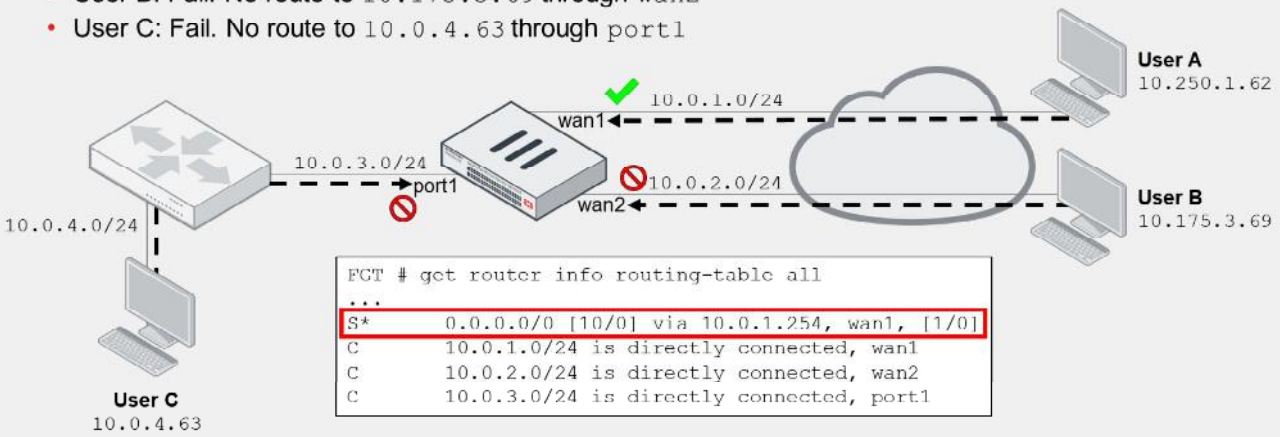
RPF—Feasible Path Example

- FortiGate checks for a route matching source address and incoming interface
- RPF check results:
  - User A: Pass. Default route through `wan1`
  - User B: Fail. No route to `10.175.3.69` through `wan2`
  - User C: Fail. No route to `10.0.4.63` through `port1`



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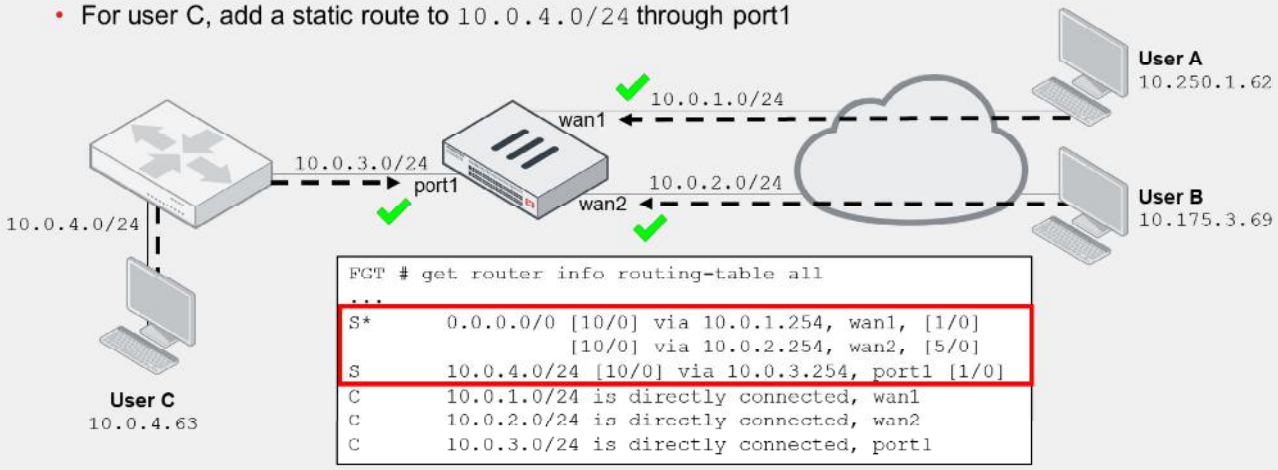
The example on this slide shows a FortiGate device using the feasible path RPF check mode. When FortiGate performs RPF check, it checks in the routing table for a route that matches the source address and the incoming interface of the first original packet.

Based on the topology and routing table shown on this slide, the RPF check results for traffic sourced from each user are:

- User A: Pass. There is a default route through `wan1`. This means that, all packets received at `wan1` pass the RPF check regardless of the source address.
- User B: Fail. FortiGate doesn't have a route to `10.175.3.69` through `wan2` in its routing table.
- User C: Fail. Like the user B case, FortiGate doesn't have a route to `10.0.4.63` through `port1` in its routing table.

RPF—Feasible Path Example (Contd)

- Solution:
  - For user B, add a second static default route, with the same distance, through wan2
    - Use different priority values if you don't want ECMP
  - For user C, add a static route to `10.0.4.0/24` through port1




```
FCT # get router info routing-table all
...
S*      0.0.0.0/0 [10/0] via 10.0.1.254, wan1, [1/0]
                 [10/0] via 10.0.2.254, wan2, [5/0]
S       10.0.4.0/24 [10/0] via 10.0.3.254, port1 [1/0]
C       10.0.1.0/24 is directly connected, wan1
C       10.0.2.0/24 is directly connected, wan2
C       10.0.3.0/24 is directly connected, port1
```

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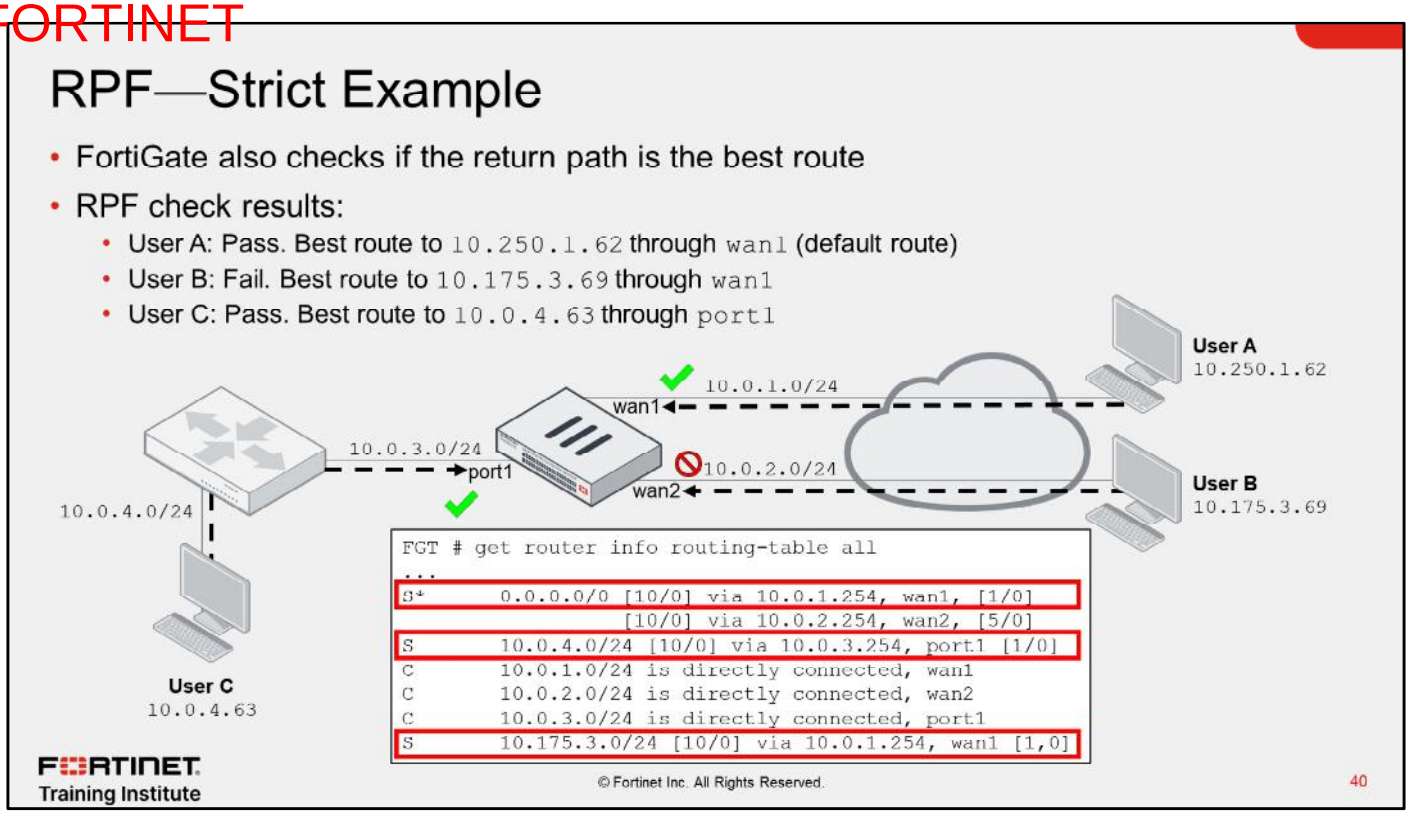
If you consider the packets from user B and user C to be legit packets, you can solve the RPC check fail issue by making sure the routing table contains routes for the return path.

In the example shown on this slide, the administrator adds two new static routes. The static route through `wan2` is a duplicate default route of `wan1`, but has a lower priority. The two default routes are not ECMP routes because of the priority difference, but FortiGate keeps both routes in the routing table. The result is that packets from user B now pass the RPF check.

The static route through `port1` references the `10.0.4.0/24` subnet. The subnet includes user C address (`10.0.4.63`), and as result, packets from user C also pass the RPF check.



The example on this slide shows a FortiGate device using the strict RPF check mode. In strict mode, FortiGate also checks if the matching route is the best route to the source.

Based on the topology and routing table shown on this slide, the RPF check results for traffic sourced from each user are:

- User A: Pass. There is a default route through `wan1`. The route is also the best (and only) route to `10.250.1.62`.
- User B: Fail. There is a default route through `wan2`. However, there is better (more specific) static route to `10.175.3.69` through `wan1`.
- User C: Pass. FortiGate has a route to `10.0.4.63` through `port1` in its routing table. Although the default routes through wan1 and wan2 are also valid routes for `10.0.4.63`, the best route to user C is the route through port1.

Like the feasible path example, you can solve the RPF fail issue for user B by making the respective changes in the routing table so the best route to user B is through wan2.

Knowledge Check

1. What is the default RPF check method on FortiGate?
   - ✓ A. Feasible path
   - B. Strict

2. Which route lookup scenario satisfies the RPF check for a packet?
   - A. Routing table has a route to the destination IP of the packet through the incoming interface.
   - ✓ B. Routing table has a route for the source IP of the packet through the incoming interface.

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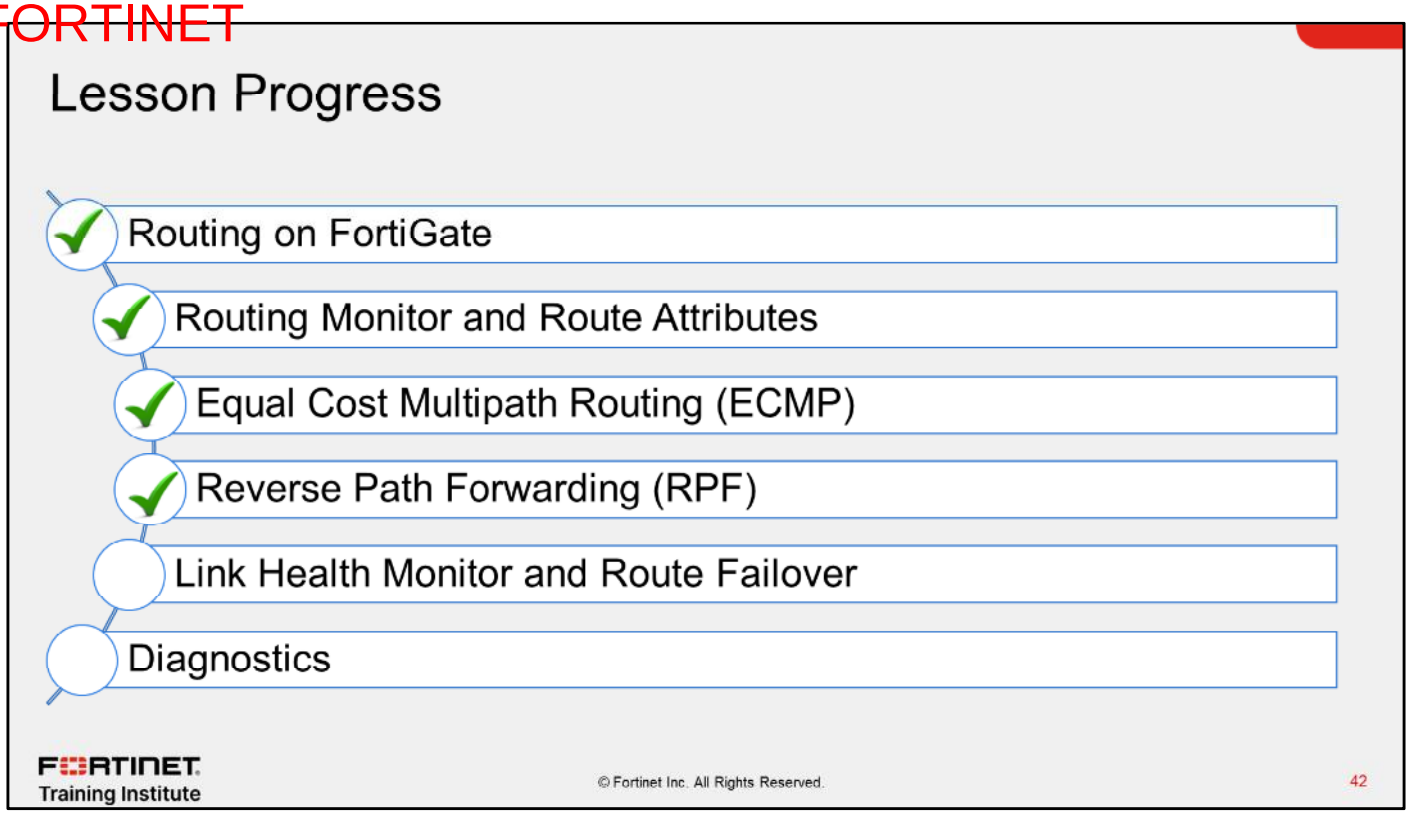
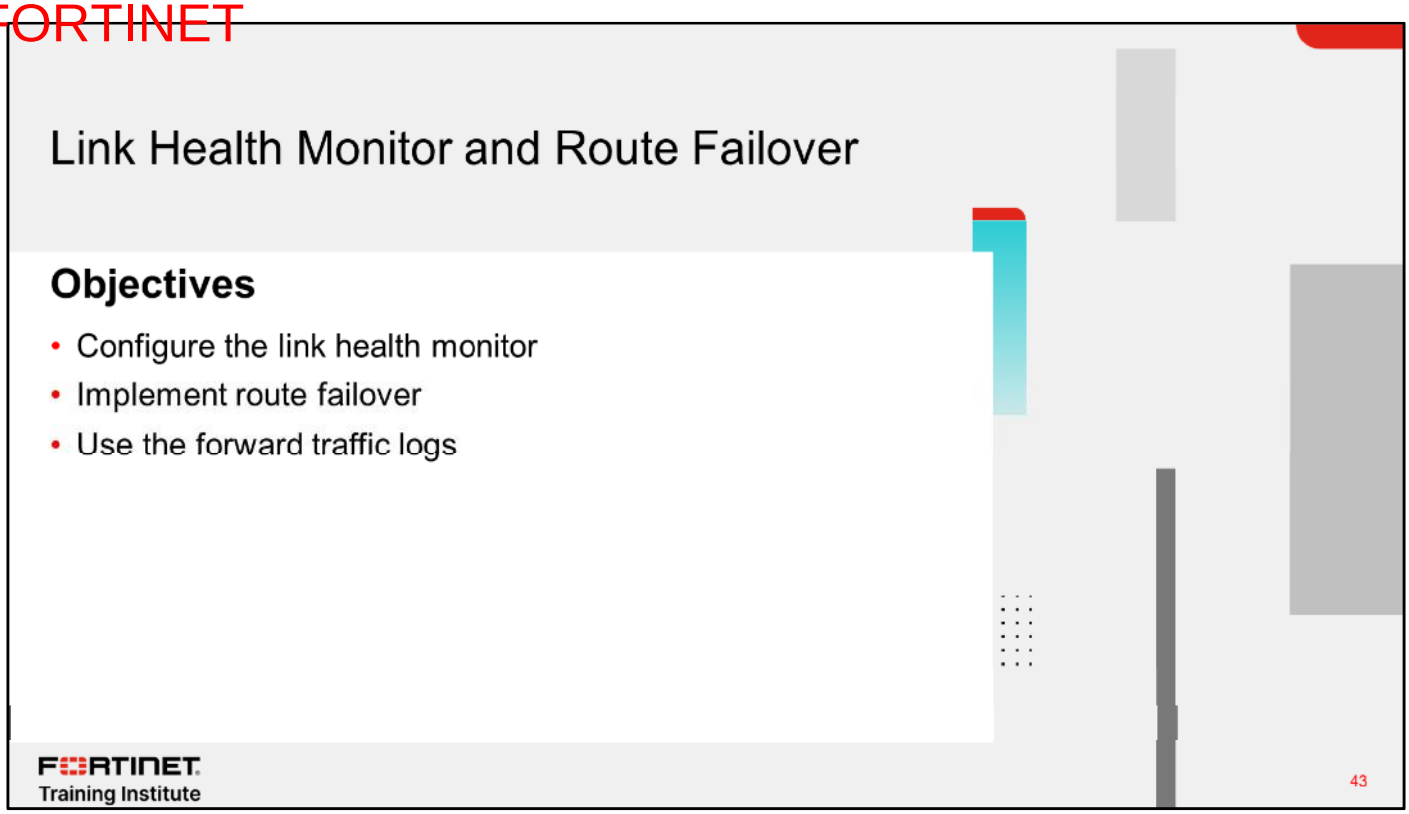


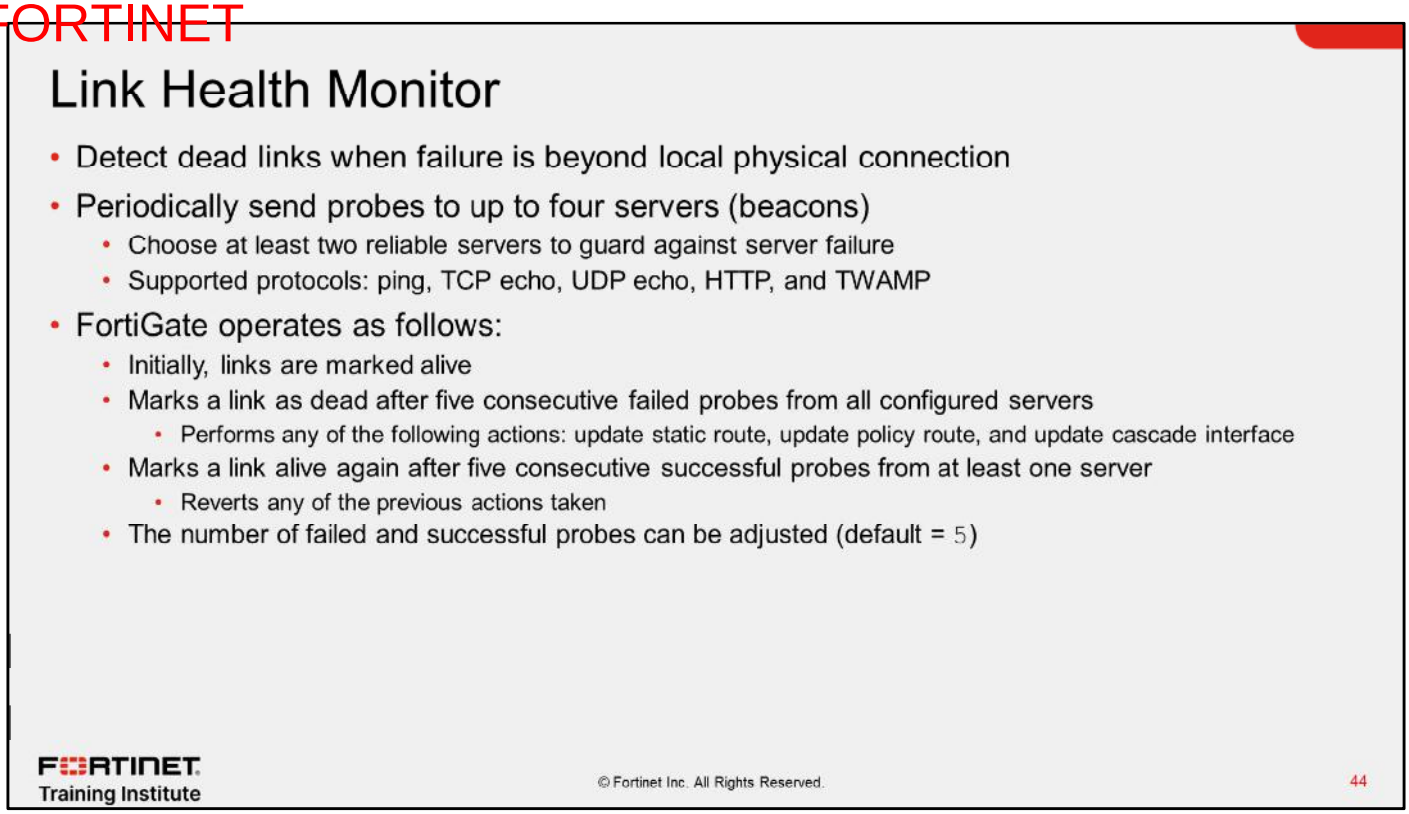
Good job! You now understand RPF.

Now, you will learn about the link health monitor and route failover.



After completing this section, you should be able to achieve the objectives shown on this slide.

By demonstrating competence in configuring link health monitor and implementing route failover, you should be able to monitor the health of your interfaces and then, when a link is detected as dead, configure FortiGate to fail over the traffic to healthy links to minimize service disruption.



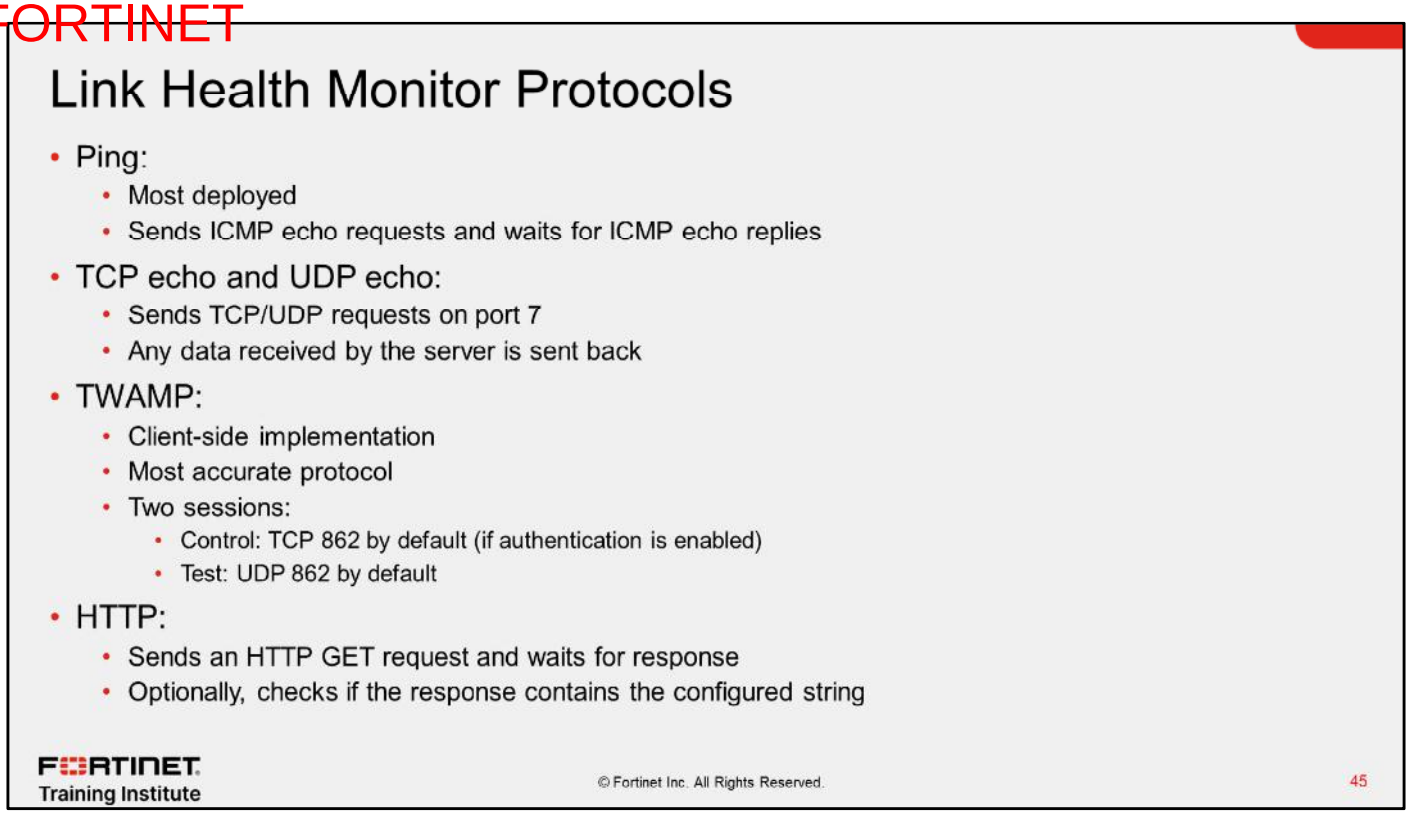
Static routes are kept in the routing table unless the associated interface is administratively down, its link goes down, or there is a duplicate route with a lower distance. Because is possible that the link circuit is dead somewhere along the path to the destination, even though the interface link is up, then it is also possible that FortiGate continues to route traffic though a dead link, which would result in service impact. A common example is the Ethernet connection provided by your ISP modem. The Ethernet connection remains physically up even though the upstream ISP network is down. The devices behind your modem will continue to use the internet connection but they won't receive any replies.

Link health monitor enables FortiGate to detect dead links when the failure is beyond the local physical connection. FortiGate periodically sends probes through the configured gateway and interface to up to four servers that act as beacons. A server can be any host that is normally reachable through that path. It's best practice to configure at least two reliable servers to guard against false positives caused by the server being at fault, and not the link. For probes, you should also use a protocol that the server normally responds to.

Initially, FortiGate considers a link as alive. However, if FortiGate detects five consecutive failed probes from each of the configured servers, FortiGate marks the link as dead. FortiGate considers a failed probe a probe for which it does not receive a reply, or whose reply isn't valid. After FortiGate detects the link as dead, it performs any of the actions shown on this slide. The goal of these actions is to redirect the impacted traffic to other healthy links.

After FortiGate detects the link as dead, it continues to monitor the link. As soon as FortiGate receives five successful replies from at least one of the configured servers, it marks the link as alive again, and then reverts any of the previous actions taken on that link.

The number of failed and successful probes is set to five by default, but can be changed if required.



This slide describes the probe protocols supported by link health monitor.

Ping is the most used network monitoring protocol because it is supported by virtually all network devices. When you use ping, FortiGate sends ICMP echo requests to the configured target servers and waits for the respective ICMP echo replies. Because some ISPs and content providers block or limit ICMP traffic on their network, you may want to switch to TCP echo, UDP echo, or TWAMP.

When you use TCP echo and UDP echo, FortiGate sends periodic packets to the configured target servers, which are listening for connections on port 7 for both TCP and UDP. Upon reception of the packets, the server sends back an identical copy of the data it received from FortiGate.

Two-Way Active Measurement Protocol (TWAMP) is the most accurate protocol among the five. Link health monitor uses the client-side implementation of TWAMP. There are two sessions used in TWAMP: control and test. The former is used to authenticate the endpoints, and the latter to exchange packets used to measure the performance. Note that if authentication is disabled—it is disabled by default—FortiGate generates the test session only. FortiGate uses port 862 as default port for both control and test sessions, but you can configure a different port.

When you configure HTTP as the protocol, FortiGate sends periodic HTTP GET requests to the target server, and then waits for a response. Optionally, you can configure FortiGate to check if the response contains a specific string in the HTML content.

Link Health Monitor Actions

Action	Dead	Alive	Effect during dead state
Update static route*	Flag associated static routes as inactive	Flag associate static routes as active	Static routes are removed from routing table
Update policy route**	Disable associated policy routes	Re-enable associated policy routes	Policy routes are skipped
Update cascade interface***	Bring down alert interfaces	Bring back up alert interfaces	Route LAN-originated traffic to a different device

* Associated static routes match the configured gateway and interface in the link health monitor settings
** Associated policy routes match the configured gateway and interface in the link health monitor settings
*** Require the configuration of alert interfaces (usually, your LAN-facing interfaces)

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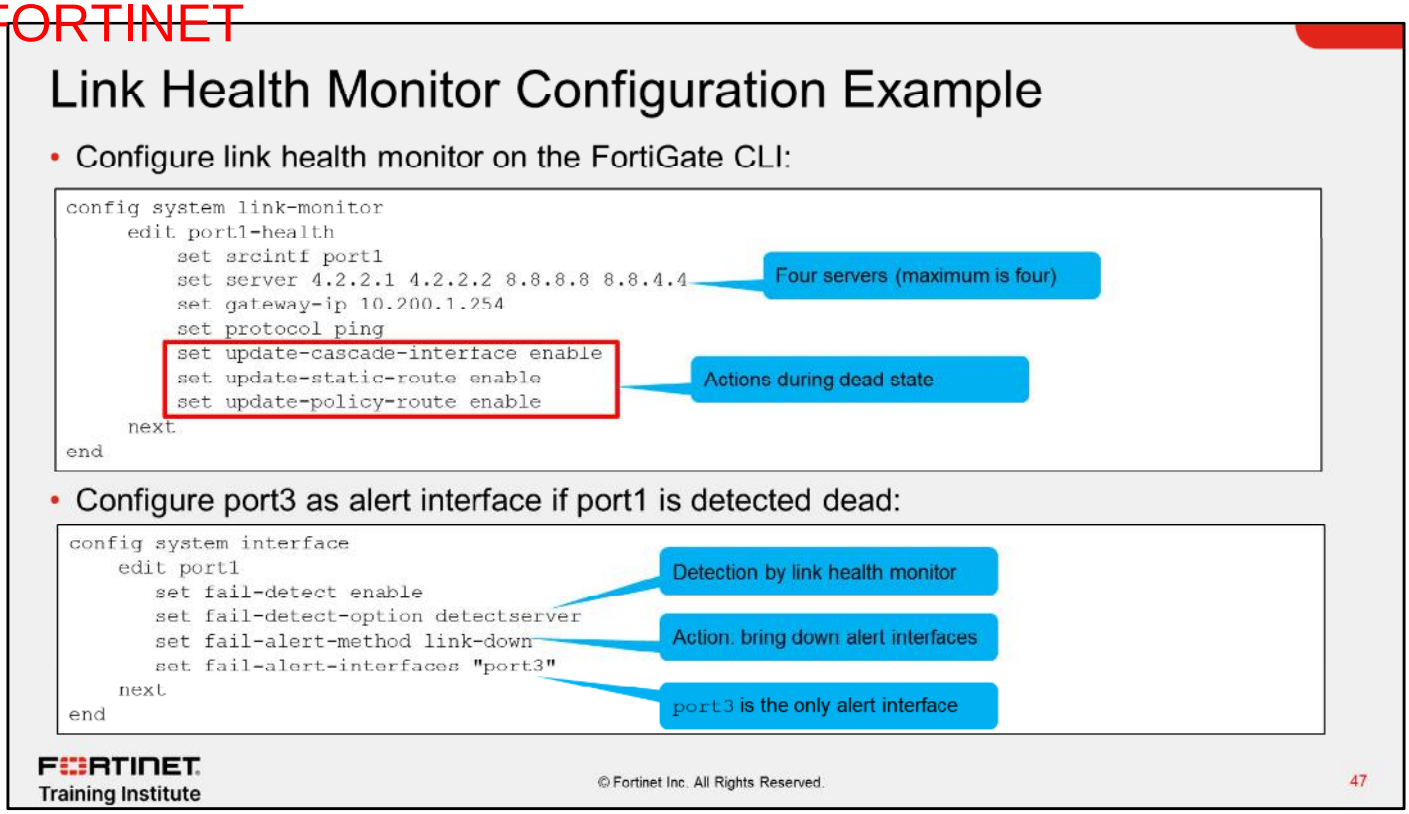
This slide describes the actions taken by link health monitor when the state of an interface changes from alive to dead, and vice-versa. All three actions are enabled by default.

When you enable update static route and link health monitor detects an interface as dead, FortiGate marks the associated static routes—those matching the configured gateway and interface—as inactive. The result is that the inactive static routes are removed from the routing table. The absence of such routes can then force FortiGate to redirect the traffic to other valid routes, if any. Note that this action applies to static routes only.

The update policy route action works the same as the update static route action, except that instead of marking the associated static routes as inactive after an interface is detected as dead, FortiGate disables the associated policy routes. For that, FortiGate checks the policy route table and disables the policy routes whose outgoing interface and gateway match the configured interface and gateway in the link health monitor settings. Like the update static route action, the goal is for FortiGate to skip the disabled policy route during the route lookup process, so the traffic matches another policy route or FIB route in the system.

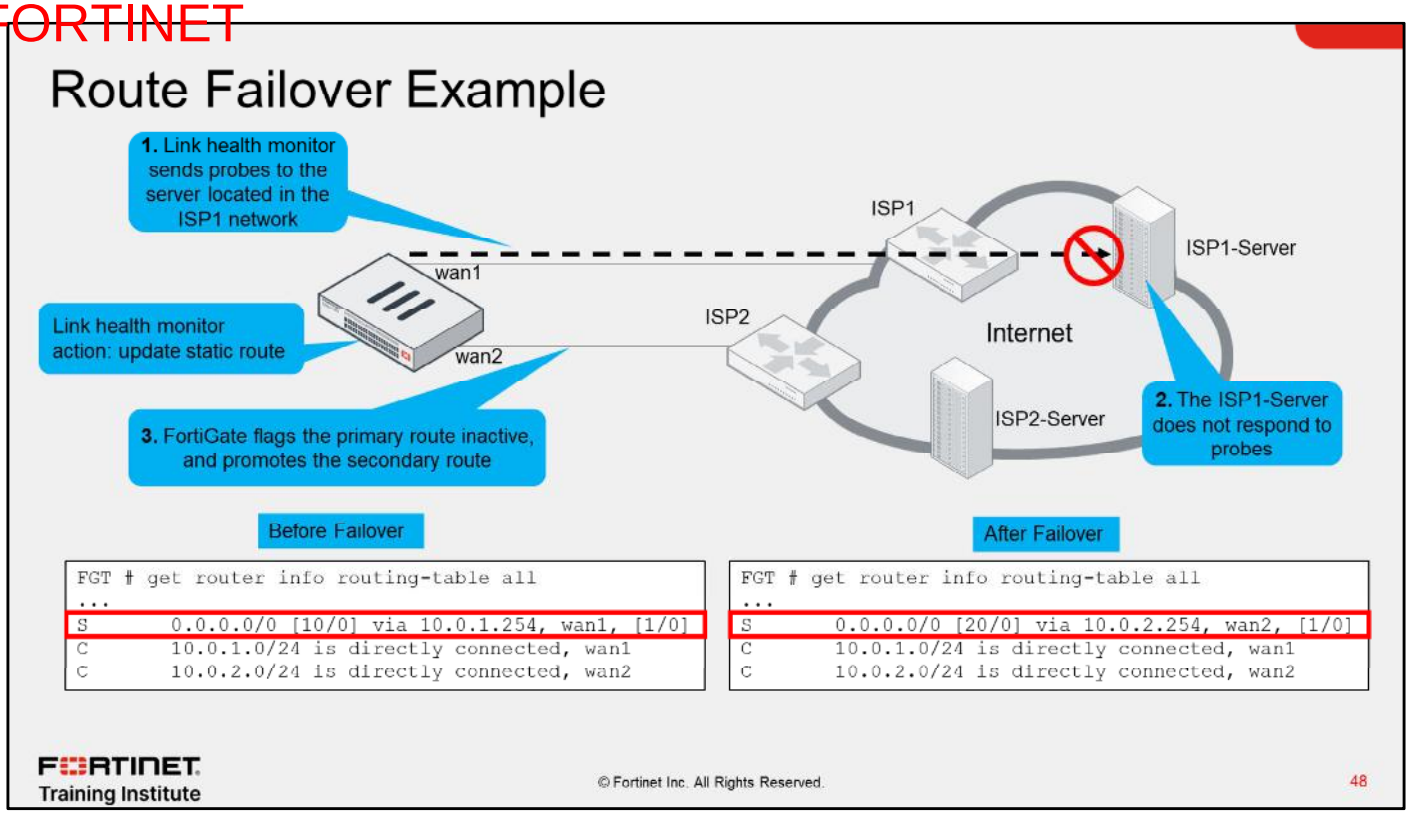
The update cascade interface action requires you to configure one or more alert interfaces. FortiGate then brings down the alert interfaces after the monitoring interface is detected dead. The goal is to force the traffic from networks behind the alert interfaces to be routed through a different device after an important interface, such as the internet-facing interface, is dead, which could mean that FortiGate is unable to forward traffic to the WAN. For example, if you are using dynamic routing or Virtual Router Redundancy Protocol (VRRP) on your LAN interface, which is configured as an alert interface, then bringing down the interface can trigger a routing failover to a backup gateway.

If FortiGate detects the interface as alive again, it reverts any action taken so far for the link. That is, FortiGate restores static routes, re-enables policy routes, and brings back up alert interfaces.



This slide shows a configuration example for link health monitor. FortiGate monitors the health of port1 against Level3 and Google DNS servers (four in total). For sending the probes, FortiGate uses `10.200.1.254` as gateway and ping as protocol.

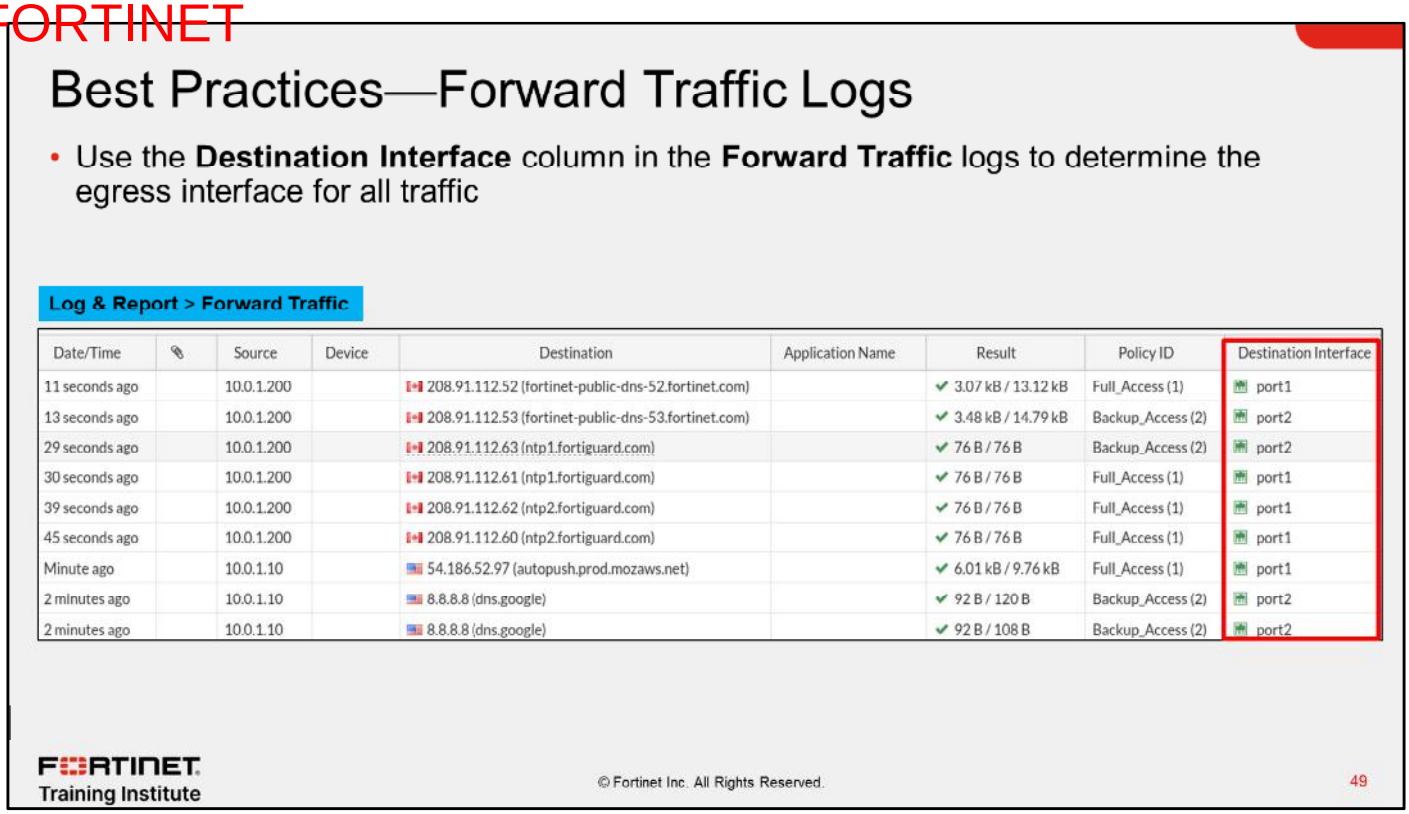
When the state of port1 changes, FortiGate updates cascade interfaces, static routes, and policy routes. For the update cascade interface action to work, you must configure the alert interfaces. This slide also shows an example of the alert interface configuration required on the monitoring interface (port1). The configuration instructs FortiGate to bring down port3 if port1 is detected dead by the link health monitor feature.



In the example shown on this slide, FortiGate has two internet connections. wan1 is connected to ISP1, and wan2 to ISP2. Within each ISP network, there is a server that FortiGate sends probes to for link health monitoring purposes. For link health monitor, the update static route action is enabled. The administrator configured two static default routes, one through wan1 and the other wan2. The static default routes are assigned a distance of 10 and 20, respectively.

Before failover, the default route over wan1 is installed in the routing table because it has a lower distance, and the default route through wan2 is present in the routing table database as a standby route. The link health monitor sends probes to ISP1-Server located within the ISP1 network through wan1. When FortiGate detects five consecutive failed probes for ISP1-Server, FortiGate flags the default route over wan1 as inactive, which results in the route being removed from the routing table. This also results in the standby default route through wan2 to be installed in the routing table. Then, FortiGate starts using the new default route to route traffic to the internet.

The example shown on this slide makes use of different distance values to control the primary and standby routes. The result is that one default route only is installed in the routing table at any time. In case you always need to have both routes installed in the routing table, you can configure the same distance on both routes, but different priorities. You assign a lower priority number to your primary route, and a higher priority number to your standby route. Having both routes in the routing table is required if you use the interfaces to terminate IPsec VPN tunnels and you want to speed up failover by ensuring the tunnel over the secondary ISP link is already up before failover.



If you enable the **Destination Interface** column in the **Forward Traffic** logs, you can view the egress interface for traffic passing through your FortiGate device. You can use this information to determine which route is applied to which traffic stream, as well as identify any routing configuration issues.

If your firewall policies do not have any security profiles applied, you should enable logging for all sessions in your policies; otherwise, FortiGate does not generate any **Forward Traffic** logs. Use this feature with some caution, since enabling all sessions logging can generate a lot of logs if the firewall policy is handling a high volume of traffic. You should enable it when necessary, and disable it immediately afterwards.

Knowledge Check

1. What is the purpose of the link health monitor setting `update-static-route`?
   - A. It creates a new static route for the backup interface.
   - ✓ B. It removes all static routes associated with an interface detected as dead by the link health monitor.

2. When using link health monitoring, which route attribute can you configure to achieve route failover protection?
   - ✓ A. Distance
   - B. Metric

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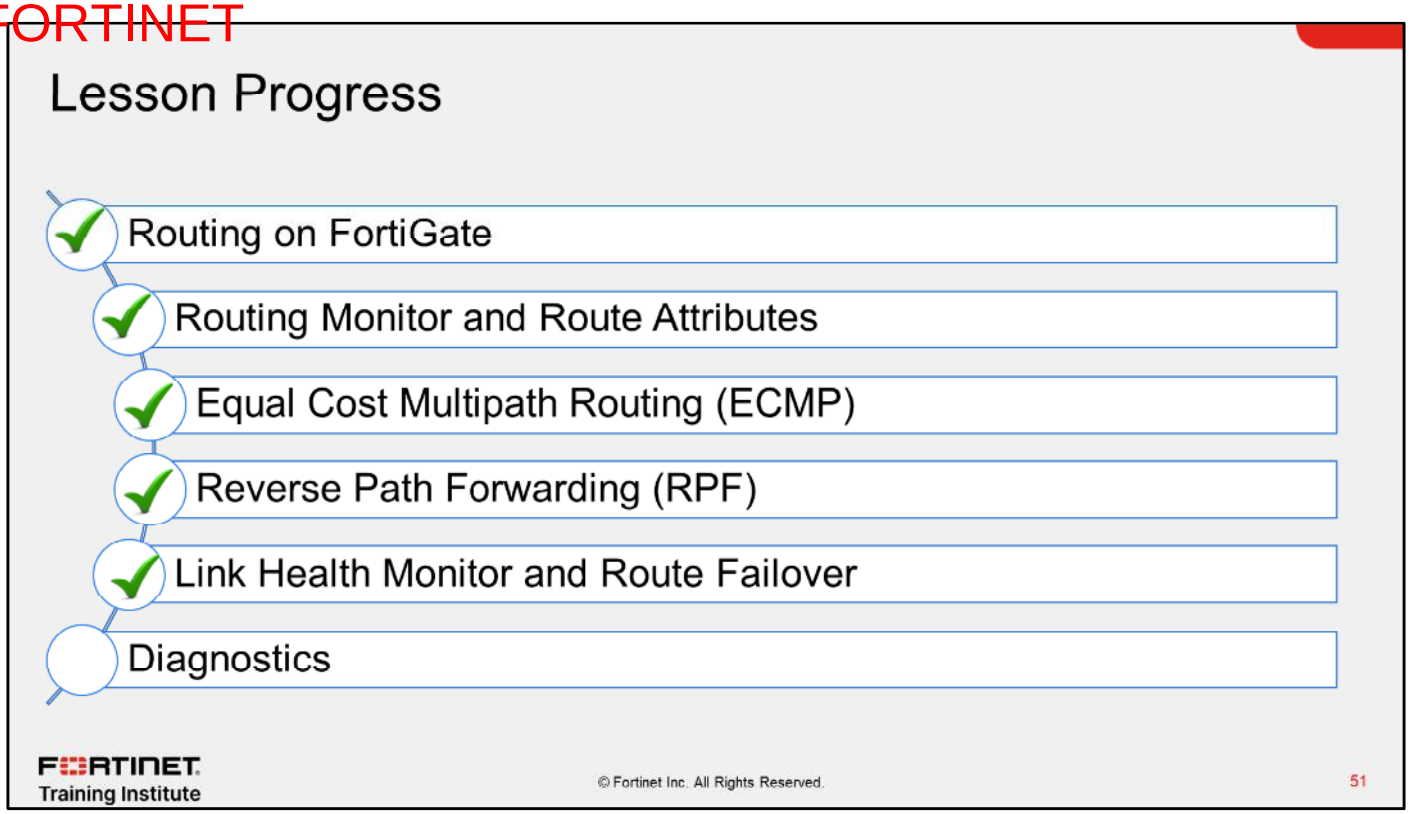
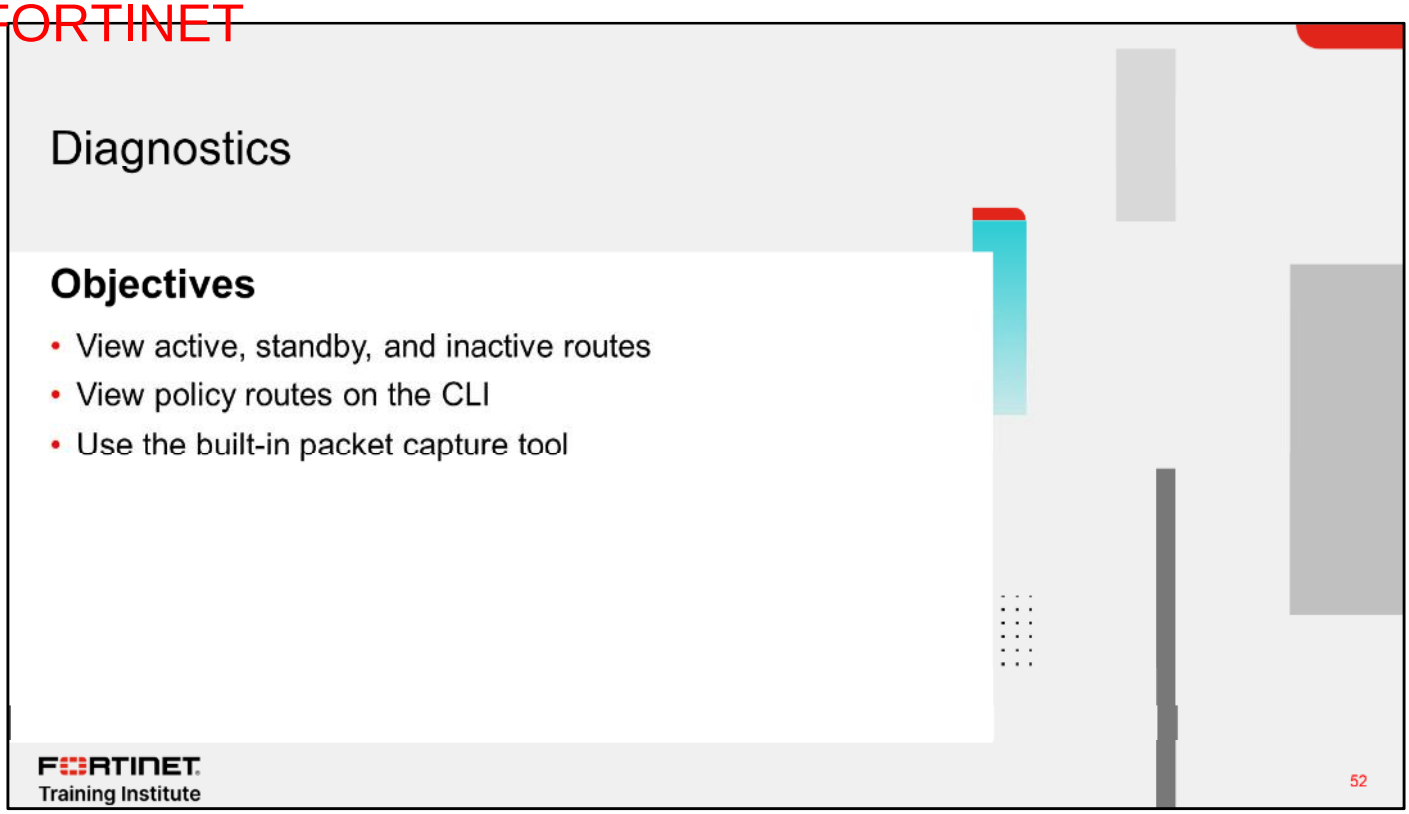


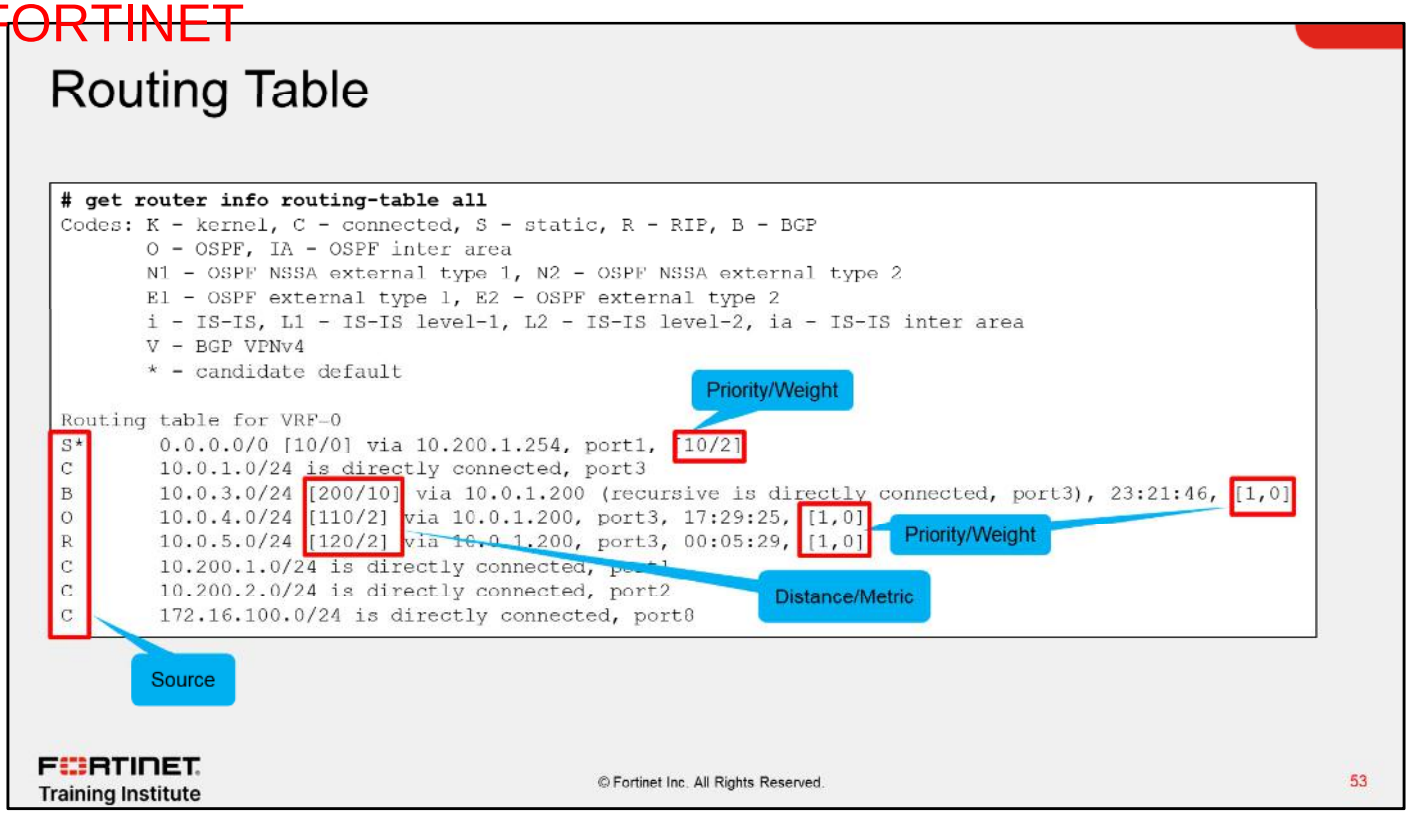
Good job! You now understand the link health monitor and route failover.

Now, you will learn about routing diagnostics.



After completing this section, you should be able to achieve the objectives shown on this slide.

By demonstrating competence in routing diagnostics, you should be able to view the entries in the routing table and routing table database, as well as to identify how packets flow across FortiGate.



The CLI command shown on this slide displays all entries in the routing table. The routing table displays the routes that make it to the FIB. That is, the best active routes to a destination.

The left-most column indicates the route source. Route attributes are shown inside square brackets. The first number, in the first pair of attributes, is distance, which applies to both dynamic and static routes. The second number is metric, which applies to dynamic routes only.

Static routes and dynamic routes also have priority and weight attributes, which are shown as the last pair of attributes for the respective route. In the case of dynamic routes, the weight is always zero.

This command doesn't show standby or inactive routes, which are present in the routing table database only. For example, when two static routes to the same destination subnet have different distances, the one with the lower distance is installed in the routing table, and the one with the higher distance in the routing table database.

Routing Table Database

```
# get router info routing-table database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       V - BGP VPNv4
       > - selected route, * - FIB route, p - stale info

Routing table for VRF=0
S     *> 0.0.0.0/0 [10/0] via 10.200.1.254, port1, [1/10]
S        0.0.0.0/0 [20/0] via 10.200.2.254, port2, [5/0]
S        8.8.8.8/32 [10/0] via 172.16.100.254, port8 inactive, [1/0]
O        10.0.1.0/24 [110/1] is directly connected, port3, 00:05:47, [1/0]
C     *> 10.0.1.0/24 is directly connected, port3
O        10.0.2.0/24 [110/1] is directly connected, port4, 00:05:47, [1/0]
C     *> 10.0.2.0/24 is directly connected, port4
B     *> 10.0.3.0/24 [200/10] via 10.0.1.200 (recursive is directly connected, port3), 00:05:40, [1/0]
O     *> 10.0.4.0/24 [110/2] via 10.0.1.200, port3, 00:05:27, [1/0]
B        10.0.4.0/24 [200/10] via 10.0.1.200 (recursive is directly connected, port3), 00:05:40, [1/0]
C     *> 10.200.1.0/24 is directly connected, port1
C     *> 10.200.2.0/24 is directly connected, port2
```

Active route

Inactive route

Standby route

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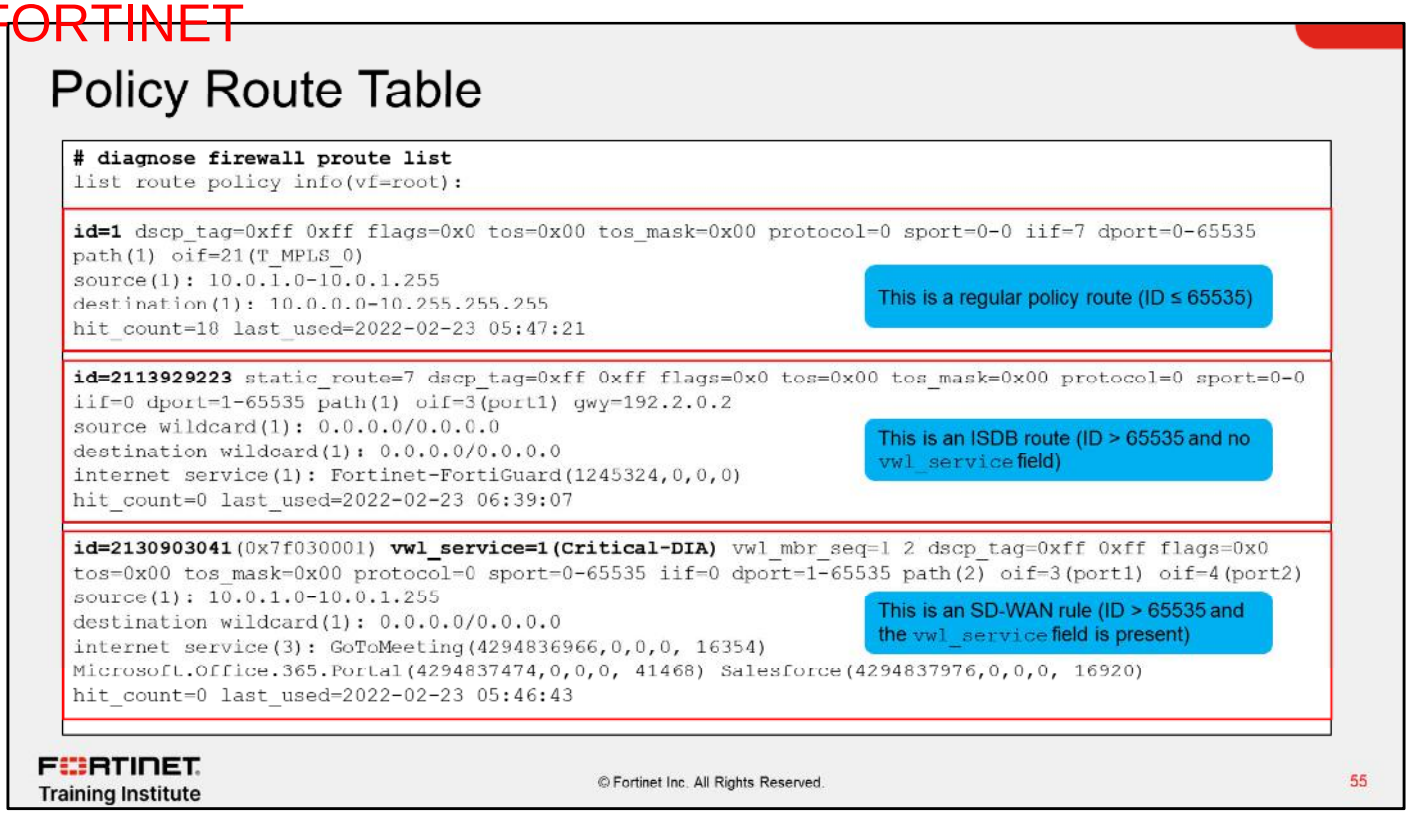
If you want to view active, standby, and inactive routes, use the CLI command shown on this slide to display the routing table database entries.

In the example on this slide, the command shows two standby routes, one static and the other BGP. Both standby routes are standby because there are better routes—lower distance—to the same destination. The better routes show an asterisk next to the route source to indicate they are FIB entries, and therefore, are used for routing traffic.

The output also shows one inactive route. Routes are marked as inactive where the corresponding interface is administratively down, has its link down, or when the interface is detected dead by link health monitor and the update static route action is enabled.

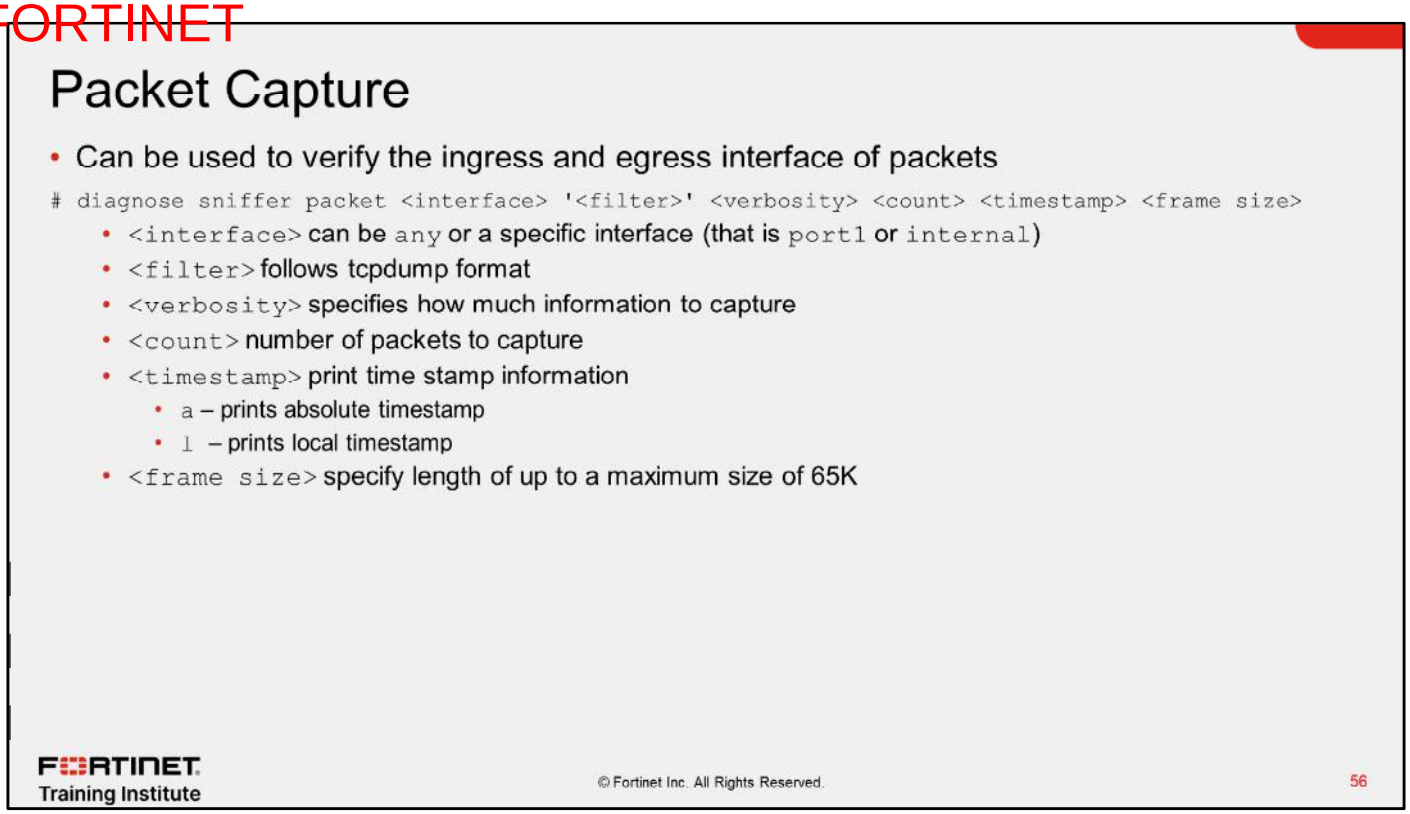


FortiOS maintains a policy route table that you can view by running the `diagnose firewall proute list` command.

There are three types of policy routes displayed in the policy route table: regular policy routes, ISDB routes, and SD-WAN rules. Follow these rules to identify each type of policy route in the table:

- Regular policy routes are assigned an ID no higher than 65535. In the output shown on this slide, the first entry is assigned ID 1, which makes it a regular policy route.
- ISDB routes and SD-WAN rules are assigned an ID higher than 65535. However, SD-WAN rule entries include the `vwl_service` field, and ISDB route entries don't. The `vwl_service` field indicates the ID and the name of the rule from the SD-WAN configuration perspective. In the output shown on this slide, the second entry is an ISDB route and the third entry an SD-WAN rule.

Note that although IDs for regular policy routes are in the 1 to 65535 range, the maximum number of regular policy routes that you can configure are much lower and varies among models. For example, you can configure up to 512 regular policy routes in a FortiGate 300D device. For more information about the maximum supported values per model, refer to the `FortiOS Maximum Values Table` on `docs.fortinet.com`. Alternatively, you can run the `print tablesize` command on the FortiGate CLI to get the maximum values for your device.



Packet captures, or *sniffers*, are one of the most useful sources of information for debugging routing problems. FortiGate includes a built-in traffic sniffer tool. You can use it to verify the ingress and egress interfaces of packets as they pass through. You can run the built-in sniffer from either the GUI or the CLI. The syntax of the CLI command is shown on this slide.

The `<interface>` option is the name of the physical or logical interface to run the sniffer on. Most of the times, you want to indicate `any` to capture packets on all interfaces. This enables you to see how packets flow across the different interfaces. Another option is to indicate the name of the interface, which is useful when you want to narrow down the packet capture to that interface. Indicating the name of the interface is also required if you want the tool to capture the MAC address information. That is, when you use `any`, the sniffer doesn't capture the real MAC addresses used by the packet.

The filter follows the Berkeley Packet Filter (BPF) syntax used by the well-known tcpdump tool. You should configure specific filters to ensure you're only capturing what you need. You can also specify a `<count>` value to automatically stop the sniffer after capturing a specific number of packets. Otherwise, the sniffer continues capturing packets until you manually stop it using `Ctrl + C`. You can use the `<time stamp>` option to print the time stamp information. Use `a` to print the absolute time stamp, or `l` (lowercase L) to print the local time-zone based time stamp. Time stamp information is particularly useful when correlating sniffer output to debug flow messages. You will learn more about debug flow in another lesson.

By default, the sniffer uses the MTU configured on the interface to limit the packet length during the capture. Using the `<frame size>` argument, you can specify a length larger or smaller than the interface MTU. Note that f you use the `any` interface, the sniffer will default to 1600 bytes.

Packet Capture Verbosity Level

Level	IP Headers	Packet Payload	Ethernet Headers	Interface Name
1	•			
2	•	•		
3	•	•	•	
4	•			•
5	•	•		•
6	•	•	•	•

- The most common levels are:
  - `4` – Prints the ingress and egress interfaces
    - You can verify how traffic is being routed, or if FortiGate is dropping packets
  - `3` or `6` – Prints the packet payload
    - You can convert this output to a packet capture (pcap) file that can be opened with a packet analyzer
  - If you don't specify a level, the sniffer uses level `1` by default

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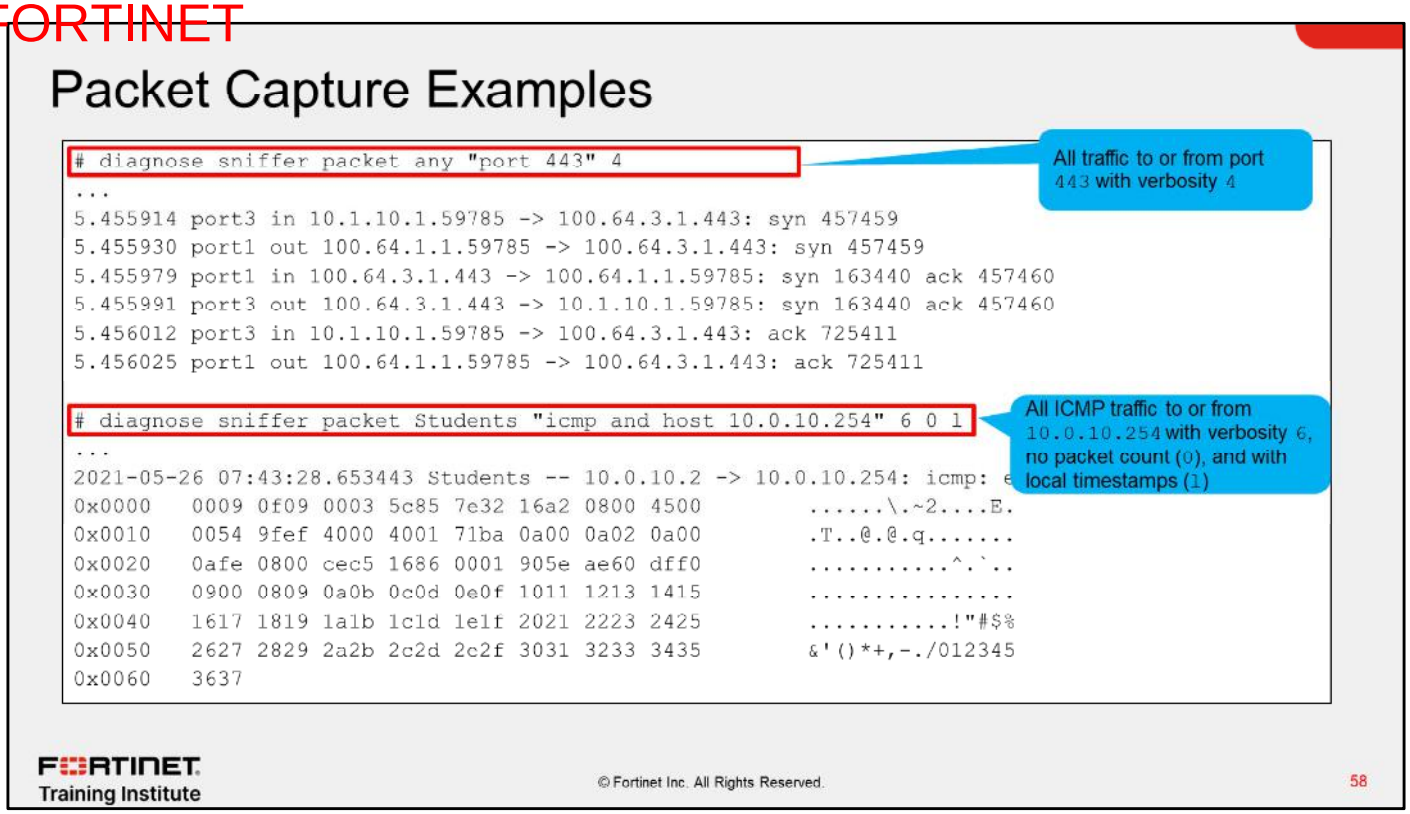
The verbosity level specifies how much information you want to display. There are six different levels and this table shows which ones display the IP headers, packet payload, Ethernet headers, and interface names.

Use verbosity level `4` to take a quick look at how the traffic is flowing through FortiGate (if packets are arriving and how FortiGate is routing them out). You can also use level 4 to check if FortiGate is dropping packets.

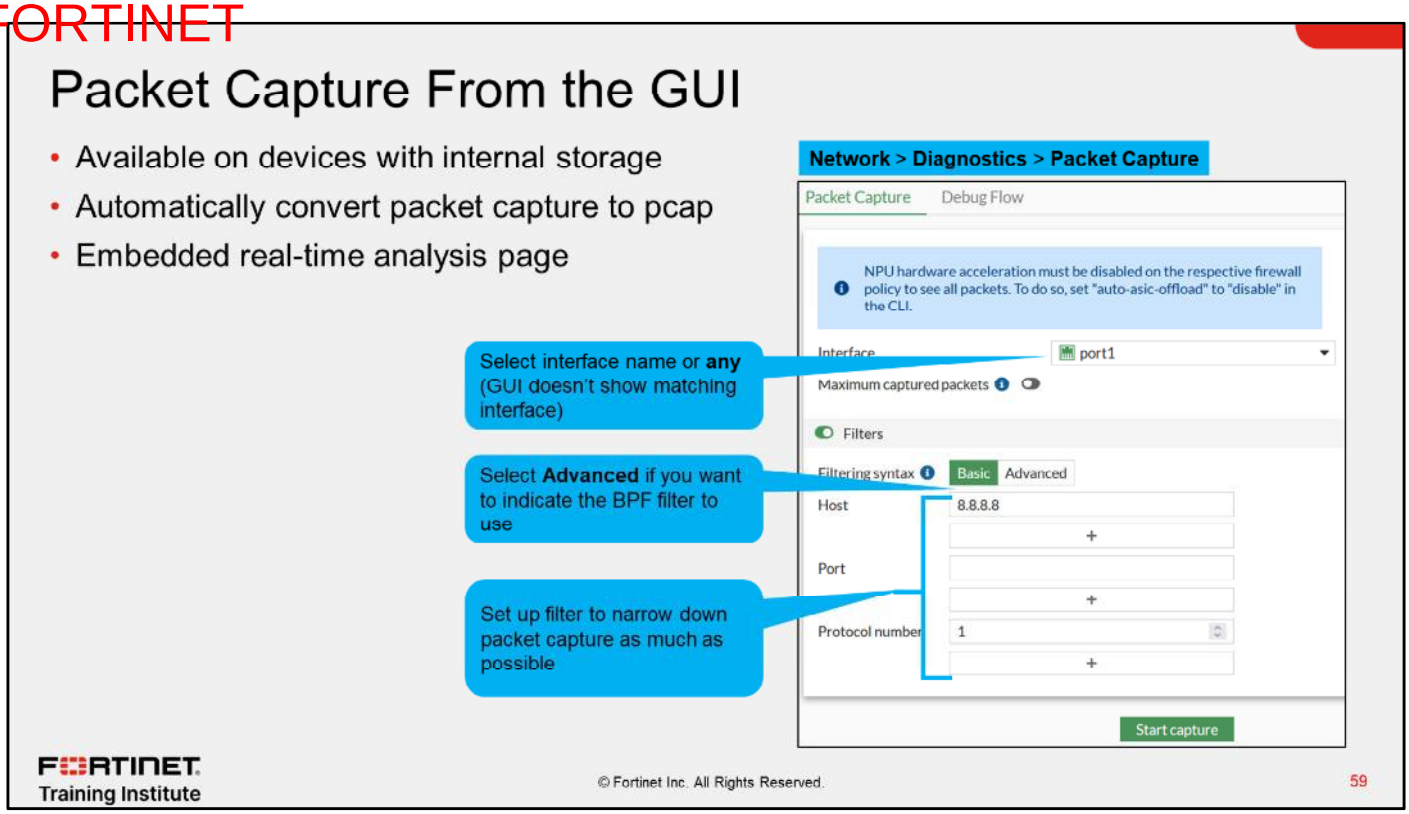
Verbosity levels `3` and `6` provide the most output. Both show the IP payloads and Ethernet headers. You can save the output and export it to a packet capture (pcap) file using a Perl script. The pcap file can then be opened with a packet analyzer, such as Wireshark, for further investigation. You can locate the Perl script that converts the sniffer output to pcap on the Fortinet Knowledge Base website (`kb.fortinet.com`).



This slide shows two examples of packet capture outputs.

The first example captures all traffic to and from port `443`. It uses verbosity `4`, so the information is easy to read. It displays one packet per line, containing the incoming and outgoing interface, IP addresses, port numbers, and type of packet (`SYN`, `SYN/ACK`, and so on). Note that the interface is set to `any`, which is useful to capture packets that enter or exit multiple interfaces in the device. This enables you to have a better understanding of how packets flow through the firewall. For example, the output shows a three-way handshake established across FortiGate. From the packet capture, you can conclude that the connection is initiated by `10.1.10.1`, which is behind `port3`, and is destined to `100.64.3.1`, which is behind `port1`. You can also conclude that FortiGate performs SNAT for the connection. That is, in the original direction, FortiGate translates the source address to `100.64.1.1` when packets leave `port1`. FortiGate then translates the reply packets back to `10.1.10.1` when they exit `port3`.

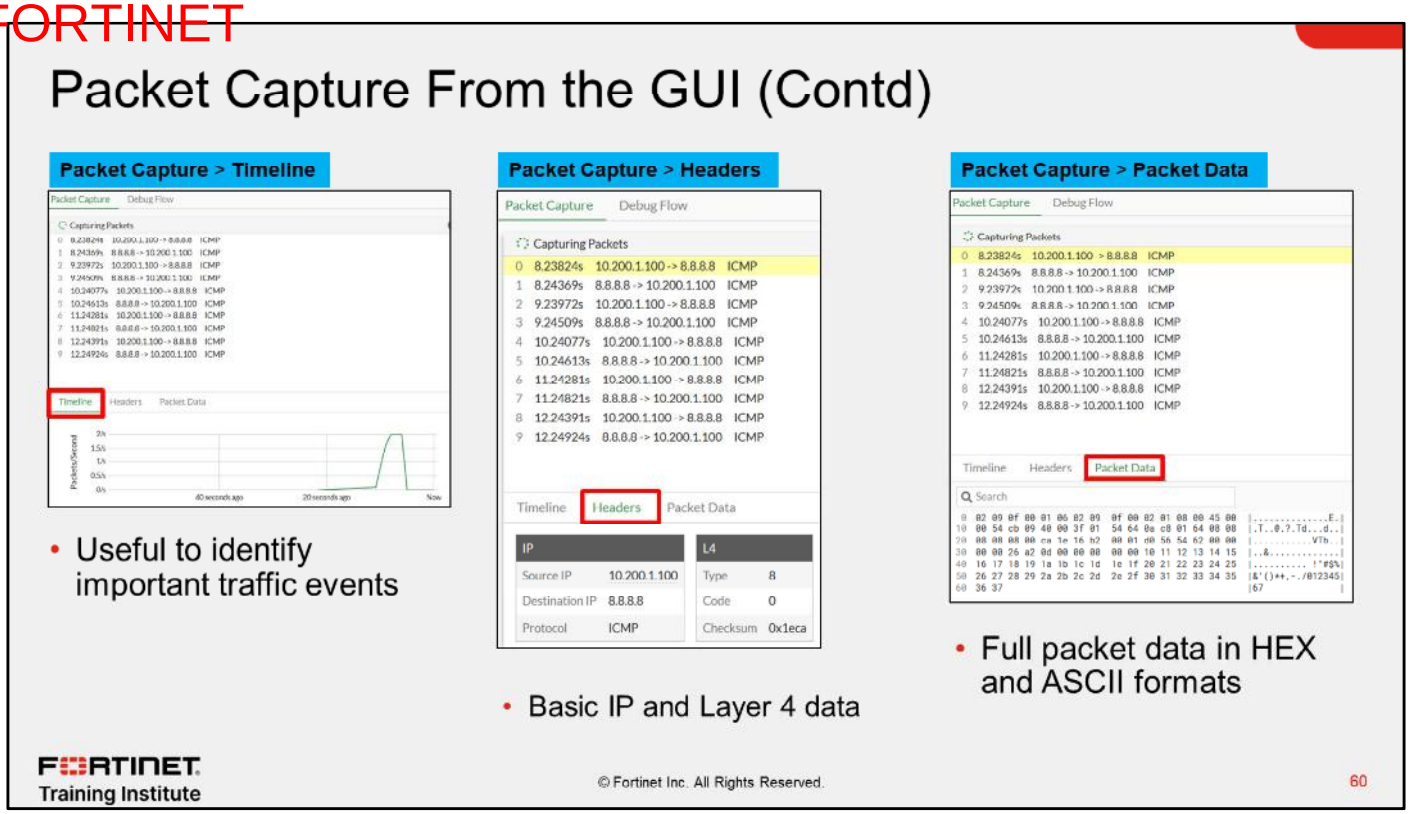
The second example captures all ICMP traffic coming from or going to `10.0.10.254`. Unlike the first example, which captures packets on any interface, this example limits the capture to packets that enter or leave the `Student` interface. Although not shown on this slide, the `Students` interface is a VLAN interface. In addition, the verbosity level is set to `6`, which includes the full packet IP payload details. The output is longer and more difficult to read. However, this is one of the two verbosity levels to use (`3` being the other one) if you need to export the output to pcap format. You can then view the pcap file using Wireshark or any other compatible packet analysis tool. Moreover, the additional arguments in the command instruct the sniffer to not set a packet count limit (`0`) and to print the local timestamp for each packet (`1`).



If your FortiGate model has internal storage, you can capture packets on the GUI. Starting FortiOS 7.2, the GUI packet capture tool was improved to also include a real-time analysis tool that enables you to examine the packet capture details directly on the GUI. You also download the respective pcap file in case you prefer to review it using Wireshark or your preferred packet analysis tool.

Before starting the packet capture, you should set up the packet capture filter by using either **Basic** or **Advanced** filter options. When you choose **Basic**, you to indicate basic filter options such as host address, port number, and protocol number. In case you want to use your own BPF filter like you do in the CLI, you can choose **Advanced**.

Regardless of which method you use (CLI or GUI), packet capture filters should be very specific to make sure only the relevant packets are captured, and large amounts of data are not being written to the disk.



This slide shows an example of the embedded real-time analysis tool included in the GUI packet capture tool starting FortiOS 7.2. After you start the packet capture, the GUI starts displaying the captured packets based on the filter set.

The **Timeline** tab displays a graph with the number of captured packets per second. The graph is useful to quicky identify peaks of traffic related by important events in the network.

The **Headers** tab enables you to examine basic IP (Layer 3) and Layer 4 information on the packet.

The **Packet Data** tab enables you to examine the full packet data using hexadecimal format. Next to the hexadecimal packet data, FortiOS displays the equivalent output in ASCII format.

Knowledge Check

1. What is the distance value for this route?

```
10.200.2.0/24 [110/2] via 10.200.2.254, [25/0]
```

✓A. 110
B. 2

2. Which CLI command can you use to view standby and inactive routes?

A. `get router info routing-table all`
✓B. `get router info routing-table database`

3. Which CLI packet capture verbosity level prints interface names?

A. 3
✓B. 4

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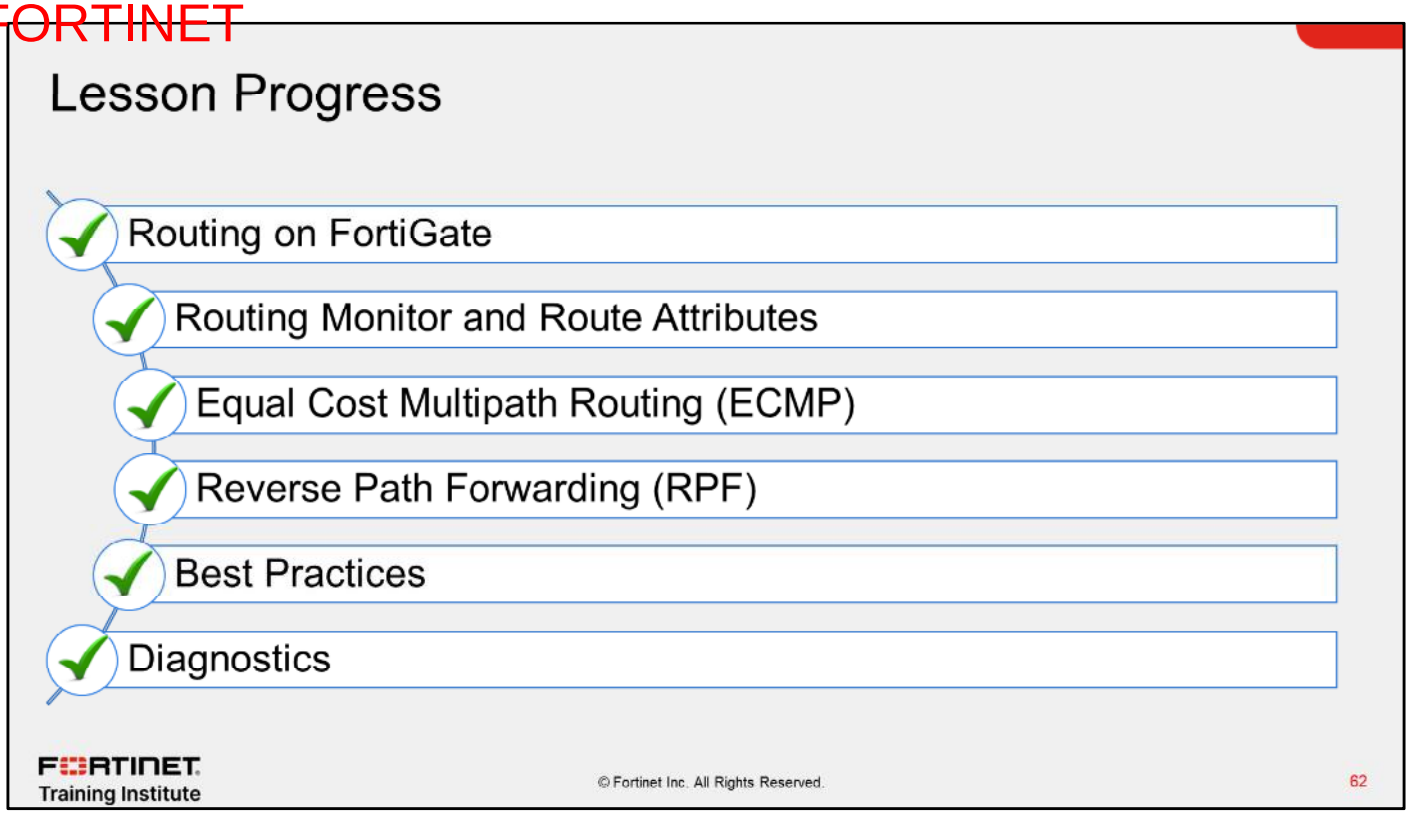
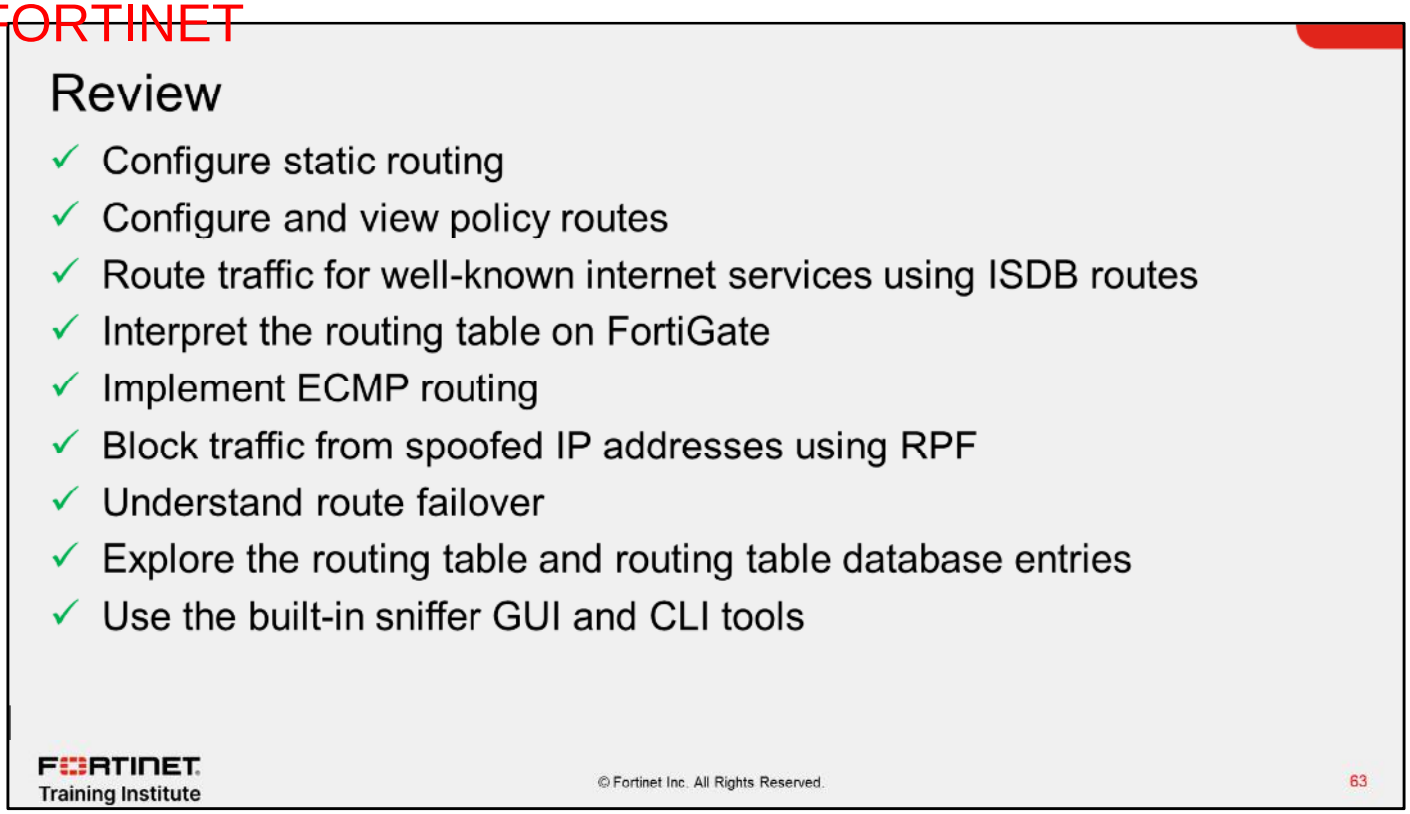


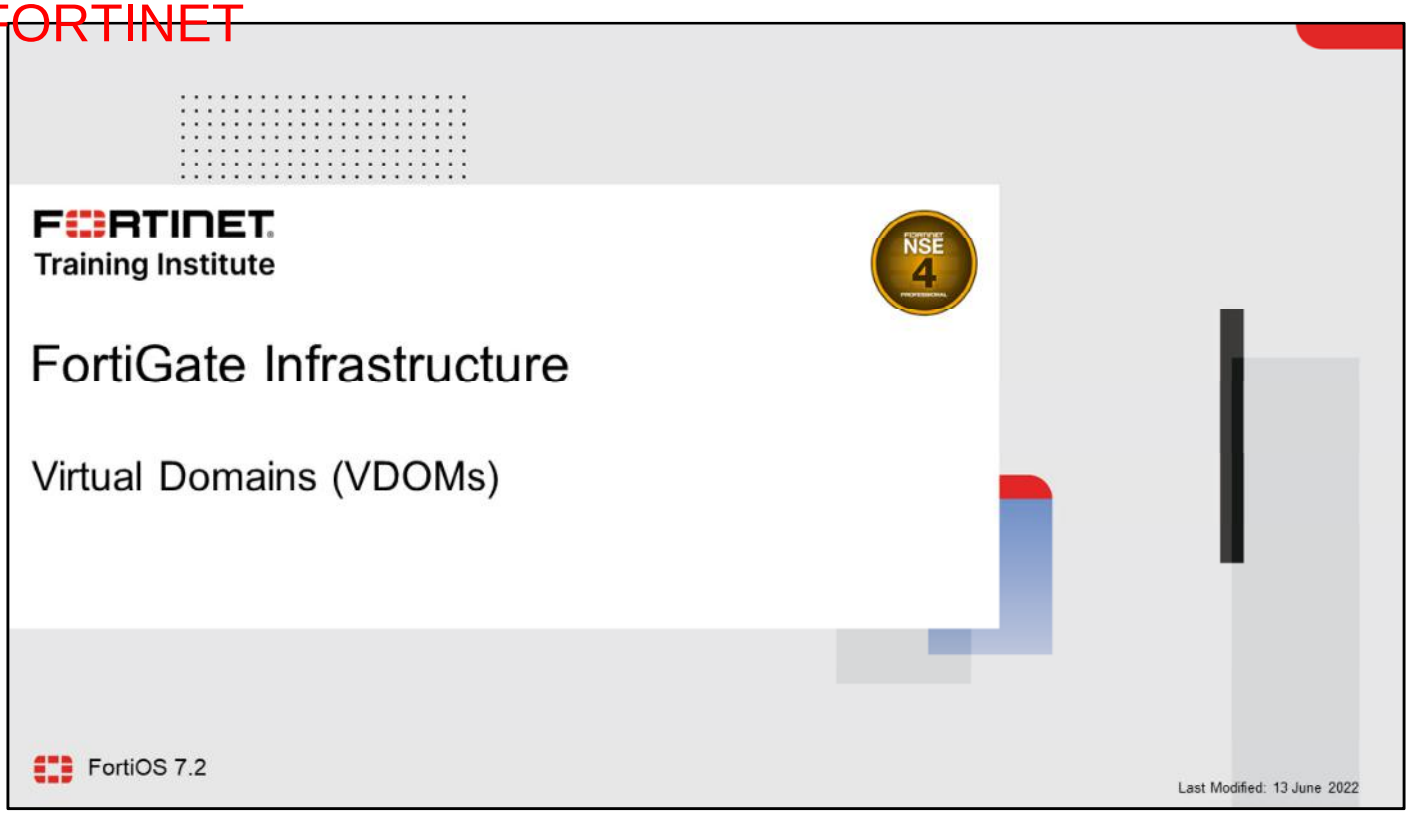
Congratulations! You have completed this lesson.

Now you will review the objectives that you covered in this lesson.

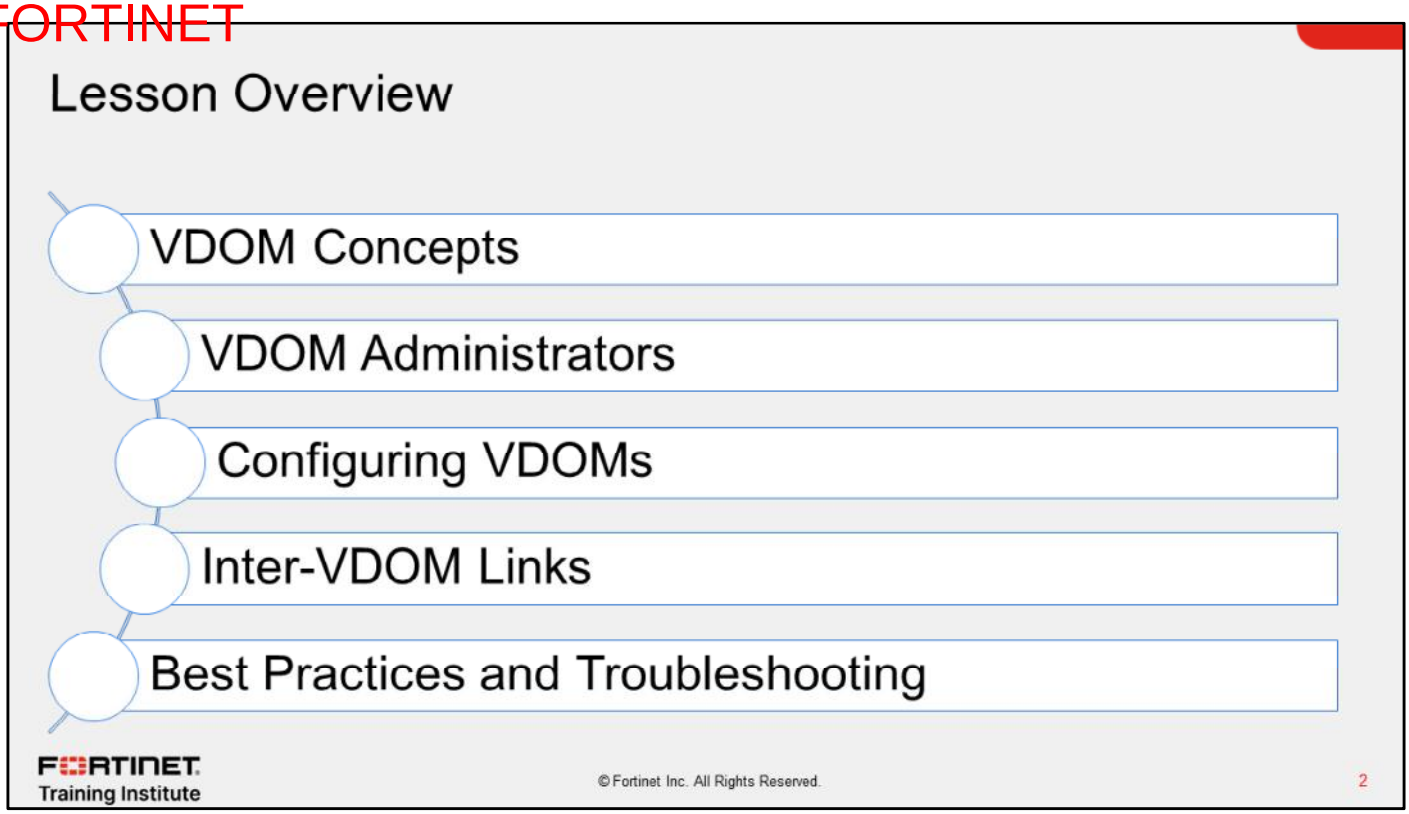


This slide shows the objectives that you covered in this lesson.

By mastering the objectives covered in this lesson, you learned how to configure, maintain, and troubleshoot the FortiGate routing configuration.



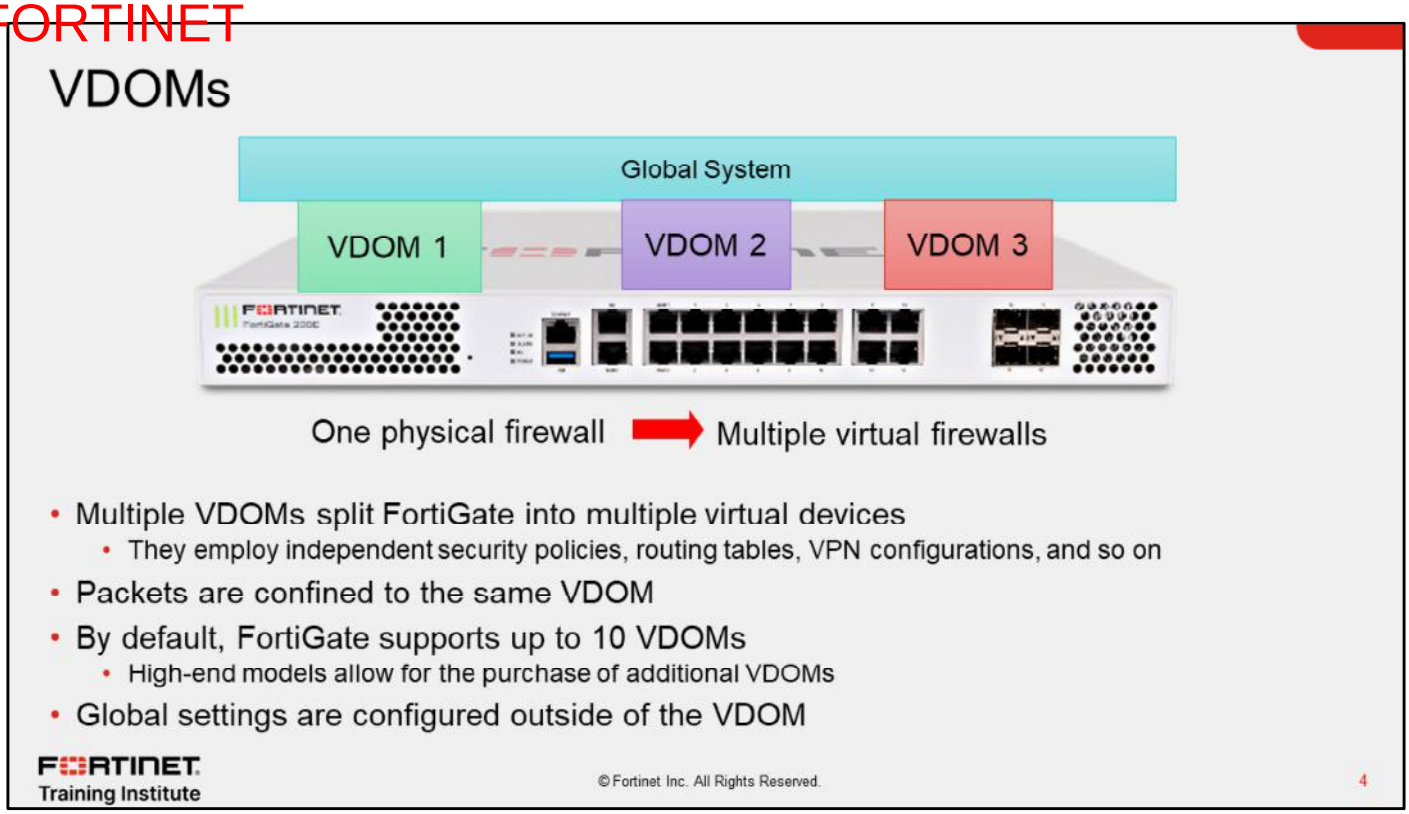
In this lesson, you will learn how to configure VDOMs, and examine examples of common use.



In this lesson, you will learn about the topics shown on this slide.

After completing this section, you should be able to achieve the objective shown on this slide.

By demonstrating competence in VDOMs, you will be able to understand the key benefits and use cases for VDOMs.



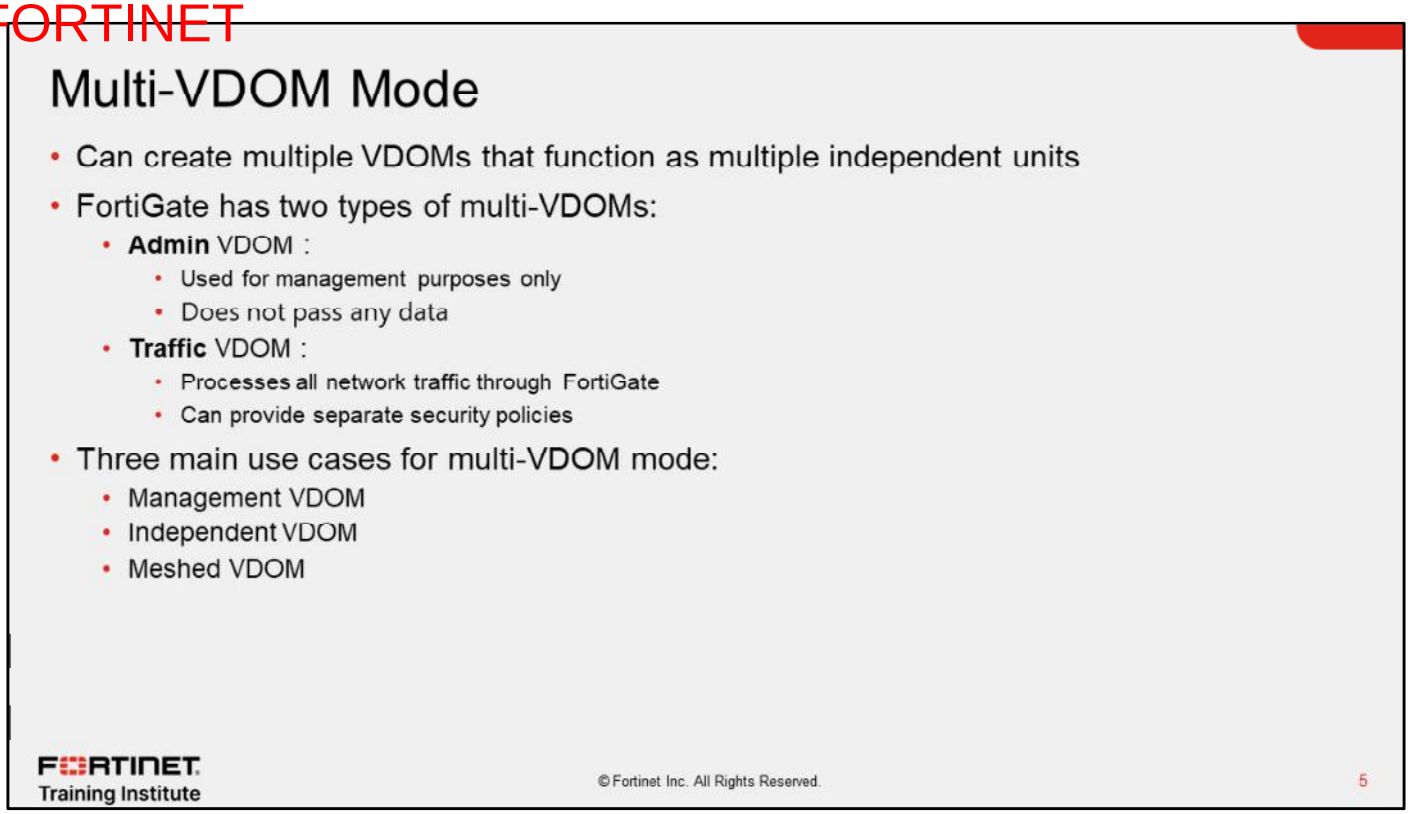
What if a campus wants to keep its departments separate? A datacenter wants to implement various security implementations in a cost-effective manner that maintains all customer traffic separate and secure while also reducing space and making configuration easier? What if you want to segment your network, and subdivide policies and administrators into multiple security domains?

The best solution is to enable FortiGate VDOMs.

A VDOM splits your FortiGate into multiple logical devices and divides one security domain into multiple security domains.

Each VDOM has independent security policies and routing tables. Also, and by default, traffic from one VDOM cannot go to a different VDOM. This means that two interfaces in different VDOMs can share the same IP address, without any overlapping subnet problems.

When you use VDOMs, a single FortiGate device becomes a virtual data center of network security, UTM inspection, and secure communication devices.

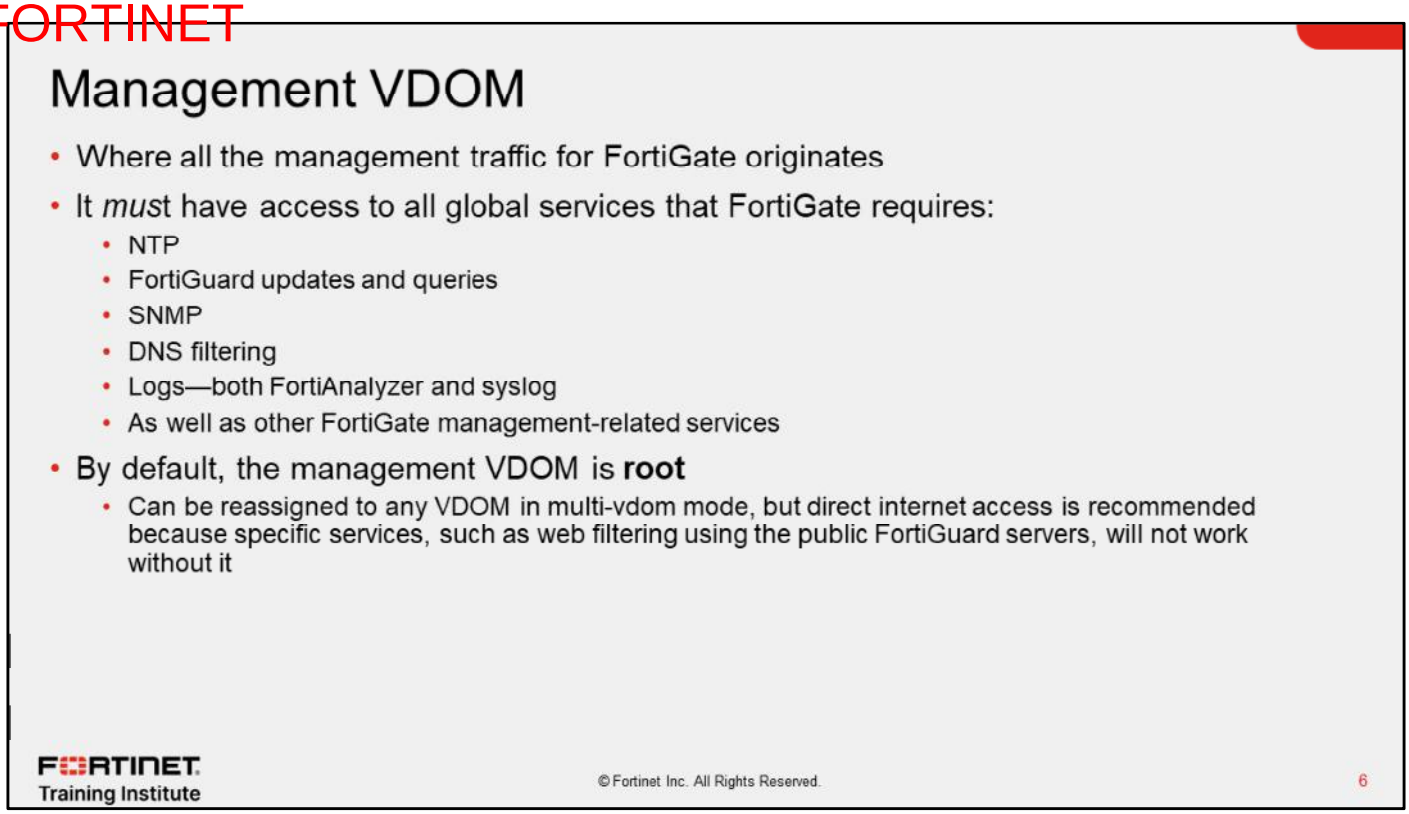


Use multi-VDOM mode when you want to create multiple logical firewalls from a single FortiGate. Each VDOM acts as an independent FortiGate.

Multi-VDOM mode works well for managed service providers leveraging multi-tenant configurations, or large enterprise environments that desire departmental segmentation. You can give each individual tenant or department, visibility and control of their VDOM, while keeping other VDOMs independent and unseen.

Two types of VDOMs can created in multi-VDOM Mode: An admin VDOM and a traffic VDOM.
Admin VDOMs are for FortiGate administration, and traffic VDOMs permit traffic to travel through FortiGate.

Upon upgrade, if a FortiGate is in split-vdom mode, it is converted to multi-vdom mode. The FG-traffic VDOM becomes a traffic type VDOM. The root VDOM becomes an admin VDOM.



Until now, you've learned about traffic passing *through* FortiGate, from one VDOM to another.

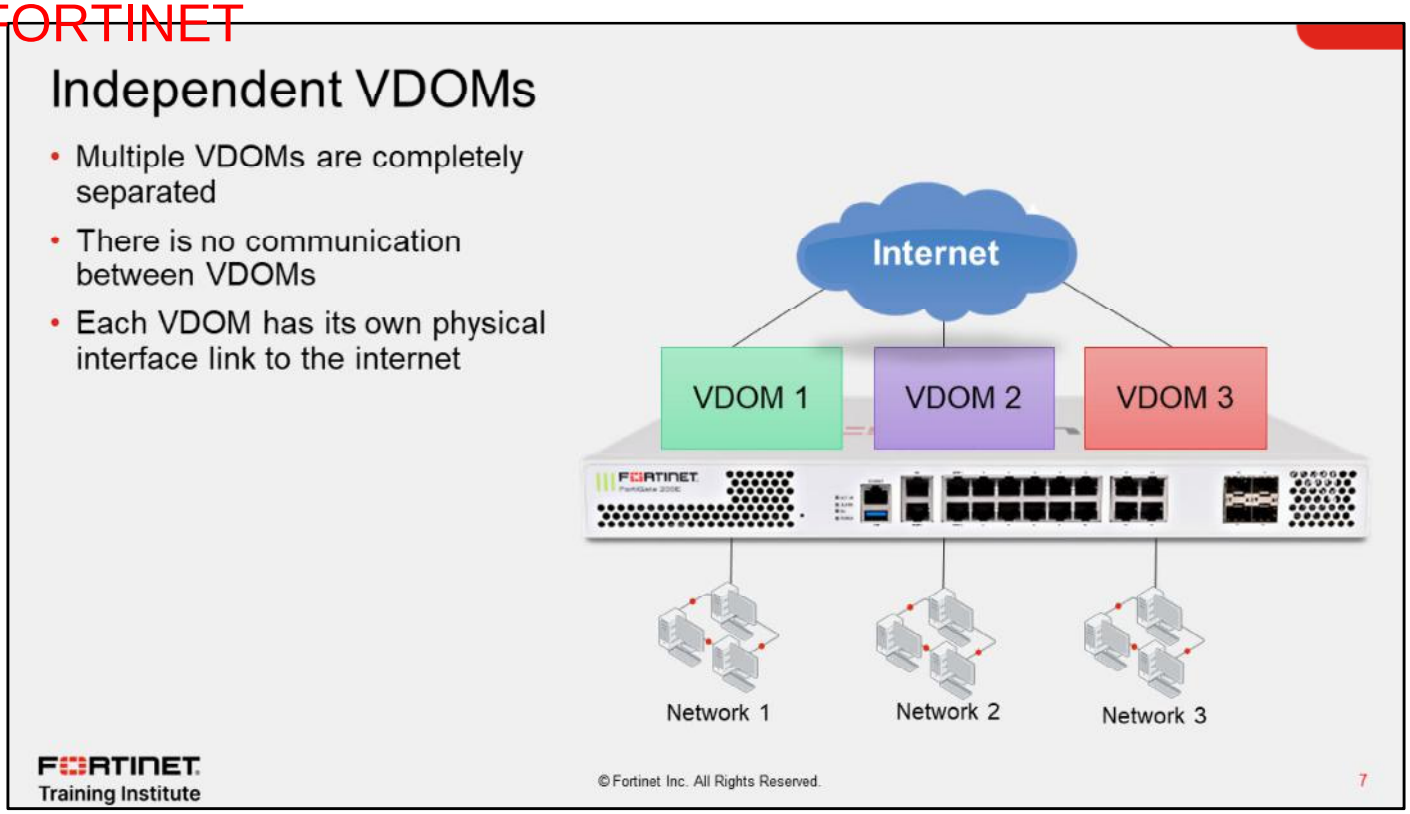
What about traffic originating *from* FortiGate? Some system daemons, such as NTP and FortiGuard updates, generate traffic coming from FortiGate.

Traffic coming from FortiGate to those global services originates from the *management* VDOM. One, and only one, of the VDOMs on a FortiGate device is assigned the role of the management VDOM.

By default, the root VDOM acts as the management VDOM, but you can manually reassign this task to a different VDOM in multi-vdom mode.

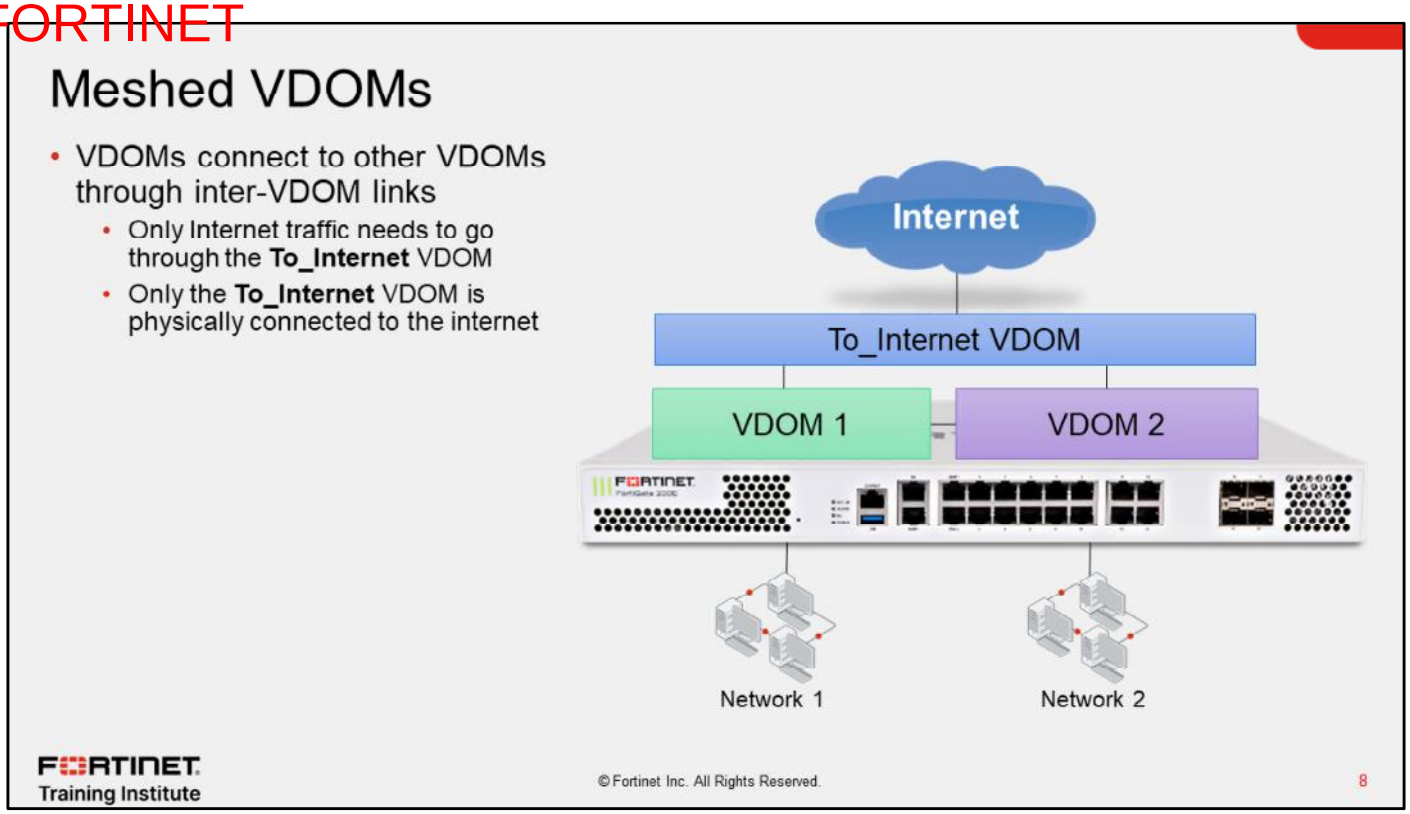
It is important to note that the management VDOM designation is solely for traffic originated by FortiGate, such as FortiGuard updates, and has no effect on traffic passing through FortiGate. As such, the management function can be performed by any designated VDOM.

Similar to FortiGate without VDOMs enabled, the administrative VDOM should have outgoing internet access. Otherwise, features such as scheduled FortiGuard updates, fail.



There are a few ways you can arrange your VDOMs. In the topology shown on this slide, each network accesses the internet through its own VDOM.

Notice that there are no inter-VDOM links. So, inter-VDOM traffic is not possible unless it physically leaves FortiGate, toward the internet, and is rerouted back. This topology would be most suitable in a scenario where multiple customers are sharing a single FortiGate, each in their own VDOM, with physically separated ISPs.



In the example topology shown on this slide, traffic again flows through a single pipe in the **To_Internet** VDOM toward the internet. Traffic between VDOMs doesn't need to leave FortiGate.

However, now inter-VDOM traffic doesn't need to flow through the **To_Internet** VDOM. Inter-VDOM links between VDOMs allow more direct communication.

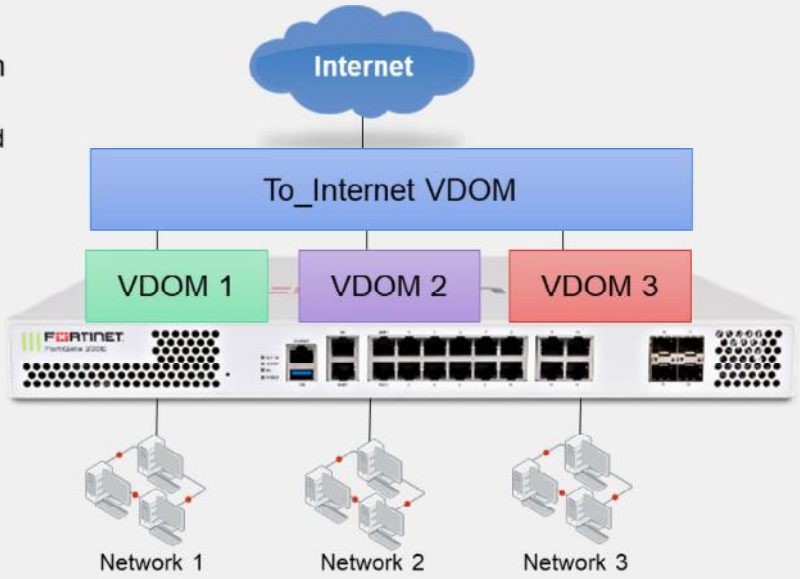
Similar to the previous example topology, inspection can be done by either the **To_Internet** or originating VDOM, depending on your requirements.

Because of the number of inter-VDOM links, the example shown on this slide is the most complex, requiring the most routes and firewall policies. Troubleshooting meshed VDOMs can also be more time consuming.

However, meshed VDOMs also provide the most flexibility. For large businesses, inter-VDOM communication may be required. Also, inter-VDOM traffic performance may be better because of a shorter processing path, which bypasses intermediate VDOMs.

Routing Through a Single VDOM

- Traffic destined to the internet will *always* be routed through *the designated VDOM* (**To_Internet** in this example)
  - The **To_Internet** VDOM is connected to other VDOMs using inter-VDOM links
  - Only the **To_Internet** VDOM is physically connected to the Internet



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Like the topology shown on the previous slide, each network in the example topology shown on this slide sends traffic through its VDOM. However, after that, traffic is routed through the **To_Internet** VDOM. So, internet-bound traffic flows through a single pipe in the **To_Internet** VDOM.

This could be suitable in a scenario where multiple customers are sharing a single FortiGate, each in their own VDOM. In this case, the internet-facing VDOM could log and monitor traffic, or provide standard services like antivirus scanning, or both.

The topology shown on this slide has inter-VDOM links. VDOMs are linked only with the **To_Internet** VDOM, but not with each other. If **VDOM1** needs to communicate with **VDOM3**, this traffic would need to be routed through the **To_Internet** VDOM through IP routing decisions and is subject to all firewall policies.

Inspection could be done by either the internet-facing or originating VDOM, depending on your requirements. Alternatively, you could split inspection so that some scans occur in the internet-facing VDOM—ensuring a common security baseline—while other more intensive scans occur in the originating VDOM.

Knowledge Check

1. Which traffic is always generated from the management VDOM?
   - A. Link Health Monitor
   - ✓ B. FortiGuard

2. Which statement about the management VDOM is true?
   - A. It is **root** by default and cannot be changed in multi-vdom mode.
   - ✓ B. It is **root** by default, but can be changed to any VDOM in multi-vdom mode.

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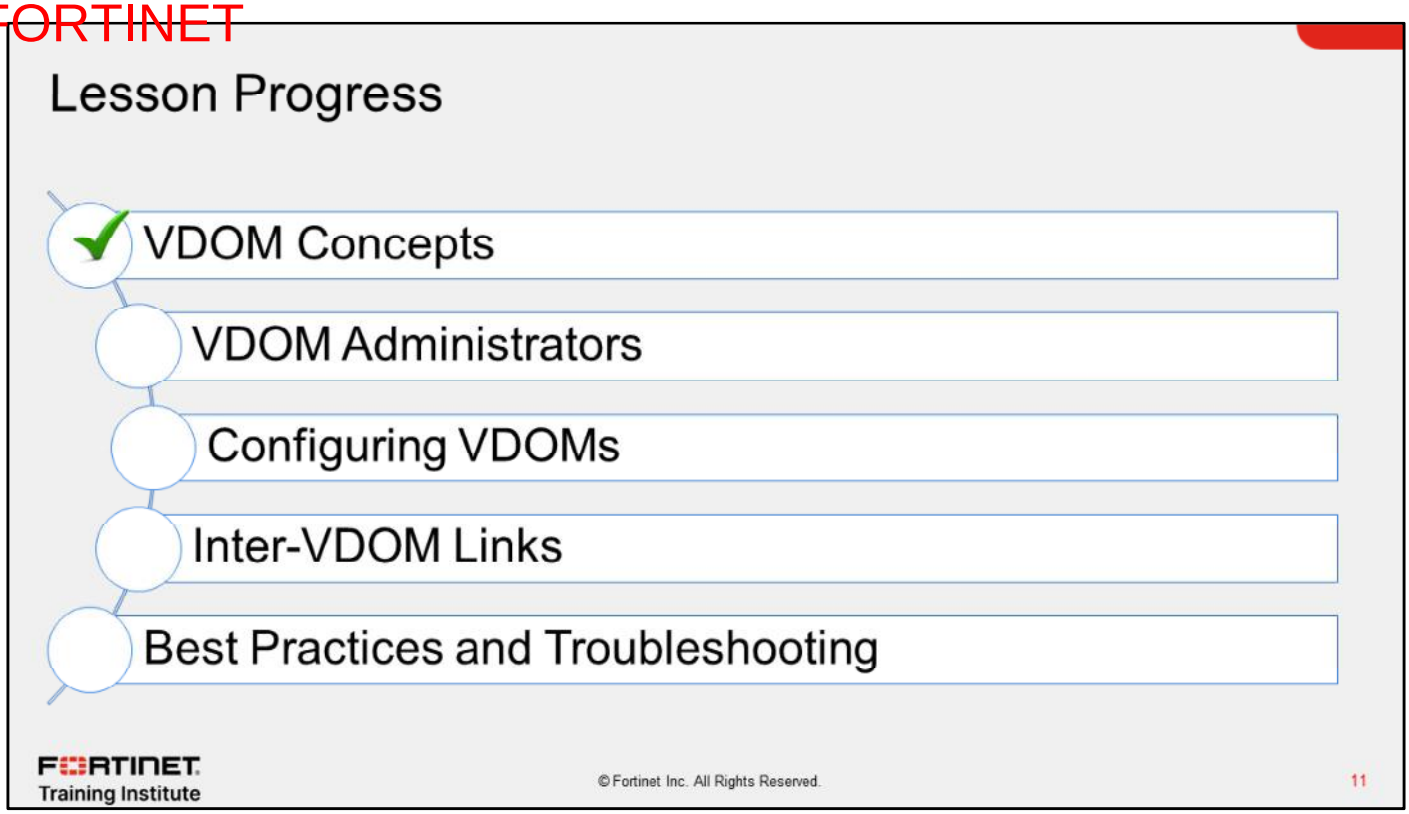
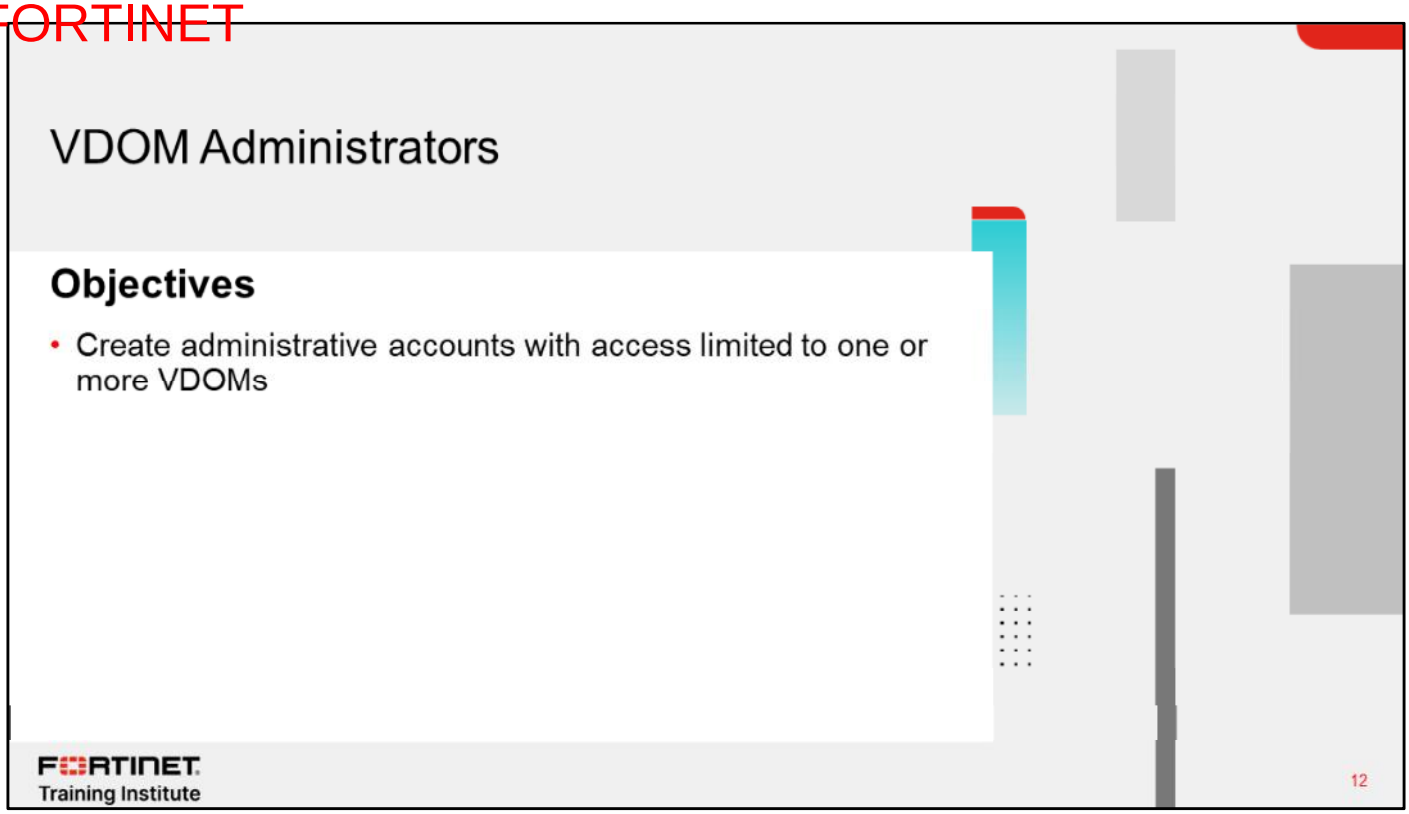


Good job! You now understand some basic concepts about VDOMs.

Now, you'll learn about VDOM administrators.

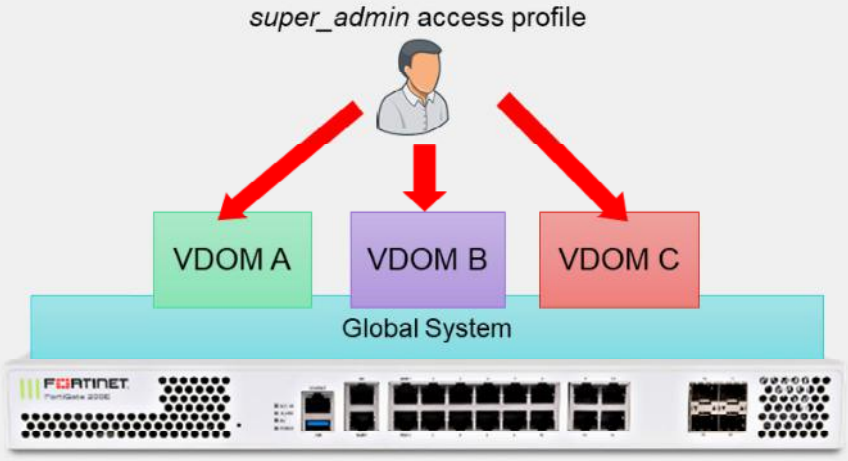


After completing this section, you should be able to achieve the objective shown on this slide.

By demonstrating competence in creating VDOM administrative accounts, you will be able to understand the differences between the various levels and types of VDOM administrators.

VDOM Administration

- Only the account named **admin** or accounts with the **super_admin** profile can configure and back up all VDOMs



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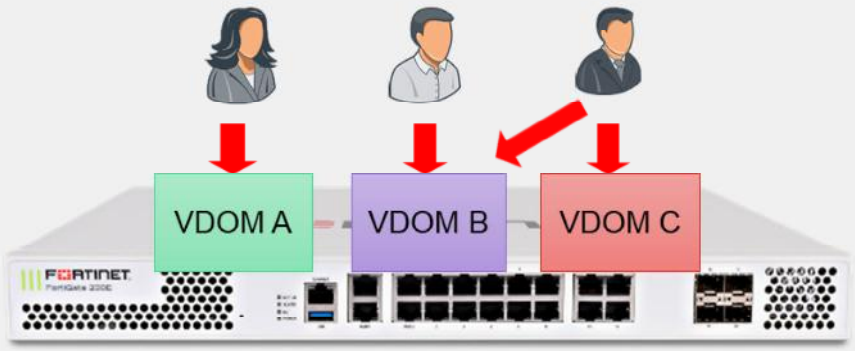
If you want to grant access to all VDOMs and global settings, select **super_admin** as the access profile when configuring the administrator account. Similar to the account named **admin**, this account can configure all VDOMs.

Per-VDOM Administration

- Other administrators can access only their *assigned* VDOMs
  - Cannot access the global settings



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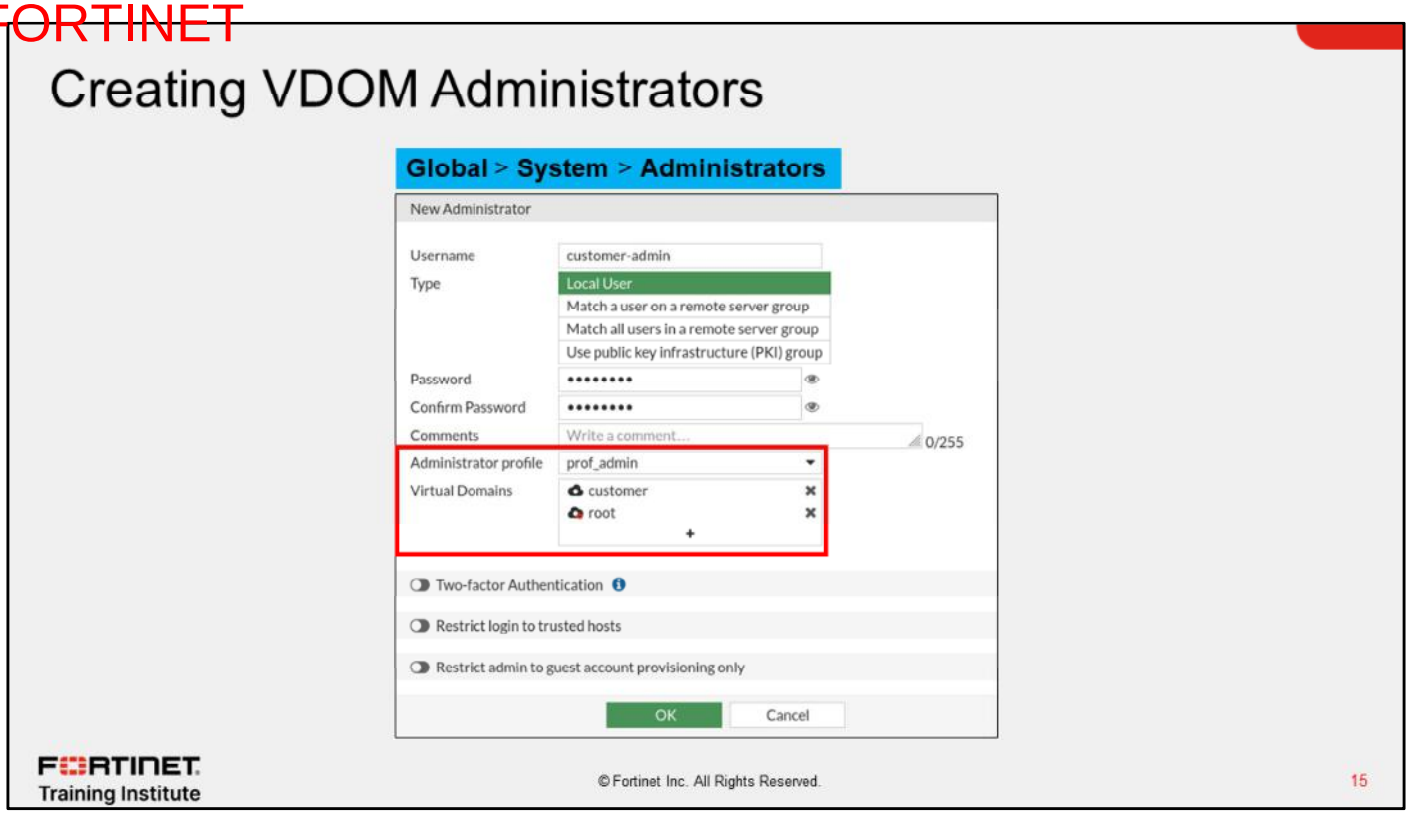
In most cases, you start by creating one administrator account per VDOM. That administrator is chiefly responsible for that domain, including the configuration backups of that VDOM. In larger organizations, you may need to make multiple VDOM administrators. You can assign multiple administrators to each VDOM. You can subdivide permissions using access profiles, in order to follow best practices for segregation of duties.

The converse is also possible. If required, you can assign an administrator to multiple VDOMs.



To create new administrator accounts and assign them to a VDOM, click **Global** > **System** > **Administrators**.

Knowledge Check

1. Which type of administrator can make changes to all VDOMs?
   - A. A custom VDOM administrator
   - ✓ B. An administrator with the **super_admin** profile

2. Which statement about VDOM administrators is true?
   - A. There can be only one administrator per VDOM.
   - ✓ B. Each VDOM can have multiple administrators.

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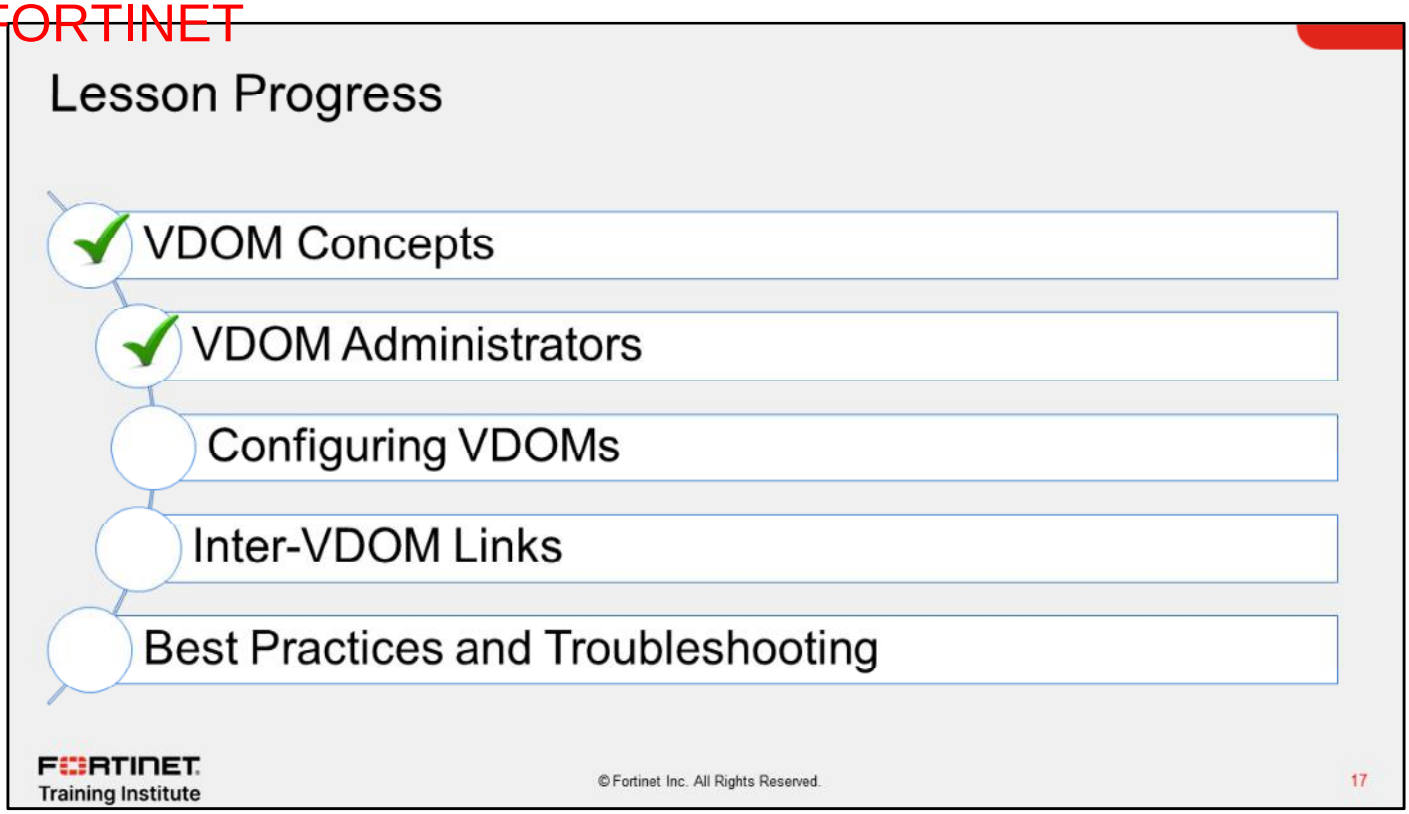
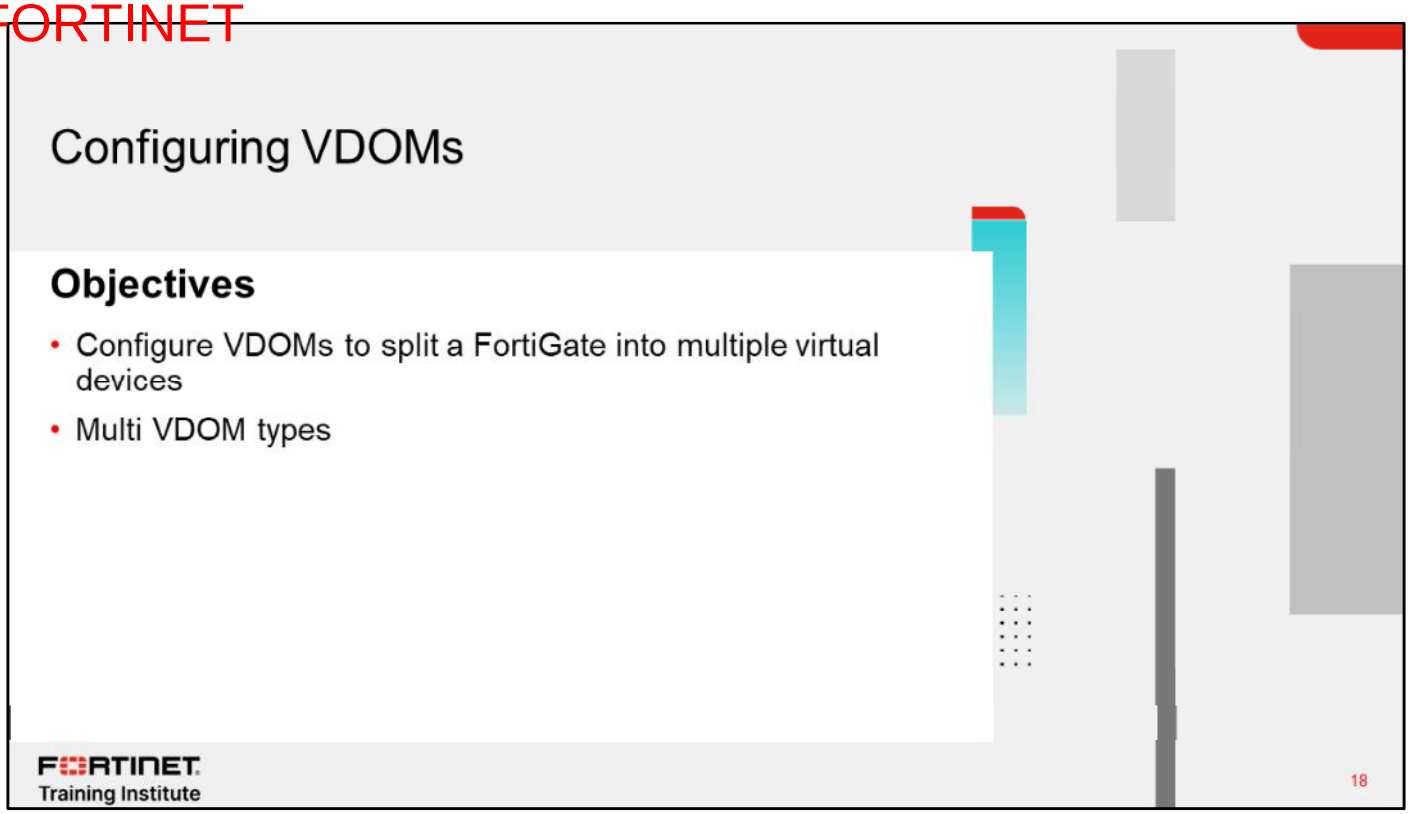


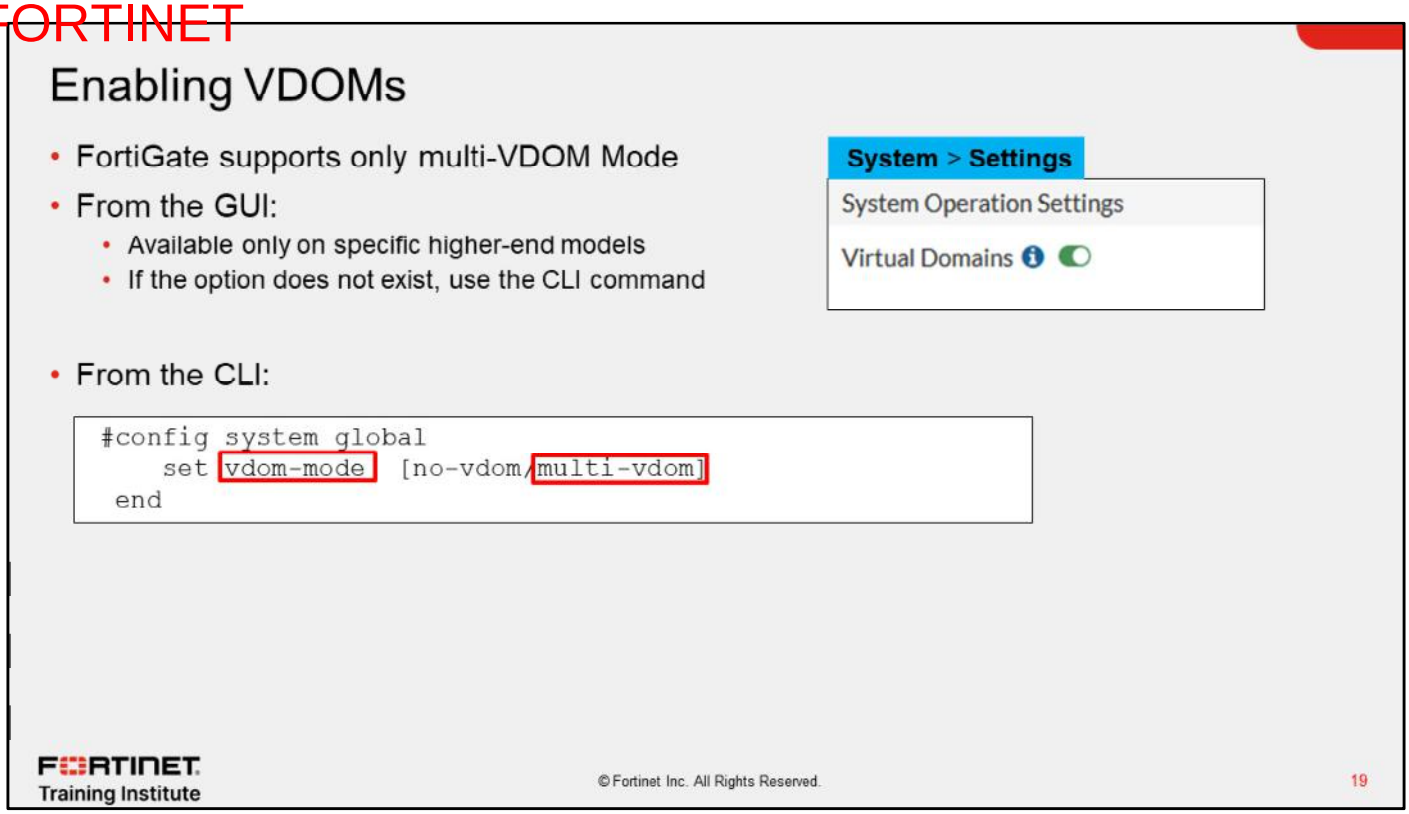
Good job! You now understand VDOM administrators.

Now, you'll learn how to configure VDOMs.



After completing this section, you will be able to achieve the objective shown on this slide.

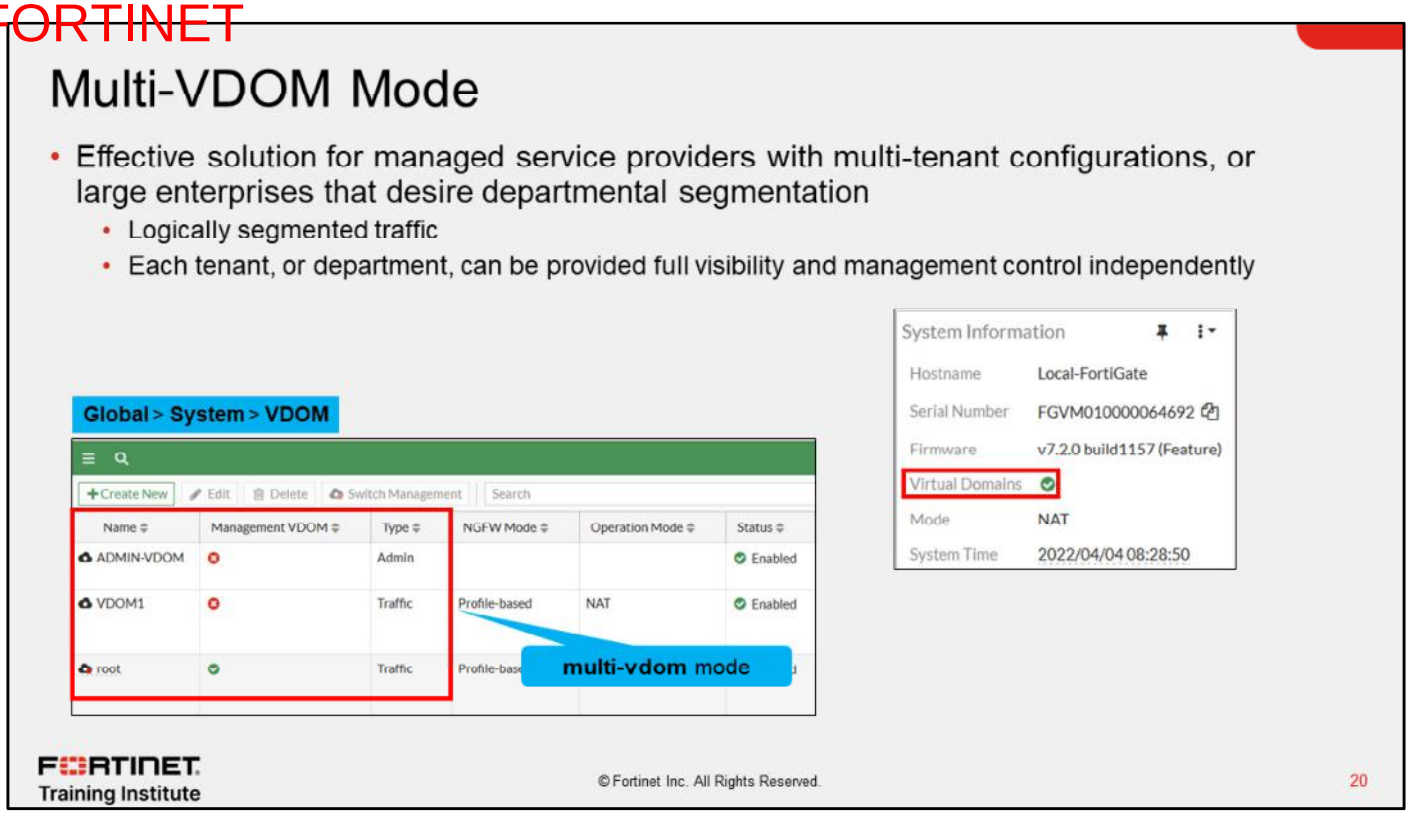
By demonstrating competence in configuring VDOMs, you will be able to effectively implement VDOMs on your FortiGate.



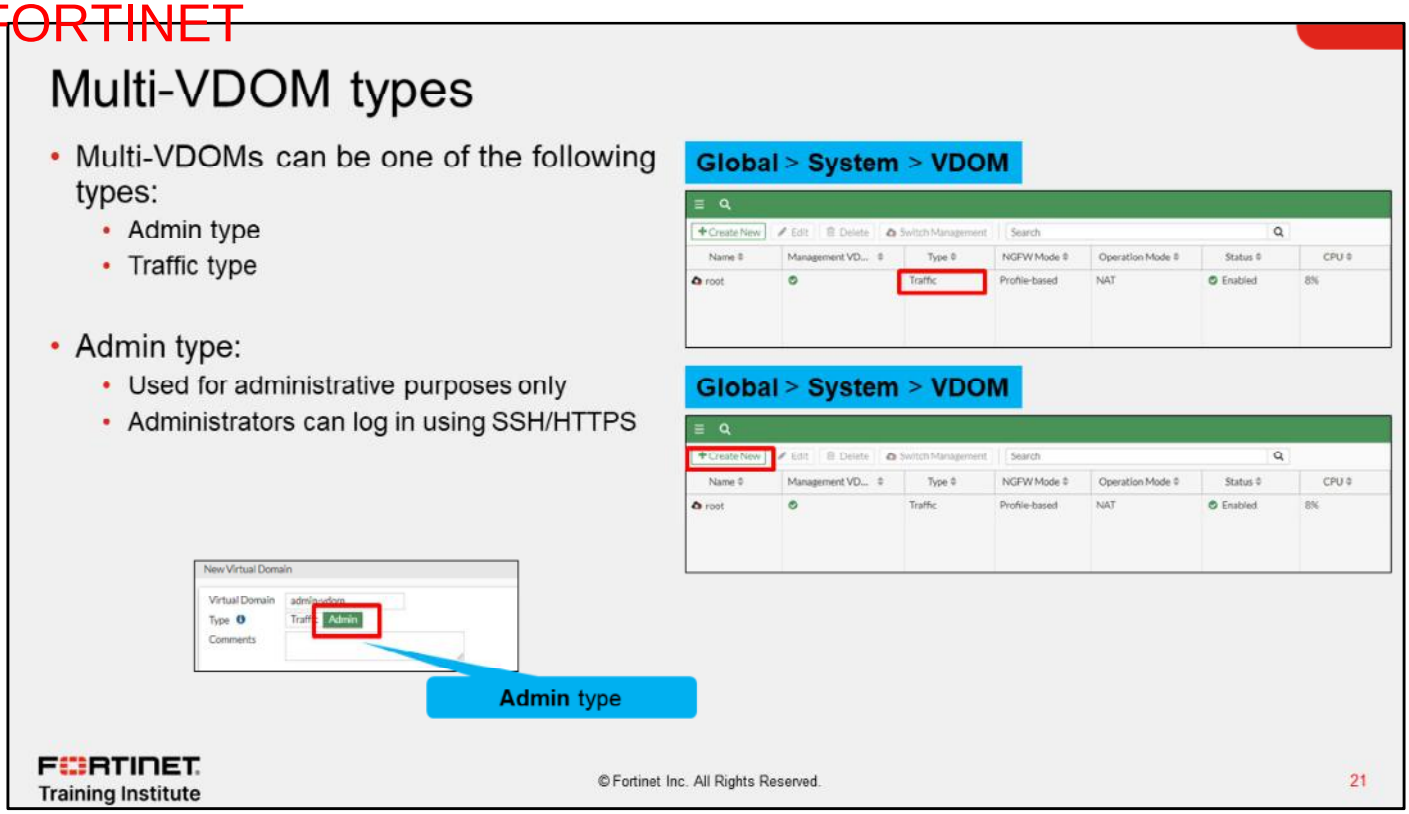
On the GUI, you can enable VDOMs under **System** > **Settings**. The GUI option is available only on higher-end FortiGate Models. Most of the FortiGate models, you can enable VDOMs on the CLI only.

Enabling VDOMs does not cause your FortiGate device to reboot, but it does log out all active administrator sessions. Traffic continues to pass through FortiGate.

Enabling VDOMs restructures both the GUI and CLI, which you will see when you log in again.



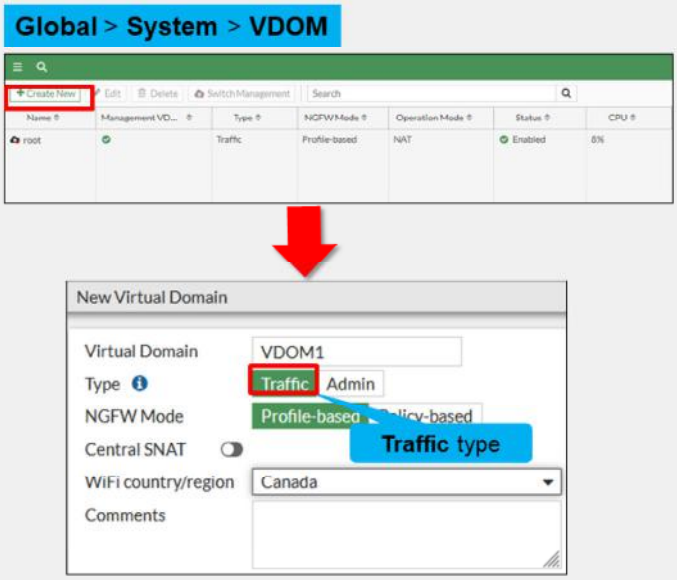
In *multi-vdom* mode, you can create multiple VDOMs that function as multiple independent units.
By default, the root is the management VDOM and can be used to do both management tasks and allow other traffic. You can select any VDOM to act as the management VDOM.



When you enable multi-vdom mode, the root VDOM exists. It is the default management VDOM and is a traffic VDOM. You can create another VDOM (traffic or admin). FortiGate supports only one admin VDOM.

Multi -VDOM types (Contd)

- Traffic type:
  - Can pass traffic like regular VDOMs



- From CLI:

```
config vdom
edit <vdom>
   config system settings
      set vdom-type [traffic/admin]
   end
```

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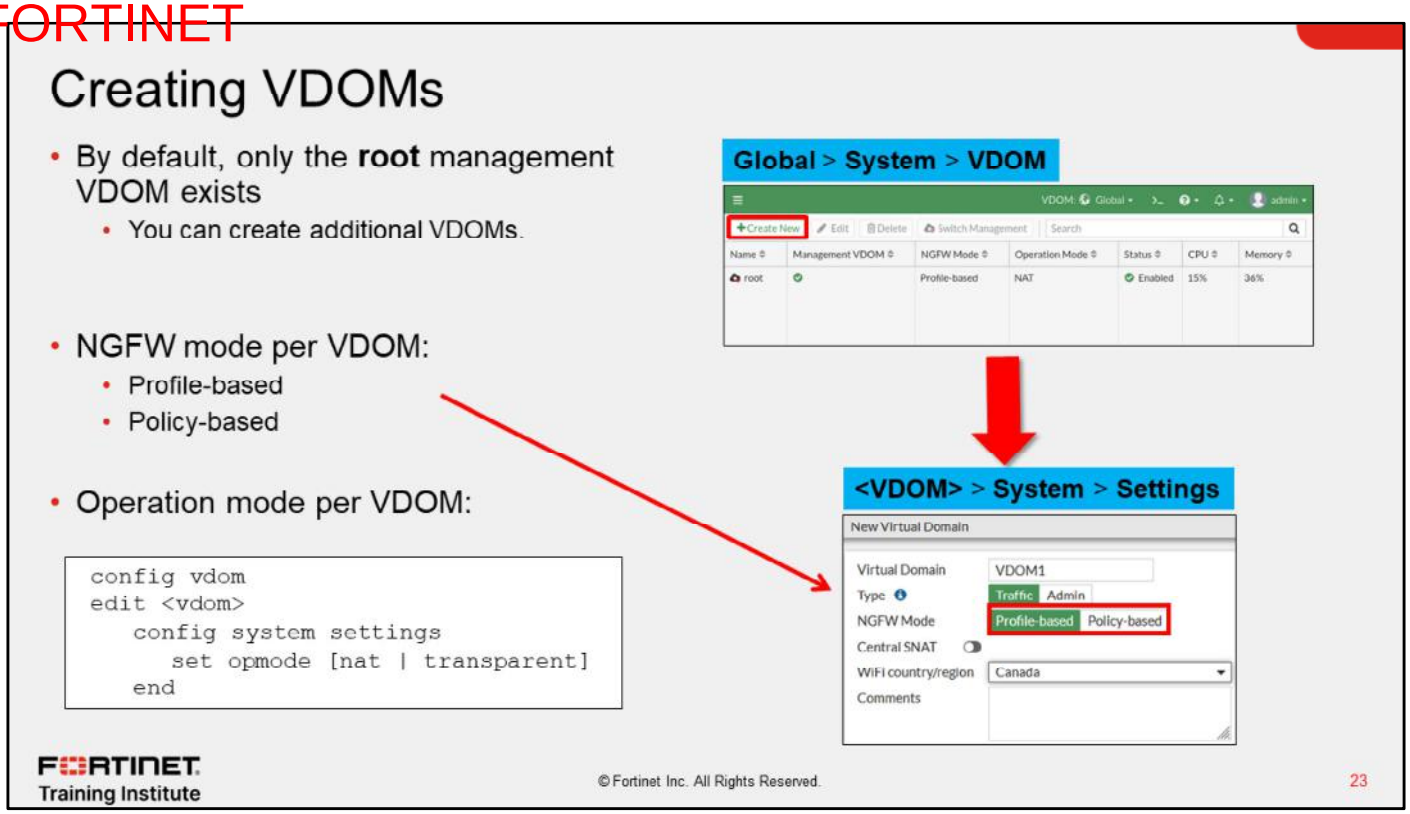
When the VDOM type is set to Traffic, the VDOM can pass traffic like a regular VDOM. If an admin VDOM exists, all newly created VDOMs are configured as traffic VDOMs.



After enabling VDOMs in multi-vdom mode, by default, only one VDOM exists: the root VDOM. It's the default management VDOM.

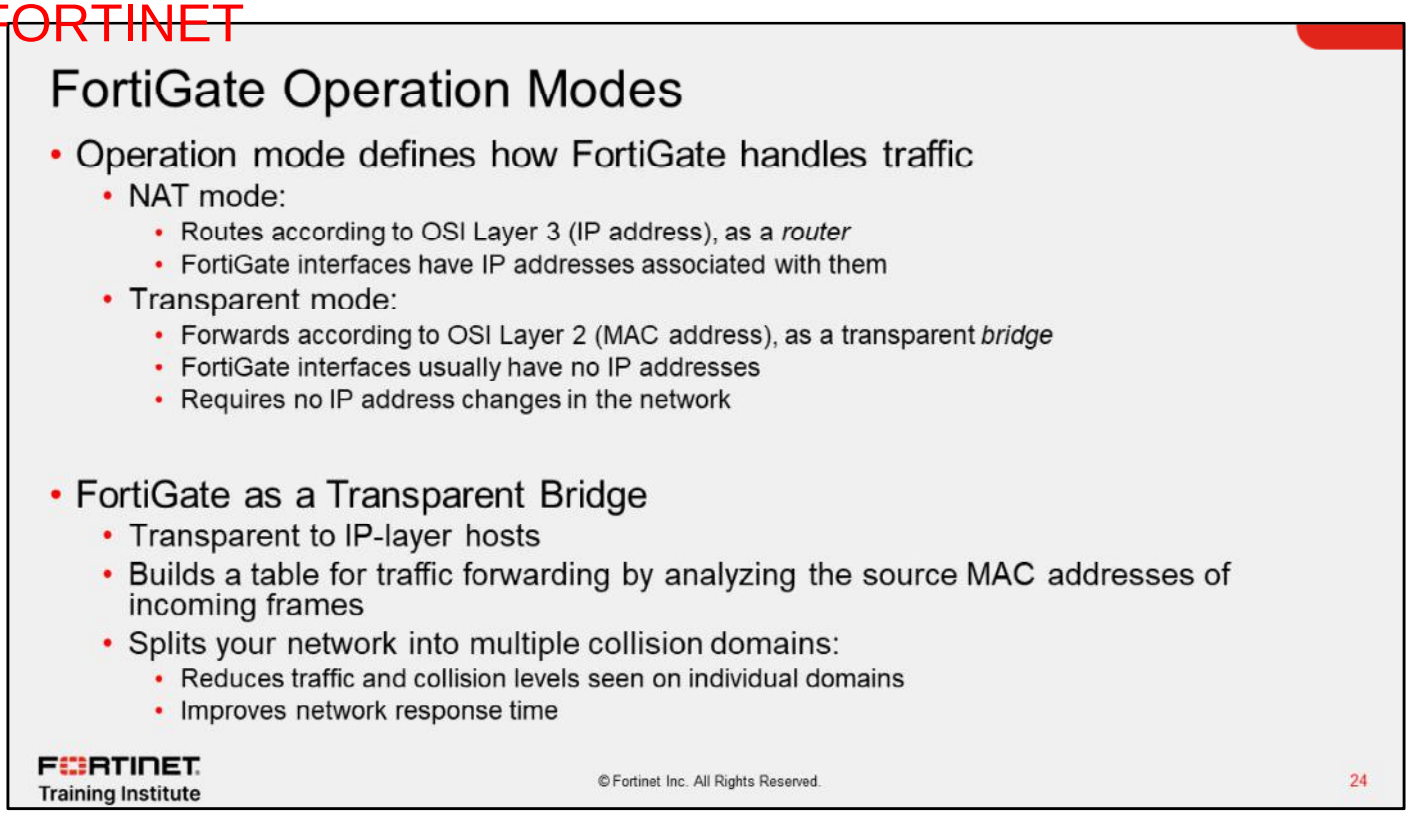
You need to add a VDOM for each of your security domains. If you're an MSSP, for example, you might add one VDOM for each client company. If you are an enterprise business, you might add one VDOM for each division of your company.

The default inspection-mode is flow, so you can change **NGFW Mode** from **Profile-based** (default) to **Policy-based** directly in **System** > **Settings** for the VDOM.

The **profile-based** NGFW is the traditional mode and you must create antivirus, web filter, and IPS profiles, which are then applied to the policy. **Policy-based** mode is actually a new policy mode. You can add applications and web filtering categories directly to a policy without having to first create and configure application control or web filtering profiles. NGFW mode is a per-VDOM setting. If you set NGFW mode to **Profile-based**, you can configure policies in that VDOM for either flow or proxy inspection. However, if NGFW mode is **Policy-based**, then the inspection mode for all policies in that VDOM is always flow and there is no option available in the policy to change it.

Switching between NGFW modes results in *the loss of all current policies* configured in the VDOM. If you don't want this to happen, or you just want to experiment with a particular NGFW mode, consider creating a new VDOM for testing purposes. You could also back up your configuration before switching modes.

Operation mode is a per-VDOM setting. You can combine transparent mode VDOMs with NAT mode VDOMs on the same physical FortiGate.



Traditional IPv4 firewalls and NAT mode FortiGate devices handle traffic the same way that routers do. Each interface must be in a different subnet and each subnet forms a different broadcast domain. FortiGate routes IP packets based on the IP header information, overwriting the source MAC address. So, if a client sends a packet to a server connected to a different FortiGate interface, the packet arrives at the server with a FortiGate MAC address, instead of the client MAC address.

In transparent operation mode, FortiGate forwards frames without changing the MAC addresses. When the client receives a packet from a server connected to a different FortiGate interface, the frame contains the real MAC address of the server—FortiGate doesn't rewrite the MAC header. FortiGate acts as a Layer 2 bridge or switch. So, the interfaces do not have IP addresses and, by default, all belong to the same broadcast domain.

This means that you can install a transparent mode FortiGate in a customer network without having to change the customer's IP address plan. Some customers, especially large organizations, don't want to reconfigure thousands of devices to define a new internal network that is separate from their external network.

A transparent mode FortiGate device acts as a transparent bridge. What does that mean? It means that FortiGate has a MAC address table that contains, among other things, the interface that must be used to reach each MAC address. FortiGate populates this table with information taken from the source MAC address of each frame.
FortiGate, as a transparent switch, splits the network into multiple collision domains, reducing the traffic in the network and improving the response time.

Forward Domains

- By default, *all* interfaces on a VDOM belong to the same broadcast domain; even interfaces with different VLAN IDs
  - Broadcast domains that contain multiple interfaces can be very large and add unnecessary broadcast traffic to some LAN segments
- Use this command to subdivide a VDOM into multiple broadcast domains:

```
config system interface
   edit <interface_name>
       set forward-domain <domain_ID>
end
```

- Interfaces with the same domain ID belong to the same broadcast domain

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By default, in transparent operation mode, each VDOM forms a separate forward domain; however, interfaces do not. How does this affect the network?

Until you change the initial VDOM configuration, all interfaces, regardless of their VLAN ID, are part of the same broadcast domain. FortiGate broadcasts from every interface in the VDOM in order to find any unknown destination MAC address. On large networks, this could generate massive broadcast traffic and overwhelming replies—a broadcast storm.

Confirmation Prompt When Creating VDOMs

- VDOM confirmation prompt added
  - So that users do not create new VDOMs accidently in CLI

```
config system global
 set edit-vdom-prompt [enable | disable]
end
```

  - Disabled by default
  - When enabled, if administrator creates a new VDOM, FortiGate displays prompt:

```
# config vdom
    edit student
    The input VDOM name doesn't exist.
    Do you want to create a new VDOM?
    Please press 'y' to continue, or press 'n' to cancel. (y/n)y

    current vf=student:3
```

Prompt to confirm before the new VDOM is created

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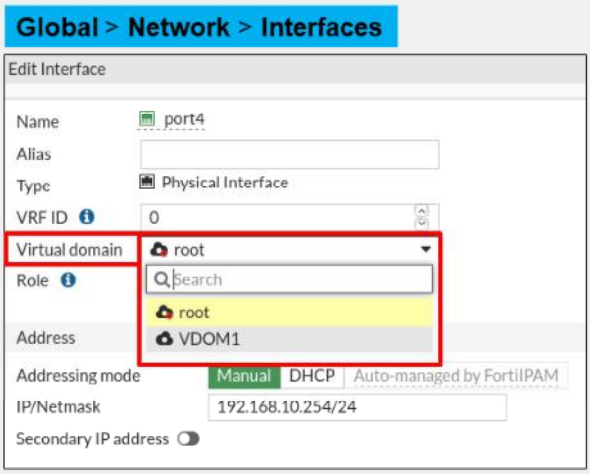
A VDOM confirmation prompt has been added so users do not create new VDOMs accidentally on the CLI. This setting is disabled by default. Once enabled, when an administrator creates a new VDOM, FortiGate displays a prompt to confirm before the VDOM is created.

Assigning Interfaces to a VDOM

- You can assign an interface to each VDOM you create
- From CLI:

```
config global
config system interface
  edit <interface_name>
     set vdom <vdom-name>
   end
```



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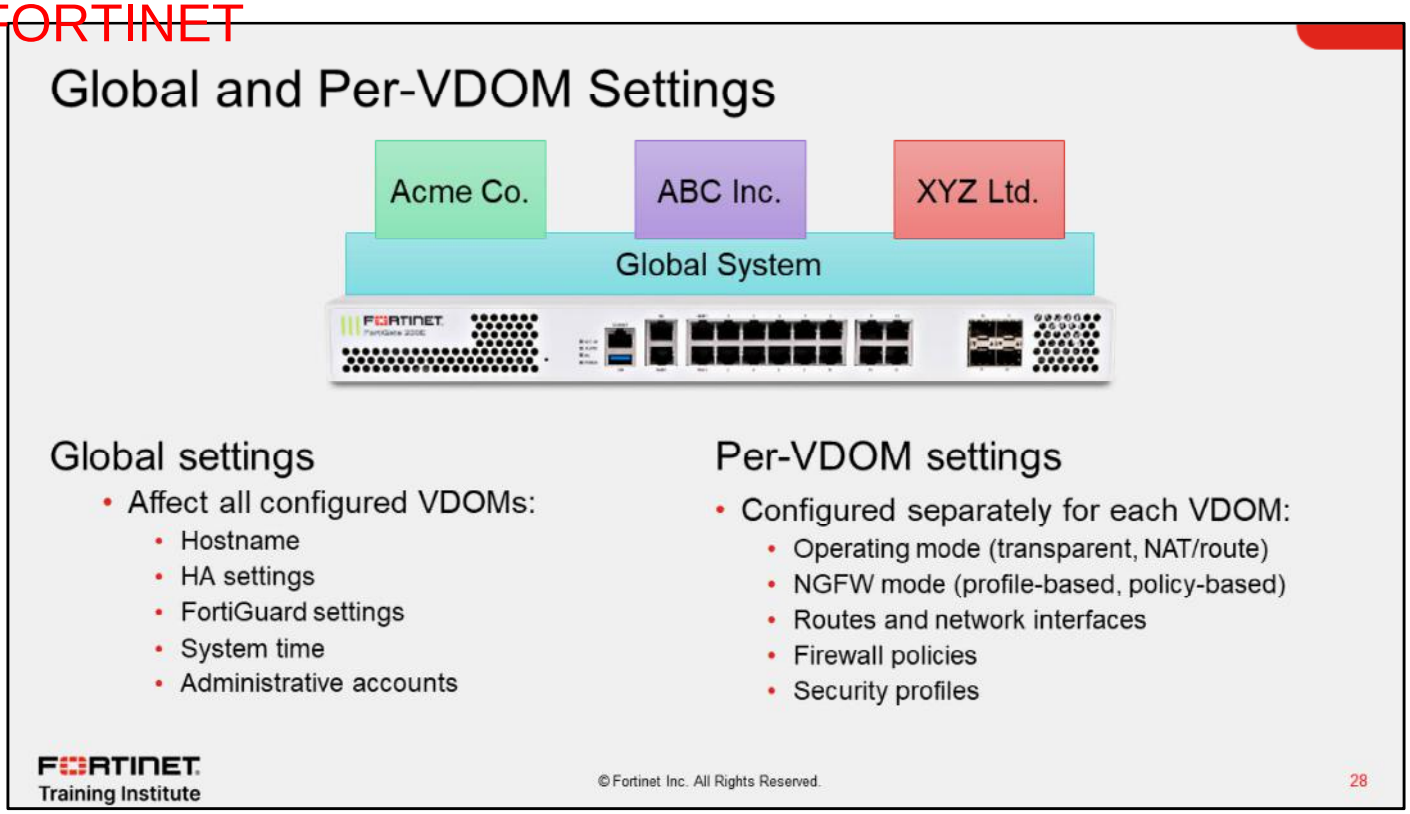
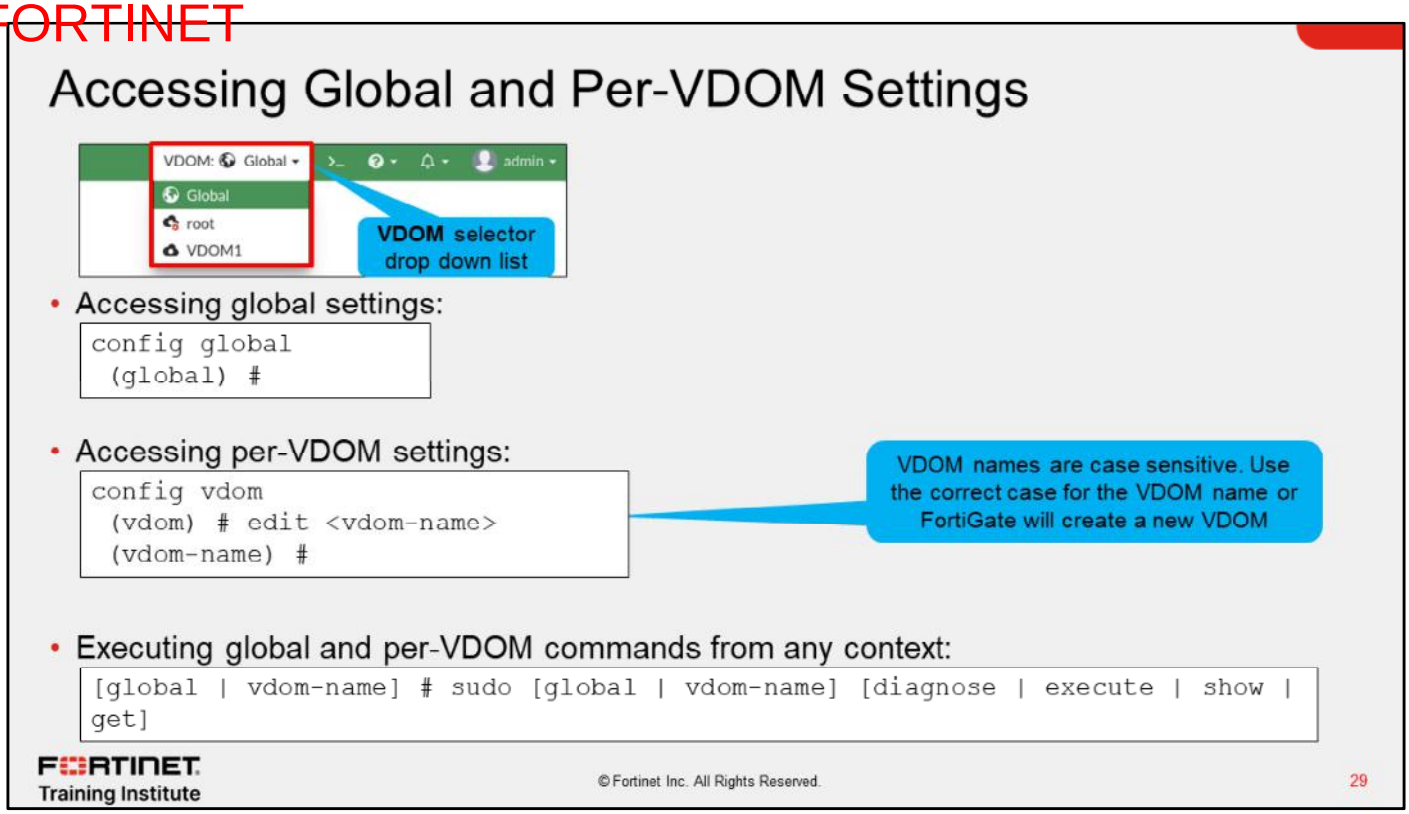
After adding a VDOM, you can specify which interface belongs to it. Each interface (physical or VLAN) can belong to only one VDOM.

You can move an interface from one VDOM to another, provided it is not associated with any references, such as firewall policies.



Global resource limits are an example of global settings. The firmware on your FortiGate device and some settings, such as system time, apply to the entire device—they are not specific to each VDOM.

However, you can configure most settings differently for each VDOM. Some examples are firewall policies, firewall objects, static routes, and protection profiles.



When you log with a regular administrator account, you automatically enter the VDOM associated with that account.

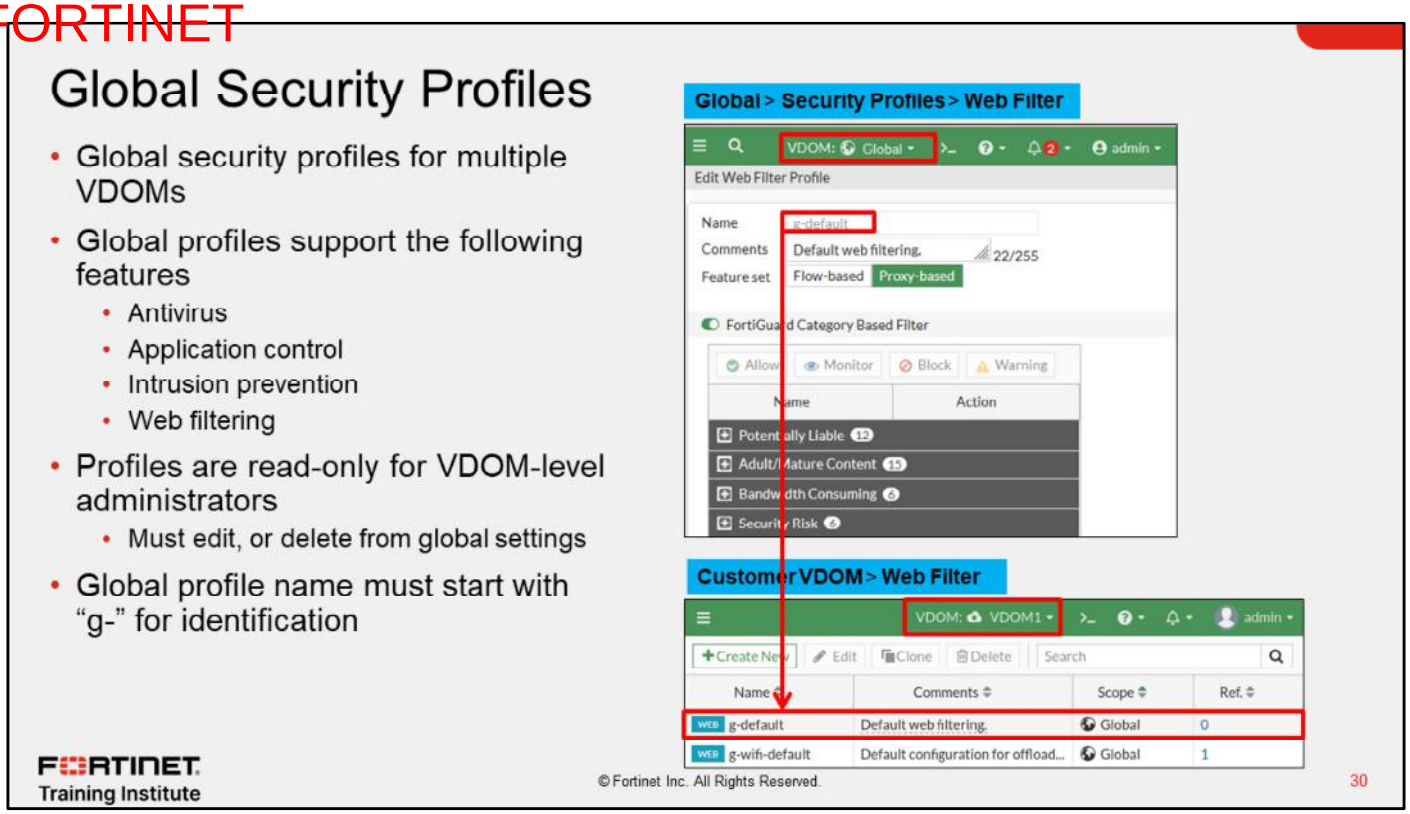
When you log in with the account named admin, you have access to all VDOMs. To access a specific VDOM, select it in the drop-down list at the top of the page.

The VDOM submenu should be familiar; it is essentially the same navigation menu from before you enabled VDOMs. However, the global settings are moved to the Global menu.

To access the global configuration settings on the CLI, you must enter config global to enter into the global context. After that, you can run global commands and change global configuration settings.

To access per-VDOM configuration settings on the CLI, you must enter config vdom, then enter edit followed by the VDOM name. From the VDOM context, you can run VDOM-specific commands and change per-VDOM configuration settings. It is important to note that VDOM names are case sensitive. If you enter the name using the incorrect case, FortiGate creates a new VDOM.

Regardless of which context you are in (global or VDOM), you can use the sudo keyword to run diagnostics commands in a context different from your current one. This allows you to run global and per-VDOM commands, for example, without switching back and forth between the global and per-VDOM contexts.



You can configure security profiles globally for use by multiple VDOMs, to avoid creating identical profiles for each VDOM separately. Global profiles are available for the following security features:

- Antivirus
- Application control
- Intrusion prevention
- Web filtering

Some security profile features, such as URL filters, are not available for use in a global profile. The name for any global profile must start with "g-" for identification. Global profiles are available as read-only for VDOM-level administrators and can be edited or deleted only in the global settings. Each security feature has at least one default global profile.

Knowledge Check

1. Which configuration settings are global settings?
   - A. Firewall policies
   - ✓B. FortiGuard settings

2. Which configuration settings are per-VDOM settings?
   - A. Host name
   - ✓B. NGFW mode

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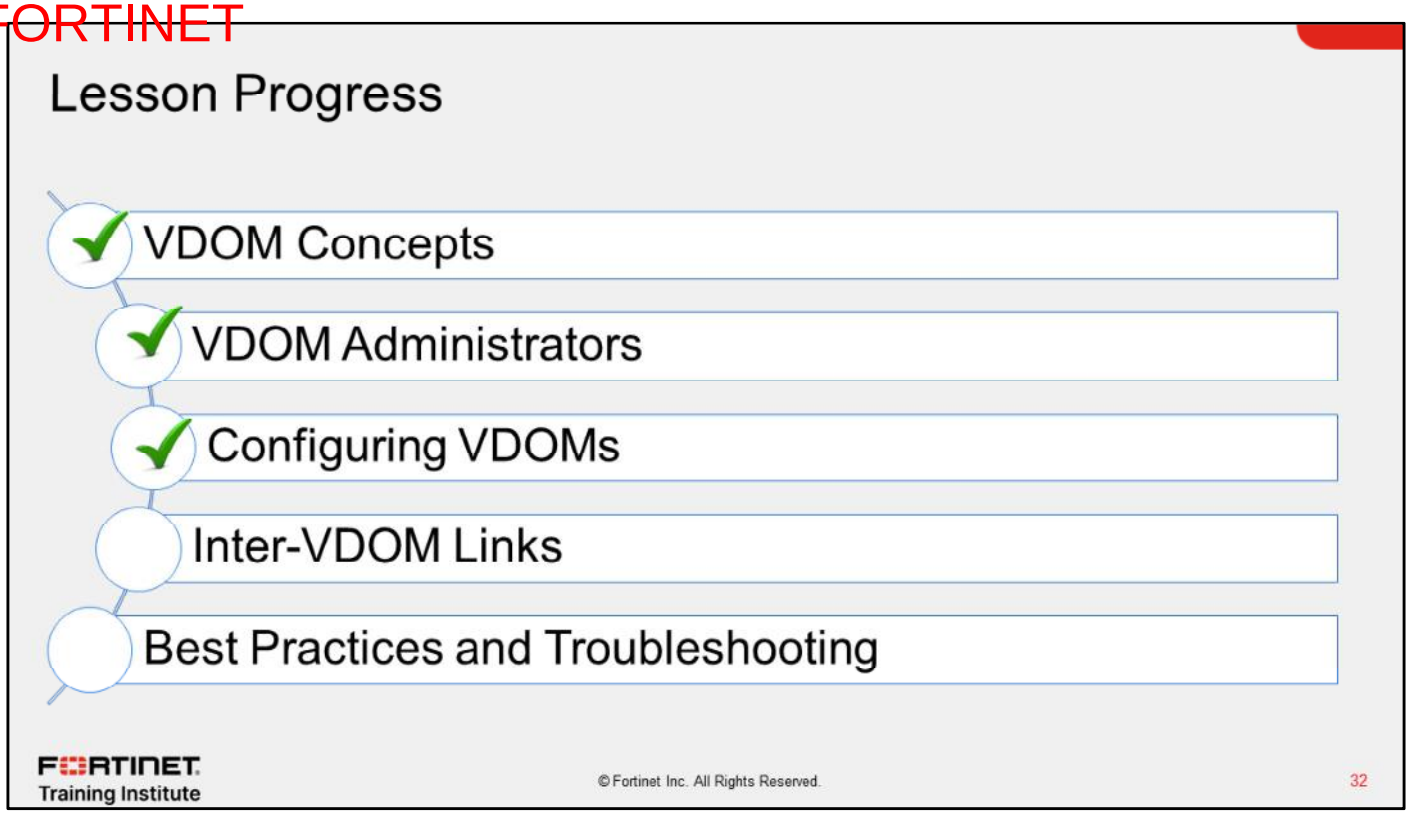
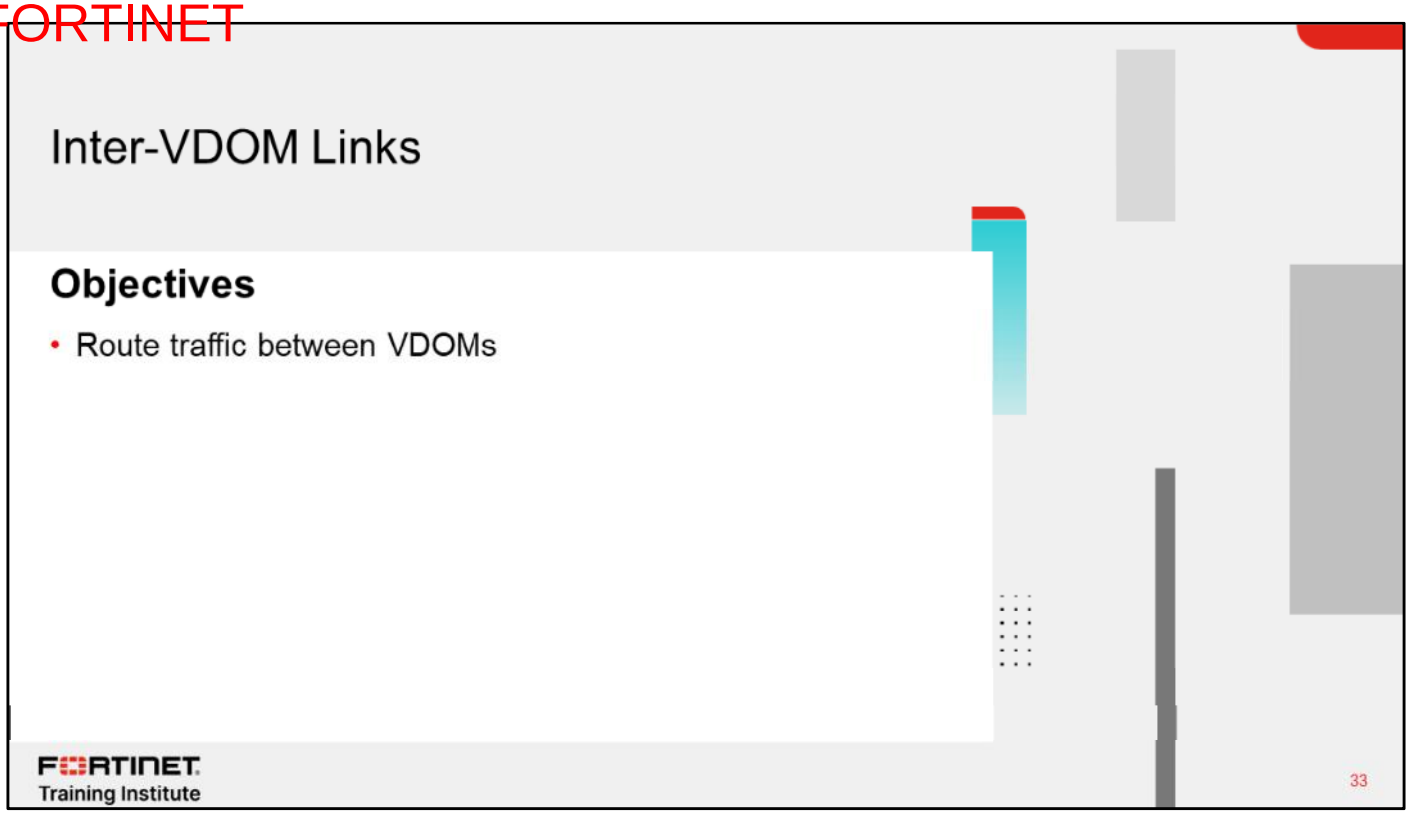


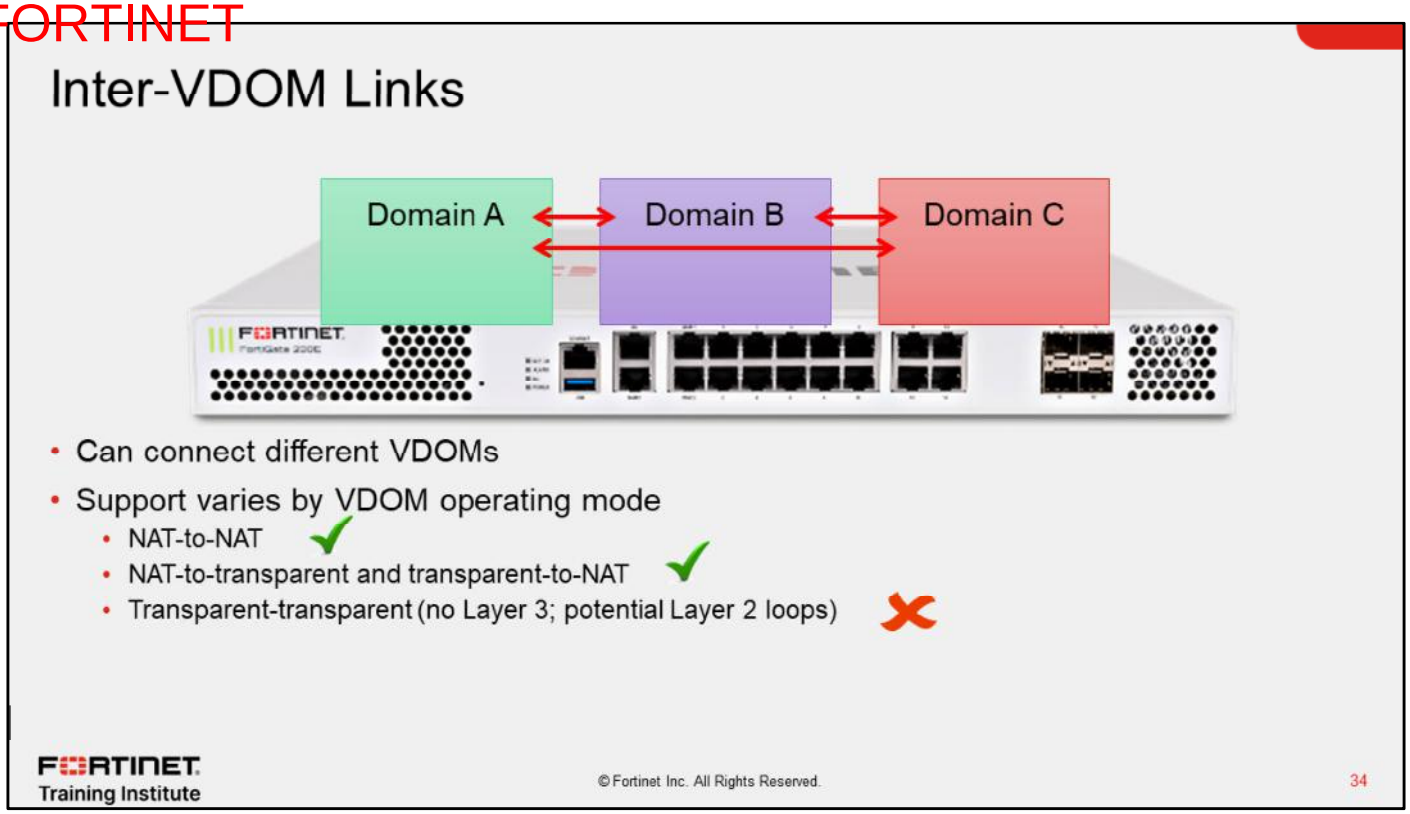
Good job! You now understand how to configure VDOMs.

Now, you'll learn about inter-VDOM links.



After completing this section, you should be able to achieve the objective shown on this slide.

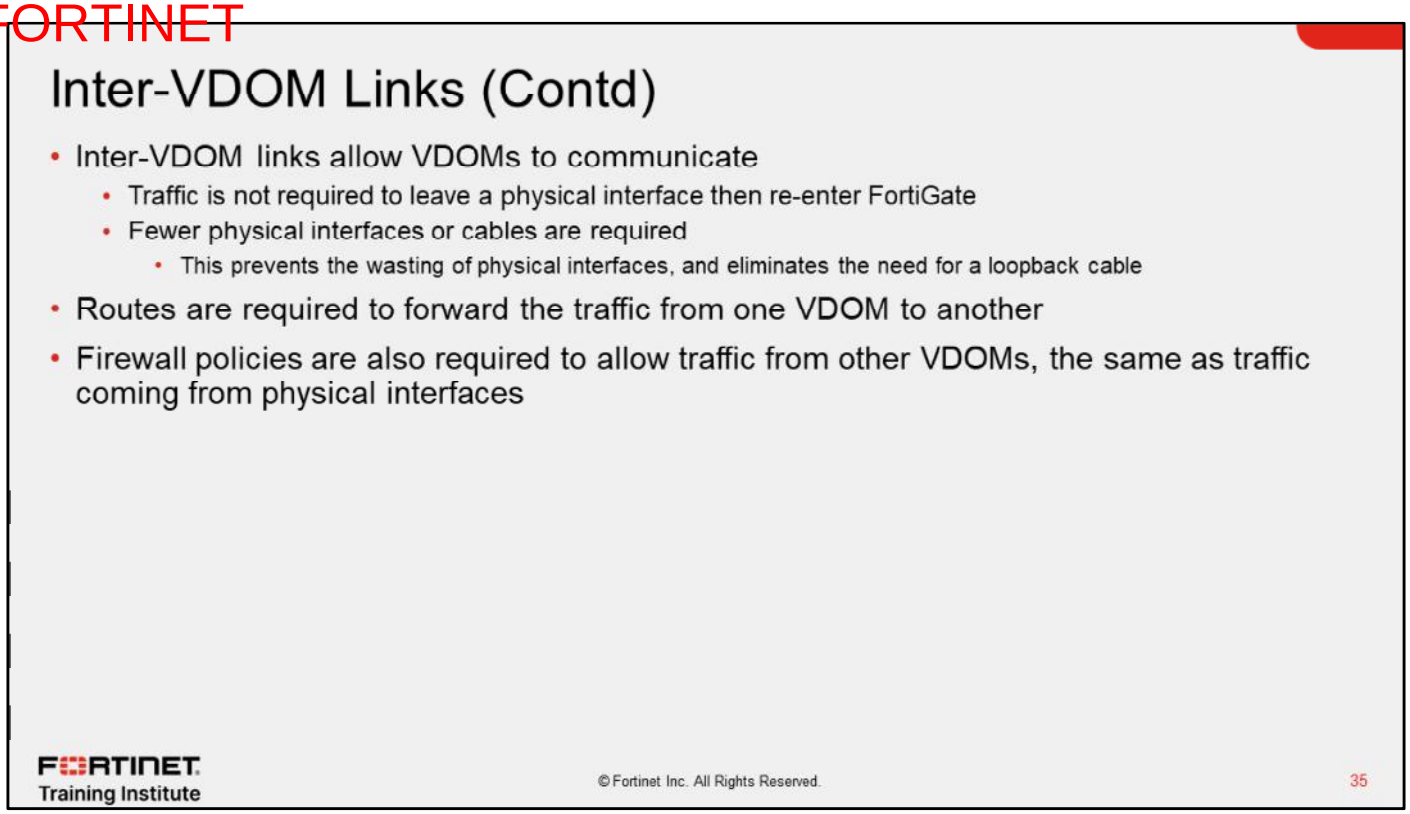
By demonstrating competence in inter-VDOM links, you will be able to effectively and efficiently route traffic between VDOMs on FortiGate.



To review, each VDOM behaves like it is on a separate FortiGate device. With separate FortiGate devices, you would normally connect a network cable and configure routing and policies between them. But VDOMs are on the same FortiGate. So, how should you route traffic between them?
The solution is inter-VDOM links. Inter-VDOM links are a type of virtual interface that route traffic between VDOMs. This removes the need to loop a physical cable between two VDOMs.

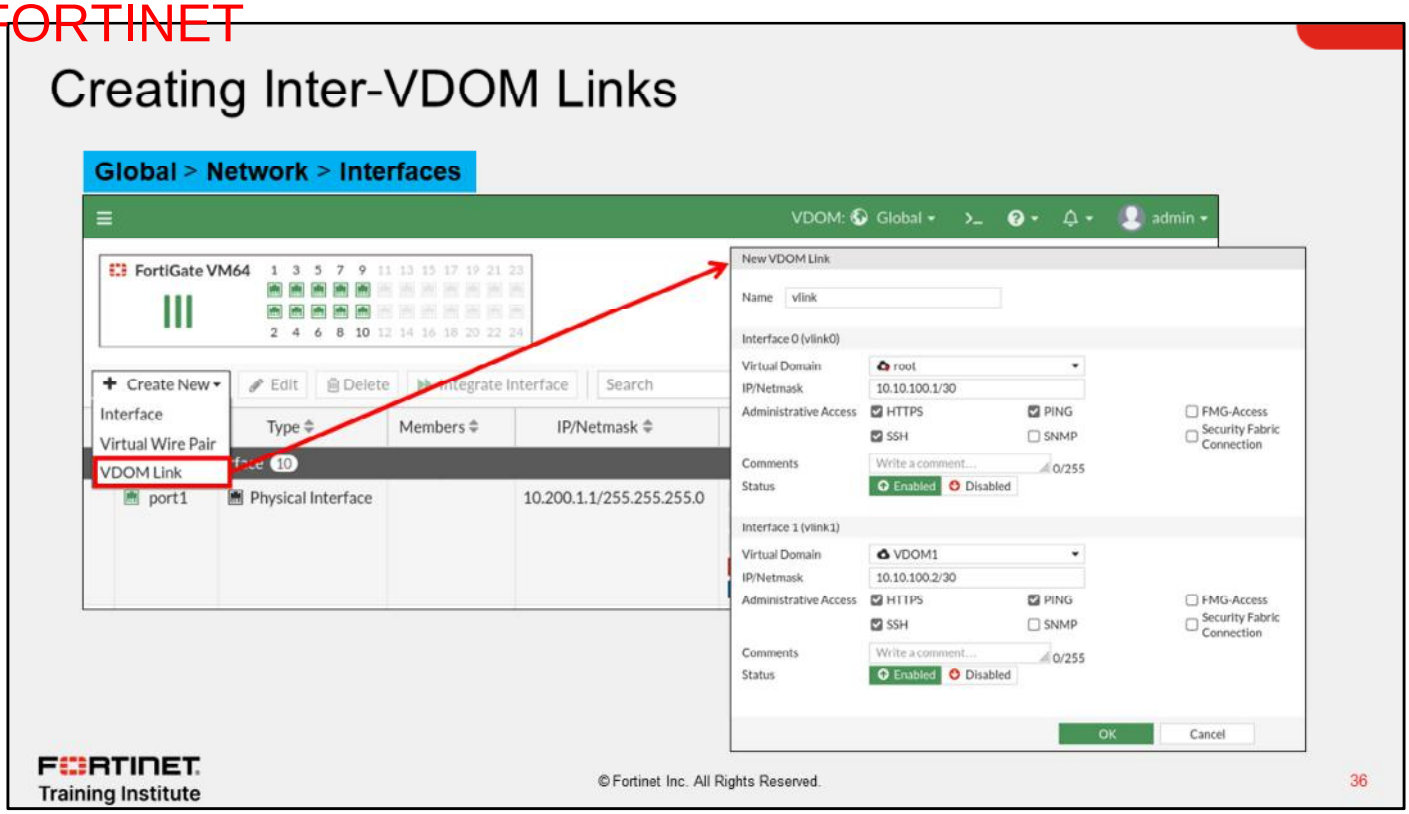
In the case of a NAT-to-NAT inter-VDOM link, both sides of the link must be on the same IP subnet, because you are creating a point-to-point network connection.

Note that like using inter-VLAN routing, Layer 3 must be involved—you cannot create an inter-VDOM link between Layer 2 transparent mode VDOMs. At least one of the VDOMs must be operating in NAT mode. This, among other benefits, prevents potential Layer 2 loops.

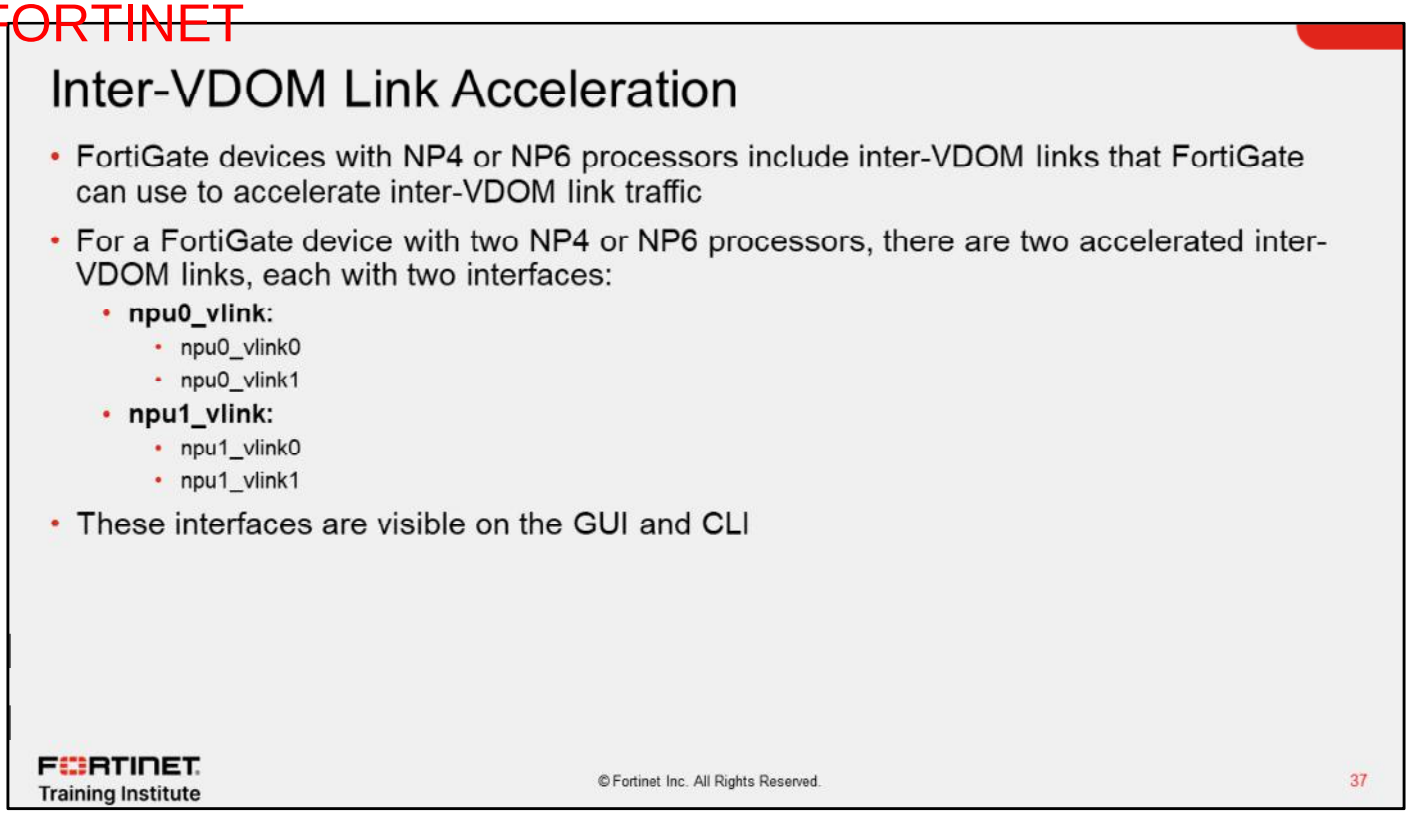


When creating inter-VDOM links, you must create the virtual interfaces. You must also create the appropriate firewall policies in each VDOM, just as you would if the traffic were arriving on a network cable, otherwise, FortiGate will block it.

Additionally, routes are required to correctly route packets between two VDOMs.



On the GUI, you create a network interface in the **Global** settings. To create the virtual interface, click **Create New**, and then select **VDOM Link**.



FortiGate devices with NP4 or NP6 processors include inter-VDOM links that FortiGate can use to accelerate inter-VDOM link traffic. For a FortiGate with two NP4 or NP6 processors, there are two accelerated inter-VDOM links, each with two interfaces:

- **npu0_vlink:**
  - npu0_vlink0
  - npu0_vlink1
- **npu1_vlink:**
  - npu1_vlink0
  - npu1_vlink1

These interfaces are visible on the GUI and CLI. By default, the interfaces in each inter-VDOM link are assigned to the root VDOM. To use these interfaces to accelerate inter-VDOM link traffic, assign each interface in the pair to the VDOMs that you want to offload traffic between. For example, if you have added a VDOM named *New-VDOM* to a FortiGate with NP4 processors, you can click **System** > **Network** > **Interfaces** and edit the **npu0-vlink1** interface and set the VDOM to *New-VDOM***.** This results in an accelerated inter-VDOM link between *root* and *New-VDOM.*

Knowledge Check

1. What is a requirement for creating an inter-VDOM link between two VDOMs?
   - A. The NGFW mode of at least one VDOM must be profile based.
   - ✓ B. At least one of the VDOMs must be operating in NAT mode.

2. Which type of VDOM link requires that both sides of the link be assigned an IP address within the same subnet?
   - A. NAT-to-transparent
   - ✓ B. NAT-to-NAT

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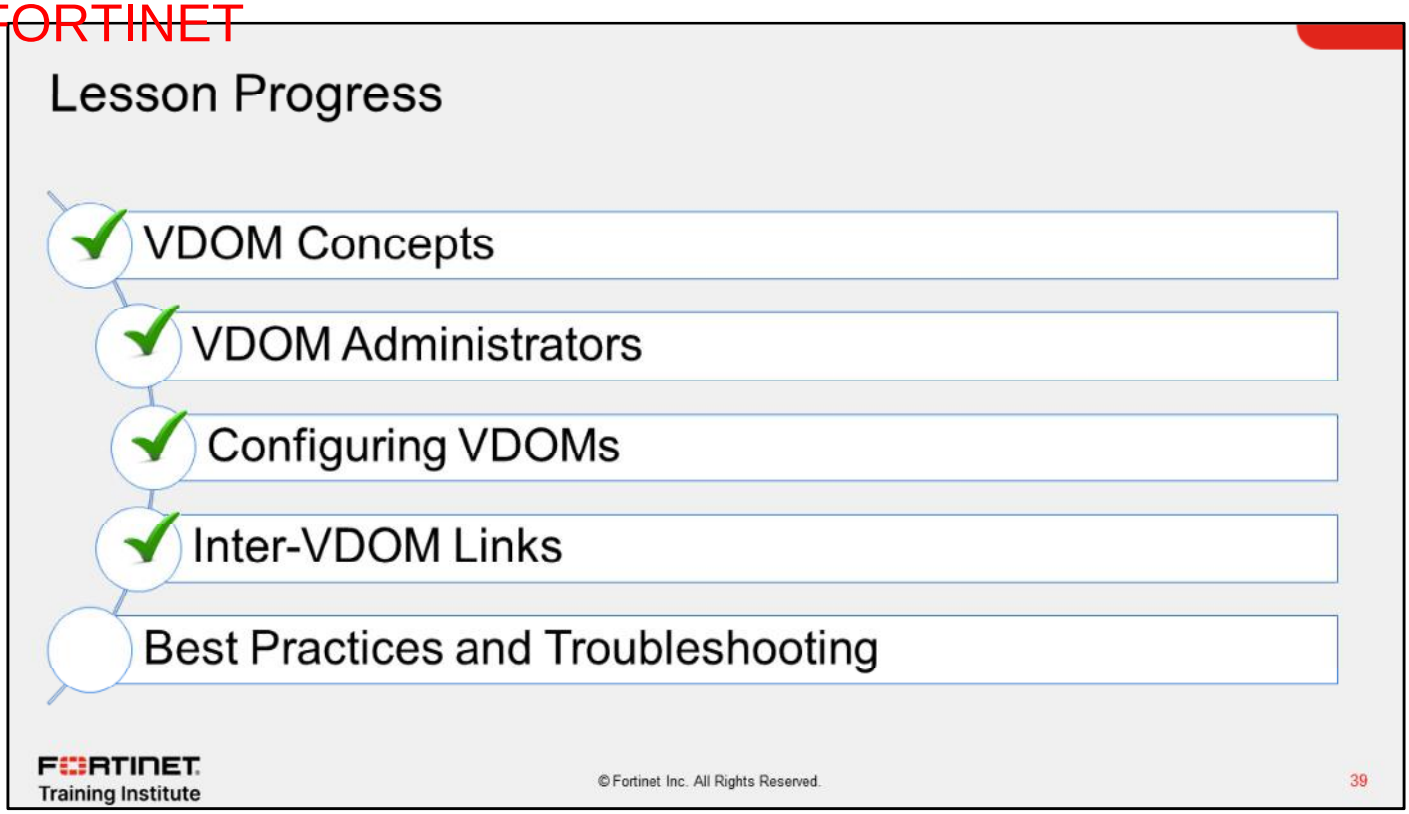
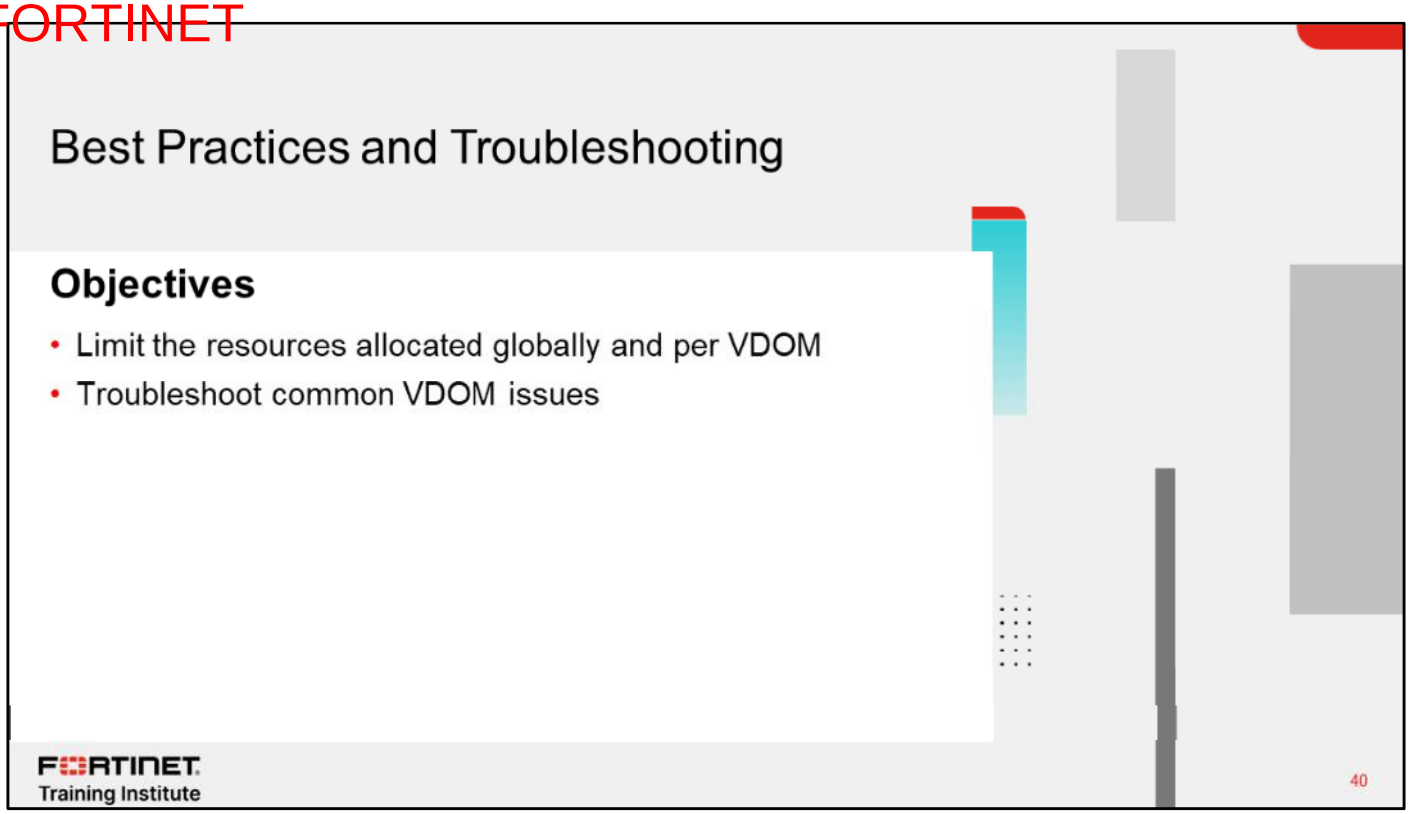


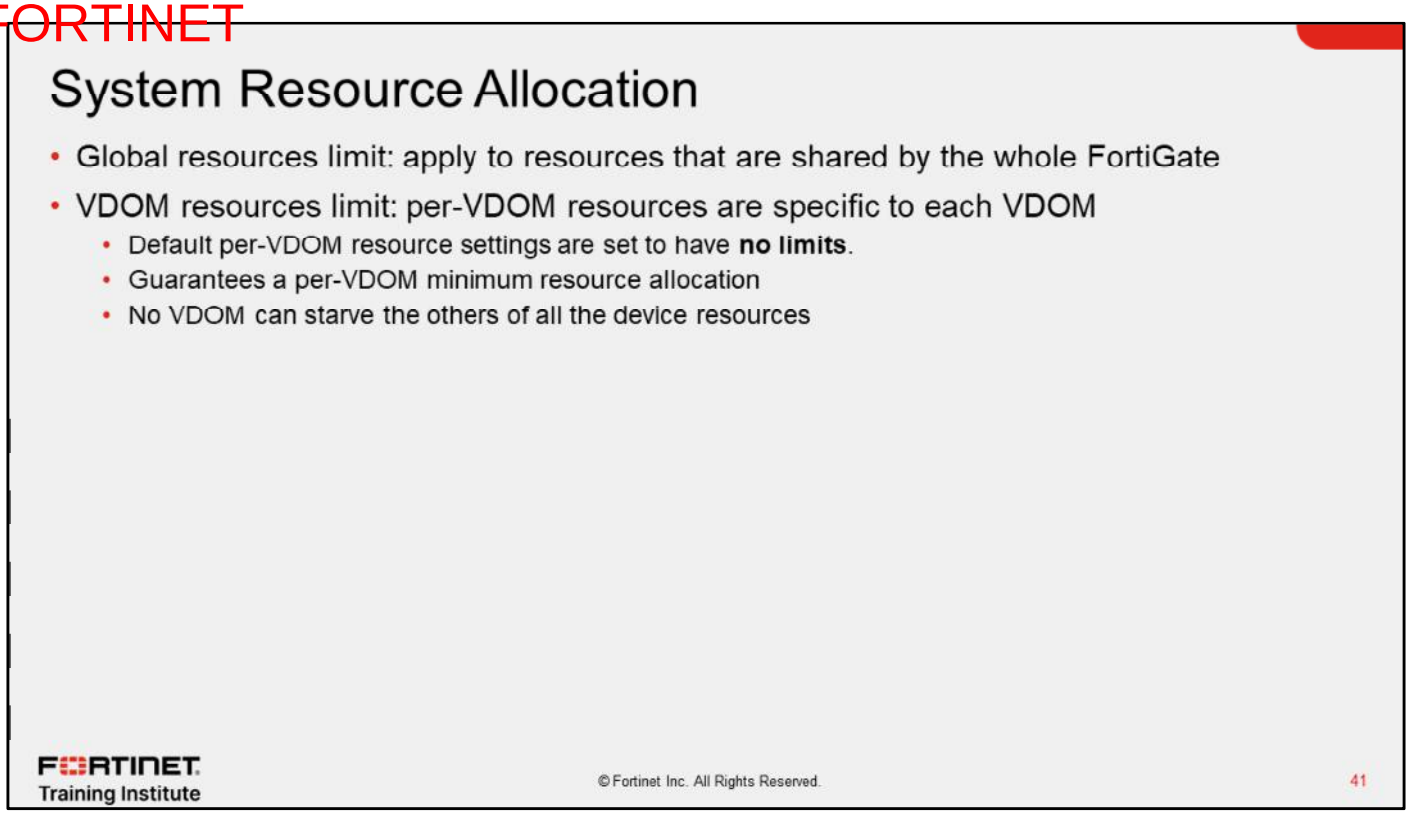
Good job! You now understand inter-VDOM Links.

Now, you'll learn about VDOM best practices and troubleshooting.



After completing this section, you should be able to achieve the objectives shown on this slide.

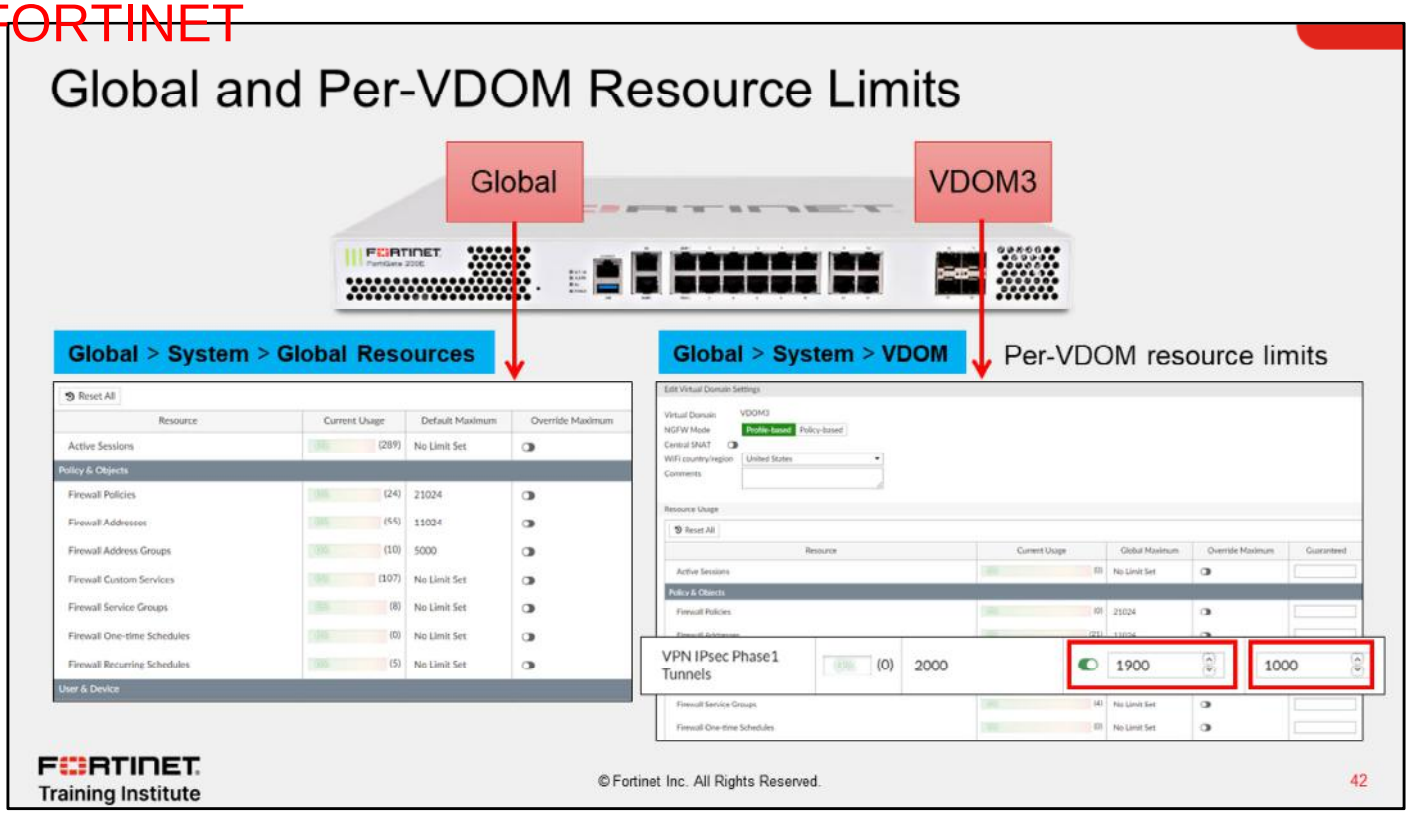
By demonstrating competence in VDOM best practices and troubleshooting, you will be able to prevent, identify, and solve common VDOM issues.



Remember, VDOMs are only a *logical* separation—each VDOM shares physical resources with the others.

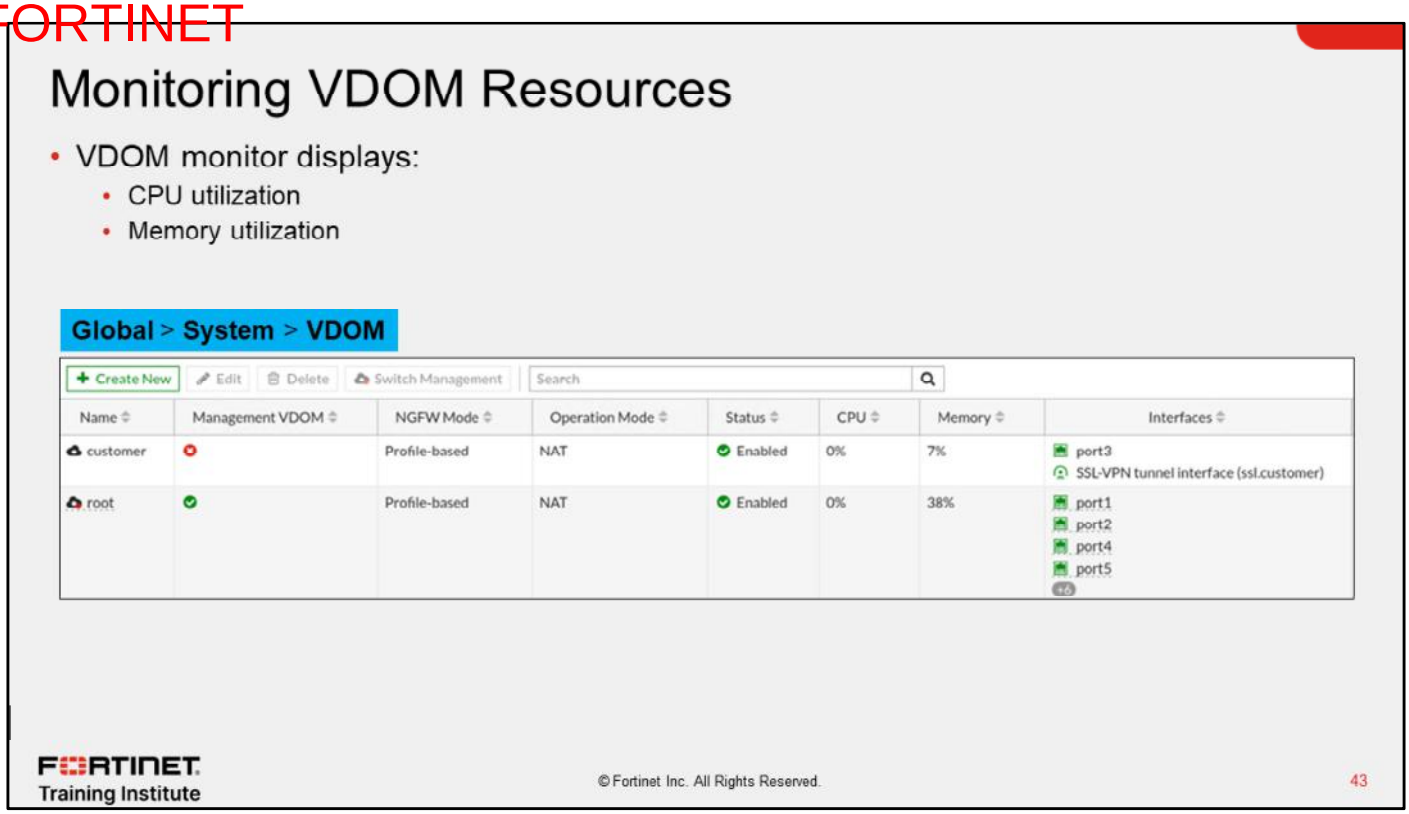
By default, all per-VDOM resource settings are set to have no limits. This means that any single VDOM can use all of the FortiGate device's resources. This could deprive other VDOMs of the resources that they require, to the point that could be unable to function.

Unlike FortiGate-VM, VDOMs are not allocated and balanced with weighted vCPU cores, vRAM, and other virtualized hardware.
To fine-tune performance, you can configure resource limits for each feature—IPsec tunnels, address objects, and so on—at the global level and at each VDOM level. This controls the ratio of the system resource usage of each VDOM to the total available resources.

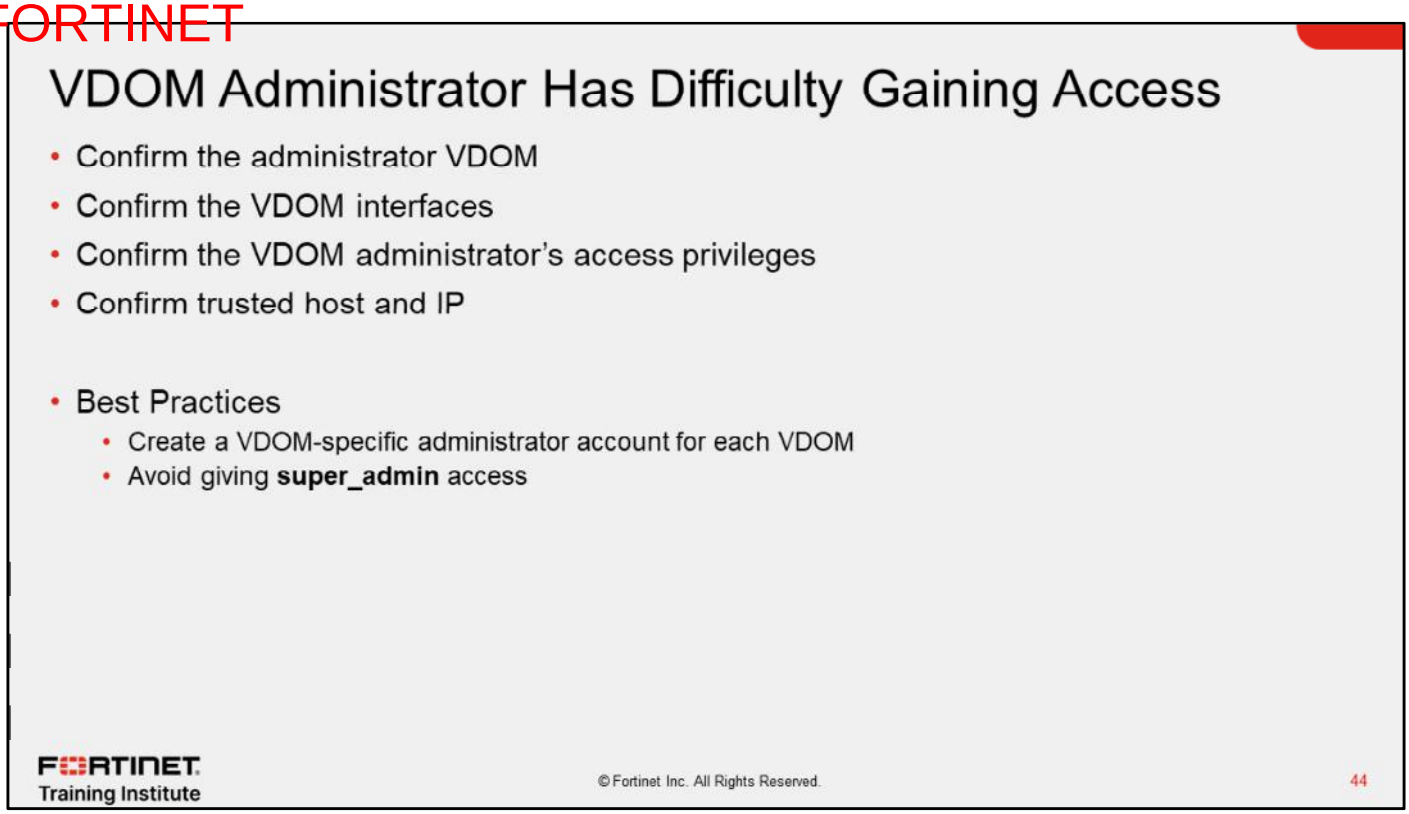


For example, a FortiGate with hardware powerful enough to handle up to 2000 IPsec VPN tunnels and configured with three VDOMs, could be configured as follows to meet specific criteria: VDOM1 and VDOM2 don't use IPsec VPN tunnels often. So, they are allowed to have up to 50 tunnels each. VDOM3, however, uses VPN extensively. Therefore, this FortiGate device is configured to allow VDOM3 to have up to 1900 tunnels, with 1000 guaranteed.

Configure your FortiGate device with global limits for critical features, such as sessions, policies, and so on. Then, configure each VDOM with its own quotas and minimums, within the global limits.



On the GUI, you can click **Global** > **System** > **VDOM** to see the VDOM monitor. It displays the CPU and memory usage for each VDOM.



With VDOMs configured, administrators have an extra layer of permissions and may have problems accessing the desired information. If an administrator cannot gain access, check the following:

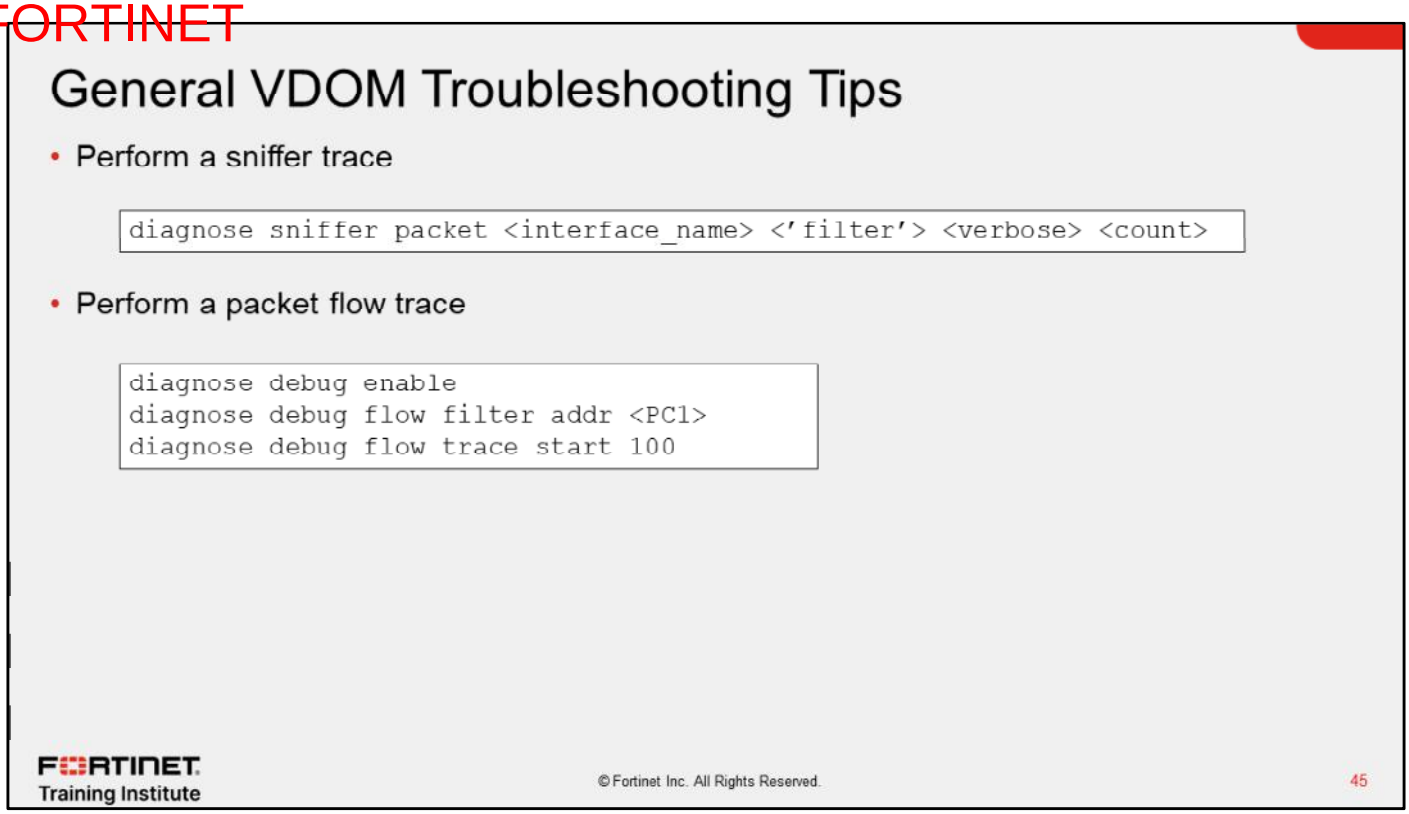
- Confirm the administrator's VDOM: each administrator account, other than the **super_admin** account, is tied to one or more specific VDOMs. That administrator is not able to access any other VDOM. It may be possible they are trying to access the wrong VDOM (one that they do not have permissions for).

- Confirm the VDOM interfaces: an administrator can access their VDOM only through interfaces that are assigned to that VDOM. If interfaces on that VDOM are disabled or unavailable, there will be no method of accessing that VDOM by its local administrator. The **super_admin** is required to either bring up the interfaces, fix the interfaces, or move another interface to that VDOM to restore access.

- Confirm the VDOM admin access: as with all FortiGate devices, administration access on the VDOM's interfaces must be enabled for the administrators of that VDOM to gain access. For example, if SSH is not enabled, that is not available to administrators. To enable admin access, the **super_admin** clicks **Global** > **Network** > **Interfaces** and enables administrator access for the interface in question.

- Confirm trusted host and IP: if trusted hosts are enabled on the administrator account, ensure the user is connecting from the correct, specified host address, and that no intermediate devices are performing NAT functions on the connection.

Best practice dictates that you should usually avoid unnecessary security holes. Do not provide **super_admin** access, if possible. Instead, restrict each administrator to their relevant domain. That way, they cannot accidentally or maliciously impact other VDOMs, and any damage or mistakes will be limited in scope.



Besides ping and traceroute, there are additional tools for troubleshooting your VDOM configurations. The primary tools for VDOM troubleshooting include packet sniffing and debugging the packet flow.

- Perform a sniffer trace: when troubleshooting networks, it helps to look inside the headers of packets to determine if they are traveling along the expected route. Packet sniffing can also be called a network tap, packet capture, or logic analyzing. The sniffer also indicates what traffic is entering or leaving the egress and ingress interfaces in all VDOMS. This makes it extremely useful for troubleshooting inter-VDOM routing issues.

- Debug the packet flow: traffic should enter and leave the VDOM. If you have identified that network traffic is not entering and leaving the VDOM as expected, debug the packet flow. You can debug only using CLI commands. This tool provides more granular details for help in troubleshooting inter-VDOM traffic because it gives details of routing selection, NAT, and policy selection.

Knowledge Check

1. Of these options, what is a possible reason why an administrator might not be able to gain access to a specific VDOM?
   - ✓ A. The administrator is using an IP address that is not specified as a trusted host.
   - B. The administrator is using the super_admin profile.

2. Which troubleshooting tool is most suitable when trying to verify the firewall policy used by an inter-VDOM link?
   - A. Sniffer trace
   - ✓ B. Packet flow trace

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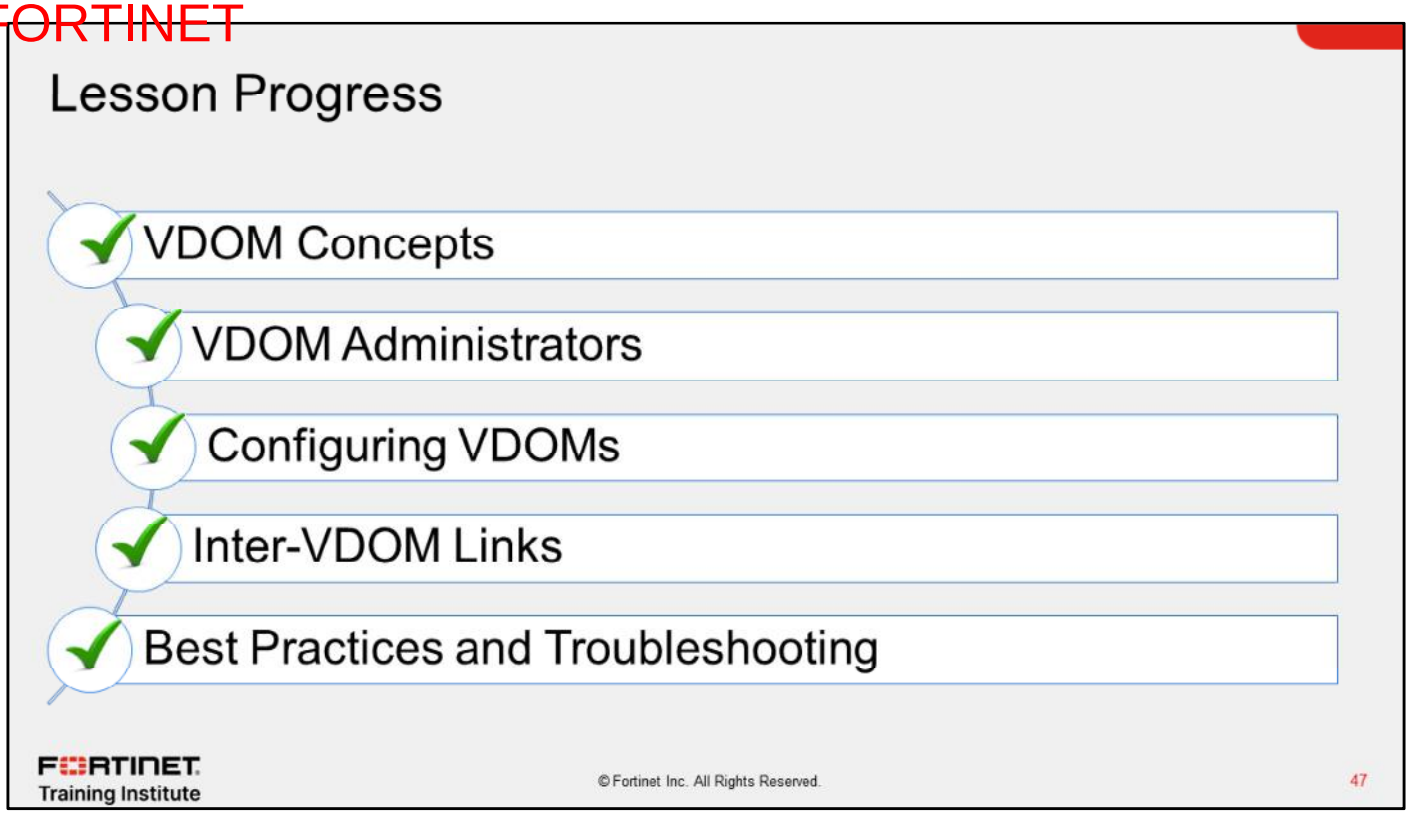
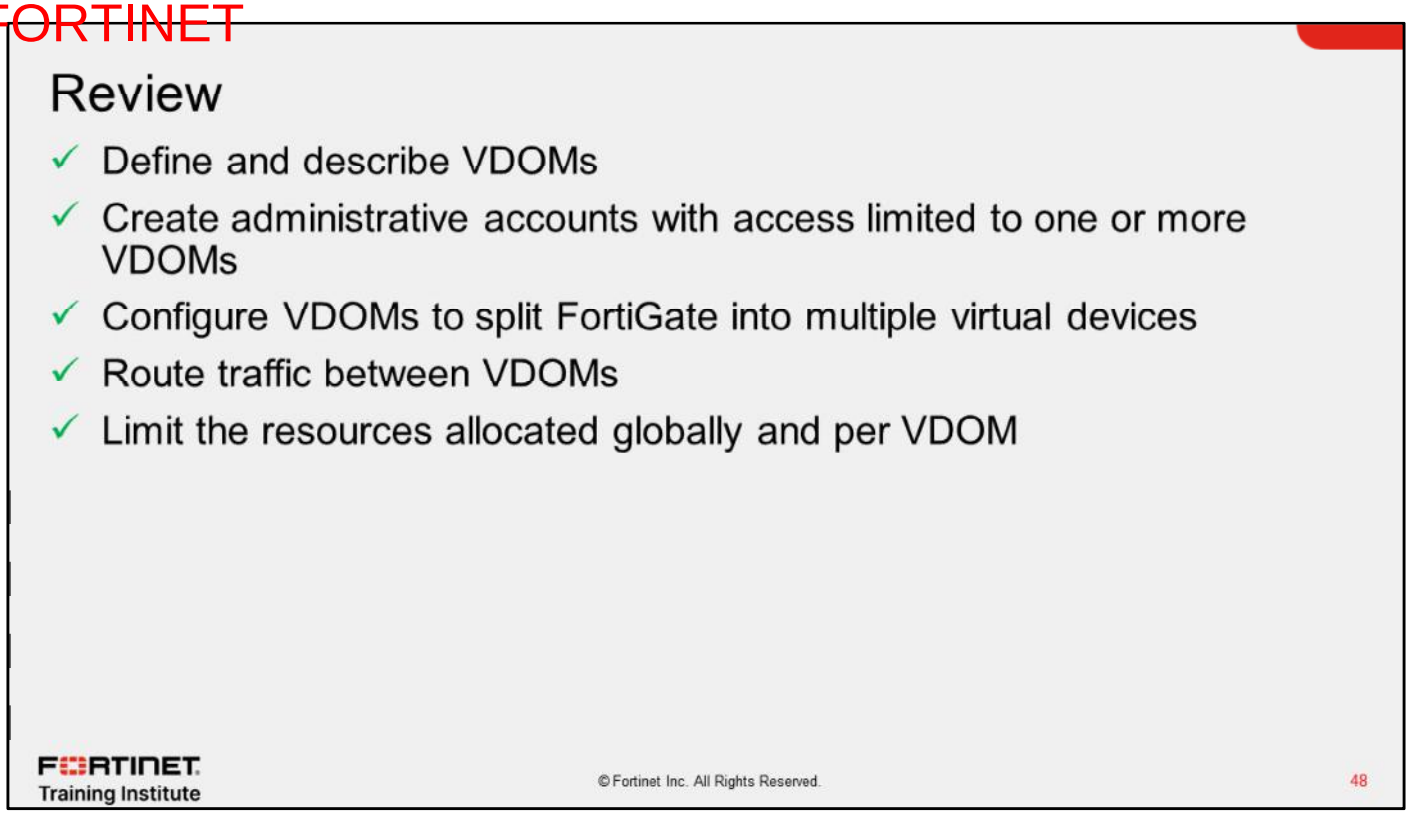


Congratulations! You have completed this lesson.

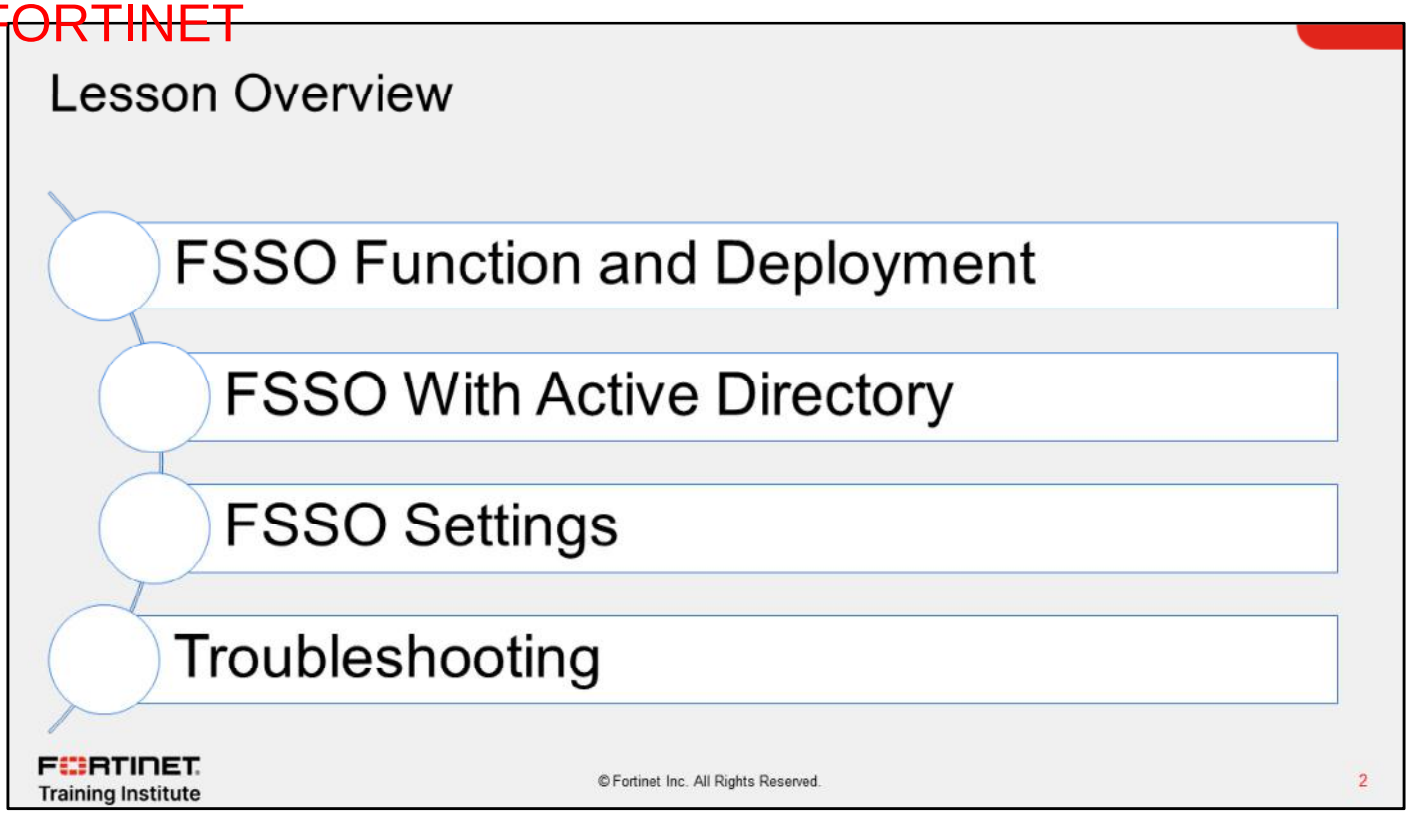
Now, you will review the objectives that you covered in this lesson.



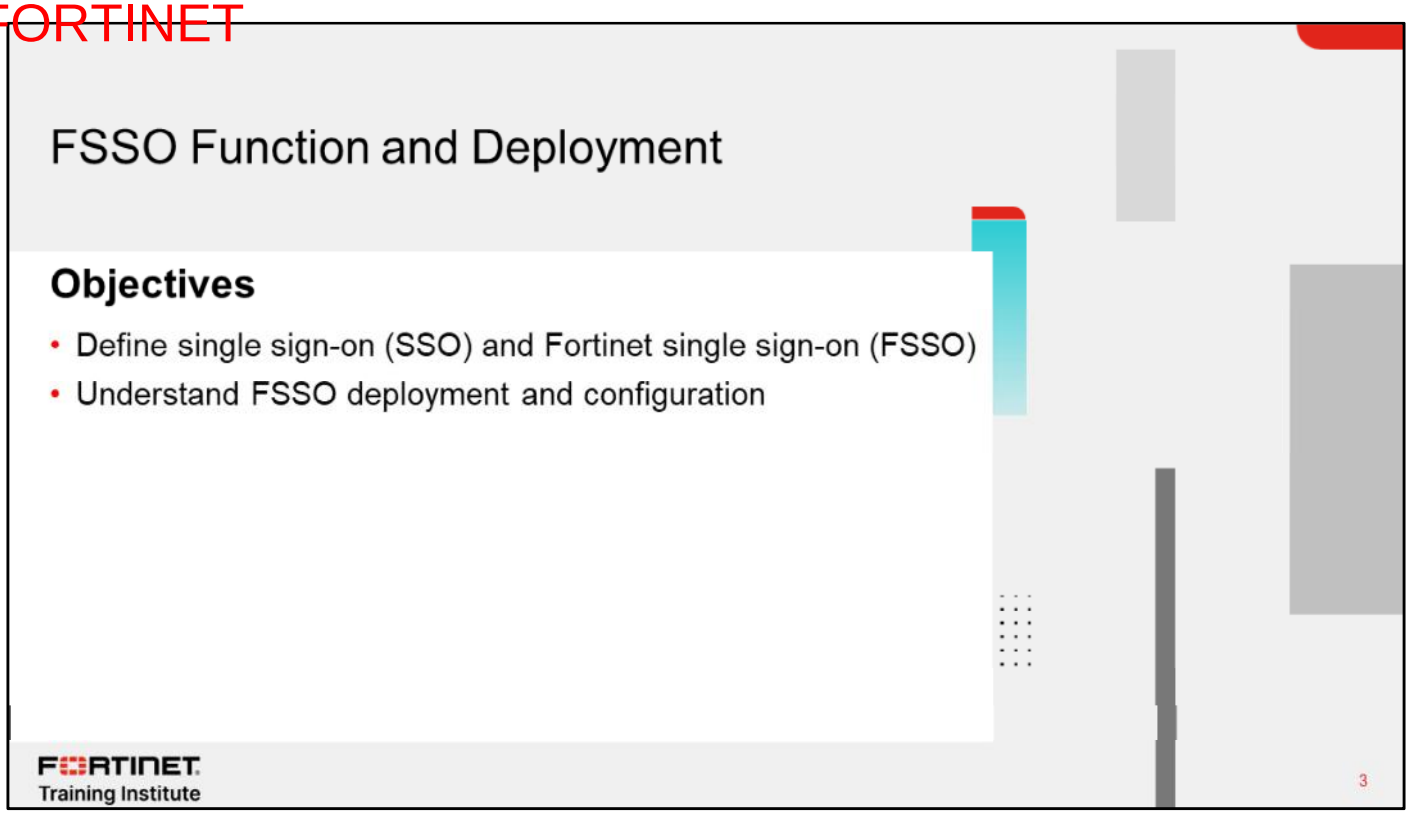
This slide shows the objectives that you covered in this lesson.

By mastering the objectives covered in this lesson, you learned how to configure VDOMs, and examined examples of common use.

In this lesson, you will learn about Fortinet single sign-on (FSSO). When you use this feature, your users don't need to log on each time they access a different network resource.

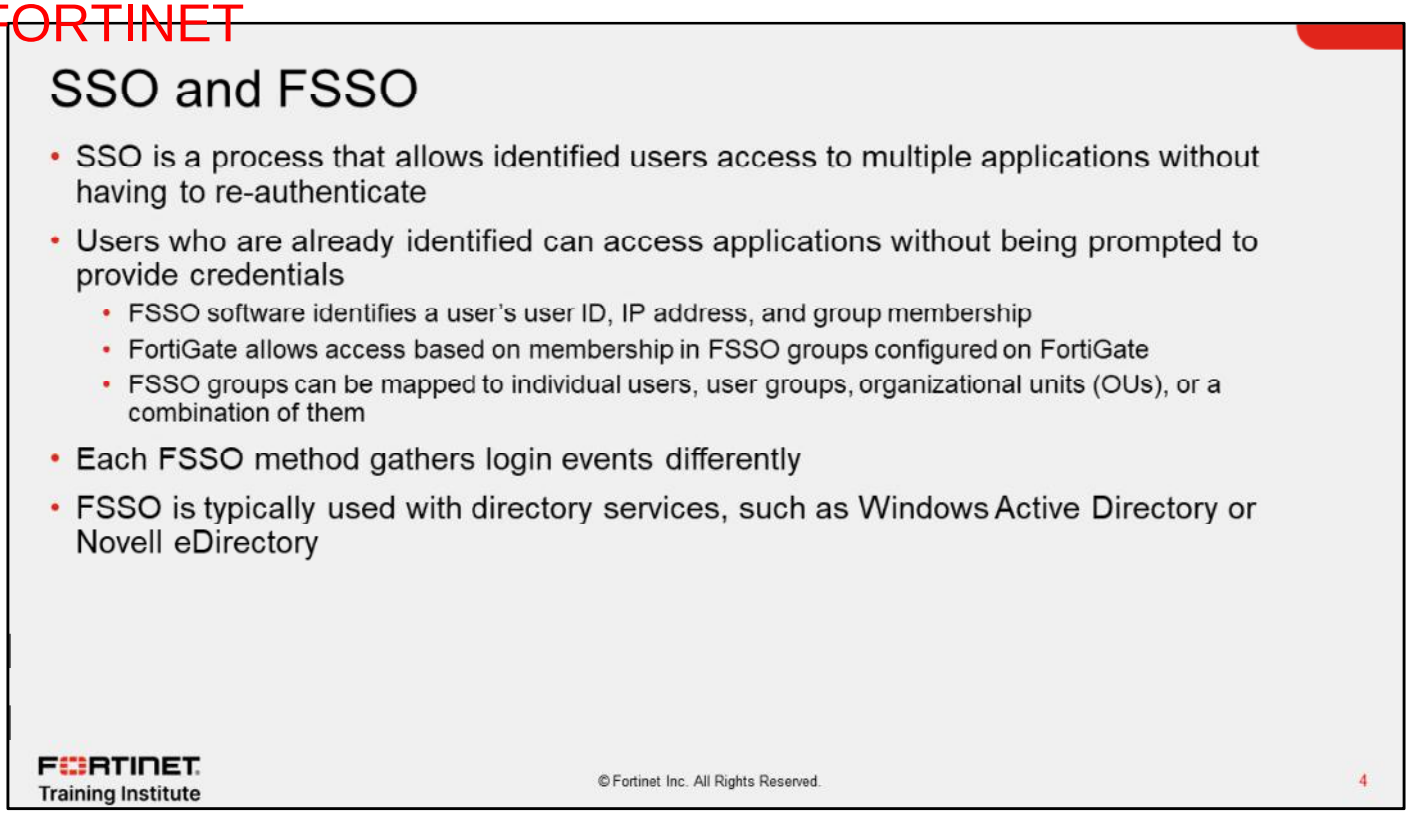


In this lesson, you will learn about the topics shown on this slide.



After completing this section, you should be able to achieve the objectives shown on this slide.

By demonstrating competence in understanding SSO concepts, you will be able to more effectively understand FSSO methods.

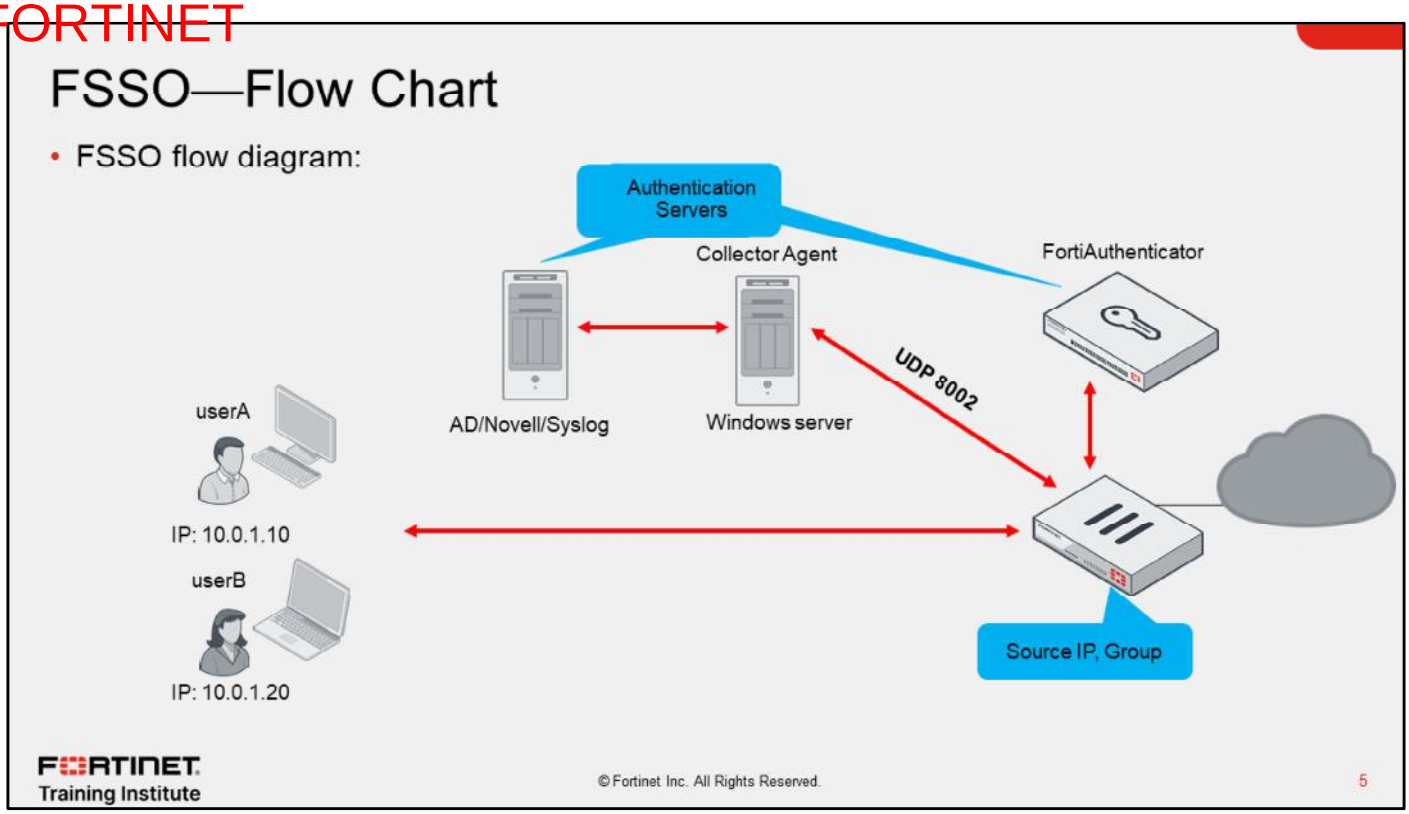


SSO is a process that allows users to be automatically logged in to every application after being identified, regardless of platform, technology, and domain.

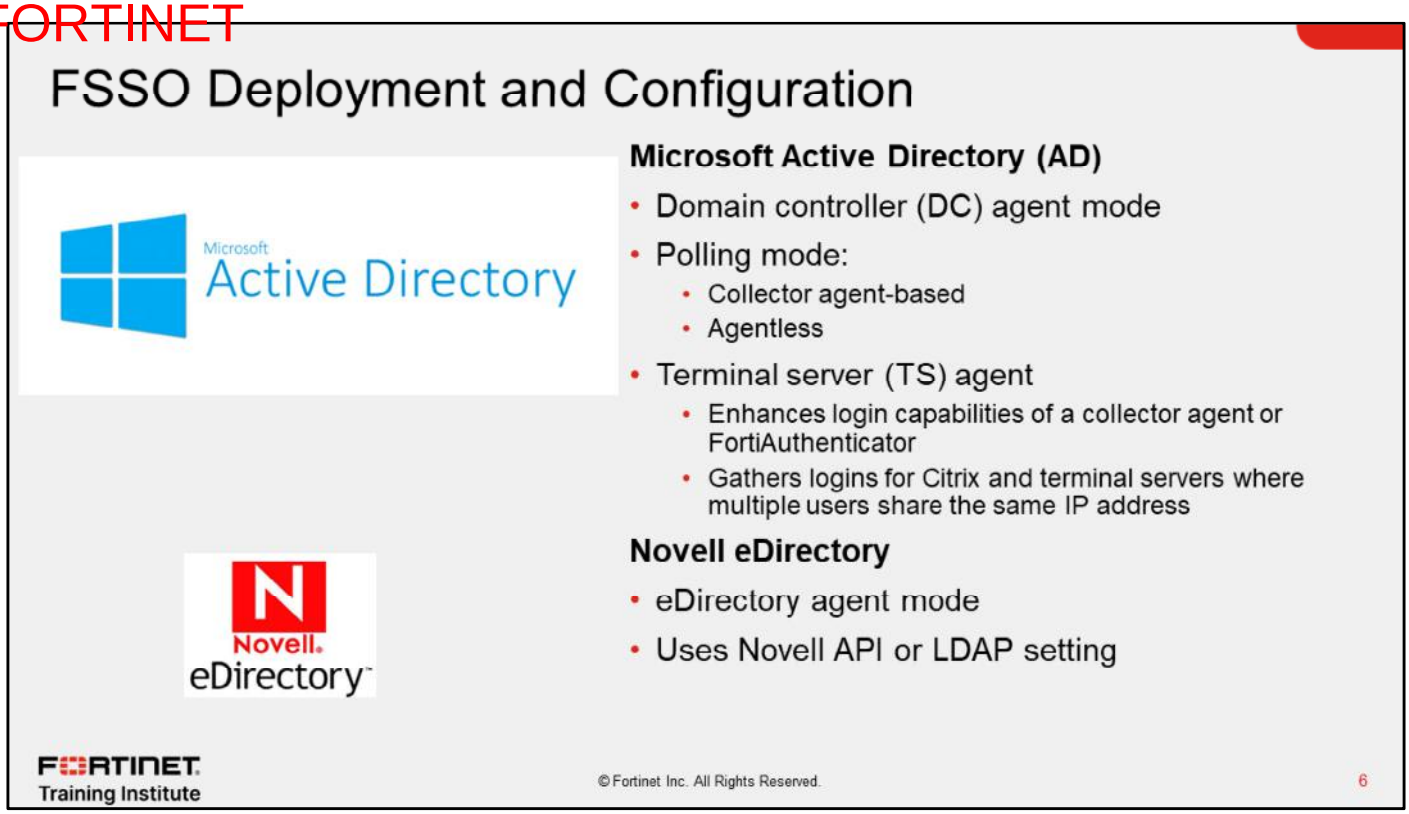
FSSO is a software agent that enables FortiGate to identify network users for security policies or for VPN access, in advanced deployments with FortiAuthenticator, without asking for their username and password. When a user logs in to a directory service, the FSSO agent sends FortiGate the username, the IP address, and the list of groups that the user belongs to. FortiGate uses this information to maintain a local database of usernames, IP addresses, and group mappings.

Because the domain controller authenticates users, FortiGate does not perform authentication. When the user tries to access network resources, FortiGate selects the appropriate security policy for the destination. If the user belongs to one of the permitted user groups, the connection is allowed.

FSSO is typically used with directory service networks such as Windows Active Directory or Novell eDirectory.



This slide shows the FSSO flow we discussed in the previous slide.

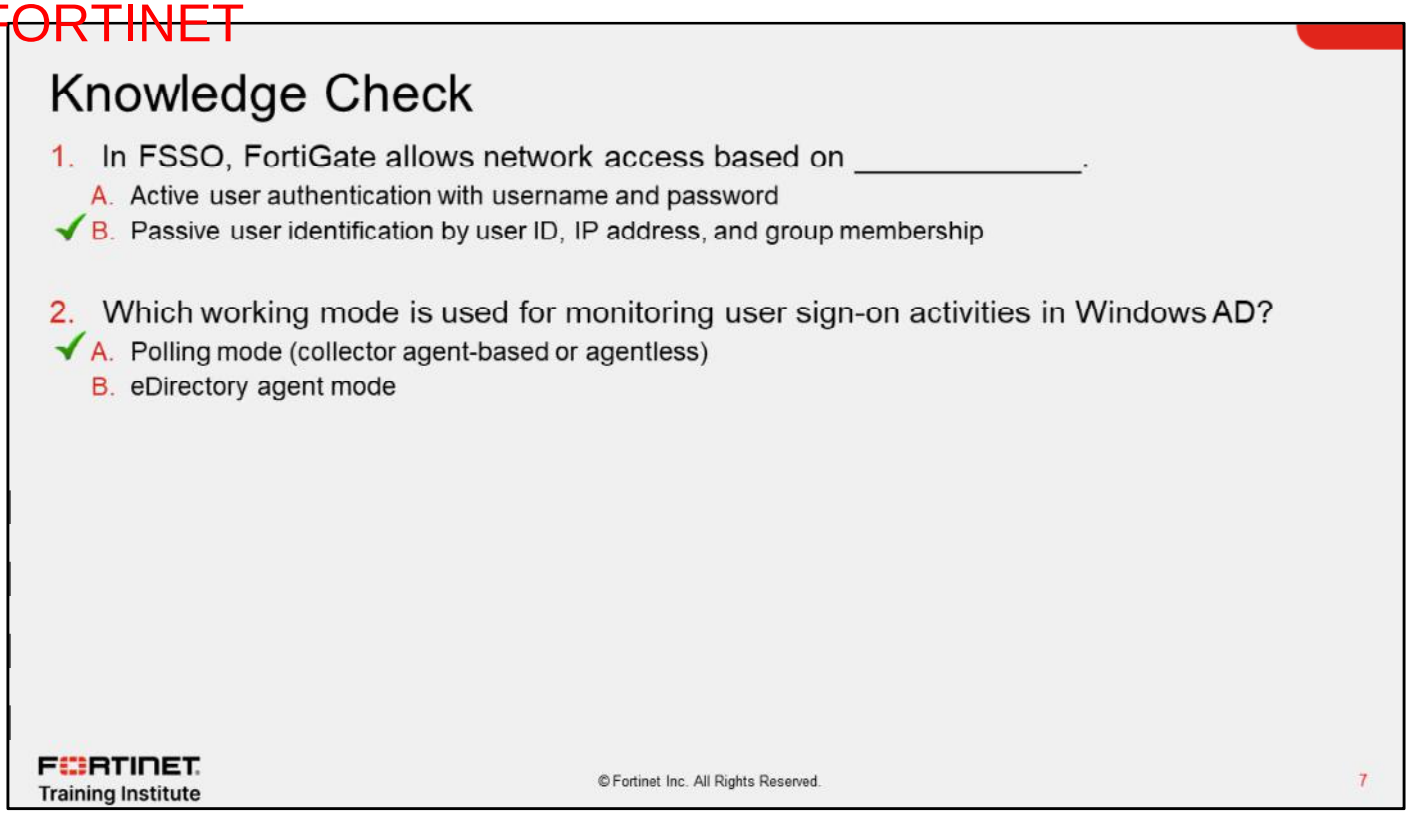


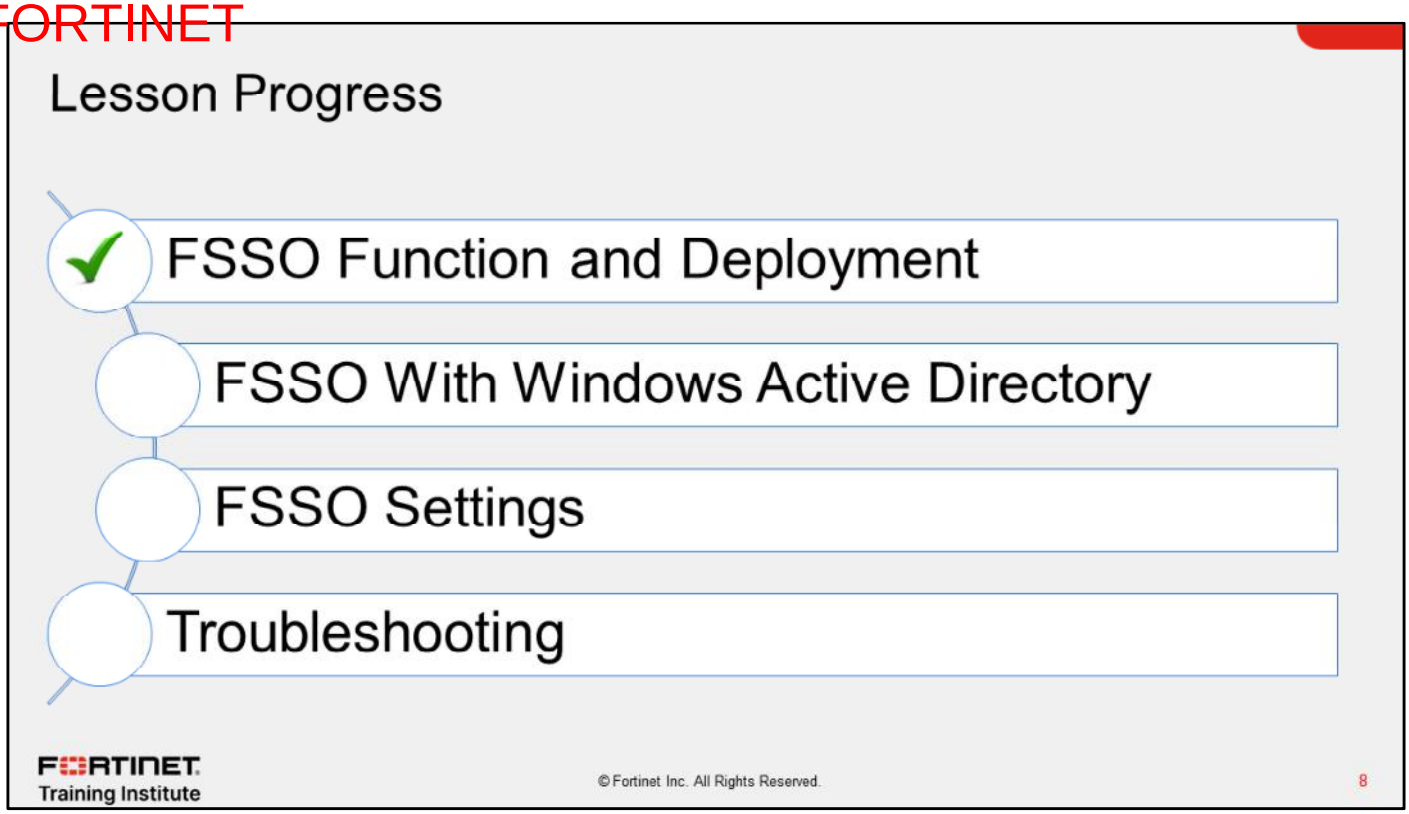
How you deploy and configure FSSO depends on the server that provides your directory services.

FSSO for Windows Active Directory (AD) uses a collector agent. Domain controller (DC) agents may also be required, depending on the collector agent working mode. There are two working modes that monitor user sign-on activities in Windows: DC agent mode and polling mode. FortiGate also offers a polling mode that does not require a collector agent, which is intended for simple networks with a minimal number of users.

There is another kind of DC agent that is used exclusively for Citrix and terminal services environments: terminal server (TS) agents. TS agents require the Windows Active Directory collector agent or FortiAuthenticator to collect and send the login events to FortiGate.

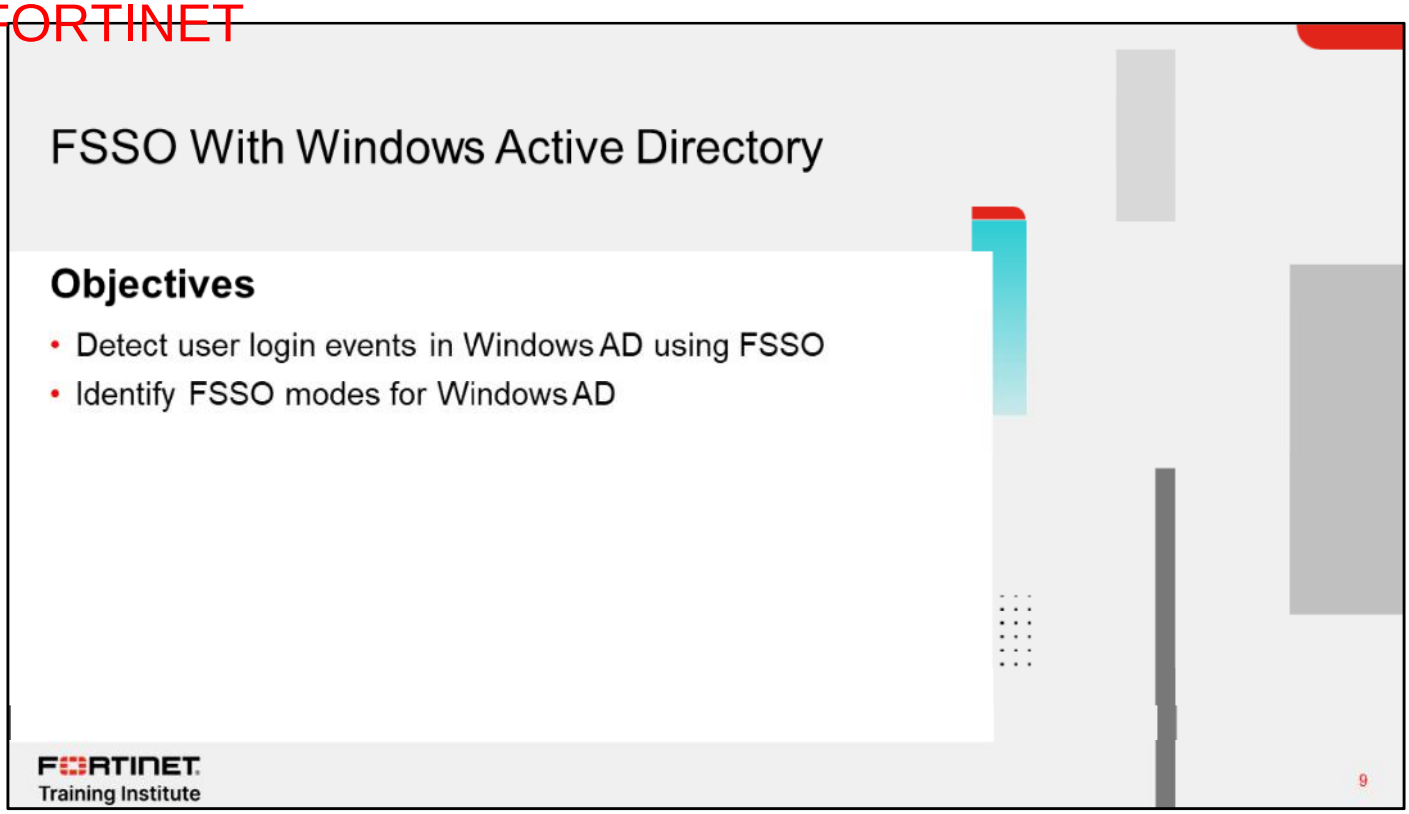
The eDirectory agent is installed on a Novell network to monitor user sign-ons and send the required information to FortiGate. It functions much like the collector agent on a Windows AD domain controller. The agent can obtain information from the Novell eDirectory using either the Novell API or LDAP.





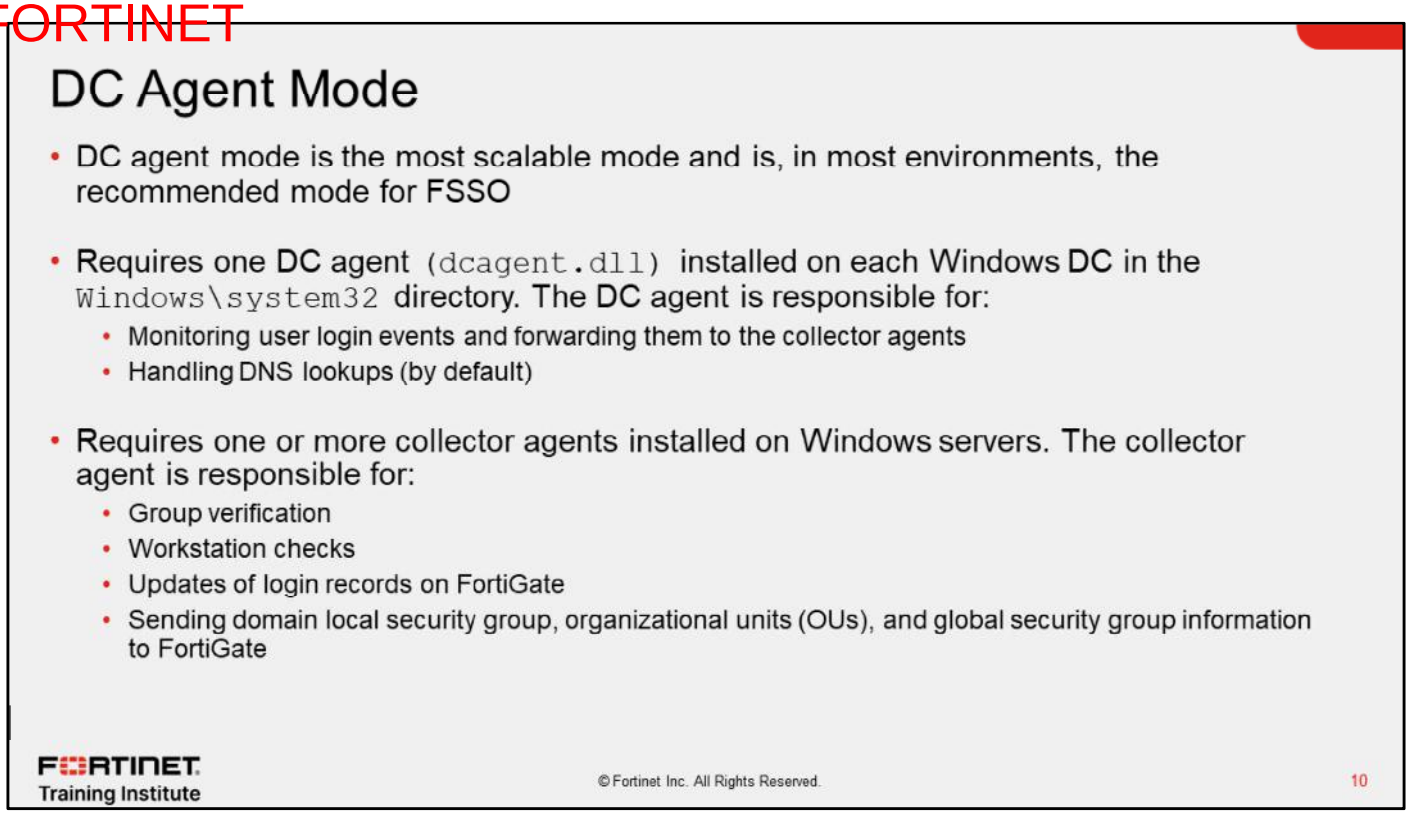
Good job! You now understand basic concepts about the function of FSSO and how it is deployed.

Now, you'll learn about user login events in Windows Active Directory using FSSO.



After completing this section, you should be able to achieve the objectives shown on this slide.

By demonstrating competence in understanding the different ways you can configure FSSO for Windows AD, you will be better able to design the architecture of your SSO system.



DC agent mode is considered the recommended mode for FSSO.

DC agent mode requires:

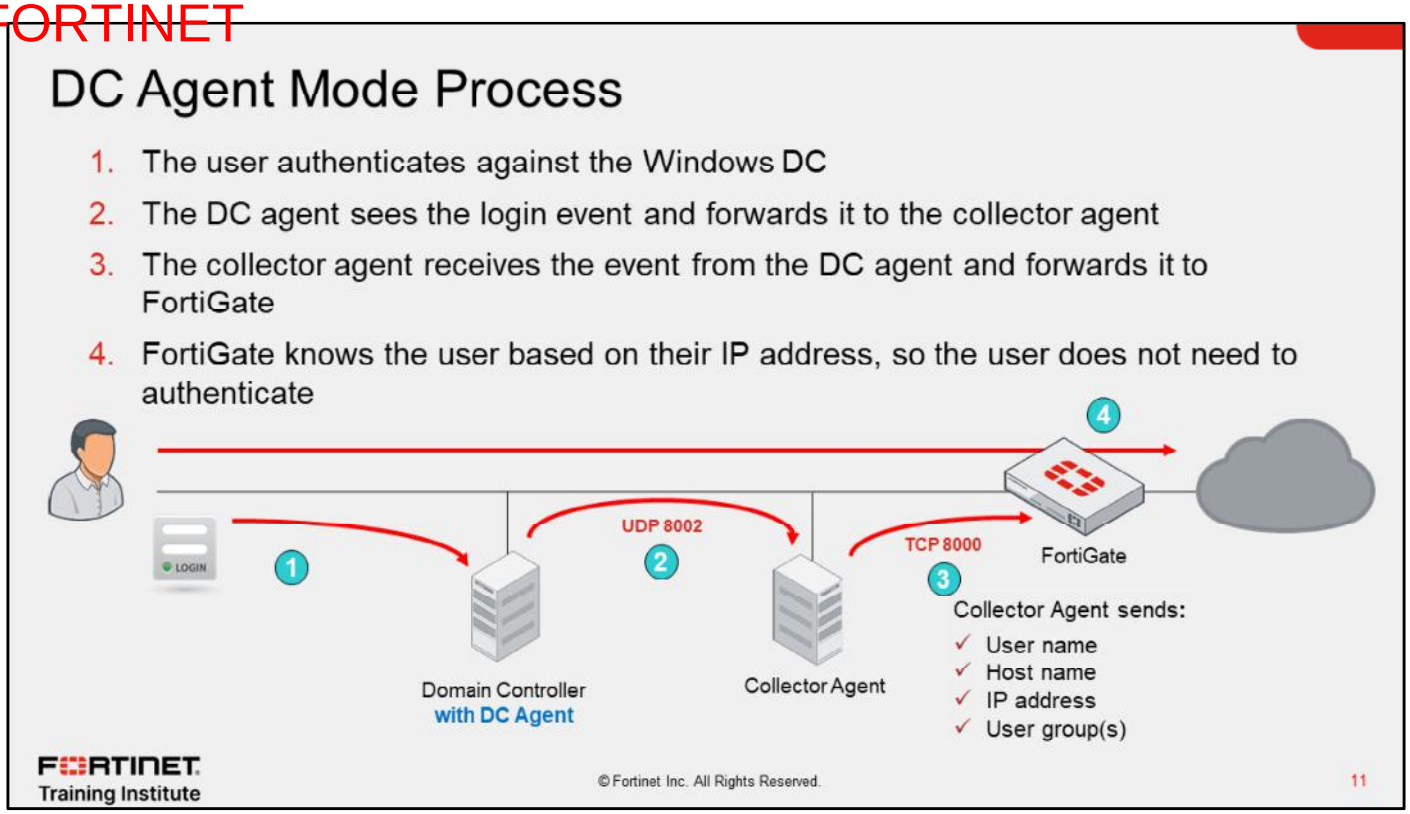
- One DC agent installed on each Windows DC
  If you have multiple DCs, this means that you need multiple DC agents. DC agents monitor and forward user login events to the collector agents.

- A collector agent, which is another FSSO component
  The collector agent is installed on a Windows server that is a member of the domain you are trying to monitor. It consolidates events received from the DC agents, then forwards them to FortiGate. The collector agent is responsible for group verification, workstation checks, and FortiGate updates of login records. The FSSO collector agent can send domain local security group, organizational units (OUs), and global security group information to FortiGate devices. It can also be customized for DNS lookups.

  When the user logs on, the DC agent intercepts the login event on the domain controller. It then resolves the DNS of the client, and sends it to the collector agent.

  The collector agent receives it and then performs a DNS resolution in order to check if the IP of the user has changed.

  In some configurations, double DNS resolution is a problem. In this case, you may configure a registry key on the domain controller that hosts the DC agent in order not to resolve the DNS:
  `donot_resolve = (DWORD) 1 at HKLM/Software/Fortinet/FSAE/dcagent`



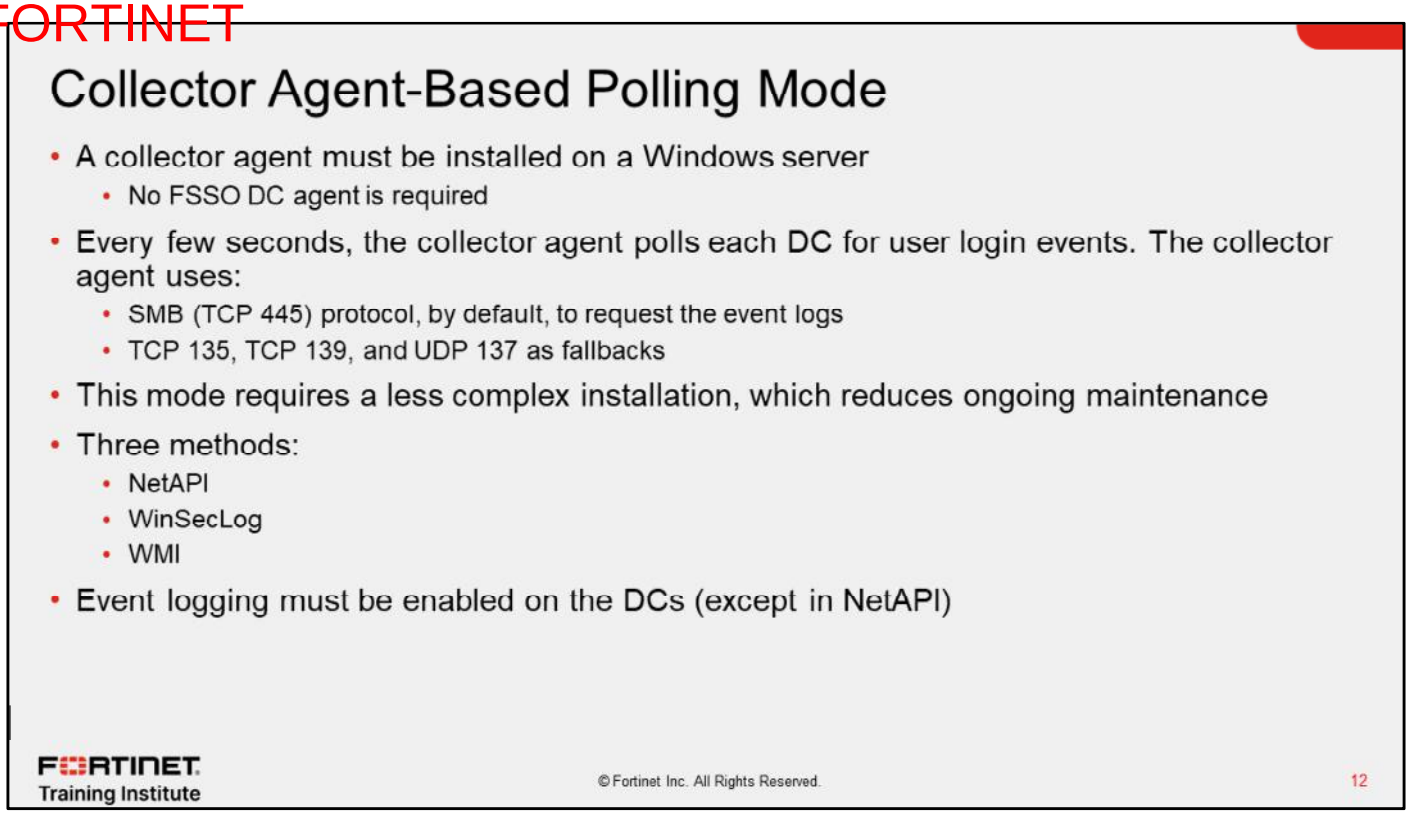
This slide shows the process of information passing between DC agents, the collector agent, and a FortiGate configured for FSSO authentication.

1. When users authenticate with the DC, they provide their credentials.

2. The DC agent sees the login event, and forwards it to the collector agent.

3. The collector agent aggregates all login events and forwards that information to FortiGate. The information sent by the collector agent contains the user name, host name, IP address, and user group(s). The collector agent communicates with FortiGate over TCP port 8000 (default) and it listens on UDP port 8002 (default), for updates from the DC agents. The ports are customizable.

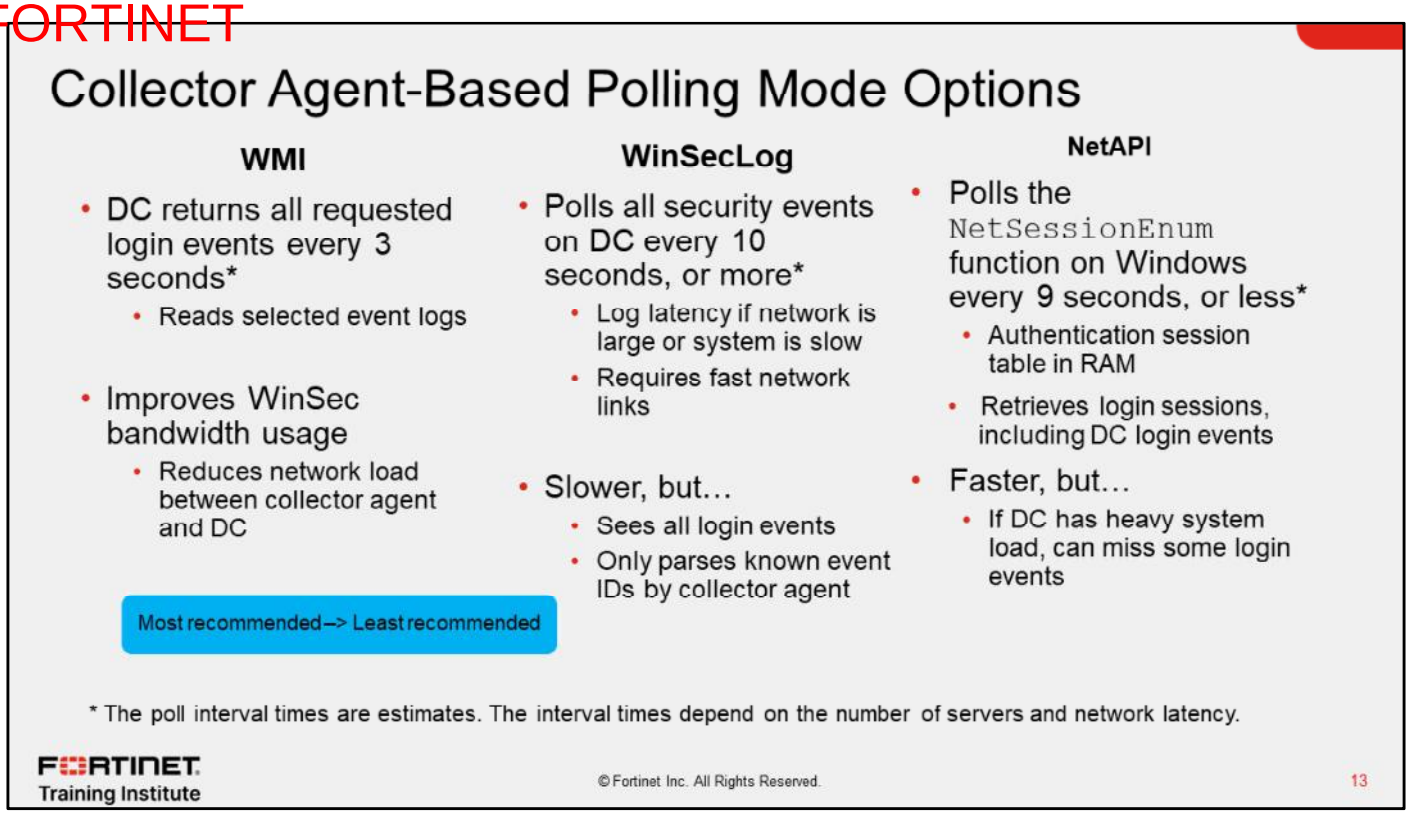
4. FortiGate learns from the collector agent who the user is, their IP address, and some of the AD groups that the user is a member of. When a user tries to access the internet, FortiGate compares the source IP address to its list of active FSSO users. Because the user in this case has already logged in to the domain, and FortiGate already has their information, FortiGate doesn't prompt the user to authenticate again. Rather it allows or denies the traffic based on the matching firewall policy.



Polling mode can be collector agent-based or agentless.

First, you'll look at the collector agent-based polling mode. Like DC agent mode, collector agent-based mode requires a collector agent to be installed on a Windows server, but it *doesn't* require DC agents to be installed on each DC. In collector agent-based polling mode, the collector agent must be more powerful than the collector agent in DC agent mode, and it also generates unnecessary traffic when there have been no login events.

In Windows Event Log Polling, the most commonly deployed polling mode, the collector agent uses the SMB (TCP port 445) protocol to periodically request event logs from the domain controllers. Other methods may gather information differently, but after the login is received by the collector agent, the collector agent parses the data and builds the user login database, which consists of usernames, workstation names/IP addresses, and user group memberships. This information is then ready to be sent to FortiGate.

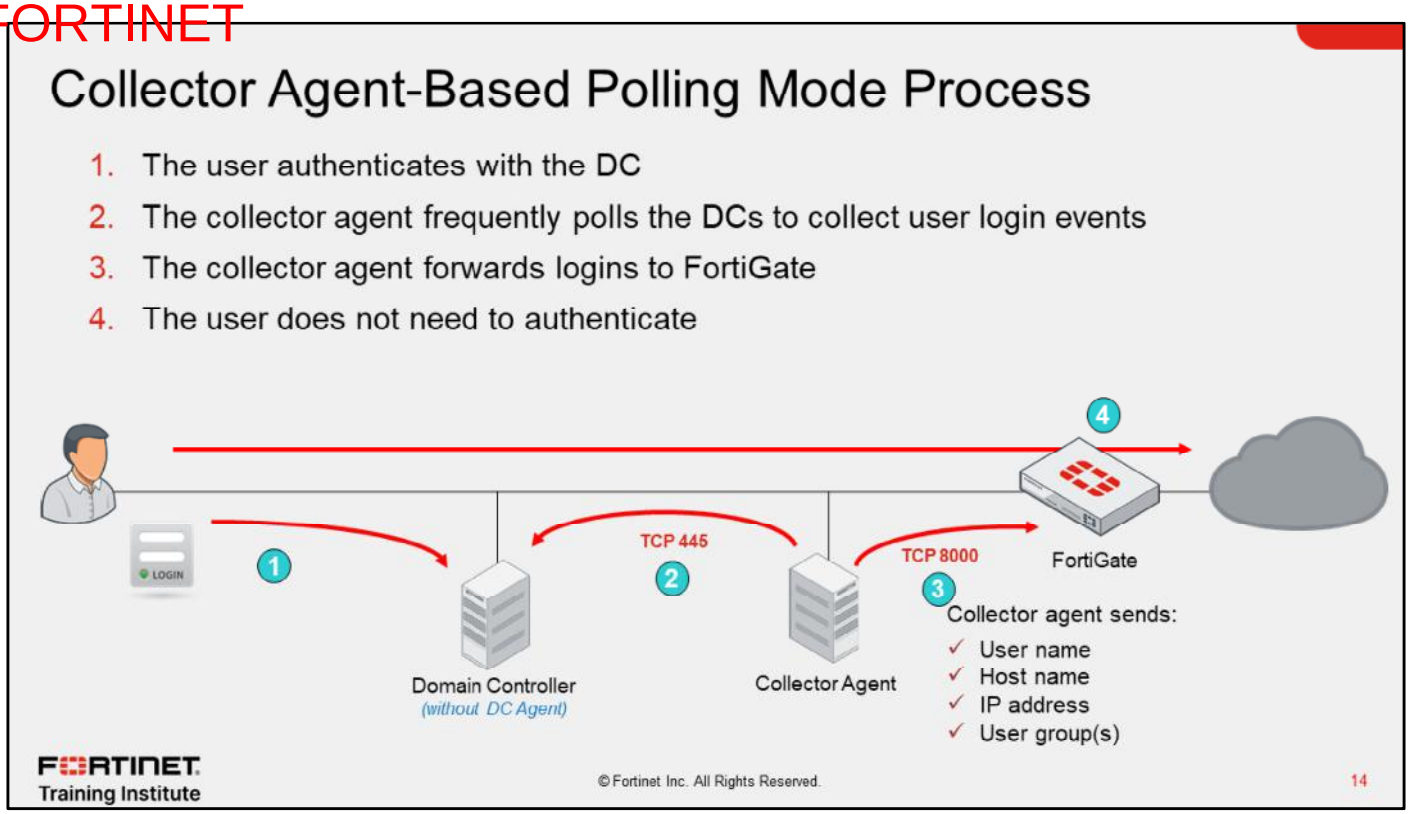


As previously stated, collector agent-based polling mode has three methods (or options) for collecting login information. The order on the slide from left to right shows most recommend to least recommended:

- **WMI**: is a Windows API that gets system information from a Windows server. The DC returns all requested login events. The collector agent is a WMI client and sends WMI queries for user login events to the DC, which, in this case, is a WMI server. The collector agent doesn't need to search security event logs on the DC for user login events; instead, the DC returns all requested login events. This reduces network load between the collector agent and DC.

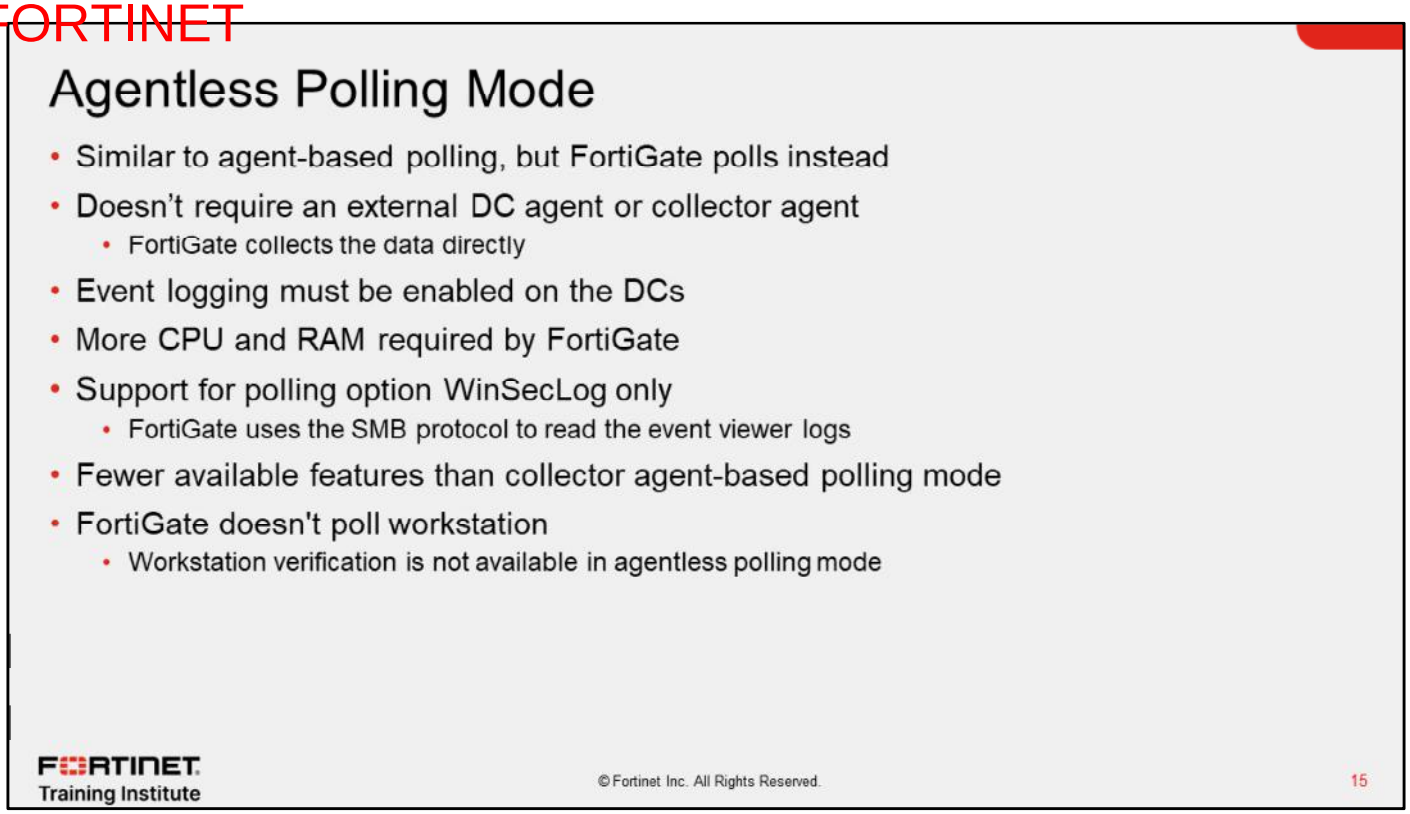
- **WinSecLog**: polls all the security event logs from the DC. It doesn't miss any login events that have been recorded by the DC because events are not normally deleted from the logs. There can be some delay in FortiGate receiving events if the network is large and, therefore, writing to the logs is slow. It also requires that the audit success of specific event IDs is recorded in the Windows security logs. For a full list of supported event IDs, visit the Fortinet Knowledge Base (http://kb.fortinet.com).

- **NetAPI**: polls temporary sessions created on the DC when a user logs in or logs out and calls the `NetSessionEnum` function on Windows. It's faster than the WinSec and WMI methods; however, it can miss some login events if a DC is under heavy system load. This is because sessions can be quickly created and purged from RAM, before the agent has a chance to poll and notify FortiGate.



This slide shows an example of FSSO using the collector agent-based polling mode. This example includes a DC, a collector agent, and FortiGate, but the DC doesn't have the dcagent (or, alternatively, dcagent.dll) installed.

1. The user authenticates with the DC, providing their credentials.
2. The collector agent periodically (every few seconds) polls TCP port 445 of each DC directly, to ask if anyone has logged in.
3. The collector agent sends login information to FortiGate over TCP port 8000. This is the same information that is sent in DC agent mode.
4. When user traffic arrives at FortiGate, FortiGate already knows which users are at which IP addresses, and no repeated authentication is required.

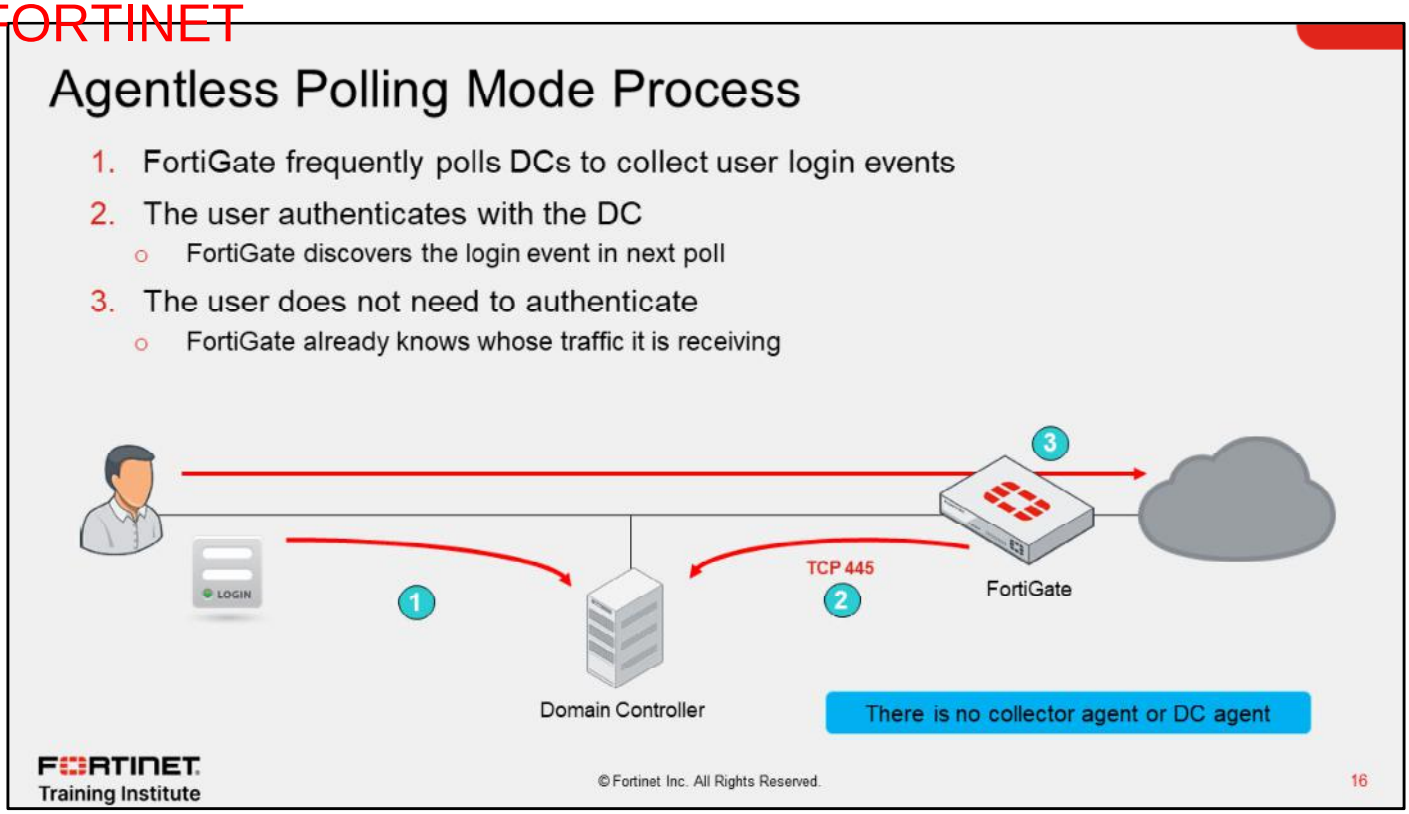


You can deploy FSSO without installing an agent. FortiGate polls the DCs directly, instead of receiving login information indirectly from a collector agent.

Because FortiGate collects all of the data itself, agentless polling mode requires greater system resources, and it doesn't scale as easily.

Agentless polling mode operates in a similar way to WinSecLog, but with only two event IDs: 4768 and 4769. Because there's no collector agent, FortiGate uses the SMB protocol to read the event viewer logs from the DCs.

In agentless polling mode, FortiGate acts as a collector. It is responsible for polling on top of its normal FSSO tasks but does not have all the extra features, such as workstation checks, that are available with the external collector agent.



This slide shows how communication is processed without agents. (There is no collector agent or DC agent.)

1. FortiGate polls the DC TCP port 445 to collect user login events.

2. After the user authenticates with the DC, FortiGate registers a login event during its next poll, obtaining the following information: the user name, the host name, and the IP address. FortiGate then queries for the user's user group(s).

3. When the user sends traffic, FortiGate already knows whose traffic it is receiving; therefore, the user does not need to authenticate.

Comparing Modes

	DC agent mode	Polling mode
Installation	Complex—multiple installations (one per DC). Requires reboot.	Easy—one or no installations. No reboot required.
DC agent required	Yes	No
Resources	Shares with DC agents	Has own resources
Scalability	Higher	Lower
Redundancy	Yes	Yes
Level of confidence	Captures all logins	Might miss a login (NetAPI), or have a delay (WinSecLog)

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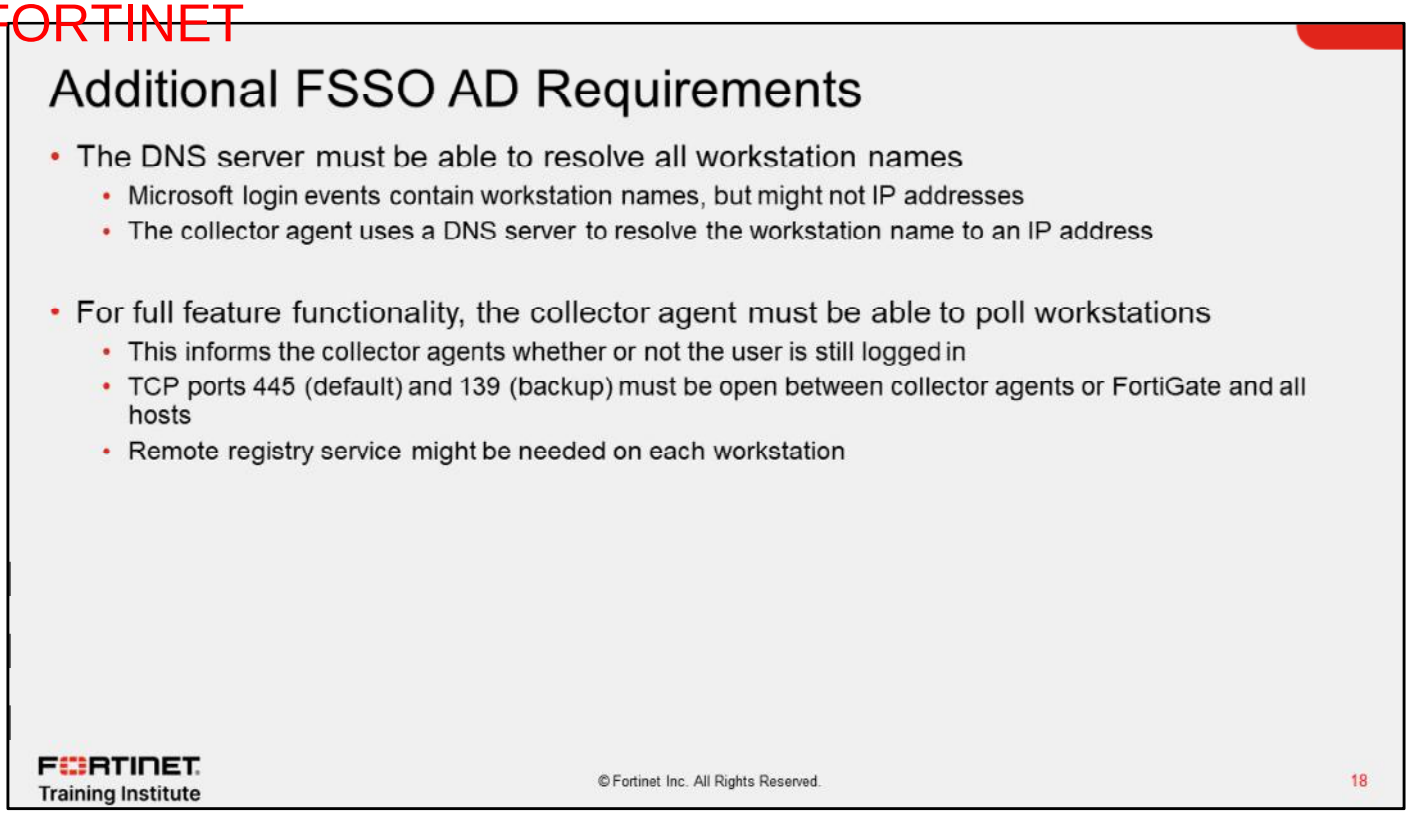
This table summarizes the main differences between DC agent mode and polling mode.

DC agent mode is more complex. It requires not only a collector agent, but also a DC agent for each monitored domain controller. However, it is also more scalable because the work of capturing logins is done by the DC agents who pass their information directly to the collector.

In polling mode, the collector needs to query every domain controller, every few seconds. So, with each DC that is added, the number of queries grows. If you want to add a second collector agent for redundancy in polling mode, both collector agents need to query every DC individually.

In DC agent mode, the DC agent just has to collect the log once, and send a copy of the necessary information to all the collector agents. In comparison, if you use polling mode, some login events might be missed or delayed, depending on the polling option used.

You do not have to install a collector agent on the DC, you can install it on any Windows machine on the network.



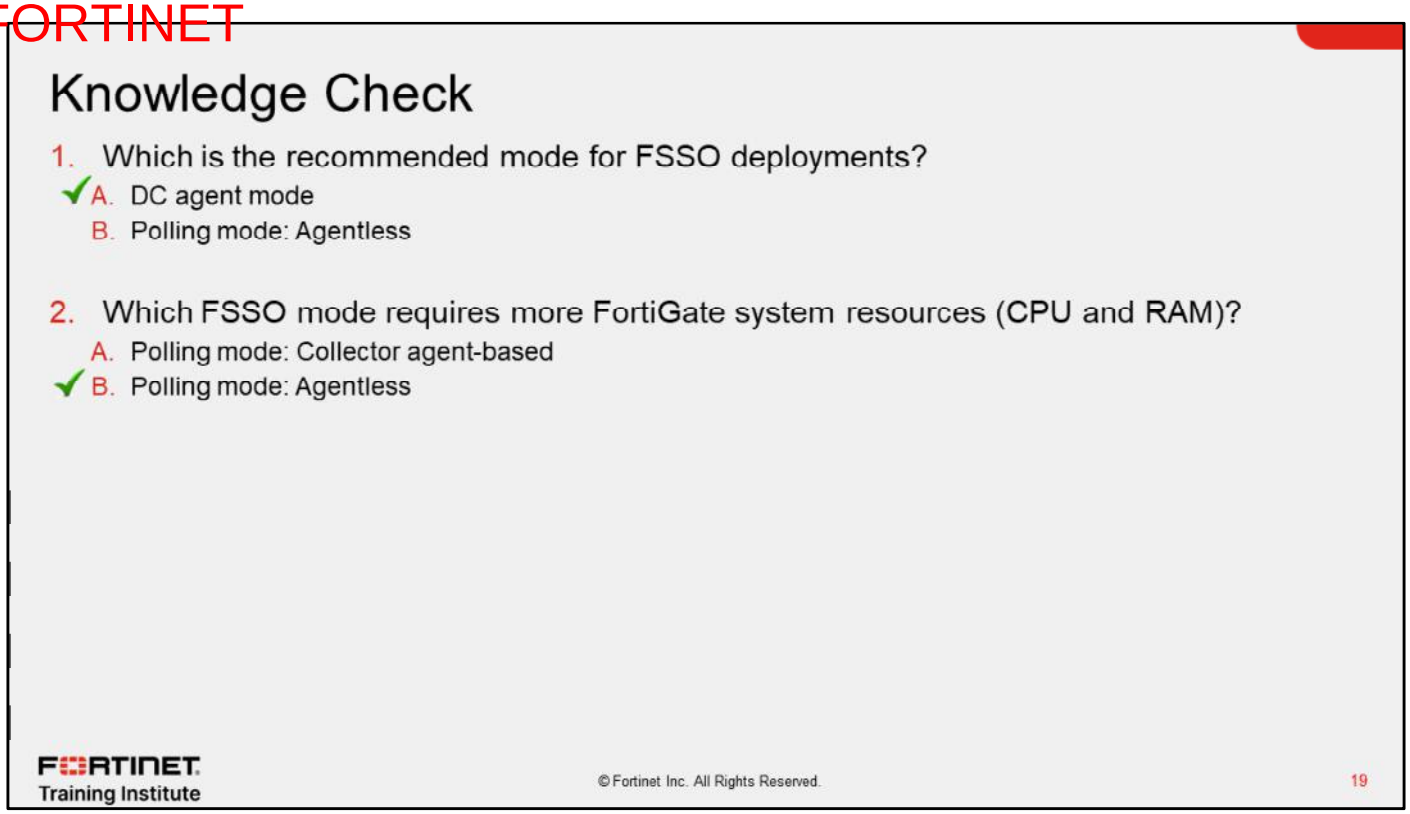
Regardless of the collector method you choose, some FSSO requirements for your AD network are the same:

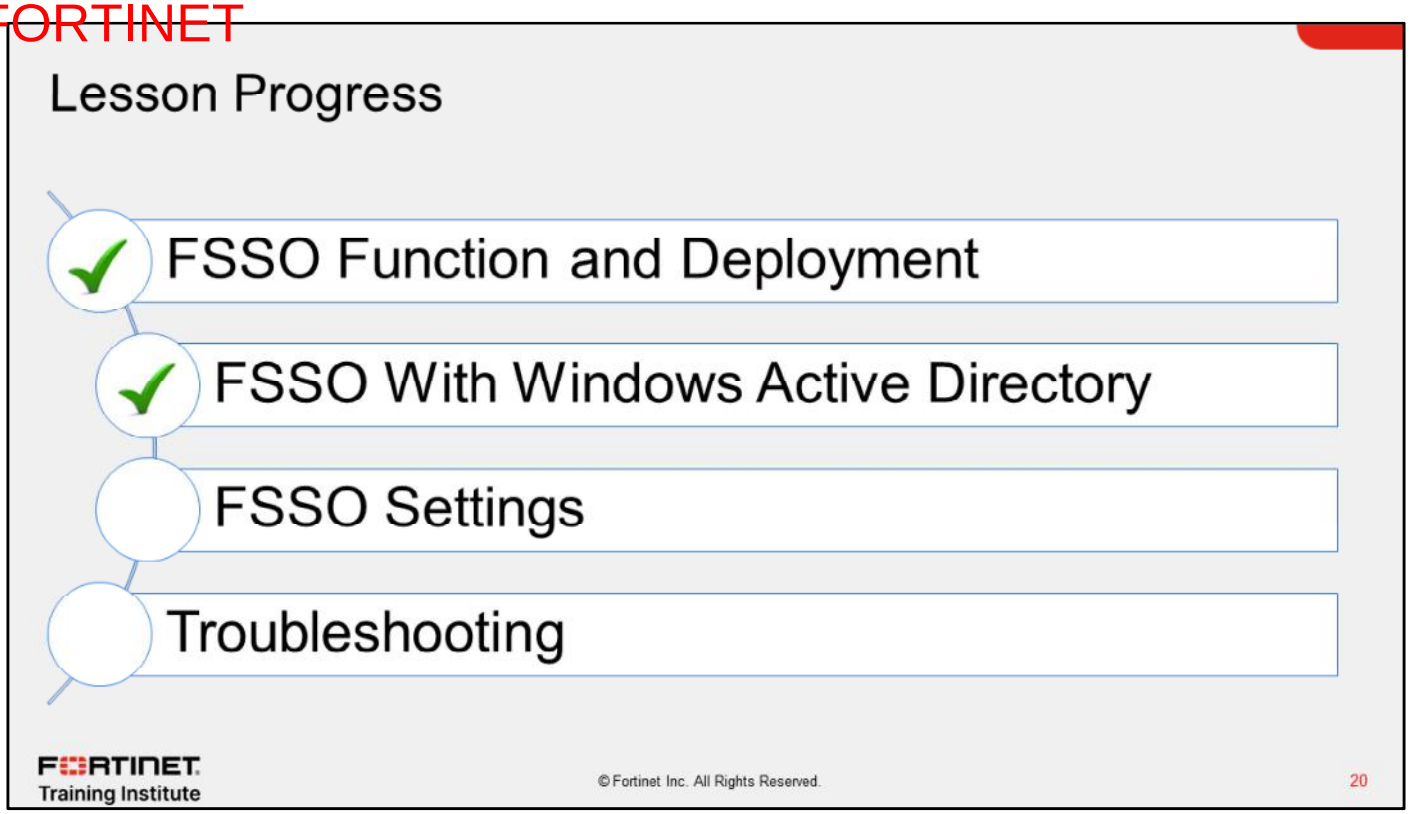
- Microsoft Windows login events have the workstation name and username, but not the workstation IP address. When the collector agent receives a login event, it queries a DNS server to resolve the IP address of the workstation. So, FSSO requires that you have your own DNS server. If a workstation IP address changes, DNS records must be updated immediately in order for the collector agent to be aware of the change and report them to FortiGate.

- For full feature functionality, collector agents need connectivity with all workstations. Since a monitored event log is not generated on logout, the collector agent (depending on the FSSO mode) must use a different method to verify whether users are still logged in. So, each user workstation is polled to see if users are still there.

- The DC agent, when the user logs in, intercepts the login event on the domain controller. It then resolves the DNS of the client, and sends it to the collector agent.

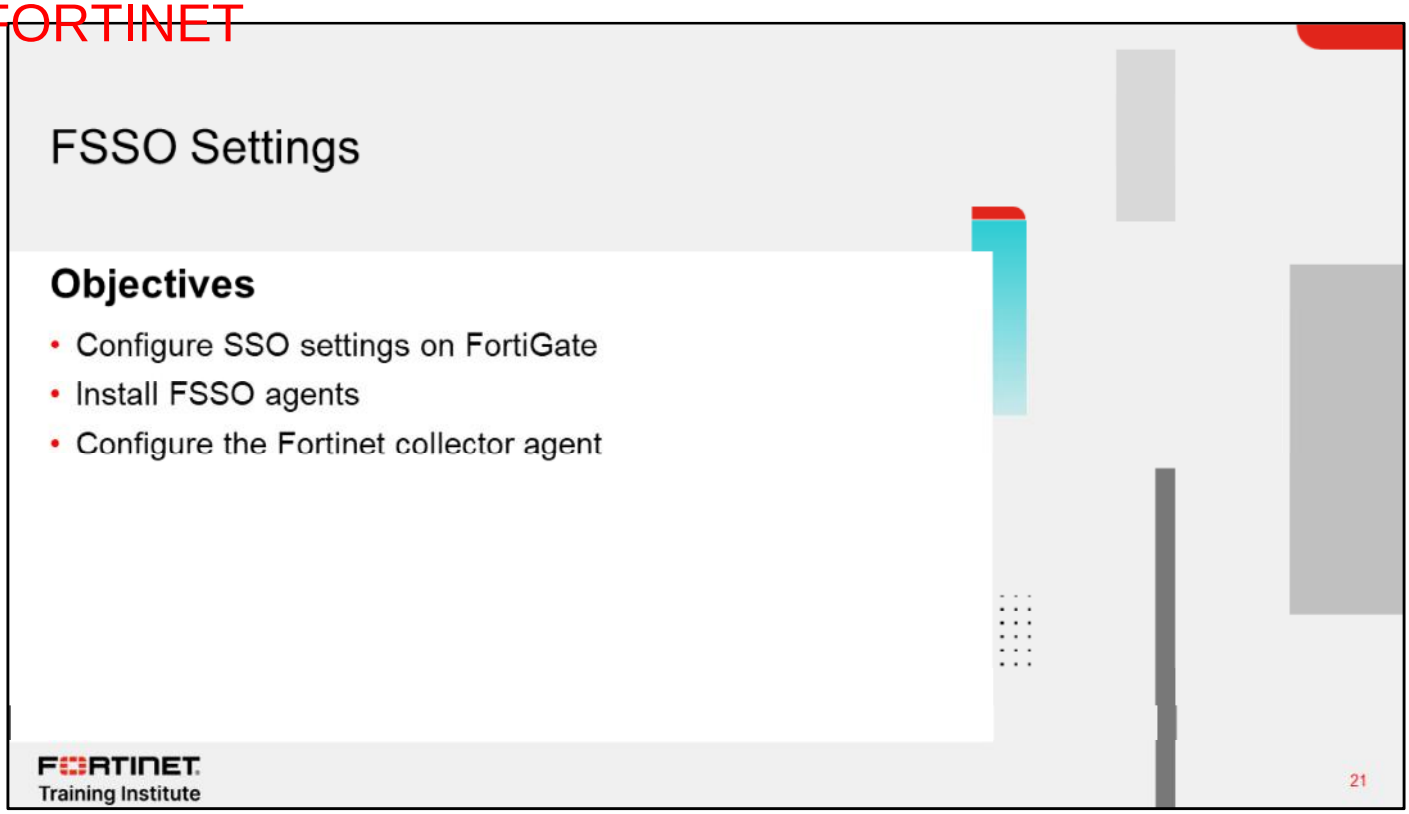
  The collector agent receives the DNS and then performs a DNS resolution in order to check if the IP of the user has changed.





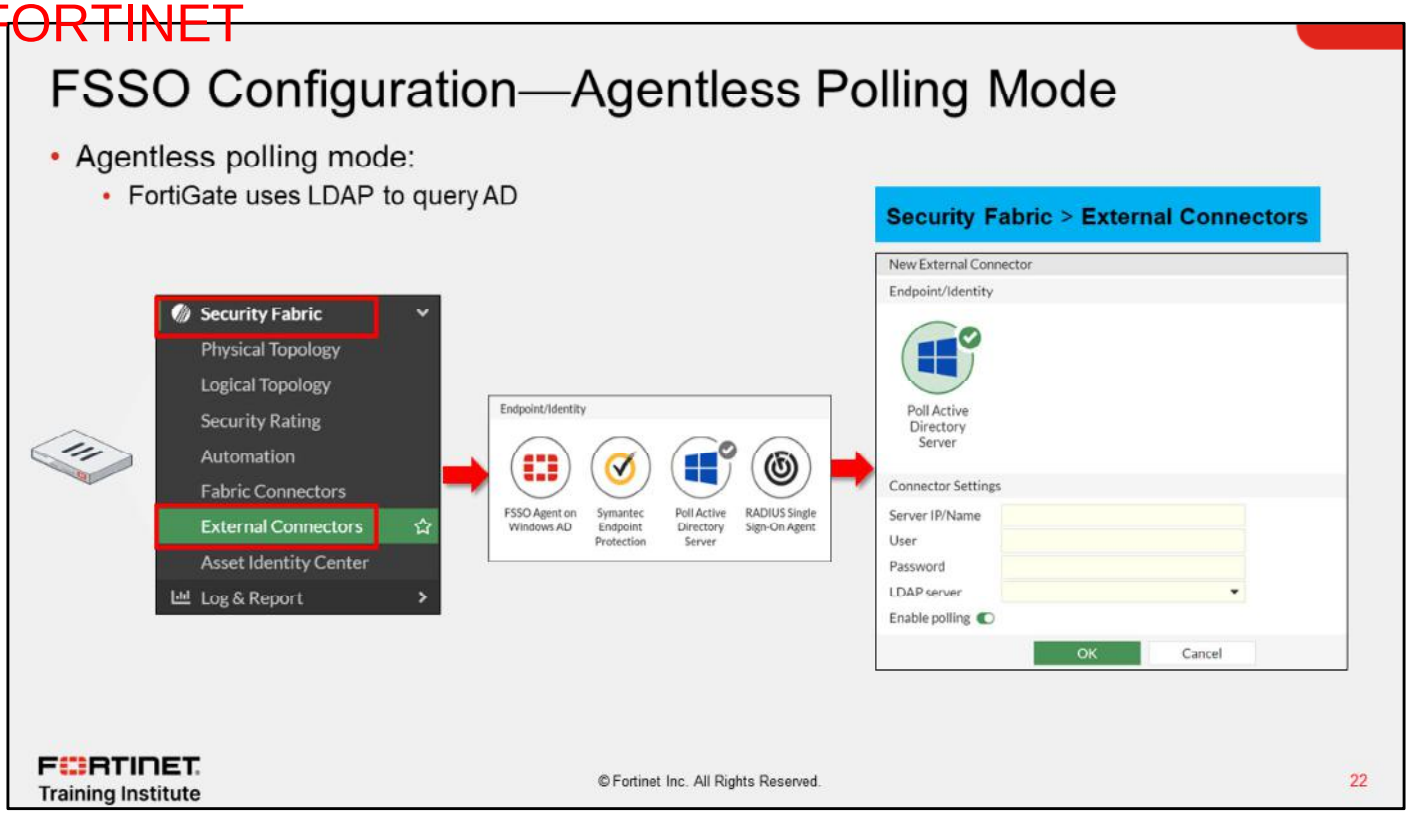
Good job! You now understand how FortiGate detects login events in Windows Active Directory (AD) using FSSO.

Now, you'll lean how to configure FSSO settings.



After completing this section, you should be able to achieve the objectives shown on this slide.

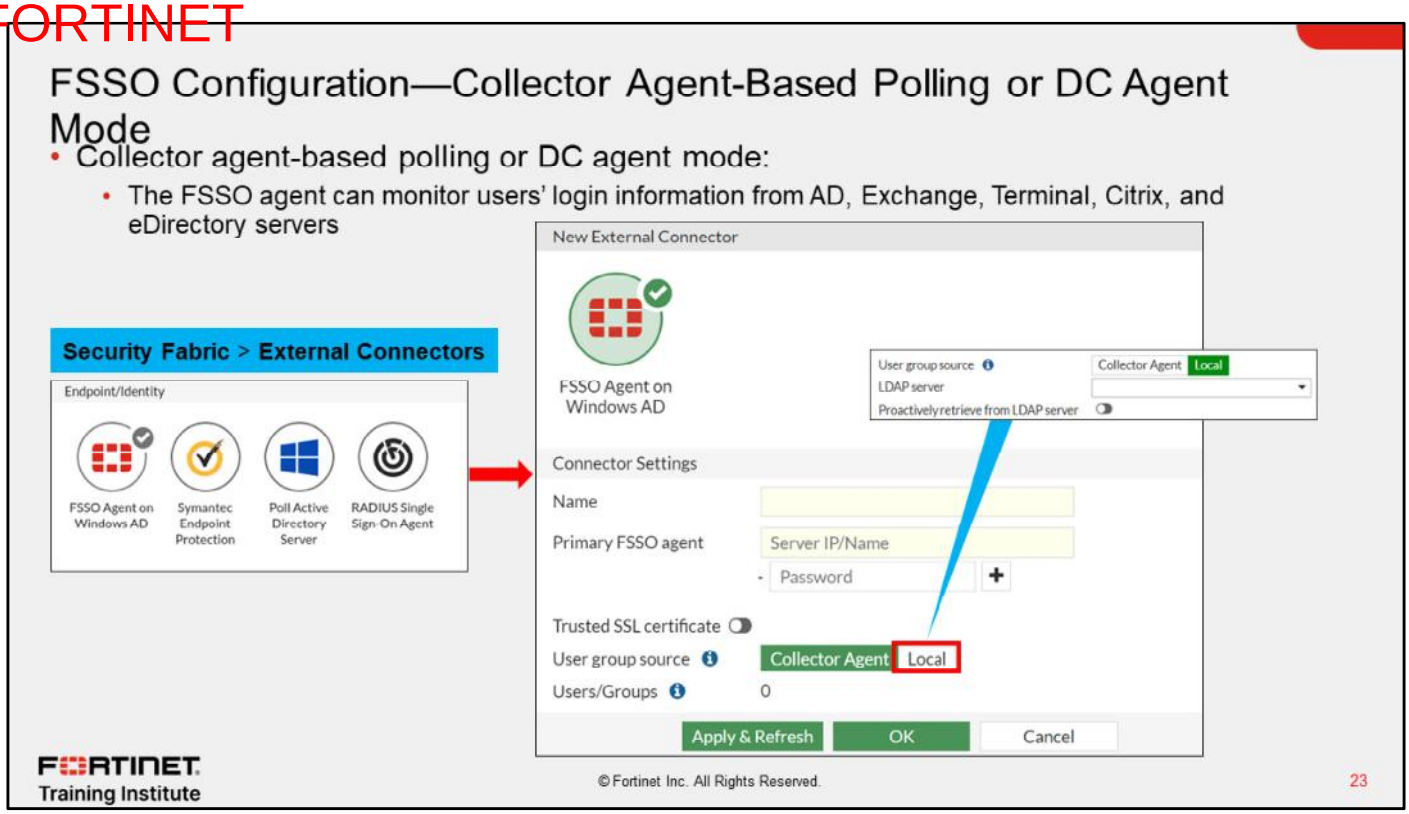
By demonstrating competence in configuring the FSSO settings on FortiGate, and installing and configuring the FSSO agents, you will be able to implement FSSO within your network.



FortiGate FSSO configuration is straightforward.

If FortiGate is acting as a collector for agentless polling mode, you must select **Poll Active Directory Server** and configure the IP addresses and AD administrator credentials for each DC.

FortiGate uses LDAP to query AD to retrieve user group information. For this to happen, you must add the LDAP server to the **Poll Active Directory Server** configuration.



If you have collector agents, using either the DC agent mode or the collector agent-based polling mode, you must select **Fortinet Single-Sign-On Agent** and configure the IP address and password for each collector agent.

The FSSO collector agent can access Windows AD in one of two modes:

- **Collector Agent**: You create group filters are created on the collector agent. You can set FortiGate to **Collector Agent** mode, and the collector agent can still use **Advanced** mode to access nested groups.
- **Local**: You create group filters on FortiGate, using the LDAP server. If you set FortiGate to **Local** mode, you must set the collector agent to **Advanced** mode, otherwise the collector agent does not recognize the group filter sent by FortiGate and does not pass down any user logins.

FSSO Agent Installation

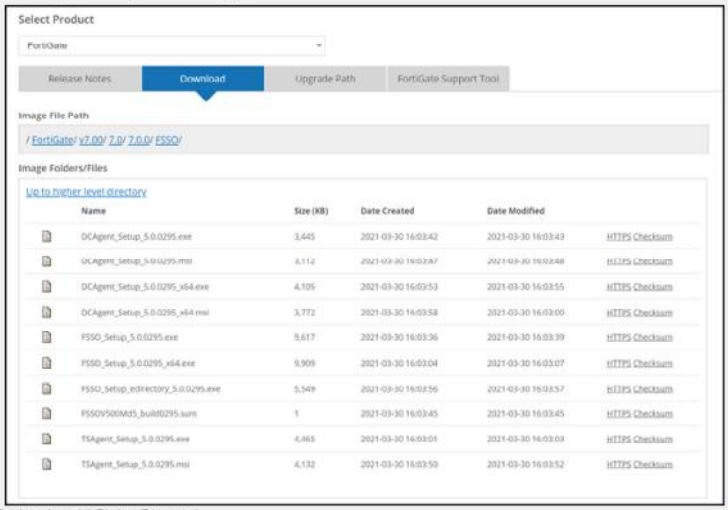
1. Visit the Fortinet support website:
   - https://support.fortinet.com
2. Click **Download** > **Firmware Images**

Available agents:

- DC agent: DCAgent_Setup
- CA for Microsoft servers: FSSO_Setup
- CA for Novell: FSSO_Setup_edirectory
- TS Agent: TSAgent_Setup

3. Select **FortiGate**, then click **Download**.
4. Click **v7.00** > **7.2** > **7.2.0** > **FSSO**

Example image below:



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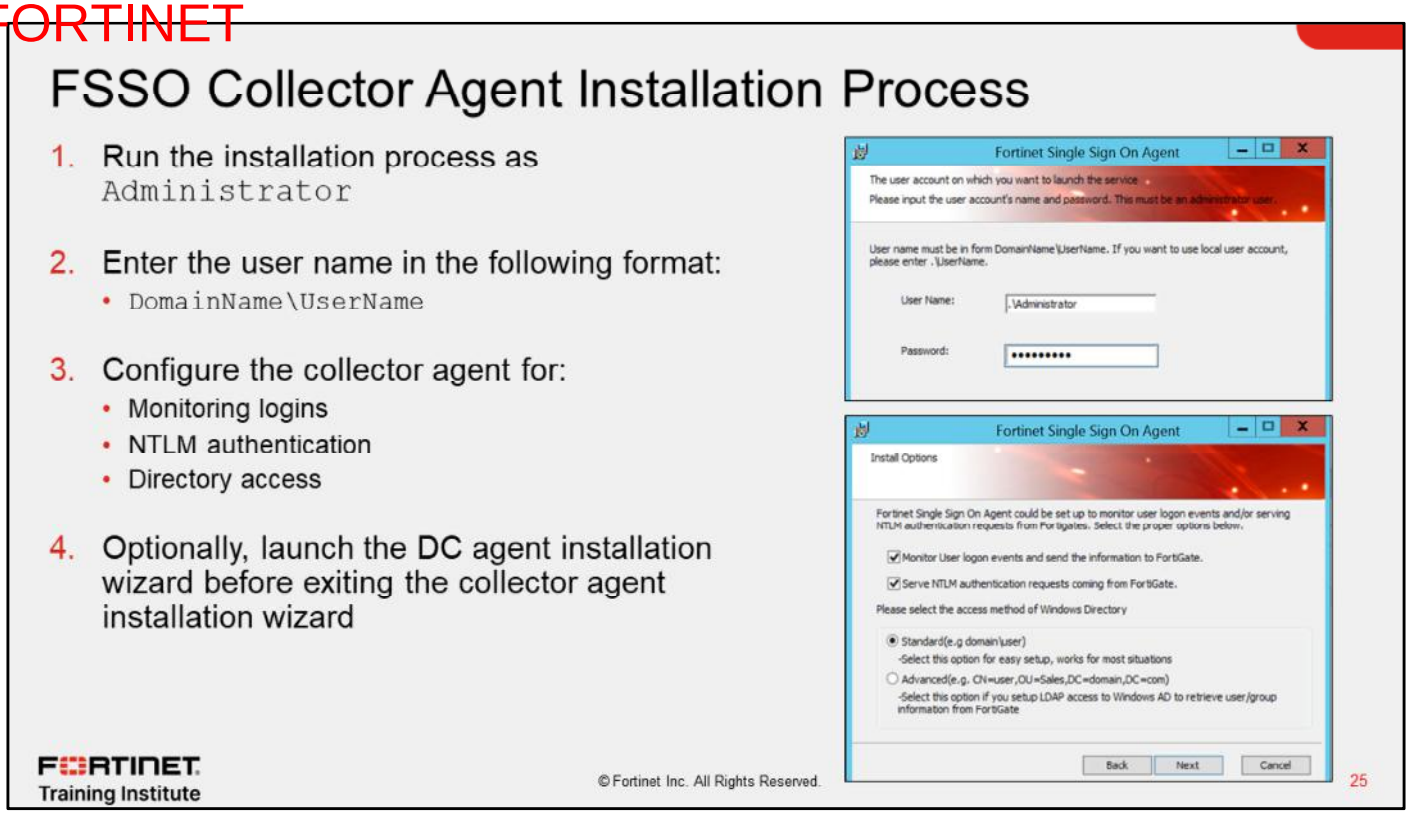
The FSSO agents are available on the Fortinet Support website. There you will find the following:

- The DC agent
- The collector agent for Microsoft servers: FSSO_Setup
- The collector agent for Novell directories: FSSO_Setup_edirectory
- The terminal server agent (TSagent) installer for Citrix and terminal servers: TSAgent_Setup

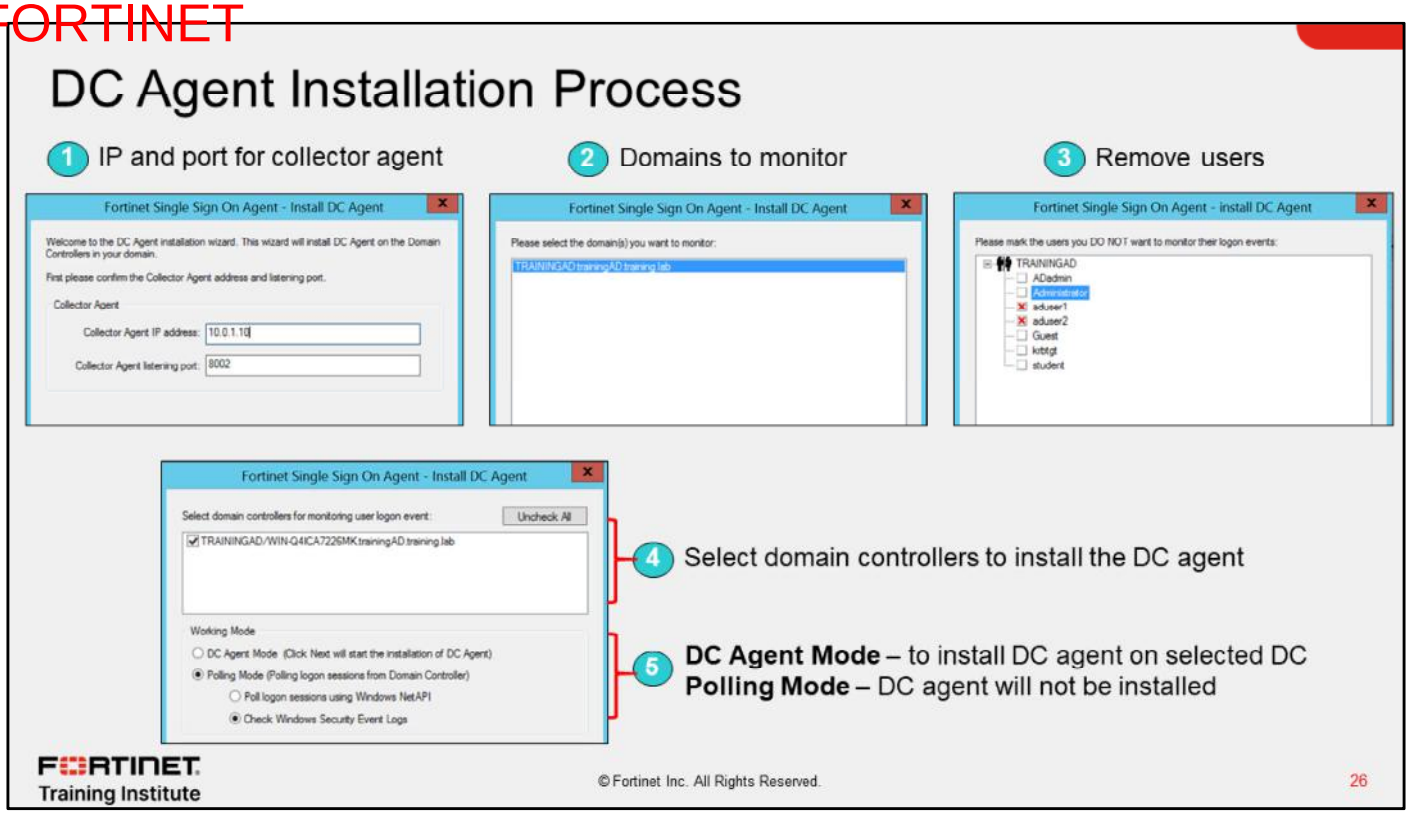
Also, for each agent, there are two versions: the executable (`.exe`) and Microsoft Installer (`.msi`).

Notice that you do not need to match the FSSO version with your exact FortiGate firmware version. When installing FSSO, grab the latest collector agent for your major release. You do however, need to match the DC agent version to the collector agent version.



After you've downloaded the collector agent, run the installation process as Administrator and follow these steps in the installation wizard:

1. Read and accept the license agreement.
2. Optionally, change the installation location. The default folder is named `FSAE` (Fortinet Server Authentication Extension).
3. Enter the username. By default, the agent uses the name of the currently running account; however, you can change it using the format: **DomainName\UserName**.
4. Alternatively, configure your collector agent for monitoring, NTLM authentication, and directory access. These options are also customizable after installation. Although the default is **Standard** mode, when doing new FSSO setups it is always a best practice to install in **Advanced** mode. You will look at some of the advantages in this lesson.
5. If you want to use DC agent mode, make sure that **Launch DC Agent Install Wizard** is selected. This automatically starts the DC agent installation.



If you have just installed the collector agent and you selected **Launch DC Agent Install Wizard,** the installation process for domain controller agent automatically starts.

1. Enter the IP address for the collector agent. Optionally, you can customize the listening port, if the default value is already used by another service.
2. Select the domains to monitor. If any of your required domains are not listed, cancel the wizard and set up the correct trusted relationship with the domain controller. Then, run the wizard again. Note that this could also be a result of using an account without all the necessary permissions.
3. Optionally, select users that you do not want to monitor; these users' login events are not recorded by the collector and therefore are not passed to FortiGate. While these users are still able to generate login events to the domain, when they are detected by the collector agent, they are discarded so as to not interfere with the logged in user. This is especially useful in environments with a centrally managed antivirus solution, or a scheduled backup service that uses an AD account to start. These accounts can create login events for the collector agent that overwrite existing user logins. This may result in FortiGate applying the incorrect policies and profiles based on the overriding account. You can also customize the option to ignore users after installation is complete.
4. Optionally, clear the checkboxes of domain controllers that you don't want to install the DC agent on. Remember, for DC agent mode FSSO, at least one domain controller must have the DC agent installed. Also remember that installing the DC agent requires a reboot of the DC before it will start gathering login events. You can add or remove the DC agent to DCs at any time after the installation is complete.
5. Select **DC Agent Mode** as the working mode. If you select **Polling Mode**, the DC agent will not be installed.

Finally, the wizard requests a system reboot.