rule)# enable
esr(config-snat-rule)# exit
esr(config-snat-ruleset)# exit
```

In order the router could response to the ARP requests for addresses from the “PROXY” translation pool, you should launch ARP Proxy service. ARP Proxy service is configured on the interface that IP address from 'PROXY' address profile subnet belongs to:

```
esr(config)# interface tengigabitethernet 1/0/1
esr(config-if-te)# ip nat proxy-arp PROXY
```

To enable 200.10.0.0/24 network access for LAN devices, they should be configured for routing – 21.12.2.1 should be defined as a gateway address.

The configuration changes come into effect after applying the following commands:

```
esr# commit
Configuration has been successfully committed
esr# confirm
Configuration has been successfully confirmed
```

You can display active translations by using the following command:

```
esr# show ip nat translations
```

10.5 HTTP/HTTPS traffic proxying

10.5.1 Configuration algorithm

Step	Description	Command	Keys
1	Create an object with a URL	`esr(config)# object-group url <NAME>`	
2	Specify the set	`esr(config-object-group-url)# url <URL>`	<URL> – web page, site address.
3	Create proxy profile	`esr(config)# ip http profile <NAME>`	<NAME> – profile name.

Step	Description	Command	Keys
4	Choose default action	`esr(config-profile)# default action {deny|permit|redirect} [redirect-url <URL>]`	<URL> – address of the host to which requests will be sent.
5	Specify description (optionally).	`esr(config-profile)# description <description>`	<description> – up to 255 characters.
6	Specify a remote or local URL list and type of operation (block/traffic pass/redirect) (optional)	`esr(config-profile)# urls {local|remote} <URL_OBJ_GROUP_NAME> action {deny|permit|redirect} [redirect-url <URL>]`	<URL_OBJ_GROUP_NAME> – specify the name of the object containing the URL set.
7	Specify the remote server where the necessary URL lists are (optional)	`esr(config)# ip http proxy server-url <URL>`	<URL> – server address where remote url lists will be taken from.
8	Specify a listening port for proxying (optional)	`esr(config)# ip http proxy listen-ports <OBJ_GROUP_NAME>`	<OBJ_GROUP_NAME> – port profile name, set by string of up to 31 characters.
9	Specify a listening port for proxying (optional)	`esr(config)# ip https proxy listen-ports <OBJ_GROUP_NAME>`	<OBJ_GROUP_NAME> – port profile name, set by string of up to 31 characters.
10	Specify a base port for proxying (optional)	`esr(config)# ip https proxy redirect-port <PORT>`	<PORT> – port number, set in the range of [1..65535]. Default value: 3128
11	Enable proxying on the interface based on the selected HTTP profile	`esr(config-if)# ip http proxy <PROFILE_NAME>`	<PROFILE_NAME> – profile name
12	Enable proxying on the interface based on the selected HTTPS profile	`esr(config-if)# ip https proxy <PROFILE_NAME>`	<PROFILE_NAME> – profile name
13	Create services lists which will be used during filtration.	`esr(config)# object-group service <obj-group-name>`	<obj-group-name> – service profile name, set by the string of up to 31 characters.
14	Specify services list description (optional).	`esr(config-object-group-service)# description <description>`	<description> – profile description, set by the string of up to 255 characters.

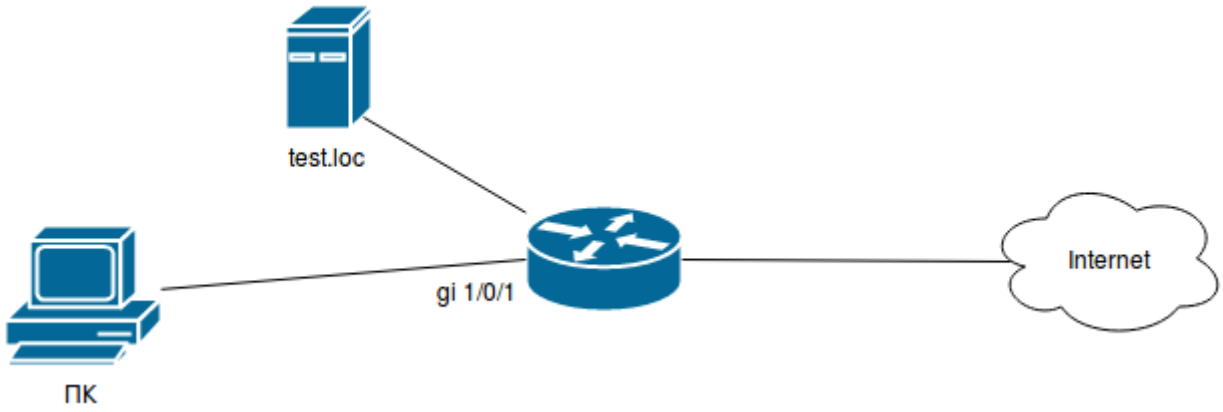
Step	Description	Command	Keys
15	Add necessary services (tcp/udp ports) to the list.	`esr(config-object-group-service)# port-range 3128-3135`	ESR proxy server uses for its operation the ports starting from the base port defined in step 10 The http proxy uses ports from base port to base port + the number of cpu of this ESR model - 1 For https proxy, the ports used are from base port + number of cpu of the given ESR model to base port + number of cpu of the given ESR model * 2 - 1
16	Create an interzone interaction rule set.	`esr(config)# security zone-pair <src-zone-name1> self`	<src-zone-name> – security zone in which the interfaces with the ip http proxy or ip https proxy function are located. self – a predefined security zone for traffic entering the ESR itself.
17	Create an interzone interaction rule set.	`esr(config-zone-pair)# rule <rule-number>`	<rule-number> – 1..10000.
18	Specify rule description (optional).	`esr(config-zone-rule)# description <description>`	<description> – up to 255 characters..
19	Specify the given rule force.	`esr(config-zone-rule)# action <action> [ log ]`	<action> – permit log – activation key for logging of sessions established according to this rule.
20	Set name of IP protocol for which the rule should work.	`esr(config-zone-rule)# match protocol <protocol-type>`	<protocol-type> – tcp ESR proxy server uses ESR protocol.
21	Set the destination TCP/UDP ports profile for which the rule should work (if the protocol is specified).	`esr(config-zone-rule)# match [not] destination-port <obj-group-name>`	<obj-group-name> – name of the service profile created in step 12.
22	Create an interzone interaction rule.	`esr(config-zone-rule)# enable`	

⚠ If the Firewall function on the ESR is not forcibly disabled, you must create an allow rule for the Self zone.

10.5.2 HTTP proxy configuration example

Objective:

Organize URL filtering for a number of addresses using a proxy.



Solution:

Create a set of URLs to filter by. Configure a proxy filter and specify the actions for the created set of URLs:

```
esr# configure
esr(config)# object-group url test1
esr(config-object-group-url)# url http://speedtest.net/
esr(config-object-group-url)# url http://www.speedtest.net/
esr(config-object-group-url)# url https://speedtest.net/
esr(config-object-group-url)# url https://www.speedtest.net/
esr(config-object-group-url)# exit
```

Create a profile:

```
esr(config)# ip http profile list1
esr(config-profile)# default action permit
esr(config-profile)# urls local test1 action redirect redirect-url http://test.loc
esr(config-profile)# exit
```

Enable proxying on the interface by profile 'list':

```
esr(config)# interface gi 1/0/1
esr(config-if)# ip http proxy list1
esr(config-if)# ip https proxy list1
```

If you use Firewall, create permissive rules for it:

For example we use the ESR-20 which has 4 CPUs.

For the http proxy we need to open ports 3128 to 3131

For the https proxy we need to open ports 3132 to 3135

Create a proxy server profile:

```
esr(config)# object-group service proxy
esr(config-object-group-service)# port-range 3128-3135
esr(config-object-group-service)# exit
```

Create a permissive interzonal interaction rule:

```
esr(config)# security zone-pair LAN self
esr(config-zone-pair)# rule 50
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol tcp
esr(config-zone-pair-rule)# match destination-port proxy
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)# exit
```

10.6 NTP configuration

NTP (Network Time Protocol) — network protocol for synchronizing the internal clock of equipment using IP networks, uses the UDP protocol for its operation, takes into account transmission times and uses algorithms to achieve high precision time synchronization.

10.6.1 Configuration algorithm

Step	Description	Command	Keys
1	Enable NTP.	`esr(config)# ntp enable`	
2	Set the IP address of the NTP server or NTP synchronization participant.	`esr(config)# ntp { server | peer } { <IP> }`	<IP> – destination IP address (gateway), defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
3	Set authentication key (optional).	`esr(config-ntp)# key <ID>`	<ID> – key identifier, set in the range of [1..255].
4	Set the maximum time interval between sending messages to the NTP server (optional).	`esr(config-ntp)# maxpoll <INTERVAL>`	<INTERVAL> – maximum value of poll interval. The command parameter is used as an indicator of the power of two when calculating the interval durability in seconds; it is calculated by raising two to power that is specified by the command parameter, takes the value of [10..17]. Default value: 10 (2^{10} = 1024 seconds or 17 minutes 4 seconds).

Step	Description	Command	Keys
5	Set the minimum time interval between sending messages to the NTP server (optional).	`esr(config-ntp)# minpoll <INTERVAL>`	<INTERVAL> – minimum value of poll interval in seconds; it is calculated by raising two to power that is specified by the command parameter, takes the value of [4..6]. Default value: 6 (2^6 = 64 seconds or 1 minutes 4 seconds)
6	Mark this NTP server as preferred (optional).	`esr(config-ntp)# prefer`	
7	Define a list of trusted IP addresses with which ntp packets can be exchanged (optional).	`esr(config)# ntp access-addresses <NAME>`	<NAME> – IP addresses profile name, set by the string of up to 31 characters.
8	Specify the key ID from the key binding profile (optional).	`esr(config)# ntp authentication trusted-key <ID>`	<ID> – key ID from the key binding profile.
9	Specify the key binding profile name (optional).	`esr(config)# ntp authentication key-chain <WORD>`	<WORD> – key binding profile name.
10	Activate key-based authentication for NTP (optional).	`esr(config)# ntp authentication enable`	
11	Enable the mode of receiving broadcast messages from NTP servers for the global configuration and all existing VRFs (optional).	`esr(config)# ntp broadcast-client enable`	
12	Set the DSCP code value for the use in IP headers of NTP server egress packets (optionally).	`esr(config)# ntp dscp <DSCP>`	<DSCP> – DSCP code value, takes values in the range of [0..63]. Default value: 46
13	Enable query-only mode that limits interaction via NTP for a certain profile of IP addresses (optional).	`esr(config)# ntp object-group query-only <NAME>`	<NAME> – IP addresses profile name, set by the string of up to 31 characters.
14	Enable serve-only mode that limits interaction via NTP for a certain profile of IP addresses (optional).	`esr(config)# ntp object-group serve-only <NAME>`	<NAME> – IP addresses profile name, set by the string of up to 31 characters.

Step	Description	Command	Keys
15	Specify source-IP addresses for NTP packets for all peers (optional).	`esr(config)# ntp source address <ADDR>`	<ADDR> – IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
16	Set the current time and date manually (optional).	`esr# set date <TIME> [<DAY> <MONTH> [ <YEAR> ] ]`	<TIME> – system timer, defined as HH:MM:SS, where: HH – hours, takes the value of [0..23]; MM – minutes, takes the value of [0 .. 59]; SS – seconds, takes the value of [0..59]; <DAY> – day of the month, takes values of [1..31]; <MONTH> – month, takes the following values [January/February/March/April/ May/June/July/August/September/ October/November/December]; <YEAR> – year, takes values of [2001..2037].

10.6.2 Configuration example

Objective:

Set the time synchronization from the NTP server.

ESR router IP address – 192.168.52.8,

NTP server IP address – 192.168.52.41.

Solution:

First, do the following

- specify security zone for gi1/0/1 interface;
- configure the IP address for the gi1/0/1 interface to provide IP connectivity to the NTP server.

Example:

```
security zone untrust
exit
object-group service NTP
  port-range 123
exit
interface gigabitethernet 1/0/1
  security-zone untrust
  ip address 192.168.52.8/24
exit
security zone-pair untrust self
  rule 10
    action permit
    match protocol udp
    match destination-port NTP
    enable
  exit
exit
```

Main configuration step:

Enable synchronization of the system clock with remote servers:

```
esr(config)# ntp enable
```

NTP server configuration:

```
esr-(config)# ntp server 192.168.52.41
```

Specify the preference for this NTP server (optional):

```
esr-1000(config-ntp)# prefer
```

Specify the time interval between sending messages to the NTP server:

```
esr(config-ntp)# minpoll 4
esr(config-ntp)# end
esr# commit
esr# confirm
```

Command to view the current configuration of the NTP protocol:

```
esr# show ntp configuration
```

Command to view the current state of NTP servers (peers):

```
esr# show ntp peers
```

11 Monitoring

11.1 Netflow configuration

Netflow is a network protocol designed for traffic accounting and analysis. Netflow allows transmitting traffic information (source and destination address, port, quantity of information) from the network equipment (sensor) to the collector. Common server may serve as a collector.

11.1.1 Configuration algorithm

Step	Description	Command	Keys
1	Specify Netflow protocol version.	`esr(config)# netflow version <VERSION>`	<VERSION> – Netflow protocol version: 5, 9 and 10.
2	Set the maximum amount of observed sessions.	`esr(config)# netflow max-flows <COUNT>`	<COUNT> – amount of observed sessions, takes values of [10000..2000000]. Default value: 512000.
3	Set the interval after which the information on outdated sessions is exported to the collector.	`esr(config)# netflow inactive-timeout <TIMEOUT>`	<TIMEOUT> – delay before sending outdated sessions information, set in seconds, takes the value of [0..240]. Default value: 15 seconds.

Step	Description	Command	Keys
4	Set the rate of the statistics sending to a Netflow collector.	`esr(config)# netflow refresh-rate <RATE>`	<RATE> – rate of the statistics sending, set in packets/flow, takes the value of [1..10000]. Default value: 10.
5	Enable Netflow on the router.	`esr(config)# netflow enable`	
6	Create the Netflow collector and switch to its configuration mode.	`esr(config)# netflow collector <ADDR>`	<ADDR> – collector IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
7	Set the Netflow service port on the statistics collection server.	`esr(config-netflow-host)# port <PORT>`	<PORT> – UDP port number in the range of [1..65535]. Default value: 2055.
8	Enable statistics sending to the Netflow server in the interface/ tunnel/network bridge configuration mode.	`esr(config-if-gi)# ip netflow export`	

11.1.2 Configuration example

Objective:

Establish accounting for traffic from gi1/0/1 interface to be sent to the server via gi1/0/8 interface for processing purposes.

Solution:

1 First, do the following:

- For gi1/0/1, gi1/0/8 interfaces disable firewall with 'ip firewall disable' command.

- Assign IP address to ports.

2 Main configuration step:

Specify collector IP address:

```
esr(config)# netflow collector 10.10.0.2
```

Enable netflow statistics export collection for gi1/0/1 network interface:

```
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)# ip netflow export
```

Enable netflow on the router:

```
esr(config)# netflow enable
```

To view the Netflow statistics, use the following command:

```
esr# show netflow statistics
```

Netflow configuration for traffic accounting between zones is performed by analogy to sFlow configuration; for description, see Section sFlow configuration.

11.2 sFlow configuration

sFlow is a computer network, wireless network and network device monitoring standard designed for traffic accounting and analysis.

11.2.1 Configuration algorithm

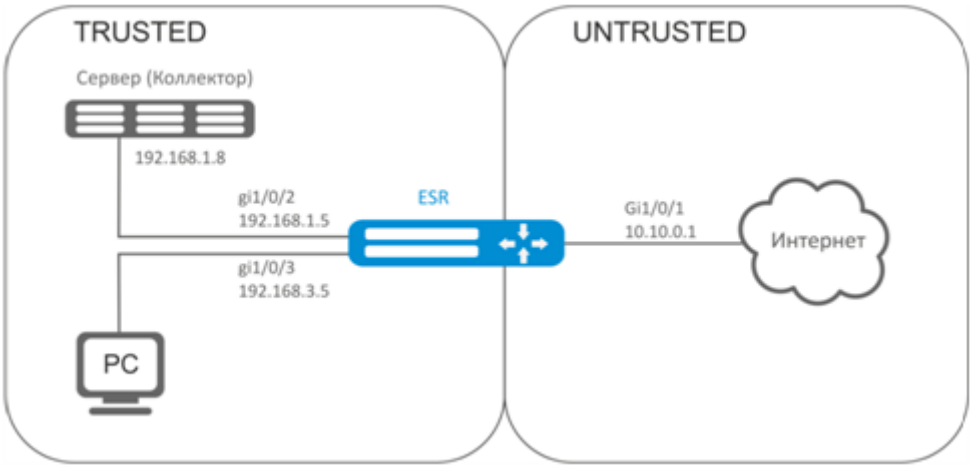
Step	Description	Command	Keys
1	Set the rate of sending the unchanged user traffic packets to sFlow collector.	`esr(config)# sflow sampling-rate <RATE>`	<RATE> – rate of sending the user traffic packets to the collector, takes the value of [1..10000000]. If the rate value is 10, one of ten packets will be sent to the collector. Default value: 1000.
2	Set the interval after which the information on the network interface counters is obtained	`esr(config)# sflow poll-interval <TIMEOUT>`	<TIMEOUT> – interval after which the information on the network interface counters is obtained, takes values of [1..10000]. Default value: 10 seconds.
3	Enable sFlow on the router.	`esr(config)# sflow enable`	

Step	Description	Command	Keys
4	Create the sFlow collector and switch to its configuration mode.	`esr(config)# sflow collector <ADDR>`	<ADDR> – collector IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
5	Enable statistics sending to the sFlow server in the interface/ tunnel/network bridge configuration mode.	`esr(config-if-gi)# ip sflow export`	

11.2.2 Configuration example

Objective:

Establish accounting for traffic between 'trusted' and 'untrusted' zones.



Solution:

Create two security zones for ESR networks:

```
esr# configure
esr(config)# security zone TRUSTED
esr(config-zone)# exit
esr(config)# security zone UNTRUSTED
esr(config-zone)# exit
```

Configure network interfaces and identify their inherence to security zones:

```
esr(config)# interface gi1/0/1
esr(config-if-gi)# security-zone UNTRUSTED
esr(config-if-gi)# ip address 10.10.0.1/24
esr(config-if-gi)# exit
esr(config)# interface gi1/0/2-3
esr(config-if-gi)# security-zone TRUSTED
esr(config-if-gi)# exit
esr(config)# interface gi1/0/2
esr(config-if-gi)# ip address 192.168.1.5/24
esr(config-if-gi)# exit
esr(config)# interface gi1/0/3
esr(config-if-gi)# ip address 192.168.3.5/24
esr(config-if-gi)# exit
```

Specify collector IP address:

```
esr(config)# sflow collector 192.168.1.8
```

Enable sFlow protocol statistics export for all traffic within 'rule1' for TRUSTED-UNTRUSTED direction:

```
esr(config)# security zone-pair TRUSTED UNTRUSTED
esr(config-zone-pair)# rule 1
esr(config-zone-pair-rule)# action sflow-sample
esr(config-zone-pair-rule)# match protocol any
esr(config-zone-pair-rule)# match source-address any
esr(config-zone-pair-rule)# match destination-address any
esr(config-zone-pair-rule)# enable
```

Enable sFlow on the router:

```
esr(config)# sflow enable
```

sFlow configuration for traffic accounting from the interface is performed by analogy to Netflow configuration.

11.3 SNMP configuration

SNMP (Simple Network Management Protocol)is a protocol designed for device management in IP networks featuring TCP/UDP architecture. SNMP provides management data as variables that describe the configuration of a system being managed.

11.3.1 Configuration algorithm

Step	Description	Command	Keys
1	Enable SNMP server	`esr(config)# snmp-server`	

Step	Description	Command	Keys
2	Specify community for the access via SNMPv2c.	`esr(config)# snmp-server community <COMMUNITY> [ <TYPE> ] [ { <IP-ADDR> | <IPV6-ADDR> } ] [ client-list <OBJ-GROUP-NETWORK-NAME> ] [ <VERSION> ] [ view <VIEW-NAME> ] [ vrf <VRF> ]`	<COMMUNITY> – community for the access via SNMP; <TYPE> – access level: • **ro** – read-only access; • **rw** – read and write access. <IP-ADDR> – IP address of the client that have access, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <IPV6-ADDR> – IPv6 address of the client, defined as X:X:X:X::X, where each part takes values in hexadecimal format [0..FFFF]; <OBJ-GROUP-NETWORK-NAME> – profile name of IP addresses, from which snmp requests are processing, set by the string of up to 31 characters; <VERSION> – the snmp version supported by this community takes the values v1 or v2c; <VIEW-NAME> – SNMP view profile name, set by the string of up to 31 characters; <VRF> – VRF instance name, set by the string of up to 31 characters, for which access will be granted.
3	Set the value of SNMP variable that contains contact information	`esr(config)# snmp-server contact <CONTACT>`	<CONTACT> – contact information, sets by string with 255 characters length.
4	Set the DSCP code value for the use in IP headers of SNMP server egress packets (optionally).	`esr(config)# snmp-server dscp <DSCP>`	<DSCP> – DSCP code value, takes values in the range of [0..63]. Default value: 63.
5	Enable router reboot by using snmp messages (optionally)	`esr(config)# snmp-server system-shutdown`	
6	Create SNMPv3 user.	`esr(config)# snmp-server user <NAME>`	<NAME> – user name, set by the string of up to 31 characters.
7	Set the value of SNMP value that contains the information on the device location	`esr(config)# snmp-server location <LOCATION>`	<LOCATION> – information about equipment location, set by the string up to 255 characters.

Step	Description	Command	Keys
8	Specify user access level via SNMPv3.	`esr(config-snmp-user)# access <TYPE>`	<TYPE> – access level: • **ro** – read-only access; • **rw** – read and write access.
9	Specify user security mode via SNMPv3.	`esr(config-snmp-user)# authentication access <TYPE>`	<TYPE> – security mode: • **auth** – used only for authentication; • **priv** – both authentication and data encryption are used.
10	Specify SNMPv3 queries authentication algorithm.	`esr(config-snmp-user)# authentication algorithm <ALGORITHM>`	<ALGORITHM> – encryption algorithm: • **md5** – password is hashed by md5 algorithm; • **sha1** – password is encrypted by sha1 algorithm.
11	Set the password for SNMPv3 queries authentication.	`esr(config-snmp-user)# authentication key ascii-text { <CLEAR-TEXT> | encrypted <ENCRYPTED-TEXT> }`	<CLEAR-TEXT> – password, set by the string of 8 to 16 characters; • **encrypted** – when specifying a command, an encrypted password is set: <ENCRYPTED-TEXT> – encrypted password of 8 to 16 bytes (from 16 to 32 characters) in hexadecimal format (0xYYYY ...) or (YYYY ...).
12	Enable filtration and set the profile of IP addresses from which SNMPv3 packets with the given SNMPv3 user name can be received.	`esr(config-snmp-user)# client-list <NAME>`	<NAME> – name of the previously conscious object-group, specified in a string of up to 31 characters.
13	Enable filtration and set IPv4/IPv6 address which is provided with the access to the router as the given SNMPv3 user.	`esr(config-snmp-user)# ip address <ADDR>`	<ADDR> – IP address of the client provided with the access, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
		`esr(config-snmp-user)# ipv6 address <ADDR>`	<IPV6-ADDR> – client IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF].
14	Enable SNMPv3 user.	`esr(config-snmp-user)# enable`	Default value: process is disabled.

Step	Description	Command	Keys
15	Specify the transmitted data encryption algorithm.	`esr(config-snmp-user)# privacy algorithm <ALGORITHM>`	<ALGORITHM> – encryption algorithm: • **aes128** – use AES-128 encryption algorithm; • **des** – use DES encryption algorithm.
16	Set password for the transmitted data encryption.	`esr(config-snmp-user)# privacy key ascii-text { <CLEAR-TEXT> | encrypted <ENCRYPTED-TEXT> }`	<CLEAR-TEXT> – password, set by the string of 8 to 16 characters; <ENCRYPTED-TEXT> – encrypted password of 8 to 16 bytes (from 16 to 32 characters) in hexadecimal format (0xYYYY ...) or (YYYY ...).
	Set the snmp view profile permitting or denying the access to one or another OID for user.	`esr(config-snmp-user)# view <VIEW-NAME>`	<VIEW-NAME> – name of SNMP view profile, on which based access to OID, set by the string up to 31 characters.
17	Enable SNMP notifications transmission to the specified IP address and switch to SNMP notifications configuration mode.	`esr(config)# snmp-server host { <IP-ADDR> | <IPV6-ADDR> } [vrf <VRF>]`	<IP-ADDR> – IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]. <IPV6-ADDR> – IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF]; <VRF> – VRF instance name, set by the string of up to 31 characters, which contains SNMP notification collector.
18	Define the port of SNMP notifications collector on the remote server (optionally).	`esr(config-snmp-host)# port <PORT>`	<PORT> – UDP port number in the range of [1..65535]. Default value: 162.

Step	Description	Command	Keys
19	Allow different types of SNMP notifications to be sent.	`esr(config)# snmp-server enable traps <TYPE>`	<TYPE> – type of filtered messages. May take the following values: config, entry, entry-sensor, environment, envmon, files-operations, flash, flash-operations, interfaces, links, ports, screens, snmp, syslog. Additional parameters depend on the filter type. See ESR-Series. CLI command reference guide. Version 1.12.0.
20	Create the snmp view profile permitting or denying the access to one or another OID for community (SNMPv2) and user (SNMPv3).	`esr(config)# snmp-server enable traps <TYPE>`	<VIEW-NAME> – SNMP view profile name, set by the string of up to 31 characters.

11.3.2 Configuration example

Objective:

Configure SNMPv3 server with authentication and data encryption for 'admin' user. ESR router IP address: 192.168.52.41, server IP address: 192.168.52.8.

Solution:

First, do the following:

- Specify zone for gi1/0/1 interface;
- Configure IP address for gi1/0/1 interface.

Main configuration step:

Enable SNMP server:

```
esr(config)# snmp-server
```

Create SNMPv3 user:

```
esr(config)# snmp-server user admin
```

Specify security mode:

```
esr(snmp-user)# authentication access priv
```

Specify authentication algorithm for SNMPv3 requests:

```
esr(snmp-user)# authentication algorithm md5
```

Set the password for SNMPv3 request authentication:

```
esr(snmp-user)# authentication key ascii-text 123456789
```

Specify the transmitted data encryption algorithm:

```
esr(snmp-user)# privacy algorithm aes128
```

Set password for the transmitted data encryption:

```
esr(snmp-user)# privacy key ascii-text 123456789
```

Enable SNMPv3 user:

```
esr(snmp-user)# enable
```

Define receiver-server of Trap-PDU messages:

```
esr(config)# snmp-server host 192.168.52.41
```

11.4 Zabbix-agent/proxy configuration

Zabbix-agent – agent designed to monitor the device, as well as execute remote commands from the Zabbix server. The agent can operate in two modes: passive and active. To operate in passive mode, by default, you need an allow rule in the firewall – tcp protocol, port 10050. For active mode – tcp protocol, port 10051.

A Zabbix proxy is a process capable of collecting monitoring data from one or more monitored devices and sending this information to a Zabbix server.

11.4.1 Configuration algorithm

Step	Description	Command	Keys
1	Switch to the agent/proxy configuration context.	`esr(config)# zabbix-agent` `esr(config)# zabbix-proxy`	

Step	Description	Command	Keys

2	Specify the host name (optionally).
	
	For active mode, the name must match the host name on the zabbix server.
		`esr(config-zabbix)# hostname <WORD>`
		
		`esr(config-zabbix-proxy)# hostname <WORD>`
			<WORD> – host name, set by the string of up to 255 characters.

3	Specify the address of the zabbix server.	`esr(config-zabbix)# server <ADDR>`
		
		`esr(config-zabbix-proxy)# server <ADDR>`
			<ADDR> – server IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].

4	Specify the server address for active checks (when using active mode).	`esr(config-zabbix)# active-server <ADDR> <PORT>`
		
		`esr(config-zabbix-proxy)# active-server <ADDR> <PORT>`
			<ADDR> – server IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
			
			<PORT> – server port, set in the range of [1..65535].
			Default value: 10051.

5	Specify the port that will be listened by the agent/proxy (optional)	`esr(config-zabbix)# port <PORT>`
		
		`esr(config-zabbix-proxy)# port <PORT>`
			<PORT> – port that will be listened by zabbix agent/proxy, may take values in the range of [1..65535].
			Default value: 10050.

6	Allow remote commands execution by zabbix agent/proxy (when using active mode).	`esr(config-zabbix)# remote-commands`
		
		`esr(config-zabbix-proxy)# remote-commands`	

7	Specify the address from which the server will interact (optionally).	`esr(config-zabbix)# source-address <ADDR>`
		
		`esr(config-zabbix-proxy)# source-address <ADDR>`
			<ADDR> – server IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255].
			Default value: nearest routing address.

8	Specify the processing time for remote commands (optionally).	`esr(config-zabbix)# timeout <TIME>`
		
		`esr(config-zabbix-proxy)# timeout <TIME>`
			<TIME> – timeout, takes value in seconds [1..30].
			Default value: 3. It is recommended to set the maximum value since some commands may take longer than the default.
			If the command is not completed within the specified time, processing of the command will be terminated.

9	Enable agent/proxy functionality	`esr(config-zabbix)# enable`
		
		`esr(config-zabbix-proxy)# enable`	

Step	Description	Command	Keys
10	Allow access to the router (to the self zone) on TCP ports 10050, 10051 from the appropriate firewall security zone. See Firewall configuration		

11.4.2 Zabbix-agent configuration example

Objective:

Configure the interaction between the agent and the server to execute remote commands from the server.

Solution:

In the context of the agent settings, specify the address of the zabbix server, and the address from which the server will interact:

```
esr(config-zabbix)# server 192.168.32.101
esr(config-zabbix)# source-address 192.168.39.170
```

To activate the active mode, specify hostname, active-server, and also enable the execution of remote commands.

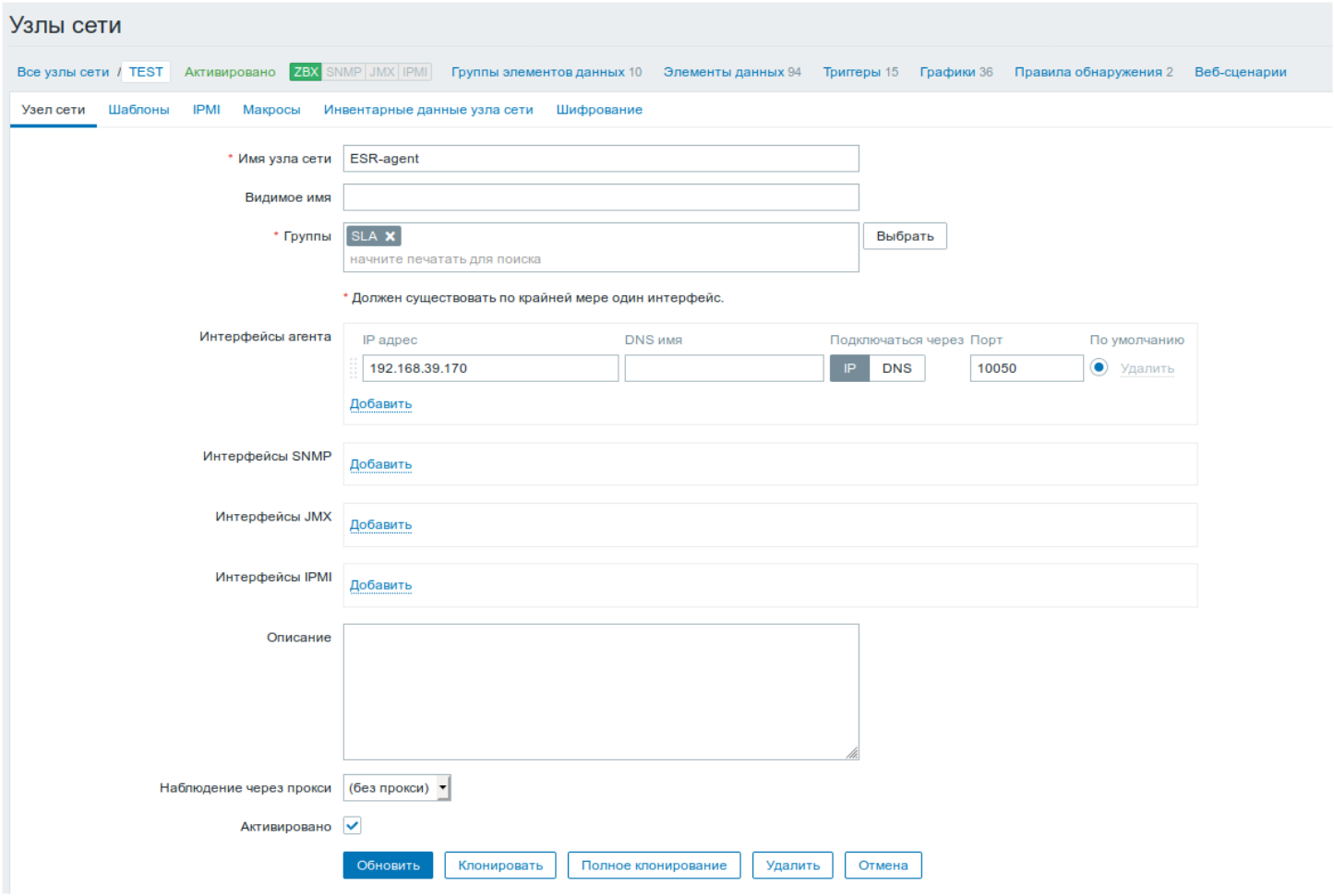
```
esr(config-zabbix)# hostname ESR-agent
esr(config-zabbix)# active-server 192.168.32.101
esr(config-zabbix)# remote-commands
```

Set the execution time of the remote commands, and activate the agent's functionality.

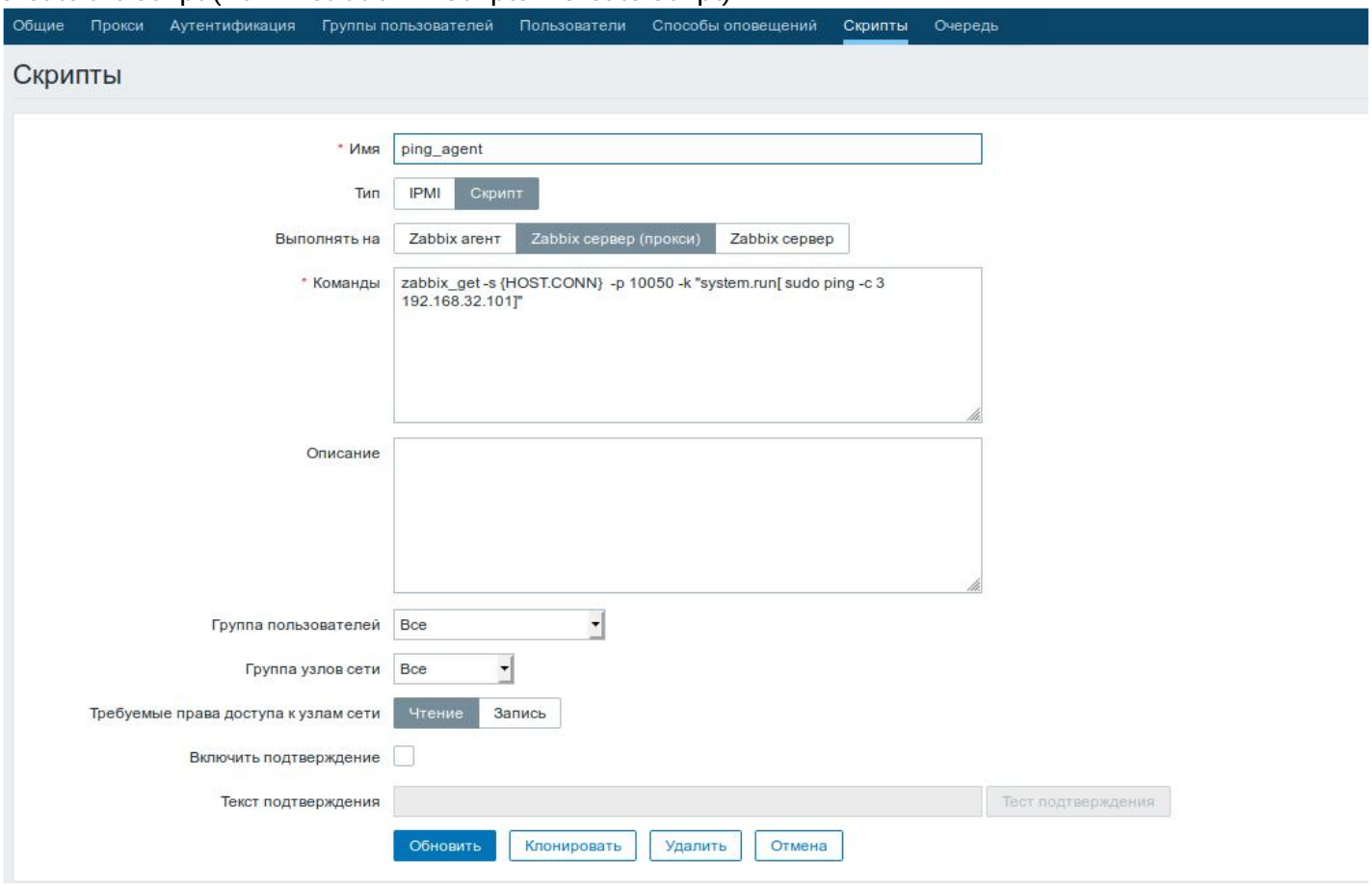
```
esr(config-zabbix)# timeout 30
esr(config-zabbix)# enable
```

11.4.3 Zabbix-agent configuration example

Create the host:



Create the script (Administration -> Scripts-> Create Script)



ESR routers support execution of the following priveleged commands:

- **Ping:**

```
zabbix_get -s {HOST.CONN}  -p 10050 -k "system.run[ sudo ping -c 3 192.168.32.101]"
```

The client (ESR) that received this command from the server will execute ping command to the specified host (in our example, up to 192.168.32.101) and return the result to the server.

Using the «-c» key with the number of packets in the test is mandatory. Without this key, the ping command will not stop on its own and the test will not be considered complete.

- **Ping in VRF:**

```
zabbix_get -s {HOST.CONN} -p 10050 -k "system.run[sudo  netns -exec -n backup sudo ping
192.168.32.101 -c 5 -W 2 ]"
```

The command above will be executed in the specified VRF with backup name.

- **Fping**

```
zabbix_get -s {HOST.CONN} -p 10050 -k "system.run[ sudo fping 192.168.32.101]"
```

The client (ESR) that received this command from the server will execute fping command to the specified host (in our example, up to 192.168.32.101) and return the result to the server.

- **Fping in VRF**

```
zabbix_get -s {HOST.CONN} -p 10050 -k "system.run[sudo  netns-exec -n backup sudo fping
192.168.32.101 ]"
```

- **Traceroute**

```
zabbix_get -s {HOST.CONN} -p 10050 -k "system.run[ sudo traceroute 192.168.32.101]
```

The client (ESR) that received this command from the server will execute traceroute command to the specified host (in our example, up to 192.168.32.101) and return the result to the server.

- **Traceroute in VRF**

```
zabbix_get -s {HOST.CONN} -p 10050 -k "system.run[ sudo  netns-exec -n backup sudo
traceroute 192.168.32.179]"
```

- **Iperf**

```
zabbix_get -s {HOST.CONN} -p 10050 -k "system.run[ sudo iperf -c 192.168.32.101 -u -b 100K
-i 1 -t 600]"
```

The client (ESR) that received this command from the server will execute iperf command to the specified server (in our example, up to 192.168.32.101) and return the result to the server.

- **Iperf in VRF**

```
zabbix_get -s {HOST.CONN} -p 10050 -k "system.run[ sudo  netns-exec -n backup  sudo iperf
-c 192.168.32.101 -u -b 100K -i 1 -t 600]"
```

- **Nslookup**

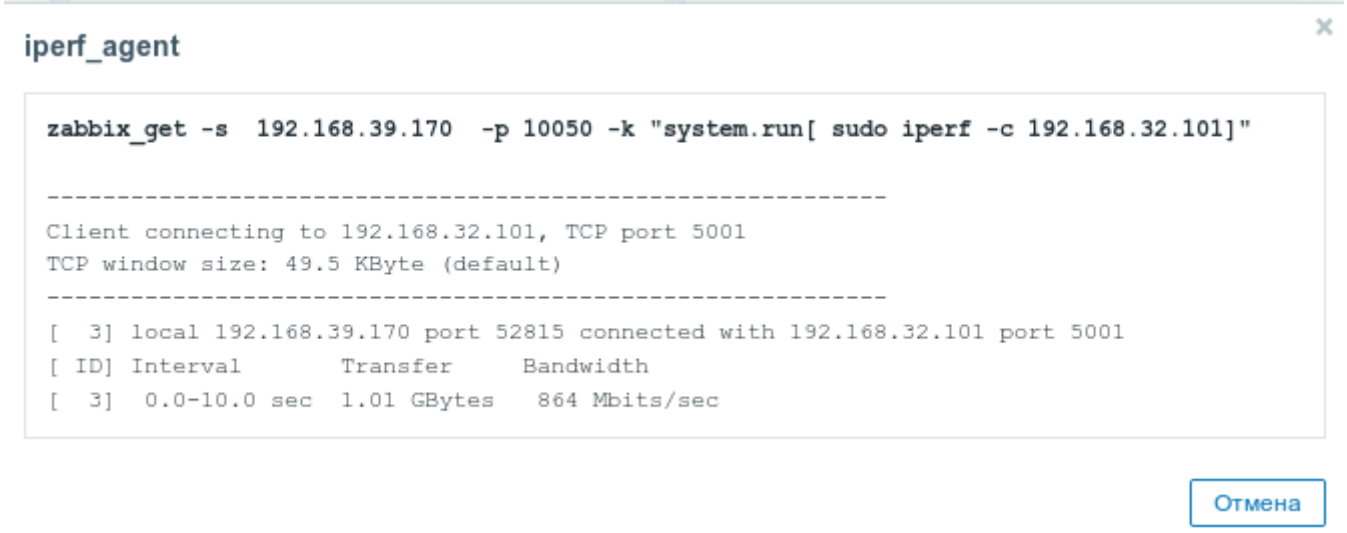
```
zabbix_get -s  {HOST.CONN} -p 10050 -k "system.run[sudo  nslookup ya.ru ]"
```

The client (ESR) that received this command from the server will execute nslookup command and return the result to the server.

- **Nslookup in VRF**

```
zabbix_get -s  {HOST.CONN} -p 10050 -k "system.run[sudo  netns-exec  sudo   nslookup
ya.ru ]"
```

Iperf command execution example:



It is also possible to execute commands that do not require privileges, such as: snmpget, cat, pwd, wget and others.

Example of the snmpget command execution:

11.5 Syslog configuration

Syslog (system log) – standard for sending and registering messages about events occurring in the system is used in networks operating over IP.

11.5.1 Configuration algorithm

Step	Description	Command	Keys
1	Set the level of syslog messages that will be sent to the snmp server in the form of snmp-trap.	`esr(config)# syslog snmp <SEVERITY>`	<SEVERITY> – message importance level, takes values (in order of decreasing importance): • **emerg** – critical error has occurred in the system, the system is not operational; • **alert** – alarms, immediate intervention by staff; • **crit** – critical system status, event reporting; • **error** – error messages; • **warning** – warnings, non-emergency messages; • **notice** – messages about important system events; • **info** – system information messages; • **debug** – debugging messages provide the user with information to correctly configure the system; • **none** – disables the output of syslog messages to the console.
2	Set the level of syslog messages that will be displayed during remote connections (Telnet, SSH) (optionally)	`esr(config)# syslog monitor <SEVERITY>`	
3	Enable the process of logging user commands entered to the local syslog server (optionally)	`esr(config)# syslog cli-commands`	
4	Enable the saving of syslog messages of a specified level of importance to the specified log file	`esr(config)# syslog file <NAME> <SEVERITY>`	<NAME> – name of the file to which messages of a given level will be recorded, specified by the string up to 31 characters; <SEVERITY> is described in syslog snmp command.
5	Specify the maximum size of the log file (optionally)	`esr(config)# syslog file-size <SIZE>`	<SIZE> – file size, takes the value [10..10000000] KB
6	Set the maximum number of files saved during rotation (optionally)	`esr(config)# syslog max-files <NUM>`	<NUM> – maximal numberf of files , takes values [1 .. 1000]

Step	Description	Command	Keys
7	Enable the sending of syslog messages of a specified level of importance to a remote syslog server	`esr(config)#syslog host <HOSTNAME> <ADDR> <SEVERITY> <TRANSPORT> <PORT>`	<HOSTNAME> – syslog server name, set by the string of up to 31 characters. Used only to identify the server during configuration. The value 'all' is used in the no syslog host command to delete all syslog servers; <ADDR> – IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <SEVERITY> – importance level of the message, optional parameter, possible values are given in section Syslog configuration example; <TRANSPORT> – data transfer protocol, optional parameter, takes values: • **TCP** – data transmission is carried out by TCP; • **UDP** – data transmission is carried out by UDP; <PORT> – number of TCP/UDP port, optional parameter, takes values of [1..65535], default value is 514
8	Enable debugging output during device boot (optionally)	`esr(config)#syslog reload debugging`	
9	Enable message enumeration (optionally)	`esr(config)#syslog sequence-numbers`	
10	Enable message date accuracy of up to milliseconds (optionally).	`esr(config)#syslog timestamp msec`	
11	Enable registration of failed authentications (optionally).	`esr(config)#logging login on-failure`	
12	Enable registration of changes to the audit system settings(optionally).	`esr(config)#logging syslog configuration`	
13	Enable registration of changes to the user settings (optionally).	`esr(config)#logging userinfo`	

11.5.2 Configuration example

Objective:

Configure message sending for the following system events:

- failed user authentication;
- changes to the configuration of logging system events;
- start/stop of the system process;
- changes are made to the user profile.

ESR router IP address: 192.168.52.8, Syslog server IP address: 192.168.52.41. Use default settings for sending messages – UDP protocol, port 514.

Solution:

First, do the following:

- Specify zone for gi1/0/1 interface;
- Configure IP address for gi1/0/1 interface.

Main configuration step:

Create a file on the router for syslog, the level of messages for logging – info:

```
esr(config)# syslog file ESR info
```

Specify the IP address and parameters of the remote Syslog server:

```
esr(config)# syslog host SERVER 192.168.17.30 info udp 514
```

Set the logging of failed authentication attempts:

```
esr(config)# logging login on-failure
```

Set the logging of syslog configuration changes:

```
esr(config)# logging syslog configuration
```

Set the logging of start/stop of the system process:

```
esr(config)# logging service start-stop
```

Set the logging of changes to the user profile:

```
esr(config)# logging userinfo
```

The configuration changes come into effect after applying the following commands:

```
esr# commit
Configuration has been successfully committed
esr# confirm
Configuration has been successfully confirmed
```

View the current syslog configuration:

```
esr# show syslog configuration
```

View the syslog entries:

```
esr# show syslog ESR
```

11.6 Integrity check

Integrity check involves checking the integrity of stored executable files.

11.6.1 Configuration process

Step	Descritpion	Command	Keys
1	Launch system integrity check	`esr# verify filesystem <detailed>`	**detailed** – detailed information output to the console.

11.6.2 Configuration example

Objective:

Check file system integrity:

Solution:

Launch integrity check

```
esr# verify filesystem
Filesystem Successfully Verified
```

11.7 Router configuration file archiving

ESR routers have the option of local and/or remote configuration file copying by timer or when applying the configuration.

11.7.1 Configuration process

Step	Description	Command	Keys
1	Switch to the configuration file backup mode.	`esr(config)# archive`	
2	Set router configuration backup type (optional)	`esr(config-ahchive)# type <TYPE>`	<TYPE> – type of the router configuration backup. Takes the following values: • **local;** • **remote;** • **both.** Default value: remote
3	Enable timer configuration backup mode (optional)	`esr(config-ahchive)# auto`	
4	Enable configuration backup after each successful configuration application mode (optional)	`esr(config-ahchive)# by-commit`	
5	Specify a path for remote copying of the router configuration (required for remote and both types)	`esr(config-ahchive)# path <PATH>`	<PATH> – defines the protocol, server address, location and prefix of the file name on the server
6	Set a period of time for automatic configuration backup (optional, relevant only for auto mode)	`esr(config-ahchive)# time-period <TIME>`	<TIME> – periodicity of automatic redundancy of the configuration, takes the value in minutes [1..35791394]. Default value: 720 minutes
7	Set the maximum number of locally saved configuration backups (optional, relevant for local and both types)	`esr(config-ahchive)# count-backup <NUM>`	<NUM> – set the maximum number of locally saved configuration backups. Takes values in the range of [1..100]. Default value: 1

11.7.2 Configuration example

Objective:

Configure local and remote backup of the router configuration once a day and upon successful configuration change. Remote copies should be sent to the tftp server 172.16.252.77 in the esr-example subfolder. The maximum number of local copies is 30.

Solution:

For successful operation of remote configuration archiving, IP connectivity should be established between the router and the server, permissions for the passage of tftp traffic over the network and saving files on the server should be configured.

1 Main configuration step:

Switch to the configuration backup mode:

```
esr# configure
esr(config)# archive
```

Set local and remote configuration backup mode:

```
esr(config)# type both
```

Configure the path for remote configuration backups and the maximum number of local backups:

```
esr(config-archive)# path tftp://172.16.252.77:/esr-example/esr-example.cfg
esr(config-archive)# count-backup 30
```

Set the interval for the configuration backup if there are no changes:

```
esr(config-archive)# time-period 1440
```

Enable archiving of router configuration by timer and upon successful configuration change:

```
esr(config-archive)# auto
esr(config-archive)# by-commit
```

After applying this configuration once a day and with each successful change of the router configuration, a configuration file with the 'esr-exampleYYYYMMDD_HHMMSS.cfg' name will be sent to the tftp server. Also, on the router itself, in the flash:backup/ section, a file with the 'config_YYYYMMDD_HHMMSS' name will be created. When 30 files are accumulated in the flash:backup/ section, the oldest one will be deleted when creating a new one.

12 BRAS (Broadband Remote Access Server) management

12.1 Configuration algorithm

Step	Description	Command	Keys
1	Add RADIUS server to the list of used servers and switch to its configuration mode.	`esr(config)# radius -server host { <IP-ADDR> | <IPV6-ADDR> } [ vrf <VRF> ]esr(config-radius-server)#`	<IP-ADDR> – RADIUS server IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <IPV6-ADDR> – RADIUS server IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF]; <VRF> – VRF instance name, set by the string of up to 31 characters.
2	Set the password for authentication on remote RADIUS server.	`esr(config-radius-server)# key ascii-text { <TEXT> | encrypted <ENCRYPTED-TEXT> }`	<TEXT> – string of [8..16] ASCII characters; <ENCRYPTED-TEXT> – encrypted password, [8..16] bytes size, set by the string of [16..32] characters.
3	Create AAA profile.	`esr(config)# aaa radius-profile <NAME>`	<NAME> – server profile name, set by the string of up to 31 characters.
4	Specify RADIUS server in AAA profile.	`esr(config-aaa-radius-profile)# radius-server host { <IP-ADDR> | <IPV6-ADDR> }`	<IP-ADDR> – RADIUS server IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255]; <IPV6-ADDR> – RADIUS server IPv6 address, defined as X:X:X:X::X where each part takes values in hexadecimal format [0..FFFF].
5	Create DAS server.	`esr(config)# das-server <NAME>`	<NAME> – DAS server name, set by the string of up to 31 characters.

Step	Description	Command	Keys
6	Set the password for authentication on remote DAS server.	`esr(config-das-server)# key ascii-text {<TEXT>|encrypted <ENCRYPTED-TEXT> }`	<TEXT> – string of [8..16] ASCII characters; <ENCRYPTED-TEXT> – encrypted password, [8..16] bytes size, set by the string of [16..32] characters.
7	Create AAA DAS profile.	`esr(config)# aaa das-profile <NAME>`	<NAME> – DAS profile name, set by the string of up to 31 characters.
8	Specify DAS server in DAs profile.	`esr(config-aaa-das-profile)# das-server <NAME>`	<NAME> – DAS server name, set by the string of up to 31 characters.
9	Configure BRAS.	`esr(config)# subscriber-control [ vrf <VRF> ]`	<VRF> – VRF instance name, set by the string of up to 31 characters, within which the user control will operate.
10	Select the profile of dynamic authorization servers to which CoS queries from PCRF will be sent.	`esr(config-subscriber-control)# aaa das-profile <NAME>`	<NAME> – DAS profile name, set by the string of up to 31 characters.
11	Select RADIUS server profile to obtain the user service parameters.	`esr(config-subscriber-control)# aaa services-radius-profile <NAME>`	<NAME> – RADIUS server profile name, set by the string of up to 31 characters.
12	Select RADIUS server profile to obtain the user session parameters.	`esr(config-subscriber-control)# aaa sessions-radius-profile <NAME>`	<NAME> – RADIUS server profile name, set by the string of up to 31 characters.
13	Set router IP address that will be used as source IP address in transmitted RADIUS packets.	`esr(config-subscriber-control)# nas-ip-address <ADDR>`	<ADDR> – source IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255];
14	Enable session authentication by MAC address (optional).	`esr(config-subscriber-control)# session mac-authentication`	
15	Organize transparent filter-based transmission of administrative traffic (DHCP, DNS and etc.).	`esr(config-subscriber-control)# bypass-traffic-a c l <NAME>`	<NAME> – name of the ACL being bound, set by the string of up to 31 characters.

Step	Description	Command	Keys
16	Switch to the default service configuration mode.	`esr(config-subscriber-control)# default-service`	
17	Bind the specified QoS class to the default service.	`esr(config-subscriber-default-service)# class-map <NAME>`	<NAME> – name of the class being bound, set by the string of up to 31 characters.
18	Specify a name of the URL list that will be used to filtrate HTTP/HTTPS traffic of non-authenticated users.	`esr(config-subscriber-default-service)# filter-name { local<LOCAL-NAME> | remote<REMOTE-NAME> }`	<LOCAL-NAME> – URL profile name, set by the string of up to 31 characters; <REMOTE-NAME> – remote server URL list name, set by the string of up to 31 characters.
19	Specify the actions that should be applied for HTTP/HTTPS packets, whose URL is included in the list of URL assigned by the “filter-name” command.	`esr(config-subscriber-default-service)# filter-action<ACT>`	<ACT> – allocated action: • **permit** – traffic transfer is permitted; • **deny** – traffic transfer is denied. redirect <URL> – redirect to the specified URL will be carried out, set by the string of up to 255 characters.
20	Specify the actions that should be applied for HTTP/HTTPS packets, whose URL is not included in the list of URL assigned by the “filter-name” command.	`esr(config-subscriber-default-service)# default -action<ACT>`	<ACT> – allocated action: • **permit** – traffic transfer is permitted; • **deny** – traffic transfer is denied. redirect <URL> – redirect to the specified URL will be carried out, set by the string of up to 255 characters.
21	Enable user control profile.	`esr(config-subscriber-control)#  enable`	
22	Change the identifier of a network interface (physical, sub interface or network bridge) (optionally).	`esr(config-if)# location <ID>`	<ID> – network interface identifier, set by the string of up to 220 characters.

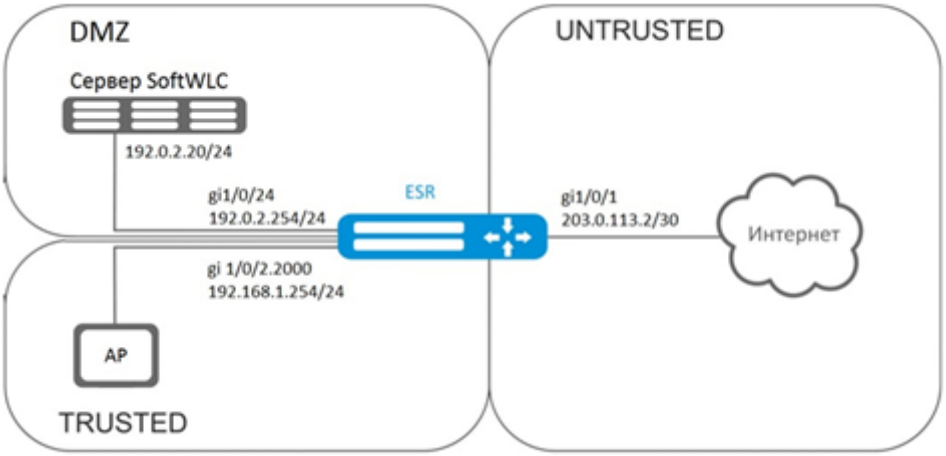
Step	Description	Command	Keys
23	Enable user control on the interface.	`esr(config-if-gi)# service-subscriber-control {any| object-group <NAME>}`	<NAME> – IP addresses profile name, set by the string of up to 31 characters.
24	Enable iterative query of quota value when it expires for user services with a configured restriction on the amount of traffic or time (optional).	`esr(config-subscriber-control)# quota-expired-reauth`	
25	Enable session authentication by IP address. (optional)	`esr(config-subscriber-control)# session ip-authentication`	
26	Enable transparent transmission of backup traffic for BRAS (optional).	`esr(config-subscriber-control)# backup traffic-processing transparent`	
27	Specify the interval after which currently unused URL lists will be removed. (optional).	`esr(config)# subscriber-control unused-filters-remove-delay <DELAY>`	<DELAY> – time interval in seconds, takes values of [10800..86400].
28	Specify the interval after which, if a user has not sent any packets, the session is considered to be outdated and is removed from the device. (optional).	`esr(config-subscriber-default-service)# session-timeout <SEC>`	<SEC> – time interval in seconds, takes values of [120..3600].
29	Specify the VRRP group on the basis of which user control service status is determined (primary/redundant) (optional).	`esr(config-subscriber-control)# vrrp-group <GRID>`	<GRID> – VRRP router group identifier, takes values in the range of [1..32].
30	Define destination TCP ports from which the traffic will be redirected to the router HTTP Proxy server (optional).	`esr(config-subscriber-control)# ip proxy http listen-ports <NAME>`	<NAME> – TCP/UDP ports profile name, set by the string of up to 31 characters.

Step	Description	Command	Keys
31	Define HTTP Proxy server port on the router (optional).	`esr(config-subscriber-control)# ip proxy http redirect-port <PORT>`	<PORT> – port number, set in the range of [1..65535].
32	Define destination TCP ports from which the traffic will be redirected to the router HTTPS Proxy server (optional).	`esr(config-subscriber-control)# ip proxy https listen-ports <NAME>`	<NAME> – TCP/UDP ports profile name, set by the string of up to 31 characters.
33	Define HTTPS Proxy server port on the router (optional).	`esr(config-subscriber-control)# ip proxy https redirect-port <PORT>`	<PORT> – port number, set in the range of [1..65535].
34	Set router IP address that will be used as source IP address in HTTP/ HTTPS packets transmitted by Proxy server (optional).	`esr(config-subscriber-control)# ip proxy source-address <ADDR>`	<ADDR> – source IP address, defined as AAA.BBB.CCC.DDD where each part takes values of [0..255];
35	Specify URL address of the server providing lists of traffic filtration applications (optional)	`esr(config)# subscriber-control apps-server-url <URL>`	<URL> – reference address, set by the string from 8 to 255 characters.
36	Enable the application control on the interface (optional)	`esr(config-if-gi)# subscriber-control application-filter <NAME>`	<NAME> – application profile name, set by the string of up to 31 characters.
37	Set/clear the upper bound of BRAS sessions amount (optionally)	`esr(config-subscriber-control)# thresholds sessions-number high <Threshold>`	<Threshold> – BRAS sessions amount, [0-50000] – for ESR-1700 • [0-10000] – for ESR-1200/1000 • [0-1000] – for ESR-100/200
38	Set/clear the lower bound of BRAS sessions amount (optionally)	`esr(config-subscriber-control)# thresholds sessions-number low <Threshold>`	<Threshold> – BRAS sessions amount, [0-50000] – for ESR-1700 • [0-10000] – for ESR-1200/1000 • [0-1000] – for ESR-100/200

12.2 Example of configuration with SoftWLC

Objective:

Provide access to the Internet only to authorized users.



Solution:

SoftWLC server keeps accounts data and tariff plan parameters. You can obtain more detailed information on installation and configuring SoftWLC server using following links:

https://docs.eltex-co.ru/display/doc/v1.16_SoftWLC – general SoftWLC article;

https://docs.eltex-co.ru/pages/viewpage.action?pageId=58230784 – installation of SoftWLC from repositories.

The BRAS license is obligatory for router, after its activation you can start device configuring.

Create 3 security zones, according to the network structure depicted in

```
esr# configure
esr(config)# security zone trusted
esr(config-zone)# exit
esr(config)# security zone untrusted
esr(config-zone)# exit
esr(config)# security zone dmz
esr(config-zone)# exit
```

Configure public port parameters and assign its default gateway:

```
esr(config)# interface gigabitethernet 1/0/1
esr(config-if-gi)# security-zone untrusted
esr(config-if-gi)# ip address 203.0.113.2/30
esr(config-if-gi)# service-policy dynamic upstream
esr(config-if-gi)# exit
esr(config)# ip route 0.0.0.0/0 203.0.113.1
```

Configure port in direction to the SoftWLC server:

```
esr (config)# interface gigabitethernet 1/0/24
esr (config-if-gi)# security-zone dmz
esr (config-if-gi)# ip address 192.0.2.1/24
esr (config-if-gi)# exit
```

Configure port for Wi-Fi access point connection:

```
esr(config)# bridge 2
esr(config-bridge)# security-zone trusted
esr(config-bridge)# ip address 192.168.0.254/24
esr(config-bridge)# ip helper-address 192.0.2.20
esr(config-bridge)# service-subscriber-control object-group users
esr(config-bridge)# location ssid1
esr(config-bridge)# enable
esr(config-bridge)# exit
esr(config)# interface gigabitethernet 1/0/2.2000
esr(config-subif)# bridge-group 1
esr(config-subif)# exit
esr(config)# interface gigabitethernet 1/0/2
esr(config-if-gi)# service-policy dynamic downstream
esr (config-if-gi)# exit
```

⚠ Customer connection must be implemented through sub-interfaces to bridges. Selection of tariff plan depends on Location parameter (see bridge 2 configuration).

The module which is responsible for AAA operations is based on eltex-radius and available by SoftWLC IP address. Numbers of ports for authentication and accounting in the example below are the default values for SoftWLC.

Define parameters for interaction with the module:

```
esr(config)# radius-server host 192.0.2.20
esr(config-radius-server)#   key ascii-text password
esr(config-radius-server)#   auth-port 31812
esr (config-radius-server)#  acct-port 31813
esr (config-radius-server)# exit
```

Create AAA profile:

```
esr(config)# aaa radius-profile RADIUS
esr(config-aaa-radius-profile)# radius-server host 192.0.2.20
esr(config-aaa-radius-profile)# exit
```

Specify parameters for access to DAS (Direct-attached storage) server:

```
esr(config)# object-group network server
esr(config-object-group-network)#   ip address-range 192.0.2.20
esr(config-object-group-network)# exit
esr(config)# das-server CoA
esr(config-das-server)#   key ascii-text password
esr(config-das-server)#   port 3799
esr(config-das-server)#   clients object-group server
esr(config-das-server)# exit
esr(config)# aaa das-profile CoA
esr(config-aaa-das-profile)#   das-server CoA
esr(config-aaa-das-profile)# exit
```

The traffic from trusted zone is blocked before authentication as well as DHCP and DNS requests. You need to configure allowing rules in order to pass DHCP and DNS requests:

```
esr(config)# ip access-list extended DHCP
esr(config-acl)#  rule 10
esr(config-acl-rule)# action permit
esr(config-acl-rule)# match protocol udp
esr(config-acl-rule)# match source-address any
esr(config-acl-rule)# match destination-address any
esr(config-acl-rule)# match source-port 68
esr(config-acl-rule)# match destination-port 67
esr(config-acl-rule)# enable
esr(config-acl-rule)# exit
esr(config-acl)# rule 11
esr(config-acl-rule)# action permit
esr(config-acl-rule)# match protocol udp
esr(config-acl-rule)# match source-address any
esr(config-acl-rule)# match destination-address any
esr(config-acl-rule)# match source-port any
esr(config-acl-rule)# match destination-port 53
esr(config-acl-rule)# enable
esr(config-acl-rule)#exit
esr(config-acl)# exit
```

Then, create rules for redirecting to portal and passing traffic to the Internet:

```
esr(config)# ip access-list extended WELCOME
esr(config-acl)# rule 10
esr(config-acl-rule)# action permit
esr(config-acl-rule)# match protocol any
esr(config-acl-rule)# match source-address any
esr(config-acl-rule)# match destination-address any
esr(config-acl-rule)# enable
esr(config-acl-rule)# exit
esr(config-acl)# exit
esr (config)# ip access-list extended INTERNET
esr(config-acl)#  rule 10
esr(config-acl-rule)# action permit
esr(config-acl-rule)# match protocol any
esr(config-acl-rule)# match source-address any
esr(config-acl-rule)# match destination-address any
esr(config-acl-rule)# enable
esr(config-acl-rule)# exit
esr(config-acl)# exit
```

Specify web resources which are available without authorization:

```
esr(config)# object-group url defaultservice
esr(config-object-group-url)# url http://eltex.nsk.ru
esr(config-object-group-url)# exit
```

The URL filtering lists are kept on SoftWLC server (you need to change only IP address of SoftWLC server, if addressing is different from the example. Leave the rest of URL without changes):

```
esr(config)# subscriber-control filters-server-url http://192.0.2.20:7070/Filters/file/
```

Configure and enable BRAS, define NAS IP as address of the interface interacting with SoftWLC (gigabitethernet 1/0/24 in the example):

```
esr(config)# subscriber-control
esr(config-subscriber-control)#  aaa das-profile CoA
esr(config-subscriber-control)#  aaa sessions-radius-profile RADIUS
esr(config-subscriber-control)#  nas-ip-address 192.0.2.1
esr(config-subscriber-control)#  session mac-authentication
esr(config-subscriber-control)#  bypass-traffic-acl DHCP
esr(config-subscriber-control)#  default-service
esr(config-subscriber-default-service)#  class-map INTERNET
esr(config-subscriber-default-service)#  filter-name local defaultservice
esr(config-subscriber-default-service)#  filter-action permit
esr(config-subscriber-default-service)#  default-action redirect http://192.0.2.20:8080/
eltex_portal/
esr(config-subscriber-default-service)#  session-timeout 3600
esr(config-subscriber-default-service)# exit
esr(config-subscriber-control)# enable
esr(config-subscriber-control)# exit
```

Configure rules for transition between security zones.

```
esr(config)# object-group service telnet
esr(config-object-group-service)#   port-range 23
esr(config-object-group-service)# exit
esr(config)# object-group service ssh
esr(config-object-group-service)#   port-range 22
esr(config-object-group-service)# exit
esr(config)# object-group service dhcp_server
esr(config-object-group-service)#   port-range 67
esr(config-object-group-service)# exit
esr(config)# object-group service dhcp_client
esr(config-object-group-service)#   port-range 68
esr(config-object-group-service)# exit
esr(config)# object-group service ntp
esr(config-object-group-service)#   port-range 123
esr(config-object-group-service)# exit
```

Enable access to the Internet from trusted and dmz zones:

```
esr(config)# security zone-pair trusted untrusted
esr(config-zone-pair)# rule 10
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol any
esr(config-zone-pair-rule)# match source-address any
esr(config-zone-pair-rule)# match destination-address any
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)# exit
esr(config)# security zone-pair dmz untrusted
esr(config-zone-pair)# rule 10
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol any
esr(config-zone-pair-rule)# match source-address any
esr(config-zone-pair-rule)# match destination-address any
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)# exit
esr(config)# security zone-pair dmz trusted
esr(config-zone-pair)# rule 10
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol any
esr(config-zone-pair-rule)# match source-address any
esr(config-zone-pair-rule)# match destination-address any
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)# exit
```

Enable DHCP transmitting from trusted to dmz:

```
esr (config)# security zone-pair trusted dmz
esr (config-zone-pair)# rule 10
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol udp
esr(config-zone-pair-rule)# match source-address any
esr(config-zone-pair-rule)# match destination-address any
esr(config-zone-pair-rule)# match source-port dhcp_client
esr(config-zone-pair-rule)# match destination-port dhcp_server
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair)# exit
```

Enable ICMP transmission to the device. For BRAS operation you need to open ports for web proxying - TCP 3129/3128 (NetPortDiscovery Port/Active API Server port:

```
esr(config)# object-group service bras
esr(config-object-group-service)#   port-range 3129
esr(config-object-group-service)#   port-range 3128
esr(config-object-group-service)# exit
esr(config)#  security zone-pair trusted self
esr(config-zone-pair)#  rule 10
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol tcp
esr(config-zone-pair-rule)# match source-address any
esr(config-zone-pair-rule)# match destination-address any
esr(config-zone-pair-rule)# match source-port any
esr(config-zone-pair-rule)# match destination-port bras
esr(config-zone-pair-rule)# enable
esr (config-zone-pair-rule)# exit
esr(config-zone-pair)# rule 20
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol icmp
esr(config-zone-pair-rule)# match source-address any
esr(config-zone-pair-rule)# match destination-address any
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair-rule)# exit
esr(config)# security zone-pair dmz self
esr(config-zone-pair)# rule 20
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol icmp
esr(config-zone-pair-rule)# match source-address any
esr(config-zone-pair-rule)# match destination-address any
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair-rule)# exit
esr(config)# security zone-pair untrusted self
esr(config-zone-pair)# rule 20
esr(config-zone-pair-rule)# action permit
esr(config-zone-pair-rule)# match protocol icmp
esr(config-zone-pair-rule)# match source-address any
esr(config-zone-pair-rule)# match destination-address any
esr(config-zone-pair-rule)# enable
esr(config-zone-pair-rule)# exit
esr(config-zone-pair-rule)# exit
```

Activate DHCP-Relay:

```
esr(config)# ip dhcp-relay
```

Configure SNAT for gigabitethernet 1/0/1 port:

```
esr(config)# nat source
esr(config-snat)# ruleset inet
esr(config-snat-ruleset)# to interface gigabitethernet 1/0/1
esr(config-snat-ruleset)# rule 10
esr(config-snat-rule)# match source-address any
esr(config-snat-rule)# action source-nat interface
esr(config-snat-rule)# enable
esr(config-snat-rule)# end
```

12.3 Example of configuration without SoftWLC

Objective:

Configure BRAS without SoftWLC support.

Given:

Subnet with clients 10.10.0.0/16, subnet for working with FreeRADIUS server 192.168.1.1/24

Solution:

12.3.1 Step 1:

RADIUS server configuration.

For FreeRADIUS server, you need to specify the subnet that can send the queries and add a user list. To do this, add the following to the users file in the directory with FreeRADIUS server configuration files:

User profile:

```
<MACADDR> Cleartext-Password := <MACADDR>
```

#User name

```
  User-Name = <USER_NAME>,
```

#Maximum session lifetime

```
  Session-Timeout = <SECONDS>,
```

#Maximum session lifetime when the system is idle

```
  Idle-Timeout = <SECONDS>,
```

#Session statistics update time

```
  Acct-Interim-Interval = <SECONDS>,
```

#Service name for a session (A – the service is enabled, N – the service is disabled)

```
  Cisco-Account-Info = "{A|N}<SERVICE_NAME>"
```

Service profile:

```
  <SERVICE_NAME> Cleartext-Password := <MACADDR>
```

Matches class-map name in ESR settings

```
  Cisco-AVPair = "subscriber:traffic-class=<CLASS_MAP>",
```

Action that is applied to the traffic by ESR (permit, deny, redirect)

```
 Cisco-AVPair = "subscriber:filter-default-action=<ACTION>",
```

The ability of IP flows passing (enabled-uplink, enabled-downlink, enabled, disabled)

```
 Cisco-AVPair = "subscriber:flow-status=<STATUS>"
```

Add a subnet, in which ESR is located, to the clients.conf file:

```
client ESR {
ipaddr = <SUBNET>
secret = <RADIUS_KEY>
}
```

In this case the RADIUS server configuration will be as follows:

Add the following strings to the “clients.conf” file:

```
client BRAS {
ipaddr = 192.168.1.1
secret = password
}
```

Add the following strings to the “users” file (specify a client MAC address instead of <MAC>):

```
"54-E1-AD-8F-37-35" Cleartext-Password := "54-E1-AD-8F-37-35"
User-Name = "Bras_user",
Session-Timeout = 259200,
Idle-Timeout = 259200,
Cisco-AVPair += "subscriber:policer-rate-in=1000",
Cisco-AVPair += "subscriber:policer-rate-out=1000",
Cisco-AVPair += "subscriber:policer-burst-in=188",
Cisco-AVPair += "subscriber:policer-burst-out=188",
Cisco-Account-Info = "AINTERNET"
INTERNET Cleartext-Password := "INTERNET"
User-Name = "INTERNET",
Cisco-AVPair = "subscriber:traffic-class=INTERNET",
Cisco-AVPair += "subscriber:filter-default-action=permit"
```

12.3.2 Step 2:

ESR configuration.

BRAS functional configuration requires the BRAS licence:

```
esr(config)# do sh licence
Licence information
-------------------
Name:    Eltex
Version: 1.0
Type:    ESR-X
S/N:     NP00000000
MAC:     XX:XX:XX:XX:XX:XX
Features:
  BRAS - Broadband Remote Access Server
```

Configuration of parameters for the interaction with RADIUS server:

```
esr(config)# radius-server host 192.168.1.2
esr(config-radius-server)# key ascii-text encrypted 8CB5107EA7005AFF
esr(config-radius-server)# source-address 192.168.1.1
esr(config-radius-server)# exit
```

Create AAA profile:

```
esr(config)#  aaa radius-profile bras_radius
esr(config-aaa-radius-profile)# radius-server host 192.168.1.2
esr(config-aaa-radius-profile)#  exit
esr(config)#  aaa radius-profile bras_radius_servers
esr(config-aaa-radius-profile)#  radius-server host 192.168.1.2
esr(config-aaa-radius-profile)#  exit
```

Specify parameters for the DAS server:

```
esr(config)# das-server das
esr(config-das-server)# key ascii-text encrypted 8CB5107EA7005AFF
esr(config-das-server)#  exit
esr(config)#  aaa das-profile bras_das
esr(config-aaa-das-profile)#  das-server das
esr(config-aaa-das-profile)# exit
esr(config)#  vlan 10
esr(config-vlan)#  exit
```

Then, create rules for redirecting to portal and passing traffic to the Internet:

```
esr(config)#  ip access-list extended BYPASS
esr(config-acl)# rule 1
esr(config-acl-rule)#  action permit
esr(config-acl-rule)# match protocol udp
esr(config-acl-rule)#  match source-address any
esr(config-acl-rule)# match destination-address any
esr(config-acl-rule)#  match source-port 68
esr(config-acl-rule)#  match destination-port 67
esr(config-acl-rule)# enable
esr(config-acl-rule)#  exit
esr(config-acl)#  rule 2
esr(config-acl-rule)#  action permit
esr(config-acl-rule)#  match protocol udp
esr(config-acl-rule)#  match source-address any
esr(config-acl-rule)#  match destination-address any
esr(config-acl-rule)#  match source-port any
esr(config-acl-rule)#  match destination-port 53
esr(config-acl-rule)# enable
esr(config-acl-rule)# exit
esr(config)# ip access-list extended INTERNET
esr(config-acl)# rule 1
esr(config-acl-rule)#  action permit
esr(config-acl-rule)# match protocol any
esr(config-acl-rule)# match source-address any
esr(config-acl-rule)# match destination-address any
esr(config-acl-rule)# enable
esr(config-acl-rule)#  exit
esr(config)# ip access-list extended WELCOME
esr(config-acl)# rule 10
esr(config-acl-rule)# action permit
esr(config-acl-rule)# match protocol tcp
esr(config-acl-rule)# match source-address any
esr(config-acl-rule)# match destination-address any
esr(config-acl-rule)# match source-port any
esr(config-acl-rule)# match destination-port 443
esr(config-acl-rule)# enable
esr(config-acl-rule)# exit
esr(config-acl)# rule 20
esr(config-acl-rule)# action permit
esr(config-acl-rule)# match protocol tcp
esr(config-acl-rule)# match source-address any
esr(config-acl-rule)# match destination-address any
esr(config-acl-rule)# match source-port any
esr(config-acl-rule)# match destination-port 8443
```

```
esr(config-acl-rule)# enable
esr(config-acl-rule)# exit
esr(config-acl)# rule 30
esr(config-acl-rule)# action permit
esr(config-acl-rule)# match protocol tcp
esr(config-acl-rule)# match source-address any
esr(config-acl-rule)# match destination-address any
esr(config-acl-rule)# match source-port any
esr(config-acl-rule)# match destination-port 80
esr(config-acl-rule)# enable
esr(config-acl-rule)# exit
esr(config-acl)# rule 40
esr(config-acl-rule)# action permit
esr(config-acl-rule)# match protocol tcp
esr(config-acl-rule)# match source-address any
esr(config-acl-rule)# match destination-address any
esr(config-acl-rule)# match source-port any
esr(config-acl-rule)# match destination-port 8080
esr(config-acl-rule)# enable
esr(config-acl-rule)# exit
```

Configuration of filtering by URL is obligatory. It is necessary to configure http-proxy filtration on BRAS for non-authorised users:

```
esr(config)# object-group url defaultserv
esr(config-object-group-url)# url http://eltex.nsk.ru
esr(config-object-group-url)# url http://ya.ru
esr(config-object-group-url)# url https://ya.ru
esr(config-object-group-url)# exit
```

Configure and enable BRAS, define NAS IP as address of the interface interacting with RADIUS server (gigabitethernet 1/0/2 in the example):

```
esr(config)#  subscriber-control
esr(config-subscriber-control)# aaa das-profile bras_das
esr(config-subscriber-control)# aaa sessions-radius-profile bras_radius
esr(config-subscriber-control)# aaa services-radius-profile bras_radius_servers
esr(config-subscriber-control)# nas-ip-address 192.168.1.1
esr(config-subscriber-control)# session mac-authentication
esr(config-subscriber-control)# bypass-traffic-acl BYPASS
esr(config-subscriber-control)# default-service
esr(config-subscriber-default-service)# class-map BYPASS
esr(config-subscriber-default-service)# filter-name local defaultserv
esr(config-subscriber-default-service)# filter-action permit
esr(config-subscriber-default-service)# default-action redirect http://192.
168.1.2:8080/eltex_portal
esr(config-subscriber-default-service)# session-timeout 121
esr(config-subscriber-default-service)# exit
esr(config-subscriber-control)# enable
esr(config-subscriber-control)# exit
```

Perform the following settings on the interfaces that require BRAS operation (minimum one interface is required for the successful start):

```
esr(config)#  bridge 10
esr(config-bridge)# vlan 10
esr(config-bridge)# ip firewall disable
esr(config-bridge)#  ip address 10.10.0.1/16
esr(config-bridge)#  ip helper-address 192.168.1.2
esr(config-bridge)# service-subscriber-control any
esr(config-bridge)# location USER
esr(config-bridge)#  protected-ports
esr(config-bridge)#  protected-ports exclude vlan
esr(config-bridge)# enable
esr(config-bridge)#  exit
```

Configure port towards the SoftWLC server:

```
esr(config)# interface gigabitethernet 1/0/2
esr(config-if-gi)# ip firewall disable
esr(config-if-gi)# ip address 192.168.1.1/24
esr(config-if-gi)#  exit
```

Port towards the Client:

```
esr(config)#  interface gigabitethernet 1/0/3.10
esr(config-subif)#  bridge-group 10
esr(config-subif)# ip firewall disable
esr(config-subif)#  exit
```

Configure SNAT for gigabitethernet 1/0/2 port:

```
esr(config)# nat source
esr(config-snat)# ruleset factory
esr(config-snat-ruleset)# to interface gigabitethernet 1/0/2
esr(config-snat-ruleset)# rule 10
esr(config-snat-rule)# description "replace 'source ip' by outgoing interface ip address"
esr(config-snat-rule)# match protocol any
esr(config-snat-rule)# match source-address any
esr(config-snat-rule)# match destination-address any
esr(config-snat-rule)# action source-nat interface
esr(config-snat-rule)# enable
esr(config-snat-rule)# exit
esr(config-snat-ruleset)# exit
esr(config-snat)# exit
esr(config)# ip route 0.0.0.0/0 192.168.1.2
```

The configuration changes come into effect after applying the following commands:

```
esr(config) # do commit
esr(config) # do confirm
```

To view the information and statistics on the user control sessions, use the following command:

```
esr # sh subscriber-control sessions status

Session id      User name    IP address      MAC address       Interface          Domain
--------------------   --------------  ---------------   -----------------
1729382256910270473    Bras_user   10.10.0.3  54:e1:ad:8f:37:35     gi1/0/3.10     --
```

13 VoIP management

VoIP (Voice over IP) – a set of protocols that allow to transmit voice data via IP networks. Within the given device, VoIP is used to connect analogue telephones to an IP network with the possibility to make phone calls.

13.1 SIP profile configuration algorithm

Step	Description	Command	Keys
1	Configure a SIP profile	`esr(config)# sip profile <NUM>`	<NUM> – SIP profile number, set in the form of a digit from 1 to 5.
2	Configure a primary SIP proxy server and registration server	`esr(config-sip-profile)# proxy primary`	
3	Configure a SIP proxy server	`esr(config-voip-sip-proxy)# ip address proxy-server <IP>`	<IP> – proxy server IP address
4	Configure a SIP proxy server port	`esr(config-voip-sip-proxy)# ip port proxy-server <PORT>`	<PORT> – number of proxy server UDP port, takes values of [1..65535]. If standard 5060 port is used, you do not need to specify it.
5	Configure a registration server address	`esr(config-voip-sip-proxy)# ip address registration-server <IP>`	<IP> – registration server IP address.
6	Configure a registration server port:	`esr(config-voip-sip-proxy)# ip portregistration-server <PORT>`	<PORT> – number of registration server UDP port, takes values of [1..65535]. If standard 5060 port is used, you do not need to specify it.
7	Enable registration	`esr(config-voip-sip-proxy)# registration`	
8	Enable proxy server and registration server:	`esr(config-voip-sip-proxy)# enable`	

Step	Description	Command	Keys
9	Configure a registration server address	`esr(config-voip-sip-proxy)# ip address registration-server <IP>`	<IP> – registration server IP address.
10	Configure a registration server port:	`esr(config-voip-sip-proxy)# ip portregistration-server <PORT>`	<PORT> – number of registration server UDP port, takes values of [1..65535]. If standard 5060 port is used, you do not need to specify it.
11	Specify SIP domain in which the device is located	`esr(config-sip-profile)# sip-domain address <ADDRESS>`	<ADDRESS> – SIP domain in which the device is located, set by ipv4 address or domain name.
12	Enable the use of SIP domain when registering	`esr(config-sip-profile)# sip-domain registration enable`	
13	Configure a SIP profile	`esr(config)# sip profile <NUM>`	<NUM> – SIP profile number, set in the form of a digit from 1 to 5.
14	Assign a dial plan to the current SIP profile	`esr(config-sip-profile)# dialplan pattern <DNAME>`	<DNAME> – name of the dial plan, set by the string of up to 31 characters.
15	Enable SIP profile	`esr(config-sip-profile)# enable`	

13.2 FXS/FXO ports configuration algorithm

Step	Description	Command	Keys
1	Switch to the FXO/FXS ports configuration mode	`esr(config)# interface voice-port <NUM>`	<NUM> – port number, takes values of [1..4].
2	Assign a subscriber number reserved for a telephone port	`esr(config-voice-port-fxs)# sip user phone <PHONE>`	<PHONE> – subscriber number reserved for a telephone port, set by the string of up to 50 characters.
3	Assign the user name matched with the port	`esr-12v(config-voice-port-fxs)# sip user display-name <LOGIN>`	<LOGIN> – user name displayed in the Display-Name field, set by the string of up to 31 characters.
4	Select SIP profile for a certain port.	`esr(config-voice-port-fxs)# profile sip <PROFILE>`	<PROFILE> – SIP profile number, set in the form of a digit from 1 to 5.

Step	Description	Command	Keys
5	Configure a login for authentication	`esr(config-voice-port-fxs)# authentication name <LOGIN>`	<LOGIN> – login for authentication, set by the string of up to 31 characters
6	Configure a password for authentication	`esr(config-voice-port-fxs)# authentication password <PASS>`	<PASS> – authentication password, set by the string of up to 16 characters.
7	Enable FXO port	`esr(config)# interface voice-port <NUM>`	<NUM> – FXO port number, takes values of [1..4].
8	Assign a subscriber number reserved for a telephone port	`esr(config-voice-port-fxo)# sip user phone <PHONE>`	<PHONE> – subscriber number reserved for a telephone port.
9	Specify UDP port from which and to which the FXO set will send and receive SIP messages	`esr(config-voice-port-fxo)# sip port <PORT>`	<PORT> – UDP port number.
10	Assign the user name matched with the port	`esr(config-voice-port-fxo)# sip user display-name <LOGIN>`	<LOGIN> – user name displayed in the Display-Name field, set by the string of up to 31 characters.
11	Configure a login for authentication	`esr(config-voice-port-fxo)# authentication name <LOGIN>`	<LOGIN> – login for authentication, set by the string of up to 31 characters.
12	Configure a password for authentication	`esr(config-voice-port-fxo)# authentication password <PASS>`	<PASS> – authentication password, set by the string of up to 16 characters.
13	Enable the number transmission to PSTN	`esr(config-voice-port-fxo)# pstn transmit-number`	
14	Disable prefix transmission	`esr(config-voice-port-fxo)# no pstn transmit-prefix`	
15	Enable the “Hostline PSTN to IP” service	`esr(config-voice-port-fxo)# hotline ipt`	

Step	Description	Command	Keys
16	Number of the subscriber that will receive calls from PSTN	`esr(config-voice-port-fxo)# hotline number ipt <PHONE>`	<PHONE> – phone number that calls are made to when using the service, takes the value from 1 to 50. “Hot/Warm line” in the direction from analogue telephone line to VoIP.

13.3 Dial plan configuration algorithm

Step	Description	Command	Keys
1	Create a dial plan	`esr(config)# dialplan pattern <DNAME>`	<DNAME> – name of the dial plan, set by the string of up to 31 characters.
2	Add dial rules	`esr(config-dial-ruleset)# pattern <REGEXP>`	<REGEXP> - regular expression specifying the dial plan. Set by the string of up to 1024 characters. The rules for creating regular expressions are described in section Dial plan configuration example.
3	Enable the dial plan	`esr(config-dial-ruleset)# enable`	

13.4 PBX server configuration algorithm

Step	Description	Command	Keys
1	PBX server configuration	`esr(config)# pbx`	
2	Enable PBX server	`esr(config-pbx)# enable`	
3	Create a routing plan	`esr(config-pbx)# ruleset <rule_name>`	<rule_name> – name of the routing plan, set by the string of up to 31 characters.
4	Create a routing rule	`esr(config-pbx-ruleset)# rule <rule_index>`	<rule_index> – number of the rule in the routing plan, takes values from 1 to 1000.
5	Creating a pattern in a routing rule	`esr(config-pbx-rule)# pattern <REGEXP>`	<REGEXP> – regular expression specifying the routing rule. Set by the string of up to 256 characters. The rules for creating regular expressions are described in section Dial plan configuration example.

Step	Description	Command	Keys
6	Applying a routing rule	`esr(config-pbx-rule)# enable`	
7	Creating a SIP profile on a PBX Server	`esr(config-pbx)# profile <PROFILE>`	<PROFILE> – name of the SIP profile, that used by PBX server, set by the string of 31 character.
8	Selecting a codec supported by a SIP profile	`esr(config-pbx-profile)# codec allow { G711A(alaw) | G711U(ulaw) | G722 | G726 }`	
9	Selecting SIP profile type	`esr(config-pbx-profile)# client { peer | user | friend }`	• **peer** – incoming and outgoing calls are allowed without authorisation. • **user** – only incoming calls are allowed. • **friend** – combines peer and user profile types.
10	Choosing a NAT interaction policy (optional)	`esr(config-pbx-profile)# nat { comedia | force-port | both }`	• **comedia** – send media stream to PBX port, regardless of SDP instructions. • **force-port** – use rport even if it is not present. • **both** – combines comedia and force-port.
11	Selecting a SIP profile routing plan	`esr(config-pbx-profile)# ruleset <NAME>`	<NAME> – name of the routing plan, set by the string of up to 31 characters.
12	Create a subscriber	`esr(config-pbx)# user <user>`	<user> – phone number or username, set by the string of up to 31 characters.
13	Create a password for the subscriber (optional)	`esr(config-pbx-user)# password <password>`	<password> – password that will be used by the user for authentication, set by the string of up to 16 characters.
14	The use of SIP profile for the subscriber	`esr(config-pbx-user)# profile <SIPPROFILE>`	<SIPPROFILE> – SIP profile used for this subscriber, set by the string of up to 31 characters.

13.5 Registration trunk creation algorithm

Step	Description	Command	Keys
1	PBX server configuration	`esr(config)# pbx`	
2	Trunk creation	`esr(config-pbx)# register-server <name>`	<name> – trunk name, set by the string of up to 31 characters.
3	Registration server address configuration	`esr(config-pbx-reg-server)# ip address <IP>`	<IP> – address of the server on which registration proceeds, takes values of an IP address or can be specified by the string of up to 31 characters.
4	Registration server port configuration	`esr(config-pbx-reg-server)# ip port <PORT>`	<PORT> – number of registration server UDP port, takes values of [1..65535]. If standard 5060 port is used, you do not need to specify it.
5	Specify the authentication name	`esr(config-pbx-reg-server)# username <user>`	<user> – username for this trunk on the upstream domain, set by the string of up to 31 characters.
6	Specify the authentication password	`esr(config-pbx-reg-server)# authentication password <password>`	<user> – password for this trunk on the upstream domain, set by the string of up to 16 characters.
7	The use of SIP profile for the trunk	`esr(config-pbx-reg-server)# profile <PROFILE>`	<PROFILE> – name of the SIP profile, that used for this trunk, set by the string of 31 character.
8	Select the transport protocol (optionally)	`esr(config-pbx-reg-server)# protocol {tcp | udp }`	The default is udp.
9	Trunk activation	`esr(config-pbx-reg-server)# enable`	

13.6 VoIP configuration example

Objective:

Connect analogue telephones and fax modems to the IP network via ESR router. SIP server, located on the ESR, functions as proxy server and registration server.

Solution:

Configure a SIP profile:

```
esr(config)# sip profile 1
```

Configure a primary SIP proxy server and registration server:

```
esr(config-sip-profile)# proxy primary
```

Configure SIP proxy server address (use an embedded SIP server as SIP proxy server):

```
esr(config-voip-sip-proxy)# ip address proxy-server 192.0.2.5
```

Configure a SIP proxy server port:

```
esr(config-voip-sip-proxy)# ip port proxy-server 5080
```

If standard 5060 port is used, you do not need to specify it.

If it is necessary to use the registration, you should perform the following steps:

Configure registration server address (use an embedded SIP server as registration server):

```
esr(config-voip-sip-proxy)# ip address registration-server 192.0.2.5
```

Configure a registration server port:

```
esr(config-voip-sip-proxy)# ip port registration-server 5080
```

If standard 5060 port is used, you do not need to specify it.

Enable registration:

```
esr(config-voip-sip-proxy)# registration
```

Enable proxy server and registration server:

```
esr(config-voip-sip-proxy)# enable
```

This completes the configuration of SIP proxy server and registration server:

```
esr(config-voip-sip-proxy)# exit
```

The next step is to continue SIP profile configuration.

⚠ If the embedded SIP server is used as SIP proxy and registration server, you should perform its configuration according to the manual «SIP server configuration on ESR series routers: ESR: ESR-12V, ESR-12VF, ESR-14VF».

Configure a SIP domain:

```
esr(config-sip-profile)# sip-domain address sipdomain.com
```

If it is necessary to use SIP Domain for the registration, use the following command:

```
esr(config-sip-profile)# sip-domain registration enable
```

In this configuration all calls will be directed to SIP proxy server. If it is necessary to specify another direction for outgoing calls, you should perform the following:

Create a numbering plan, see section Dial plan configuration example.

Next, assign the created dial plan to the SIP profile:

```
esr(config)# sip profile 1
esr(config-sip-profile)# dialplan pattern firstDialplan
```

This completes the configuration of a dial plan for SIP profile.

Enable SIP profile:

```
esr-12v(config-sip-profile)# enable
```

This completes the baseline configuration of SIP profile:

```
esr(config-sip-profile)# exit
```

The next step is to configure subscriber ports:

```
esr(config)# interface voice-port 1
```

Specify a subscriber number:

```
esr(config-voice-port-fxs)# sip user phone 4101
```

Specify a displayed name:

```
esr(config-voice-port-fxs)# sip user display-name user-one
```

Used SIP profile:

```
esr(config-voice-port-fxs)# profile sip 1
```

Configure login and password for authentication

```
esr(config-voice-port-fxs)# authentication name login-4101
esr(config-voice-port-fxs)# authentication password superpassword
```

This completes the baseline configuration of a subscriber port:

```
esr(config-voice-port-fxs)# exit
```

13.7 Dial plan configuration example

Objective:

Configure a dial plan in such a manner that calls to local numbers (connected to the given ESR-12V) are switched locally and calls to all other directions – through SIP proxy.

Solution:

Create a dial plan:

```
esr(config)# dialplan pattern firstDialplan
```

Dial plan is specified by regular expressions:

```
esr(config-dial-ruleset)# pattern "<regular expressions>"
```

For the objective mentioned above, the '<*regular* expressions>' is given by:

"S5, L5 (410[1-3]@{local} | [xABCD*#].S)"

where:

410[1-3]@{local} – calls to 4101, 4102, 4103 numbers will be switched locally;

[xABCD*#]. S – calls to all other numbers will be directed to SIP proxy.

Enable the dial plan:

```
esr(config-dial-ruleset)# enable
```

Dial plan configuration is finished.

```
esr(config-dial-ruleset)# exit
```

Regular expression structure:

Sxx, Lxx ( ),

where:

xx – random values of S and L timers;

() – dialplan limits.

The basis is designators for dialled digits sequence to be written. Dialed digits sequence is recording using several designations: numbers dialed from the phone keypad: 0, 1, 2, 3, ..., 9, # and *.

The use of # character in dial plan can block the completion of dialing with this key!

Bracketed sequence of digits corresponds to any bracketed character.

- Example: ([1239]) - corresponds to any of this digits: 1, 2, 3 and 9.
  You may specify the hyphenated range of characters. Usually it is used inside the square brackets.
- Example 1: (1-5) - any digit from 1 to 5.

- Example 2: ([1-39]) – example from previous paragraph with other record format.
  'X' character corresponds to any digit from 0 to 9.
- Example: (1XX) - any three-digit number, starting at 1.

'.' - Previous symbol repeating from 0 to infinity.

«+» – repeating the previous character from 1 to infinity number of times.

{a,b} – repeating the previous character from a to b times;

{a,} – repeating the previous character equal to or more than a times;

{,b} – repeating the previous character equal to or less than b times.

- Example: (810X.) - international number with any digits amount.
  Settings influencing on the dial plan processing:
- Interdigit Long Timer (letter "L" in dial plan entry) – timeout to enter the next digit if there are no templates matching the dialled combination;
- Interdigit Short Timer (letter "S" in dial plan entry) – timeout to enter the next digit if at least one pattern completely matches the dialled combination and there is at least one more pattern before matching with that it is necessary to perform the extension dialing.

Additional features:

1. Replacement of a dialed sequence
   Syntax: *<arg1:arg2>*
   This feature allows to replace a dialled sequence to any sequence of dialled characters. In this case, the second argument must be specified with a certain value, both arguments may be empty.
   - Example: (<83812:> XXXXXX) – this record will comply to dialed digits 83812, but this sequence will ommited and will not be transmitted to SIP server.
2. Insert a tone in the set
   For long-distance access (for city access in case of office PBX), it is common to hear a ringback, that may be implemented by inserting comma in a sequence of digits.
   - Example: (8, 770) – after digit 8 a continious tone will output when dialing number 8770.
3. Number dialing deny
   If at the end of pattern add symbol '!' the dialing of numbers corresponding to the template will be blocked.
   - Example: (8 10X xxxxxxx ! | 8 xxx xxxxxxx) – expression allows dialing only intercity numbers and exclude international calls.
4. Replacement of number dialing timers values
   Timers values can be assigned both to a whole dial plan and to a certain template. 'S' is responsible for the *«Interdigit Short Timer»* setup and 'L' – for the *«Interdigit Long Timer»* setup. Timers values can be specified for all templates in a dial plan if the values are listed before the opening parenthesis.
   - Example: S4 (8XXX.) or S4,L8 (XXX)
     If these values are listed in one sequence only, they are effective only for this sequence. Also, in this case it is not necessary to put a colon between the key and the timeout value, the value can be located anywhere in the template.
   - Example: (S4 8XXX. | XXX) or ([1-5] XX S0) – entry will call instant call transmission when three-digit number starting at 1, 2, ..., 5 is dialed.
5. Dialing via direct address (IP Dialing)
   "@" character put after the number means that the address of the server, to which the dialled number call will be sent, will be specified. We recommend to use *'IP Dialing'* and receive and transmission of call without registration *('Call Without Reg', 'Answer Without Reg'*). This can help in case of server failure.
   In addition, the format of address with IP Dialing can be used in numbers intended to forward calls.
   - Example 1: (8 xxx xxxxxxx) – 11-digit number, starting with 8.
   - Example 2: (8 xxx xxxxxxx | <:8495> xxxxxxx) – 11-digit number, starting with 8; if 7-digit number was entered, add 8495 to the number being transmitted.
   - Example 3: (0[123] | 8 [2-9]xx [2-9]xxxxxx) – emergency service numbers dialing as well as unusual dialing of long-distance call numbers.

- Example 4: (S0 <:82125551234>) – specified number speed dial, «Hotline» mode analogue on another gateways.
- Example 5: (S5 <:1000> | xxxx) – the given dial plan allows to dial any number consisting of digits; if nothing is entered during 5 seconds, call number 1000 (let it be a secretary).
- Example 6: (8, 10x.|1xx@10.110.60.51:5060) – the given dial plan allows to dial numbers starting with 810 and containing at least one digit after “810”. After entering 8, the “station response” signal will be returned. Also a set of three-digit numbers starting with “1”, the Invite of which will be sent to 10.110.60.51 IP address and 5060 port, will be returned.
- Example 7: (S3 *xx#|#xx#|#xx#|*xx*x+#) – management and the use of VAS.
  Local calls inside the device may be required in some cases. If the device’s IP address is not known or is periodically changed, it is convenient to use the reserved word {local} as the server address, which means sending the corresponding sequence of digits to the device’s own address.
- Example: (123@{local}) – call on number 123 will be locally processed within the device.

13.8 FXO port configuration

Objective:

Add the ability to make a call to PSTN subscriber through the ESR-12V FXO port.

Solution:

Enable FXO port:

```
esr(config)# interface voice-port 4
```

Specify FXO port number same as PSTN access prefix:

```
esr(config-voice-port-fxo)# sip user phone 9
```

Specify UDP port from which and to which the FXO set will send and receive SIP messages:

```
esr(config-voice-port-fxo)# sip port 5064
```

Specify a displayed name:

```
esr(config-voice-port-fxo)# sip user display-name user-one
```

Configure login and password for authentication

```
esr(config-voice-port-fxo)# authentication name login-9
esr(config-voice-port-fxo)# authentication password superpassword
```

Assign SIP profile to FXO port:

```
esr(config-voice-port-fxo)# profile sip 1
```

Enable the number transmission to PSTN:

```
esr(config-voice-port-fxo)# pstn transmit-number
```

Disable prefix transmission:

```
esr(config-voice-port-fxo)# no pstn transmit-prefix
```

For outgoing calls to work, you need to specify the following rule in the dial plan settings, which means that outgoing calls to numbers with prefix 9 are routed locally to the FXO set:

9x.@{local}:5064

This completes the baseline configuration of outgoing calls to PSTN. To make a call to PSTN, you should dial the callee number with the specified prefix (FXO set phone number).

To receive calls from PSTN, you should select the subscriber that will receive all calls from PSTN, let it be a subscriber with number 305.

Enable the «Hostline PSTN to IP» service:

```
esr(config-voice-port-fxo)# hotline ipt
```

Specify number of the subscriber that will receive calls from PSTN:

```
esr(config-voice-port-fxo)# hotline number ipt 305
```

14 Safe configuration recommendations

The safe configuration recommendations are general and suitable for most installations. These recommendations greatly improve the safe operation of the unit, but are not exhaustive. Depending on the application of the device, other safety parameters must also be configured. In some specific cases, the implementation of these recommendations may result in a non-functional network. When configuring the device, firstly it is necessary to follow the technical requirements and regulations of the networks in which the device will be used.

14.1 General recommendations

- It is recommended to always disable unused physical interfaces with the **shutdown** The command is described in detail in the Interface monitoring and configuration section of the CLI Command Reference.
- It is recommended to always set the system clock to synchronize with trusted network time sources (NTP). The NTP setup algorithm is described in the NTP configuration section of this manual. For detailed information on the NTP configuration commands, see System timer management in the CLI Command Reference.
- It is recommended to disable the NTP broadcast client, which is enabled by default in the factory configuration.
- It is not recommended to use the **ip firewall disable** command that disables firewalling. Always assign appropriate security zones to interfaces and configure the correct firewall rules. The firewall configuration algorithm is described in the Firewall configuration section of this manual. For detailed information on the Firewall configuration commands, see Firewall management in the CLI Command Reference.

14.2 Event logging system configuration

Event logging system configuration algorithms are described in the «Syslog configuration» subsection of the Monitoring section of this manual.

For detailed information on the Event logging system configuration commands, see SYSLOG management management in the CLI Command Reference.

14.2.1 Recommendations

- It is recommended to configure the event message storage in a syslog file on the device and transfer these events to an external syslog server.
- It is recommended to limit the size of the syslog file on the device.
- It is recommended to configure syslog file rotation on the device.
- It is recommended to enable syslog message enumeration.
- It is recommended that timestamp msec tags be added to syslog messages on ESR-1500 and ESR-1511.

14.2.2 Warnings

- The data stored in the **tmpsys:syslog** file system is not saved when the device is rebooted. This type of file system is recommended for storing operational logs.
- It is not recommended to use the **flash:syslog** file system to store logs, as it may cause premature ESR device failure.

14.2.3 Configuration example

Objective:

Configure the storage of event messages of info level and higher in a syslog file on the device and configure transmission of these events to an external syslog server. Limit the file size to 512kb. Enable rotation of 3 files. Enable syslog message enumeration

Solution:

Configure the storage of syslog messages in the file:

```
esr(config)# syslog file tmpsys:syslog/default info
```

Configure size limitation and file rotation:

```
esr(config)# syslog max-files 3
esr(config)# syslog file-size 512
```

Configure the transmission of messages to an external server:

```
esr(config)# syslog host mylog 192.168.1.2 info udp 514
```

Enable syslog message enumeration:

```
esr(config)# syslog sequence-numbers
```

14.3 Password usage policy configuration

The configuration algorithms for the password usage policy are described in the AAA configuration section of this manual.

For detailed information on the configuration commands for the password usage policy, see AAA configuration in the CLI Commands Reference.

14.3.1 Recommendations

- It is recommended to always enable the default password change request for the admin user.
- It is recommended to limit the lifetime of passwords and prohibit reusing at least the previous password.
- It is recommended to set the minimum password length requirement greater than 8 characters.
- It is recommended to set requirements for the use of lowercase and uppercase letters, numbers and special characters.

14.3.2 Configuration example

Objective:

- Configure a password policy with a requirement to change the default password, a password validity period of 1 month, and a ban on using the last 12 passwords.
- Set the minimum password length to 16 characters, the maximum to 64 characters.
- The password must contain at least 3 uppercase letters, at least 5 lowercase letters, at least 4 digits and at least 2 special characters. The password must contain all 4 types of characters.

Solution:

Enable the default password reset request for admin user:

```
esr(config)# security passwords default-expered
```

Set the password lifetime to 30 days and prohibit the use of the previous 12 passwords:

```
esr(config)# security passwords lifetime 30
esr(config)# security passwords history 12
```

Set a limit to the password length:

```
esr(config)# security passwords min-length 16
esr(config)# security passwords max-length 64
```

Set a limit on the minimum number of characters of the respective types:

```
esr(config)# security passwords upper-case 3
esr(config)# security passwords lower-case 5
esr(config)# security passwords special-case 2
esr(config)# security passwords numeric-count 4
esr(config)# security passwords symbol-types 4
```

14.4 AAA policy configuration

The algorithms for AAA policy are described in the AAA configuration section of this manual.

For detailed information on the commands for AAA policy, see AAA configuration in the CLI Commands Reference.

14.4.1 Recommendations

- It is recommended to use a role-based access model on the device.
- It is recommended to use personal accounts to authenticate on the device.
- It is recommended to enable logging of commands entered by the user.
- It is recommended to use several authentication methods for logging in to devices via console, remote login to devices and privilege escalation. A combination of RADIUS/TACACS/LDAP authentication and local authentication is considered optimal.
- It is recommended to lower the built-in **admin** account privileges to 1.
- It is recommended to configure logging of changes of local accounts.
- It is recommended to configure AAA policy change logging.

14.4.2 Warnings

- The built-in admin account cannot be deleted.
- The **no username admin** command does not remove the **admin** user, it resets his configuration to defaults. After applying this command, the **admin** user will not appear in the configuration.
- The **no password** command for the **admin** user also does not remove the **admin** user's password, but resets it to its default value. After applying this command, the **admin** user password is no longer displayed in the configuration and becomes 'password'.
- Attention! You must have a user with privilege level 15 or an ENABLE password configured before you can set the admin user to downgrade privileges.

14.4.3 Configuration example

Objective:

Configure AAA policy:

- Use RADIUS authentication for remote login via SSH.
- Use RADIUS authentication for local console login, use local authentication if there is no connection to RADIUS servers.
- Use ENABLE password set via RADIUS, if there is no connection to RADIUS servers, use local ENABLE password.
- Set the admin user to a reduced privilege level.
- Configure logging of changes of local accounts.
- Configure AAA policy changes logging.
- Configure the logging of entered commands.

Solution:

Create a **local-operator** user with privilege level 8:

```
esr(config)# username local-operator
esr(config-user)# password Pa$$w0rd1
esr(config-user)# privilege 8
esr(config-user)# exit
```

Set local ENABLE password:

```
esr(config)# enable password $6e5c4r3e2t!
```

Lower the privileges of the admin user:

```
esr(config)# username admin
esr(config-user)# privilege 1
esr(config-user)# exit
```

Configure the connection to the two RADIUS servers, the primary 192.168.1.11 and the backup 192.168.2.12:

```
esr(config)# radius-server host 192.168.1.11
esr(config-radius-server)# key ascii-text encrypted 8CB5107EA7005AFF
esr(config-radius-server)# priority 100
esr(config-radius-server)# exit
esr(config)# radius-server host 192.168.2.12
esr(config-radius-server)# key ascii-text encrypted 8CB5107EA7005AFF
esr(config-radius-server)# priority 150
esr(config-radius-server)# exit
```

Configure AAA policy:

```
esr(config)# aaa authentication login CONSOLE radius local
esr(config)# aaa authentication login SSH radius
esr(config)# aaa authentication enable default radius enable
esr(config)# aaa authentication mode break
esr(config)# line console
esr(config-line-console)# login authentication CONSOLE
esr(config-line-console)# exit
esr(config)# line ssh
esr(config-line-ssh)# login authentication SSH
esr(config-line-ssh)# exit
```

Configure logging:

```
esr(config)# logging userinfo
esr(config)# logging aaa
esr(config)# syslog cli-commands
```

14.5 Remote management configuration

For more information on remote access configuration commands, see SSH, Telnet access configuration in the CLI command reference.

14.5.1 Recommendations

- It is recommended to disable remote control via telnet.
- It is recommended to generate new cryptographic keys.
- It is recommended to use crypto-resistant sha2-256, sha2-512 authentication algorithms and disable all others.
- It is recommended to use crypto-resistant aes256, aes256ctr encryption algorithms and disable all others.
- It is recommended to use dh-group-exchange-sha256 crypto-proof encryption key exchange algorithm and disable all others.
- It is recommended to allow access to remote control of the device only from certain IP addresses.

14.5.2 Configuration example

Objective:

Disable telnet. Generate new encryption keys. Use crypto-resistant algorithms.

Solution:

Disable remote telnet control:

```
esr(config)# no ip telnet server
```

Generate new encryption keys:

```
esr-20(config)# crypto key generate dsa
esr-20(config)# crypto key generate ecdsa
esr-20(config)# crypto key generate ed25519
esr-20(config)# crypto key generate rsa
esr-20(config)# crypto key generate rsa1
```

Disable outdated and not crypto-resistant algorithms:

```
esr(config)# ip ssh server
esr(config)# ip ssh authentication algorithm md5 disable
esr(config)# ip ssh authentication algorithm md5-96 disable
esr(config)# ip ssh authentication algorithm ripemd160 disable
esr(config)# ip ssh authentication algorithm sha1 disable
esr(config)# ip ssh authentication algorithm sha1-96 disable
esr(config)# ip ssh encryption algorithm aes128 disable
esr(config)# ip ssh encryption algorithm aes128ctr disable
esr(config)# ip ssh encryption algorithm aes192 disable
esr(config)# ip ssh encryption algorithm aes192ctr disable
esr(config)# ip ssh encryption algorithm arcfour disable
esr(config)# ip ssh encryption algorithm arcfour128 disable
esr(config)# ip ssh encryption algorithm arcfour256 disable
esr(config)# ip ssh encryption algorithm blowfish disable
esr(config)# ip ssh encryption algorithm cast128 disable
esr(config)# ip ssh key-exchange algorithm dh-group-exchange-sha1 disable
esr(config)# ip ssh key-exchange algorithm dh-group1-sha1 disable
esr(config)# ip ssh key-exchange algorithm dh-group14-sha1 disable
esr(config)# ip ssh key-exchange algorithm ecdh-sha2-nistp256 disable
esr(config)# ip ssh key-exchange algorithm ecdh-sha2-nistp384 disable
esr(config)# ip ssh key-exchange algorithm ecdh-sha2-nistp521 disable
```

14.6 Configuration of protection against network attacks mechanisms

The algorithms for configuring the network attack protection mechanisms are described in the Logging and network protection configuration section of this manual.

For detailed information about the commands to configure the password policy, see Management of logging and protection against network attacks in the CLI Command Reference.

14.6.1 Recommendations

- It is recommended to always enable protection against ip spoofing.

- It is recommended to always enable protection against TCP packets with incorrectly set flags.
- It is recommended to always enable protection against fragmented TCP packets with the SYN flag set.
- It is recommended to always enable protection against fragmented ICMP packets.
- It is recommended to always enable protection against large ICMP packets.
- It is recommended to always enable protection against unregistered ip-protocols.
- It is recommended to enable logging of the protection mechanism against network attacks.

14.6.2 Configuration example

Objective:

Configure the protection mechanism against network attacks in accordance with the recommendations.

Solution:

Enable protection against ip spoofing and logging of the protection mechanism:

```
esr(config)# ip firewall screen spy-blocking spoofing
esr(config)# logging firewall screen spy-blocking spoofing
```

Enable protection against TCP packets with incorrectly set flags and logging of the protection mechanism:

```
esr(config)# ip firewall screen spy-blocking syn-fin
esr(config)# logging firewall screen spy-blocking syn-fin
esr(config)# ip firewall screen spy-blocking fin-no-ack
esr(config)# logging firewall screen spy-blocking fin-no-ack
esr(config)# ip firewall screen spy-blocking tcp-no-flag
esr(config)# logging firewall screen spy-blocking tcp-no-flag
esr(config)# ip firewall screen spy-blocking tcp-all-flags
esr(config)# logging firewall screen spy-blocking tcp-all-flags
```

Enable protection against fragmented ICMP packets and protection mechanism logging:

```
esr(config)# ip firewall screen suspicious-packets icmp-fragment
esr(config)# logging firewall screen suspicious-packets icmp-fragment
```

Enable protection against large ICMP packets and logging of the protection mechanism:

```
esr(config)# ip firewall screen suspicious-packets large-icmp
esr(config)# logging firewall screen suspicious-packets large-icmp
```

Enable protection against unregistered ip-protocols and logging protection mechanism:

```
esr(config)# ip firewall screen suspicious-packets unknown-protocols
esr(config)# logging firewall screen suspicious-packets unknown-protocols
```

15 FREQUENTLY ASKED QUESTIONS

- **Receiving of routes, which are configured in VRF via BGP or/and OSPF, failed. The neighbouring is successfully installed, but record of routes in RIB is denied**
  %ROUTING-W-KERNEL: Can not install route. Reached the maximum number of BGP routes in the RIB
  Allocate RIB resource for VRF (0 by default). Do it in VRF configuration mode:

```
esr(config)# ip vrf <NAME>
esr(config-vrf)# ip protocols ospf max-routes 12000
esr(config-vrf)# ip protocols bgp max-routes 1200000
esr(config-vrf)# end
```

- **SSH/Telnet sessions, which go through ESR router, are closing.**
  Configure transmission of keepalive packets in order to keep session active. Keepalive transmission option is configured on SSH client, for instance, section "Connection" for PuTTY client.
  It is possible to set time to closing inactive TCP sessions (1 hour in example):

```
esr(config)# ip firewall sessions tcp-estabilished-timeout 3600
```

- **Firewall was disabled on interface (ip firewall disable). However access for active sessions from the port was not closed, according to security zone-pair rules, after including this interface to security zone, removing from 'ip firewall disable' configuration and applying changes.**
  Changes in Firewall configuration will be active only for new sessions. The reset of Firewall active sessions does not occur. You can clear active sessions in firewall, using following command:

```
esr# clear ip firewall session
```

- **LACP does not launch on XG ports of ESR-1000/1200/1500/1700**
  Port-channel has speed 1000M mode by default. Enable speed 10G mode:

```
esr(config)# interface port-channel 1
esr(config-port-channel)# speed 10G
```

- **How to clear ESR configuration completely and reset it to factory default?**
  Copy blank configuration in candidate-config and apply it in running-config.

```
esr# copy system:default-config system:candidate-config
```

  Reset to factory default is similar.

```
esr# copy system:factory-config system:candidate-config
```

- **How to attach sub-interface to created VLAN?**
  While sub-interface creation, VLAN is created and attached automatically (direct correlation index sub – VID).

```
esr(config)# interface gigabitethernet 1/0/1.100
```

  Information messages are shown after applying:

```
2016-07-14T012:46:24+00:00 %VLAN: creating VLAN 100
```

- **Do the ESR-series routers have features for traffic analysis?**
  Opportunity of analysing traffic through CLI interfaces is realized on ESR-series routers. A packet sniffer is launched by monitor command.

```
esr# monitor gigabitethernet 1/0/1
```

- **How to configure ip-prefix-list 0.0.0.0./0?**
  Example of prefix-list configuration is shown below. The configuration allows route reception by default.

```
esr(config)# ip prefix-list eltex
esr(config-pl)# permit default-route
```

- **Problem of asynchronous traffic transmission is occurred.**
  In case of asynchronous routing, Firewall will forbid "incorrect" ingress traffic (which does not open new connection and does not belong any established connection) for security reasons.
  Allowing rule in Firewall does not solve the problem.
  Firewall should be disabled on the ingress interface.

```
esr(config-if-gi)# ip firewall disable
```

- **How to save the local copy of the router configuration?**
  If you need to copy the current running or candidate configuration on the router itself, you can use the copy command specifying "system:running-config" or 'system:candidate-config' as the copy source, and the file in the 'flash:data/' section as the copy destination.

```
esr# copy system:candidate-config flash:data/temp.txt
```

  Also, it is possible to copy previously saved configuration files (automatically from the flash:backup/ section or manually from the flash:data/ section) to the candidate configuration:

```
esr# copy flash:data/temp.txt system:candidate-config
esr# copy flash:backup/config_20190918_164455 system:candidate-config
```

16 ESR technical support

For technical assistance in issues related to operation of Eltex Ltd. equipment, please contact the Service Centre.

Feedback form on the site: http://eltex-co.com/support/

Sevicedesk: https://servicedesk.eltex-co.ru/

Visit Eltex official website to get the relevant technical documentation and software, benefit from our knowledge base, send us online request or consult a Service Centre Specialist in our technical forum:

Official website: http://eltex-co.com/

Technical forum: http://eltex-co.ru/forum

Knowledge base: https://docs.eltex-co.ru/display/EKB/Eltex+Knowledge+Base

Download center: http://eltex-co.com/support/downloads