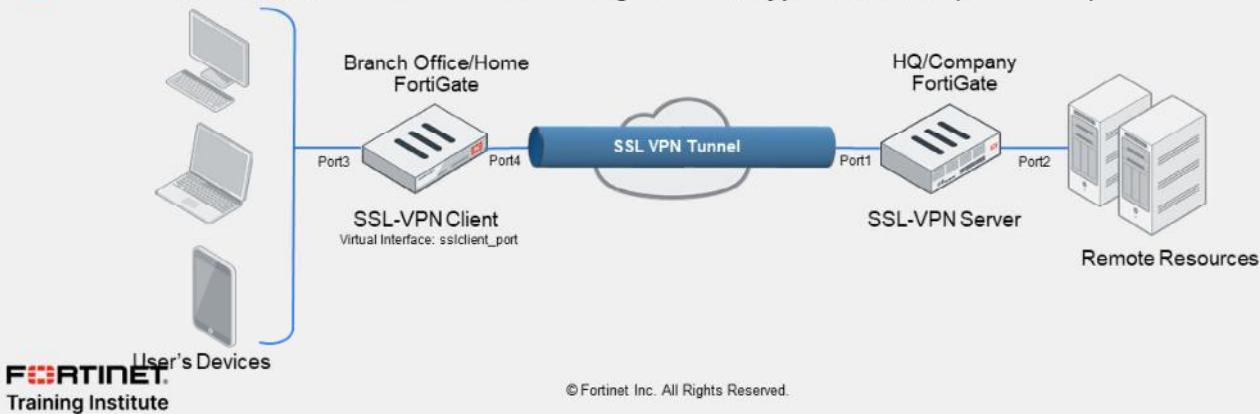


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Tunnel Mode—FortiGate as Client (Contd)

1. SSL VPN client FortiGate initiates connection to SSL VPN server FortiGate
2. SSL VPN client FortiGate uses PSK(local user account) and PKI client to authenticate
3. The virtual *SSL VPN tunnel* interface creates the tunnel
 - IP address assigned from SSL VPN server FortiGate
 - Route is added to client to access subnets on remote FortiGate
4. User's devices access resources through an encrypted tunnel (SSL/TLS)



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How does tunnel mode work when FortiGate is configured as client?

1. Client FortiGate connects to server FortiGate using SSL/TLS
2. Client FortiGate provides credentials to successfully authenticate. It includes both PSK (local or remote user account) and PKI (certificate) accounts.
3. Server FortiGate establishes the tunnel and assigns an IP address to the client's virtual network adapter. This is the client's source IP address for the duration of the connection.
4. Then, users can access services and network resources through the encrypted tunnel behind client FortiGate.

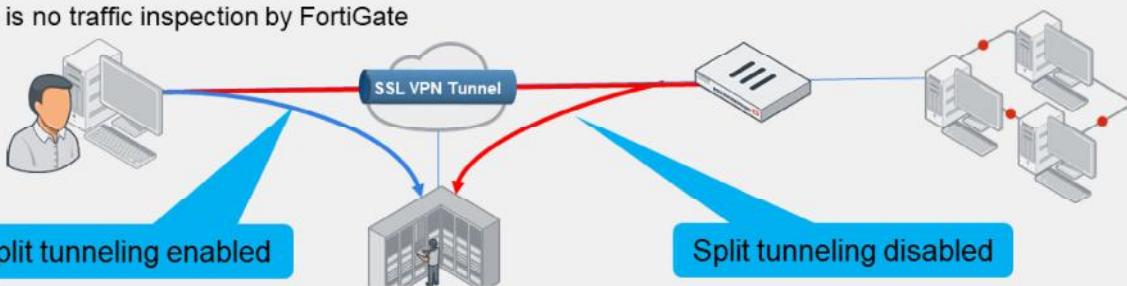
SSL VPN client FortiGate device encrypts all traffic from the remote computer and sends it over the SSL VPN tunnel. SSL VPN server FortiGate receives the encrypted traffic, de-encapsulates the IP packets, and forwards them to the private network as if the traffic originated from inside the network.

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Tunnel Mode—Split Tunneling

- **Disabled:**
 - All traffic routes through an SSL VPN tunnel to a remote FortiGate, then to the destination. This includes internet traffic
 - An egress firewall policy is required
 - Traffic inspection and security features can be applied
- **Enabled:**
 - Only traffic destined for the private network is routed through the remote FortiGate
 - Internet traffic uses the local gateway; unencrypted route
 - Conserves bandwidth and alleviates bottlenecks
 - There is no traffic inspection by FortiGate



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Tunnel mode also supports split tunneling.

When split tunneling is disabled, all IP traffic generated by the client's computer—including internet traffic—is routed across the SSL VPN tunnel to FortiGate. This sets up FortiGate as the default gateway for the host. You can use this method in order to apply security features to the traffic on those remote clients, or to monitor or restrict internet access. This adds more latency and increases bandwidth usage.

In a FortiGate (client) to FortiGate (server) setup, a default route is effectively dynamically created on the SSL VPN client FortiGate, and the new default route is added to the existing default route in the form of ECMP. The following options are available to configure routing:

- To make all traffic default to the SSL VPN server and still have a route to the server's listening interface, on the SSL VPN client, set a lower distance for the default route that is learned from the server.
- To include both default routes in the routing table, with the route learned from the SSL VPN server taking priority, on the SSL VPN client, set a lower distance for the route learned from the server. If the distance is already zero, then increase the priority on the default route.

When split tunneling is enabled, only traffic that is destined for the private network behind the remote FortiGate is routed through the tunnel. All other traffic is sent through the usual unencrypted route. There is no traffic inspection by FortiGate.

Split tunneling helps to conserve bandwidth and alleviates bottlenecks.

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Knowledge Check

1. A web-mode SSL VPN user connects to a remote web server. What is the source IP address of the HTTP request the web server receives?
 - A. The remote user IP address
 - B. The FortiGate device internal IP address

2. Which statement about tunnel-mode SSL VPN is correct?
 - A. It supports split tunneling.
 - B. It requires bookmarks.

3. A web-mode SSL VPN user uses _____ to access internal network resources.
 - A. bookmarks
 - B. FortiClient

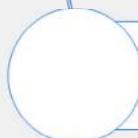
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Lesson Progress



SSL VPN Deployment Modes



Configuring SSL VPNs



Monitoring and Troubleshooting

Good job! You now understand the SSL VPN operation modes supported by FortiGate.

Now, you will learn about how to configure SSL VPNs.

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Configuring SSL VPNs

Objectives

- Define authentication for SSL VPN users
- Configure SSL VPN portals
- Configure SSL VPN settings
- Define firewall policies for SSL VPNs
- Configure client integrity check

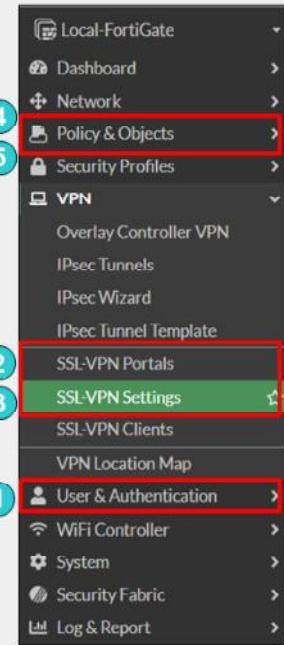
After completing this section, you should be able to achieve the objectives shown on this slide.

By demonstrating competence in configuring the SSL VPN settings on FortiGate, you will be able to better design the architecture of your SSL VPN tunnels.

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Configuring SSL VPN—User as Client

1. Set up user accounts and groups for remote SSL VPN users
2. Configure SSL VPN portals
3. Configure SSL VPN settings
4. Create a firewall policy to and from the SSL VPN interface
 - Accepts and decrypts packets
 - Allows traffic from SSL VPN clients to the internal network and the reverse
5. Optionally:
 - Create a firewall policy to allow SSL VPN traffic to the internet:
 - Useful to allow all clients' traffic through FortiGate to Internet when split tunneling is disabled
 - FortiGate can be used to apply security profiles



To configure SSL VPN, you must take these steps:

1. Configure user accounts and groups.
2. Configure the SSL VPN portal.
3. Configure SSL VPN settings.
4. Create a firewall policy to accept and decrypt packets. This policy is also used to provide access to internal networks.
5. Optionally, configure a firewall policy to allow traffic from the SSL VPN client to the internet and apply security profiles. User traffic will go to the internet through FortiGate, where you can monitor or restrict client access to the internet.

The first step is to create the accounts and user groups for the SSL VPN clients.

All FortiGate authentication methods, with the exception of remote password authentication using the Fortinet Single Sign-On (FSSO) protocol, can be used for SSL VPN authentication. This includes local password authentication and remote password authentication (using the LDAP, RADIUS, and TACACS+ protocols).

Some steps can be configured in a different order than what is shown on this slide.

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Configure the SSL VPN Portal

VPN > SSL VPN Portals

Name	Tunnel Mode	Web Mode
full-access	Enabled	Enabled
tunnel-access	Enabled	Disabled
web-access	Disabled	Enabled

- SSL VPN portals determine the access profiles
 - Configure portals for different user or groups
- SSL VPN portals can operate in:
 - Tunnel mode
 - Activate split tunneling in the **Enable Split Tunneling** option
 - Assign an IP address to the end user virtual network adapter in **Source IP Pool:** fortissl
 - Web mode
 - Use direct connection or bookmarks to several applications such as: FTP, HTTP/HTTPS, RDP, SMB/CIFS, SSH, TELNET, VNC

Tunnel Mode

Web Mode

Administrator-defined bookmarks

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The next step is to configure the SSL VPN portal(s). An SSL VPN portal contains tools and resource links for the users to access.

In tunnel mode, when you enable split tunneling, you need to select either **Enabled Based on Policy Destination** or **Enabled for Trusted Destination** setting, which usually specifies networks behind the FortiGate for the SSL VPN users to access. **Enabled Based on Policy Destination** allows client traffic in which destination is matched with the destination configured on the SSL VPN firewall policy where as **Enabled for Trusted Destination** allows client traffic that does not match the explicitly trusted destination.

Also, for tunnel mode you need to select an IP pool for users to acquire an IP address when connecting. There is a default pool available within the address objects if you do not create your own.

If you enable web mode, you can customize the SSL VPN portal and preconfigure bookmarks to appear for all users who log in to the SSL VPN portal. Also, you can individually configure and link each portal to a specific user or user group, so they have access to only required resources.

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Configure SSL VPN Settings

- FortiGate interface for SSL VPN portal:
 - Default port is 443
 - By default, the admin GUI interface and the SSL VPN portal use same HTTPS port
 - Advised to use different interfaces for admin GUI access and SSL VPN portal
 - If both services use the same interface and port, only the SSL VPN portal appears

- Restrict access to known hosts
- SSL VPN time out:
 - Default idle: 300 sec (5 min)
- Digital server certificate:
 - Self-signed certificate used by default
 - To avoid browser security warnings, use a certificate issued by a public CA, generate a trusted certificate or install the self-signed certificate on all clients

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After you configure the SSL VPN portal, the next step is to configure the SSL VPN settings.

Let's start with the **Connection Settings** section. Here, you need to map a FortiGate interface to the SSL VPN portal. The default port for the SSL VPN portal is 443. This means users need to connect to the IP address of the FortiGate interface mapped to the SSL VPN portal, using port443 HTTPS. If you enable **Redirect HTTP to SSL VPN**, users who connect using HTTP (TCP port 80) will be redirected to HTTPS.

Port 443 is the standard default port for administration of the HTTPS protocol. This is convenient because users do not need to specify the port in their browsers. For example, <https://www.example.com/> automatically uses port443 in any browser. This is considered a valid setup on FortiGate because you usually don't access the SSL VPN login through every interface. Likewise, you generally don't enable administrative access on every interface of your FortiGate. So, even though the ports may overlap, the interfaces that each one uses to access may not. However, if the SSL VPN login portal and HTTPS admin access both use the same port, and are both enabled on the same interface, only the SSL VPN login portal will appear. To have access to both portals on the same interface, you need to change the port number for one of the services. If you change the administrator access port, this will affect the port number for that service on all interfaces.

Also, an inactive SSL VPN is disconnected after 300 seconds (5 minutes) of inactivity. You can change this timeout using the **Idle Logout** setting on the GUI.

Finally, like other HTTPS websites, the SSL VPN portal presents a digital certificate when users connect. By default, the portal uses a self-signed certificate, which triggers the browser to show a certificate warning. To avoid the warning, you should use a digital certificate signed by a publicly known certificate authority (CA). You can also generate a certificate for interface. Alternatively, you can load the FortiGate self-signed digital certificate into the browser as a trusted authority.

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Configure SSL VPN Settings (Contd)

- Define the IP range for the SSL VPN

- IPs are assigned to clients' virtual adapters while joined to VPN
- IP allocation has two methods:

- First-available (default) or Round robin
- CLI only

```
conf vpn ssl settings
    set tunnel-addr-assigned-method first-available/round-robin
end
```

- Resolve names by DNS server

- Use internal DNS if resolving internal domain names
- Optionally, resolve names by WINS servers

- Specify authentication portal mapping

- Specify portals for each user or group
- Define portal for all other users or groups
 - It cannot be deleted

Define the tunnel-mode client settings and the authentication rules that map users to the appropriate portal.

When users connect, the tunnel is assigned an IP address. You can choose to use the default range or create your own range. The IP range determines how many users can connect simultaneously. There are two IP allocation methods and only available in CLI as shown in the slide:

- First-available (default setting)
- Round robin

Please note when round-robin is used, address pools defined in web portal is ignored, and the `tunnel-ip-pools` or `tunnel-ipv6-pools` under `ssl vpn` setting must be set. Only one set of IP pool address is allowed.

DNS server resolution is effective only when the DNS traffic is sent over the VPN tunnel. Generally, this will be the case only when split tunnel mode is disabled and all traffic is being sent from the user's computer across the tunnel.

Finally, you can allow different groups of users to access different portals. In the example shown on this slide, teachers have access only to the web portal. Accountants can use FortiClient to connect in tunnel mode.

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Firewall Policies to and from SSL VPN Interface

- Listens for connections to the SSL VPN portal
- **ssl.<vdom_name>** policy enables portal with user authentication
- The selected **Incoming Interface** is the SSL VPN virtual interface
 - Example: **ssl.root** for root VDOM
- Passes decrypted traffic to the selected **Outgoing Interface**

Policy & Objects > Firewall Policy

Name	SSL-VPN
Incoming Interface	SSL-VPN tunnel interface (ssl.root)
Outgoing Interface	port3
Source	SSLVPN_TUNNEL_ADDR1 Accounts SSL_VPN_USERS Teachers
Destination	LOCAL_SUBNET
Schedule	always
Service	ALL
Action	ACCEPT

The fourth, and last, mandatory step involves creating firewall policies for logging on.

SSL VPN traffic on FortiGate uses a virtual interface called `ssl.<vdom_name>`. Each virtual domain (VDOM) contains a different virtual interface based on its name. By default, if VDOMs are not enabled, then the device operates with a single VDOM called `root`.

To activate and successfully log in to the SSL VPN, there must be a firewall policy from the SSL VPN interface to the interface to which you want to allow access for the SSL VPN users, including all of the users and groups that can log in as the source. Without a policy like this, no login portal is presented to users.

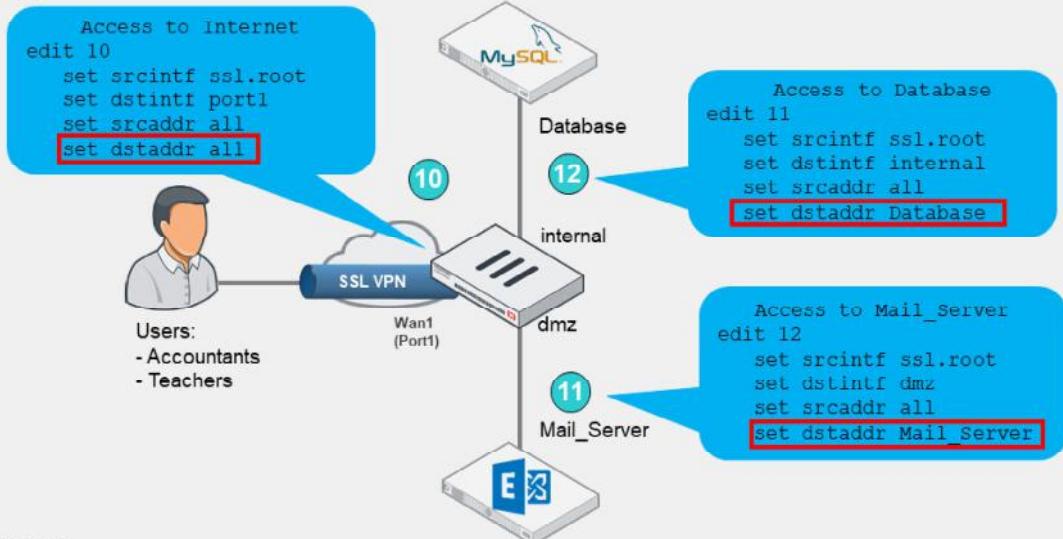
If there are resources behind other interfaces that users need access to, then you need to create additional policies that allow traffic from `ssl.root` to exit those interfaces.

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Example: Access to Resources

- All traffic generated by the user exits through the `ssl.<vdom_name>` interface
 - Applies to both web and tunnel mode



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Any traffic from SSL VPN users, whether in web portal or tunnel mode, exits from the `ssl.<vdom_name>` interface.

This slide shows an example of firewall policies that are configured to allow access to resources behind other interfaces that users need access to when connected through SSL VPN.

Optionally, if split tunneling is disabled, you need to create an additional firewall policy from `ssl.root` to the egress interface to allow clients access to the internet.

You can also apply security profiles to this firewall policy to restrict user access to the internet.

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Configuring SSL VPN—FortiGate as Server

- SSL VPN Server FortiGate

- Set up user accounts and groups for remote SSL VPN users
 - Create two accounts: local/remote and PKI
 - Require clients to authenticate using their certificates as well as username and password
- Configure SSL VPN portals
- Configure SSL VPN settings
 - Authentication rules include both accounts using CLI
- Create a firewall policy to and from the SSL VPN interface
- Create a firewall policy to allow SSL VPN traffic to the internet (optional)

Use CLI to create first PKI user to get PKI menu on GUI

User & Authentication > User Definition

Edit User	
Username	clientfortigate
User Account Status	<input checked="" type="radio"/> Enabled <input type="radio"/> Disabled
User Type	Local User
Password	*****
User Group	<input checked="" type="radio"/> SSL-VPN-Users <input type="radio"/> +
<input type="checkbox"/> Two-factor Authentication	
<input type="button" value="OK"/> <input type="button" value="Cancel"/>	

User & Authentication > PKI

Edit PKI User	
Name	pki
Subject	
CA	CA.Cert.1
<input type="checkbox"/> Two-factor authentication	
<input type="button" value="OK"/> <input type="button" value="Cancel"/>	

```
config user peer
  edit pki
    set ca "CA_Cert_1"
    set cn "FGVM01TM905"
end
```

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To configure SSL VPN, you must take these steps:

SSL VPN server FortiGate:

- Set up user accounts and groups for remote SSL VPN users.
 - Create two accounts: local/remote and PKI. The PKI menu is only available in the GUI after a PKI user has been created using the CLI, and a CN can only be configured in the CLI. If no CN is specified, then any certificate that is signed by the CA will be valid and matched.
 - Require clients to authenticate using their certificates as well as username and password.
- Configure SSL VPN portals.
- Configure SSL VPN settings.
 - Authentication rules include both accounts using CLI.
- Create a firewall policy to and from the SSL VPN interface.
- Create a firewall policy to allow SSL VPN traffic to the internet (optional).

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Configuring SSL VPN—FortiGate as Client

- SSL VPN Client FortiGate

- Create PKI user
 - Select CA certificate that allows the FortiGate to complete the certificate chain and verify the server's certificate
- Create SSL VPN tunnel interface using `ssl.<vdom>` interface
- Create and configure the SSL VPN Client settings on **VPN > SSL-VPN Clients**
- Create a firewall policy from internal interface to the SSL VPN interface

The screenshot displays two configuration windows side-by-side:

Network > Interface > Create New

- Interface Name:** ssclient_port
- Type:** ssl.<vdom_name>
- Select port to reach server FortiGate:** Interface port4
- Administrative Access:** IPv4 checkboxes: HTTPS (checked), SSH (unchecked), PING (checked), SNMP (unchecked), RADIUS Accounting (unchecked), Security Fabric Connection (unchecked).

VPN > SSL-VPN Clients > Create New

- Client Name:** ssclienttoHQ
- Virtual SSLInterface:** ssclient_port
- Server FortiGate IP Address and SSL Port:** 10.200.1.1, Port 10443
- Local and PKI user details including local cert to identify this client:** Username ClientFortigate, Pre-shared Key (redacted), Client Certificate (disabled), Peer pki.
- Dynamic route priority and distance settings:** Administrative Distance (10), Priority (0), Status Enabled.

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To configure SSL VPN, you must take these steps:

SSL VPN Client FortiGate:

- Create PKI user:
 - Set the same CN using CLI if PKI user on server FortiGate has CN configured.
 - Select CA certificate that allows the FortiGate to complete the certificate chain and verify the server's certificate.
- Create SSL VPN tunnel interface using `ssl.<vdom>` interface.
- Create and configure the SSL VPN client settings on **VPN > SSL-VPN Clients**, it includes:
 - Client name
 - Virtual SSL VPN interface
 - SSL VPN server FortiGate IP address and SSL port number
 - Local username and password and PKI(Peer) user. The **Client Certificate** is the local certificate that is used to identify this client, and is assumed to already be installed on the FortiGate. The SSL VPN server requires it for authentication.
 - When split tunnel is disabled, new default route is added and priority and distance plays an important role.
- Create a firewall policy to allow traffic from internal interface to the SSL VPN interface.

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Client Integrity Checking

- SSL-VPN gateway checks client integrity
 - Requires Microsoft Windows
 - Supported in SSL VPN tunnel mode only
- Detects client security applications recognized by the Windows Security Center
 - Antivirus and firewall software
 - Security attributes recorded on the client's computer
- Checks the status of applications through their globally unique identifier (GUID)
 - Custom host checks
- Determines the state of the applications
 - Active/inactive
 - Current version number
 - Signature updates



When a user connects to your network through an SSL-VPN, a portal is established between your network and the user's PC. The VPN session is secured natively in two ways: the connection is encrypted and the user must log in with their credentials, such as a username and password. However, you can configure additional checks to increase the security of the connection.

One method of increasing your security is by using client integrity checking. Client integrity ensures that the connecting computer is secure by checking whether specific security software, such as antivirus or firewall software, is installed and running. This feature supports only Microsoft Windows clients, because it accesses the Windows Security Center to perform its checks. Alternatively, you can customize this feature to check the status of other applications using their GUIDs. A GUID is a unique ID in the Windows Configuration Registry that identifies each Windows application. Client integrity can also check the current software and signature versions for the antivirus and firewall applications.

Client integrity checking is applicable to tunnel mode only.

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Configure the Client Integrity Check

- Uses external vendor software to ensure client integrity:
FortiClient, AVG, CA, F-Secure, Kaspersky, McAfee, Norton, Symantec, Panda, Sophos, Trend-Micro, Zone Alarm,...
- Checks whether the software is installed on host client:
 - Configure through CLI or GUI
 - Software must be updated and recognized by Windows Security Center
 - None – No host checking
 - av – Verify if there is any antivirus software
 - fw – Verify if there is any firewall software
 - av-fw – Verify if there is both antivirus and firewall software
 - Custom – Verify custom or proprietary software
 - If the software is not installed, FortiGate rejects SSL-VPN connection attempt

```
config vpn ssl web host-check-software
show
```

VPN > SSL-VPN Portals > portal-name

<input checked="" type="radio"/> Host Check	Realtime AntiVirus	Firewall	Enable both
Type	Restrict to specific OS versions <input type="checkbox"/>		

```
config vpn ssl web portal
edit <portal_name>
  set host-check [none|av|fw|av-fw|custom]
  set host-check-interval <seconds>
end
```

Administrators should have in-depth knowledge of the Windows OS to use and maintain this feature

FortiGate performs the client integrity check while the VPN is still establishing, just after user authentication has finished. If the required software is not running on the user's PC, FortiGate rejects the VPN connection attempt, even with valid user credentials. You enable client integrity for each web portal, and you configure it using CLI commands or the FortiGate GUI.

The list of recognized software, along with the associated registry key value, is available on the CLI only. Software is split into three categories: antivirus (av), firewall (fw), and custom. Custom is used for customized or proprietary software that an organization may require. Administrators can configure av, fw, or both settings on the GUI or CLI, but the custom setting is available only on the CLI.

Administrators can also configure OS versions and patch settings to allow or deny VPN connections from specific OS versions.

The disadvantage of enabling client integrity checking is that it can result in a lot of administrative overhead because of the following factors:

- All users must have their security software up to date in order to successfully establish a connection.
- Software updates can result in a change to the registry key values, which can also prevent a user from successfully connecting.

As such, administrators must have in-depth knowledge of the Windows operating system and subsequent registry behavior in order to properly make extended use of and maintain this feature.

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Knowledge Check

1. Which step is necessary to configure SSL VPN connections?
 A. Create a firewall policy from the SSL VPN interface to the resource's interface.
 B. Enable event logs for SSL VPN traffic: users, VPN, and endpoints.

2. Which action may allow internet access in tunnel mode, if the remote network does not allow internet access to SSL VPN users?
 A. Enable split tunneling
 B. Configure the DNS server to use the same DNS server as the client system DNS

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Lesson Progress



SSL VPN Deployment Modes



Configuring SSL VPNs



Monitoring and Troubleshooting

Good job! You now understand how to configure FortiGate for SSL VPN connections.

Now, you'll learn how to monitor SSL VPN sessions, review logs, configure SSL VPN timers, and troubleshoot common issues.

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Monitoring and Troubleshooting

Objectives

- Monitor SSL VPN-connected users
- Review SSL VPN logs
- Configure SSL VPN timers
- Troubleshoot common SSL VPN issues
- Identify hardware acceleration components for SSL VPN

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

By demonstrating competence in SSL VPN monitoring and troubleshooting, you will be able to avoid, identify, and solve common issues and misconfigurations.

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Monitoring SSL VPN Sessions

- Monitor which SSL VPN users are connected
 - GUI: Dashboard > Network > SSL VPN
- Shows SSL VPN user names, connection times, and IP addresses
 - For tunnel mode, **Active Connections** displays IP address assigned to `fortissl` virtual adapter
- Force end user disconnection
 - Right-click the user name and select **End Session**

Dashboard > Network > SSL VPN



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You can monitor which SSL VPN users are connected on the **SSL VPN** widget. This shows the names of all SSL VPN users that are currently connected to FortiGate, their IP addresses (both inside the tunnel and outside), and connection times.

When a user connects using tunnel model, the **Active Connections** column shows the IP address assigned by FortiGate to the `fortissl` virtual adapter on the client's computer. Otherwise, the user is connected only to the web portal page.

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SSL VPN Logs

The screenshot shows the FortiGate Log & Report interface. On the left, under the 'Log & Report' dropdown, the 'System Events' option is highlighted with a red box. A red arrow points from this box to two separate event log tables. The top table, 'VPN Events', shows logs for SSL tunnel events:

Date/Time	Level	Action	Status	Message
2020/01/21 04:50:...	ssl-new-con			SSL new connection
2020/01/21 04:50:...	tunnel-down			SSL tunnel shutdown
2020/01/21 04:49:...	tunnel-stats			SSL tunnel statistics
2020/01/21 04:39:...	tunnel-up			SSL tunnel established
2020/01/21 04:39:...	ssl-new-con			SSL new connection

The bottom table, 'User Events', shows logs for user authentication actions:

Date/Time	Level	User	Action	Message
2020/01/21 04:50:33	Student		auth-logout	User Student removed from auth logon
2020/01/21 04:39:02	Student		auth-logon	User Student added to auth logon

- Review if the SSL VPN tunnel is established or closed
- Review the authentication action related to SSL VPN users
- Review SSL VPN connections in tunnel mode with FortiClient

You can also review SSL VPN logs. On **Log & Report > System Events**:

- Select **VPN Events** widget to show new connection requests, and if the SSL VPN tunnel is established or closed.
- Select **User Events** widget to see the authentication action related to SSL VPN users.

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SSL VPN Idle Timeout vs. Authentication Session

- Firewall policy authentication session is associated with SSL VPN tunnel session
 - Firewall policy authentication session is forced to end when SSL VPN tunnel session ends
 - Prevents reuse of authenticated SSL VPN firewall sessions (not yet expired) by a different user, after the initial user terminates the SSL VPN tunnel session
- SSL VPN authentication is not subject to the firewall authentication timeout setting
 - It has a separate idle setting: default 300 seconds

VPN > SSL VPN Settings

Redirect HTTP to SSL-VPN

Restrict Access Allow access from any host Limit access

Idle Logout

Inactive For Seconds

```
config vpn ssl settings
  set idle-timeout <0-259200>
end
```

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When an SSL VPN is disconnected, either by the user or through the SSL VPN idle setting, all associated sessions in the FortiGate session table are deleted. This prevents the reuse of authenticated SSL VPN sessions (not yet expired) after the initial user terminates the tunnel.

The SSL VPN user idle setting is not associated with the firewall authentication timeout setting. It is a separate idle option specifically for SSL VPN users. A remote user is considered idle when FortiGate does not see any packets or activity from the user within the configured timeout period.

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SSL VPN Timers

- Set up timers to avoid logouts when SSL VPN users are connected over high latency connections

- DTLS hello timeout—default 10 seconds
- Login timeout—default 30 seconds

```
config vpn ssl settings
    set login-timeout <10-180>
    set dtls-hello-timeout <10-60>
    set http-request-header-timeout <1-60>
    set http-request-body-timeout <1-60>
end
```

- Timers can also help to mitigate DoS attacks within SSL VPN caused by partial HTTP requests, such as Slowloris and R-U-Dead-Yet

When connected to SSL VPN over high latency connections, FortiGate can time out the client before the client can finish the negotiation process, such as DNS lookup and time to enter a token. Two new CLI commands under `config vpn ssl settings` have been added to address this. The first command allows you to set up the login timeout, replacing the previous hard timeout value. The second command allows you to set up the maximum DTLS hello timeout for SSL VPN connections.

Also, timers can help you to mitigate vulnerabilities such as Slowloris and R-U-Dead-Yet, that allow remote attackers to cause a denial of service through partial HTTP requests.

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Best Practices for Common SSL VPN Issues

- For web mode connections, make sure that:
 - Cookies are enabled and the internet privacy options are set to high in your web browser
 - SSL VPN clients are following the proper URL structure: <https://<FortiGateIP>:<port>>
- For tunnel mode connections, make sure that:
 - The FortiClient version is compatible with the FortiOS firmware
 - Refer to release notes for product compatibility and integration
 - Split tunneling is enabled to allow internet access without backhauling all user's data to the remote network, or
 - Split tunneling is disabled and an egress firewall policy is created for SSL VPN connections
- For general SSL VPN connections, make sure that:
 - Users are connecting to the correct port number
 - To check SSL VPN port assignment, click **VPN > SSL VPN Settings**
 - Firewall policies include SSL VPN groups or users, and the destination address
 - The timeout timer is configured to flush inactive sessions after a short time
 - Users are encouraged to log out if they are not using the network resources only accessible by SSL VPN



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The following are some best practices to keep in mind when using SSL VPNs. These best practices can also be helpful in many SSL VPN troubleshooting situations:

- Enable cookies in your web browser
- Set internet privacy options to high in your web browser
- Use a FortiClient version that is compatible with your FortiOS firmware
- Enable split tunneling or create an egress firewall policy for SSL VPN connections in order to allow access for external resources
- Connect to the correct port number
- Add SSL VPN groups, SSL VPN users, and destination addresses to the firewall policies
- Flush inactive sessions by timeout

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Useful Troubleshooting Commands

```
# diagnose debug enable
# diagnose vpn ssl <...>
    list      → Show current connections
    info      → General SSL VPN information
    statistics → Show statistics about memory usage on FortiGate, maximum and
                  current connections
    debug-filter → Debug message filter for SSL VPN
    hw-acceleration-status → Display the status of SSL hardware acceleration
    tunnel-test → Enable/disable SSL VPN old tunnel mode IP allocation method
    web-mode-test → Enable/disable random session ID in proxy URL for testing
```

```
# diagnose debug application sslvpn -1
```

} Display debug messages for SSL VPN; -1 debug level
produces detailed results

- Check debug logs on the FortiClient



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There are several useful troubleshooting commands available under `diagnose vpn ssl`. They include:

- `list`: Lists logged-on users
- `info`: Shows general SSL VPN information
- `statistics`: Shows statistics about memory usage on FortiGate
- `hw-acceleration-status`: Displays the status of SSL hardware acceleration
- `tunnel-test`: Enables or disables SSL VPN old tunnel mode IP allocation method
- `web-mode-test`: Enables or disables random session ID in proxy URL for testing

The command `diagnose debug application sslvpn` shows the entire list of debug messages for SSL VPN connections.

Remember, to use the commands listed above, you must first run the `diagnose debug enable` command. Also, check SSL VPN debug logs on FortiClient.

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Hardware Acceleration for SSL VPN

- FortiGate devices with content processors (CP8 or CP9), which offload specific CPU-intensive operations, support high-performance SSL VPN bulk data engines
 - SSL/TLS protocol processor
- Administrators can disable CP offloading through firewall policies
 - For example: test purposes

```
config firewall policy
    edit 1
        set auto-asic-offload [enable | disable]
    end
```

- To view the status of SSL VPN acceleration, use the following command:

```
get vpn status ssl hw-acceleration-status
```

```
Acceleration hardware detected: kxp-on      No acceleration hardware detected
cipher=on
```

FortiGate devices that have CP8 or CP9 content processors, which accelerate many common resource-intensive, security-related processes, can offload SSL VPN traffic to a high-performance VPN bulk data engine.

This specialized IPsec and SSL/TLS protocol processor processes most of the latest well-known algorithms for encryption.

By default, the offloading process is set up. If, for testing purposes you want to disable it, you can do it using the CLI only at the firewall policy configuration level.

You can also view the status of SSL VPN acceleration using the CLI.

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Knowledge Check

1. What does the SSL VPN monitor feature allow you to do?
 - A. Monitor SSL VPN user actions, such as authentication
 - B. Force SSL VPN user disconnections

2. Which statement about SSL VPN timers is correct?
 - A. SSL VPN timers can prevent logouts when SSL VPN users experience long network latency.
 - B. The login timeout is a non-customizable hard value.

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Lesson Progress



SSL VPN Deployment Modes



Configuring SSL VPNs



Monitoring and Troubleshooting

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Congratulations! You have completed this lesson.

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

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Review

- ✓ Describe the differences between SSL VPN modes
- ✓ Define authentication for SSL VPN users
- ✓ Configure SSL VPN portals
- ✓ Configure SSL VPN settings
- ✓ Define firewall policies for SSL VPN
- ✓ Configure the client integrity check
- ✓ Monitor SSL VPN connected users
- ✓ Review SSL VPN logs
- ✓ Configure SSL VPN timers
- ✓ Troubleshoot common SSL VPN issues



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

By mastering the objectives covered in this lesson, you learned how to configure and use SSL VPNs to give remote users access to your private network.

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FortiGate Infrastructure

IPsec VPN



Last Modified: 23 August 2022

In this lesson, you will learn about the architectural components of IPsec VPN and how to configure them.

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Lesson Overview



IPsec Introduction



IPsec Configuration



Routing and Firewall Policies



Redundant VPNs



Monitoring and Logs

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

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IPsec Introduction

Objectives

- Describe the benefits of IPsec VPN
- Be familiar with the IPsec protocol
- Understand how IPsec works
- Select an appropriate VPN topology

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

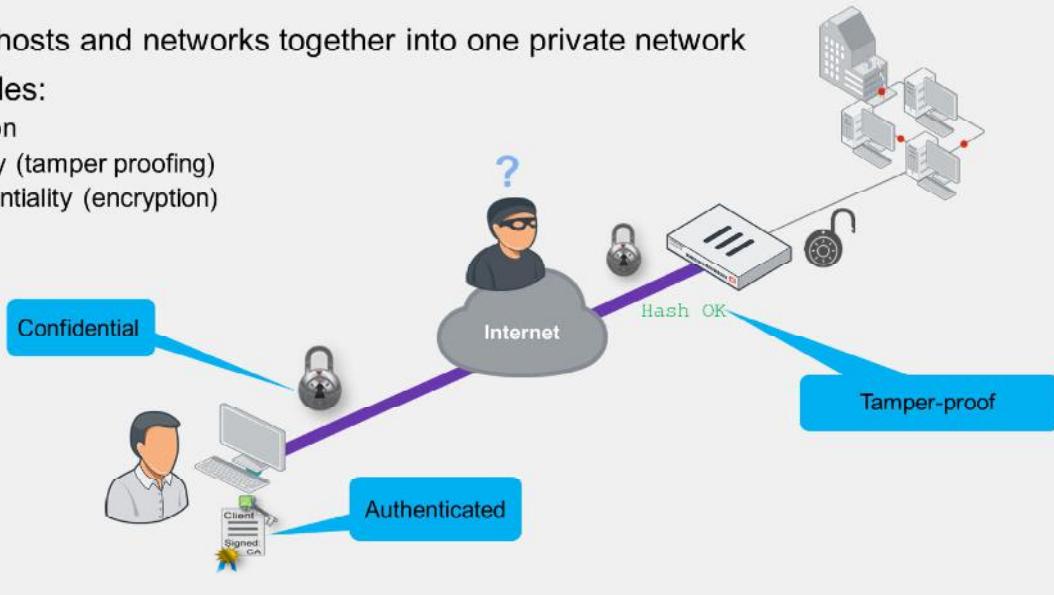
By demonstrating competence in IPsec basics, you will be able to understand IPsec concepts and benefits.

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What Is IPsec?

- Joins remote hosts and networks together into one private network
- Usually provides:
 - Authentication
 - Data integrity (tamper proofing)
 - Data confidentiality (encryption)



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What is IPsec? When should you use it?

IPsec is a vendor-neutral set of standard protocols that is used to join two physically distinct LANs. The LANs are joined as if they were a single logical network, despite being separated by the internet.

In theory, IPsec *does* support null encryption—that is, you can make VPNs that don't encrypt traffic. IPsec also supports null data integrity. But does that provide any advantages over plain traffic? No. No one can trust traffic that may have had an attack injected by an attacker. Rarely do people want data sent by an unknown source. Most people also want private network data, such as credit card transactions and medical records, to remain private.

Regardless of the vendor, IPsec VPNs almost always have settings that allow them to provide three important benefits:

- Authentication: to verify the identity of both ends
- Data integrity (or HMAC): to prove that encapsulated data has not been tampered with as it crosses a potentially hostile network
- Confidentiality (or encryption): to make sure that only the intended recipient can read the message

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What Is the IPsec Protocol?

- Multiple protocols that work together
 - Authentication Header (AH) provides integrity but not encryption
 - AH is defined in the RFC, but FortiGate does not use it
- Port numbers and encapsulation vary by network address translation (NAT)

Protocol	NAT Traversal (NAT-T)	No NAT
IKE RFC 2409 (IKEv1) RFC 4306 (IKEv2)	IP protocol 17: UDP port 500 (UDP 4500 for rekey, quick mode, mode-cfg)	IP protocol 17: UDP port 500
ESP RFC 4303	IP protocol 17: UDP port 4500 (encapsulated)	IP protocol 50

- If required, set a custom port for both IKE and IKE NAT-T (initiator and responder)*:

```
config system settings
  set ike-port <port>
end
```

* Custom port range: 1024–65535. FortiGate always listens on UDP port 4500 (responder only)

If you're passing your VPN through firewalls, it helps to know which protocols to allow.

IPsec is a suite of separate protocols, which includes:

- Internet Key Exchange (IKE): used to authenticate peers, exchange keys, and negotiate the encryption and checksums that will be used—essentially, it is the *control channel*
- AH: contains the authentication header—the checksums that verify the integrity of the data
- Encapsulating Security Payload (ESP): the encapsulated security payload—the encrypted payload, which is essentially the *data channel*

So, if you must pass IPsec traffic through a firewall, remember that allowing only one protocol or port number is usually not enough.

Note that the IPsec RFC mentions AH, however, AH does not offer encryption, which is an important benefit. Therefore, FortiGate does not use AH. As a result, you don't need to allow the AH IP protocol (51).

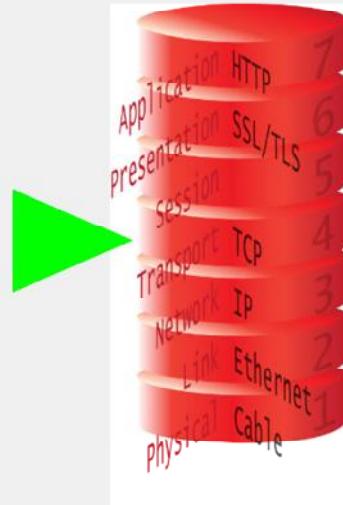
To set up a VPN, you must configure matching settings on both ends of the VPN—whether the VPN is between two FortiGate devices, FortiGate and FortiClient, or a third-party device and FortiGate. If the settings don't match, the tunnel setup fails.

The default ports for standard IKE traffic and IKE NAT-T traffic is UDP 500 and UDP 4500, respectively. You can use the CLI command shown on this slide to configure a custom port for both IKE and IKE NAT-T. The custom port is used to initiate and respond to tunnel requests. If NAT is detected, then the custom port can be used for both IKE and UDP-encapsulated ESP traffic. Note that FortiGate always listens for port UDP 4500 regardless of the custom port settings. This enables FortiGate to negotiate NAT-T tunnels on custom and standard ports.

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How Does IPsec Work?

- Encapsulation
 - Other protocols wrapped inside IPsec
 - What's inside? Varies by mode:
 - Transport mode—TCP/UDP
 - Tunnel mode—additional IP layer, then TCP/UDP
- Negotiation
 - Authentication
 - Handshake to exchange keys, settings

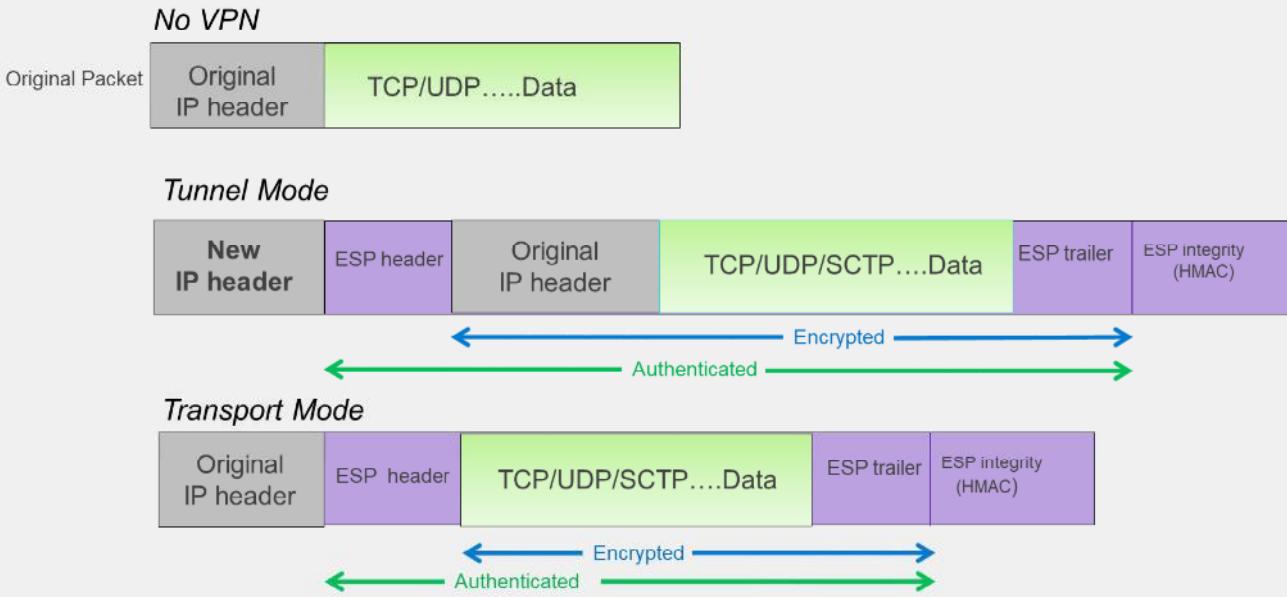


IPsec provides services at the IP (network) layer. During tunnel establishment, both ends negotiate the encryption and authentication algorithms to use.

After the tunnel has been negotiated and is up, data is encrypted and encapsulated into ESP packets.

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ESP Encapsulation—Tunnel or Transport Mode



What's encapsulated? It depends on the encapsulation mode being used. IPsec can operate in two modes: transport mode and tunnel mode.

- Transport mode directly encapsulates and protects the fourth layer (transport) and above. The original IP header is not protected and no additional IP header is added.
- Tunnel mode is a true tunnel. The whole IP packet is encapsulated and a new IP header is added at the beginning. After the IPsec packet reaches the remote LAN and is unwrapped, the original packet can continue on its journey.

Note that after you remove the VPN-related headers, a transport mode packet can't be transmitted any further; it has no second IP header inside, so it's not routable. For that reason, this mode is usually used only for end-to-end (or client-to-client) VPNs.

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What Is IKE?

- Default ports: UDP port 500 (and UDP port 4500 when crossing NAT)
- Negotiates a tunnel's private keys, authentication, and encryption
- Phases:
 - Phase 1
 - Phase 2
- Versions
 - IKEv1 (legacy, wider adoption)
 - IKEv2 (new, simpler operation)



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IKE uses UDP port 500. If NAT-T is enabled in a NAT scenario, IKE uses UDP port 4500.

IKE establishes an IPsec VPN tunnel. FortiGate uses IKE to negotiate with the peer and determine the IPsec security association (SA). The IPsec SA defines the authentication, keys, and settings that FortiGate uses to encrypt and decrypt that peer's packets. It is based on the Internet Security Association and Key Management Protocol (ISAKMP).

IKE defines two phases: phase 1 and phase 2.

There are two IKE versions: IKEv1 and IKEv2. Even though IKEv2 is a newer version and features a simpler protocol operation, this lesson focuses on IKEv1 only, because of its much wider adoption.

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IKEv1 vs. IKEv2

Feature	IKEv1	IKEv2
Exchange modes	<ul style="list-style-type: none"> Main <ul style="list-style-type: none"> Total messages: 9 (6 for phase 1, 3 for phase 2) Aggressive <ul style="list-style-type: none"> Total messages: 6 (3 for phase 1, 3 for phase 2) 	<ul style="list-style-type: none"> One exchange procedure only Total messages: 4 (one child SA only)
Authentication methods	Symmetric: <ul style="list-style-type: none"> Pre-shared key (PSK) Certificate signature Extended authentication (XAuth) 	Asymmetric: <ul style="list-style-type: none"> PSK Certificate signature EAP (pass-through—no client support)
NAT-T	Supported as extension	Native support
Reliability	Unreliable—messages are not acknowledged	Reliable—messages are acknowledged
Dial-up phase 1 matching by ID	<ul style="list-style-type: none"> Peer ID + aggressive mode + PSK Peer ID + main mode + certificate signature 	<ul style="list-style-type: none"> Peer ID Network ID
Traffic selector narrowing	Not supported	Supported



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This slide shows a table comparing some of the IKEv1 and IKEv2 features that FortiOS supports. IKEv2 provides a simpler operation, which is the result of using a single exchange mode and requiring less messages to bring up the tunnel.

Authentication-wise, both versions support PSK and certificate signature. Although only IKEv1 supports XAuth, IKEv2 supports EAP, which is equivalent to XAuth. However, the FortiOS IKEv2 EAP implementation is pass-through only. That is, FortiOS doesn't support EAP as a client, which means that you cannot revoke access to peers using IKEv2 unless you use a certificate signature. With IKEv1, you can deny access to VPN peers without having to use a certificate signature by using XAuth. IKEv2 also supports asymmetric authentication, which enables you to configure each peer to use a different authentication method.

Both IKE versions support NAT-T. However, IKEv2 supports NAT-T natively, while IKEv1 supports NAT-T as an extension. Also, IKEv2 is a more reliable protocol than IKEv1 because, like TCP, peers must acknowledge the messages exchanged between them. IKEv1 doesn't support such a mechanism.

When you configure multiple dial-up IPsec VPNs, IKEv2 makes it simpler to match the intended gateway by peer ID. With IKEv2, you can either use the standard peer ID attribute or the Fortinet proprietary network ID attribute to indicate the phase 1 gateway to match on the dial-up server, regardless of the authentication mode in use. However, with IKEv1, you can use the peer ID only, and then combine it with aggressive mode and pre-shared key authentication, or with main mode and certificate signature authentication.

Finally, IKEv2 allows the responder to choose a subset of the traffic the initiator proposes. This is called traffic selector narrowing and enables you to have more flexible phase 2 selector configurations. Traffic selector narrowing enables a peer to automatically narrow down its traffic selector addresses, so it agrees with the traffic selector the remote peer proposes.

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Negotiation—Security Association (SA)

- IKE allows the parties involved in a transaction to set up their Security Associations (SAs)
 - SAs are the basis for building security functions into IPsec
 - In normal two-way traffic, the exchange is secured by a pair of SAs
 - IPsec administrators decide the encryption and authentication algorithms that can be used in the exchange
- IKE uses two distinct phases:
 - Phase 1 → Outcome: IKE SA
 - Phase 2 → Outcome: IPsec SA



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In order to create an IPsec tunnel, both devices must establish their SAs and secret keys, which are facilitated by the IKE protocol.

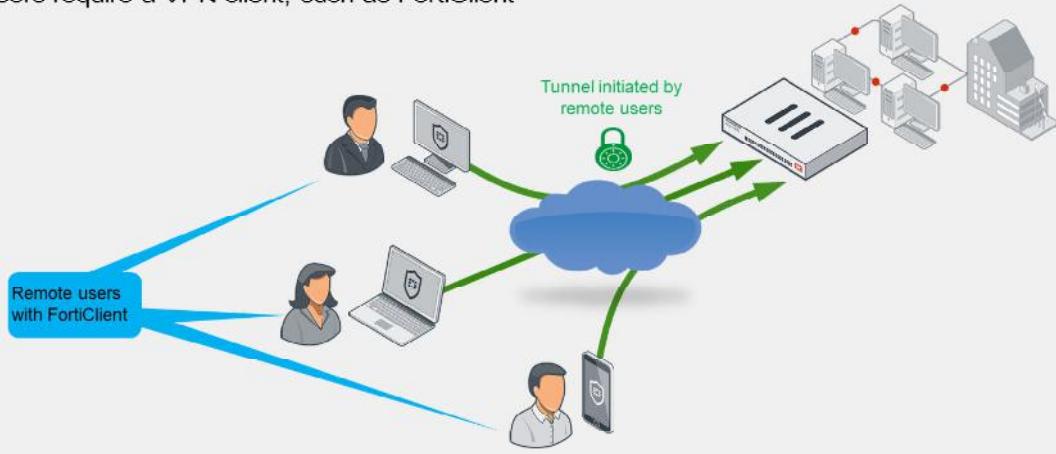
The IPsec architecture uses SAs as the basis for building security functions into IPsec. An SA is the bundle of algorithms and parameters being used to encrypt and authenticate data travelling through the tunnel. In normal two-way traffic, this exchange is secured by a pair of SAs, one for each traffic direction. Essentially, both sides of the tunnel must agree on the security rules. If both sides cannot agree on the rules for sending data and verifying each other's identity, then the tunnel is not established. SAs expire and need to be renegotiated by the peers after they have reached their lifetime.

IKE uses two distinct phases: phase 1 and phase 2. Each phase negotiates different SA types. The SA negotiated during phase 1 is called IKE SA, and the SA negotiated during phase 2 is called IPsec SA. FortiGate uses IKE SAs for setting up a secure channel to negotiate IPsec SAs. FortiGate uses IPsec SAs for encrypting and decrypting the data sent and received, respectively, through the tunnel.

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VPN Topologies—Remote Access

- Remote users connect to corporate resources
 - FortiGate is configured as dial-up server—only clients can initiate the VPN
 - Users require a VPN client, such as FortiClient



Use remote access VPNs when remote internet users need to securely connect to the office to access corporate resources. The remote user connects to a VPN server located on the corporate premises, such as FortiGate, to establish a secure tunnel. After the user is authenticated, FortiGate provides access to network resources, based on the permissions granted to that user.

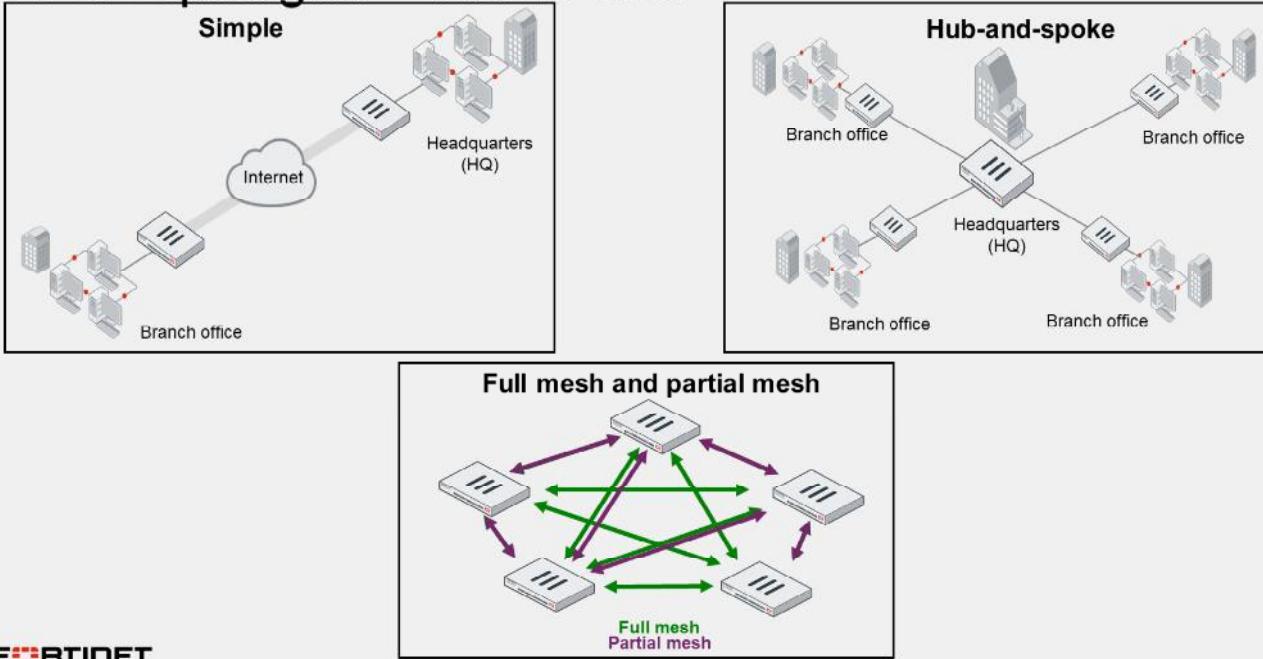
In a remote access VPN, FortiGate is usually configured as a dial-up server. You will learn more about dial-up VPNs in this lesson. The IP address of the remote internet user is usually dynamic. Because FortiGate does not know the IP address of the remote user, only the remote user can initiate a VPN connection request.

The remote user side needs a VPN client, such as FortiClient. You must configure FortiClient to match the VPN server settings. FortiClient takes care of establishing the tunnel, as well as routing the traffic destined to the remote site through the tunnel.

In addition, you can use one remote access VPN configuration on your FortiGate device for many remote users. FortiGate establishes a separate tunnel for each of them.

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VPN Topologies—Site-to-Site



Site-to-site VPN is also known as LAN-to-LAN VPN. A simple site-to-site deployment involves two peers communicating directly to connect two networks located at different offices.

When you need to connect more than two locations, you can use a hub-and-spoke topology. In hub-and-spoke, all clients connect through a central hub. In the example shown on this slide, the clients—spokes—are branch office FortiGate devices. For any branch office to reach another branch office, its traffic must pass through the hub. One advantage of this topology is that the configuration needed is easy to manage. Another advantage is that only the FortiGate at HQ must be very powerful because it handles all tunnels simultaneously, while the branch office FortiGate devices require much fewer resources because they maintain only one tunnel. One disadvantage is that communication between branch offices through HQ is slower than in a direct connection, especially if your HQ is physically distant. Also, if the FortiGate device at HQ fails, VPN failure is company-wide.

In a mesh topology, you can connect FortiGate devices directly and therefore bypass HQ. Two variations of mesh topology exist: full mesh and partial mesh. Full mesh connects every location to every other location. The higher the number of FortiGate devices, the higher the number of tunnels to configure on each FortiGate device. For example, in a topology with five FortiGate devices, you would need to configure four tunnels on each device, for a total of 20 tunnels. This topology causes less latency and requires much less HQ bandwidth than hub-and-spoke, but requires each FortiGate device to be more powerful. Partial mesh attempts to compromise, minimizing required resources but also latency. Partial mesh can be appropriate if communication is not required between every location. However, the configuration of each FortiGate device is more complex than in hub-and-spoke. Routing, especially, may require extensive planning.

Generally, the more locations you have, hub-and-spoke will be cheaper, but slower, than a mesh topology. Mesh places less strain on the central location. It's more fault-tolerant, but also more expensive.

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VPN Topologies—Comparison

Hub-and-Spoke	Partial Mesh	Full Mesh
Easy configuration	Moderate configuration	Complex configuration
Few tunnels	Medium number of tunnels	Many tunnels
High central bandwidth	Medium bandwidth in hub sites	Low bandwidth
Not fault tolerant	Some fault tolerance	Fault tolerant
Low system requirements on average, but high for center	Medium system requirements	High system requirements
Scalable	Somewhat scalable	Difficult to scale
No direct communication between spokes	Direct communication between some sites	Direct communication between all sites

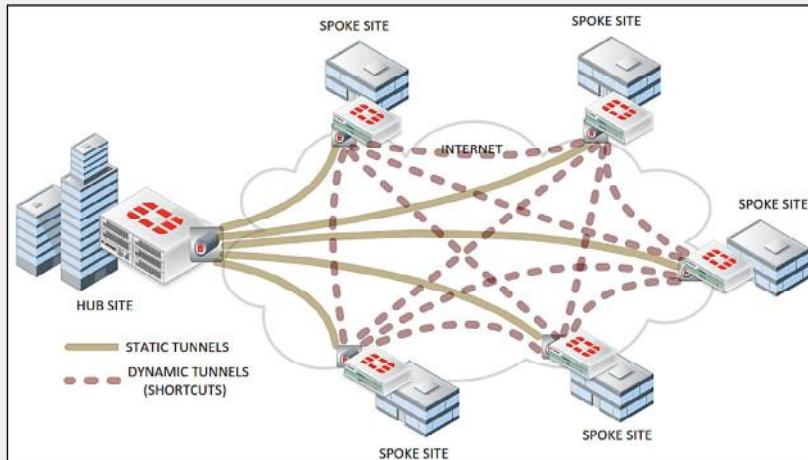
To review, this slide shows a high-level comparison of VPN topologies. You should choose the topology that is most appropriate to your situation.

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Auto-Discovery VPN

- Dynamically negotiates on-demand direct VPNs between spokes
 - Provides the benefits of a full mesh topology over a hub-and-spoke or partial mesh deployment
 - Dynamic routing is recommended to learn routes between hub and spokes and scale up easier
 - Static routing also works, but should be used for small deployments only



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Each VPN topology has its advantages and disadvantages.

Auto-discovery VPN (ADVPN) is a FortiGate feature that achieves the benefits of a full-mesh topology with the easier configuration and scalability benefits of hub-and-spoke and partial-mesh topologies.

First, you add the VPN configurations for building either a hub-and-spoke or a partial-mesh topology, to the FortiGate devices. Then, you enable ADVPN on the VPNs. ADVPN dynamically negotiates tunnels between spokes (without having them preconfigured) to get the benefits of a full-mesh topology.

You can use dynamic routing and static routing to deploy ADVPN. A dynamic routing protocol, such as BGP, is usually deployed in large networks because it enables you to exchange routing information between spokes and hub easier, and as a result, to scale up. You can also use static routing to deploy ADVPN, but it is recommended to do so in small networks that are not likely to grow considerably.

Whether you use dynamic routing or not, after a shortcut is negotiated, FortiGate automatically adds routes through the shortcut to redirect spoke-to-spoke traffic through it.

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Knowledge Check

1. Which IPsec protocol is not supported by FortiGate?

- A. IKEv2
- B. AH

2. Which VPN topology is the most fault tolerant?

- A. Full mesh
- B. Hub-and-spoke

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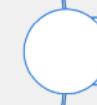
Lesson Progress



IPsec Introduction



IPsec Configuration



Routing and Firewall Policies



Redundant VPNs



Monitoring and Logs

Good job! You have now been introduced to IPsec.

Now, you will learn about IPsec configuration.

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IPsec Configuration

Objectives

- Learn about the IPsec wizard
- Identify and understand the phases of IKEv1
- Understand IPsec phase 1 and phase 2 settings

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

By demonstrating competence in IPsec configuration, you will be able to successfully determine the settings required for your IPsec VPN deployment.

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IPsec Wizard

The screenshot shows the FortiGate IPsec Wizard interface. At the top, a blue header bar reads "VPN > IPsec Wizard". Below it, a progress bar indicates "4 Review Settings" is the current step. The main area is titled "VPN Creation Wizard". It shows the following configuration:

- Name:** ToRemoteBackup
- Template type:** Site to Site (selected)
- NAT configuration:** No NAT between sites
- Remote device type:** FortiGate (selected)

A network diagram titled "Site to Site - FortiGate" is displayed, showing two FortiGates connected via the Internet. A red arrow points from the "Review Settings" step in the progress bar down to the "Object Summary" table.

Object Summary	
Phase 1 interface	ToRemoteBackup
Local address group	ToRemoteBackup_local
Remote address group	ToRemoteBackup_remote
Phase 2 interface	ToRemoteBackup
Static route	static
Blackhole route	static
Local to remote policies	vpn_ToRemoteBackup_local
Remote to local policies	vpn_ToRemoteBackup_remote

A callout box labeled "Network diagram describing deployment type" points to the network diagram. Another callout box labeled "Summary of objects created by the IPsec wizard" points to the "Object Summary" table. The bottom right corner of the interface shows "© Fortinet Inc. All Rights Reserved." and the number "18".

When you create an IPsec tunnel on the GUI, FortiGate redirects you to the **IPsec Wizard**. The wizard simplifies the creation of the new VPN by walking you through a four to five-step process. The first step is to select a template type. If you want to manually configure your VPN, you can select **Custom** as **Template type**, upon which FortiGate takes you directly to the phase 1 and phase 2 settings of the new VPN.

If you want the wizard to configure the VPN for you, then select the template type (**Site to Site**, **Hub-and-Spoke**, or **Remote Access**) that best matches your VPN. After that, the wizard asks you for key information such as the remote gateway information, authentication method, interfaces involved, and subnets. Based on the input you provide, the wizard applies one of the preconfigured IPsec tunnel templates comprising IPsec phase 1 and 2 settings and other related firewall address objects, routing settings, and firewall policies needed for the new tunnel to work.

In addition, the wizard shows a network diagram that changes based on the input provided. The purpose of the diagram is for the administrator to have a visual understanding of the IPsec VPN deployment that the wizard configures based on the input received.

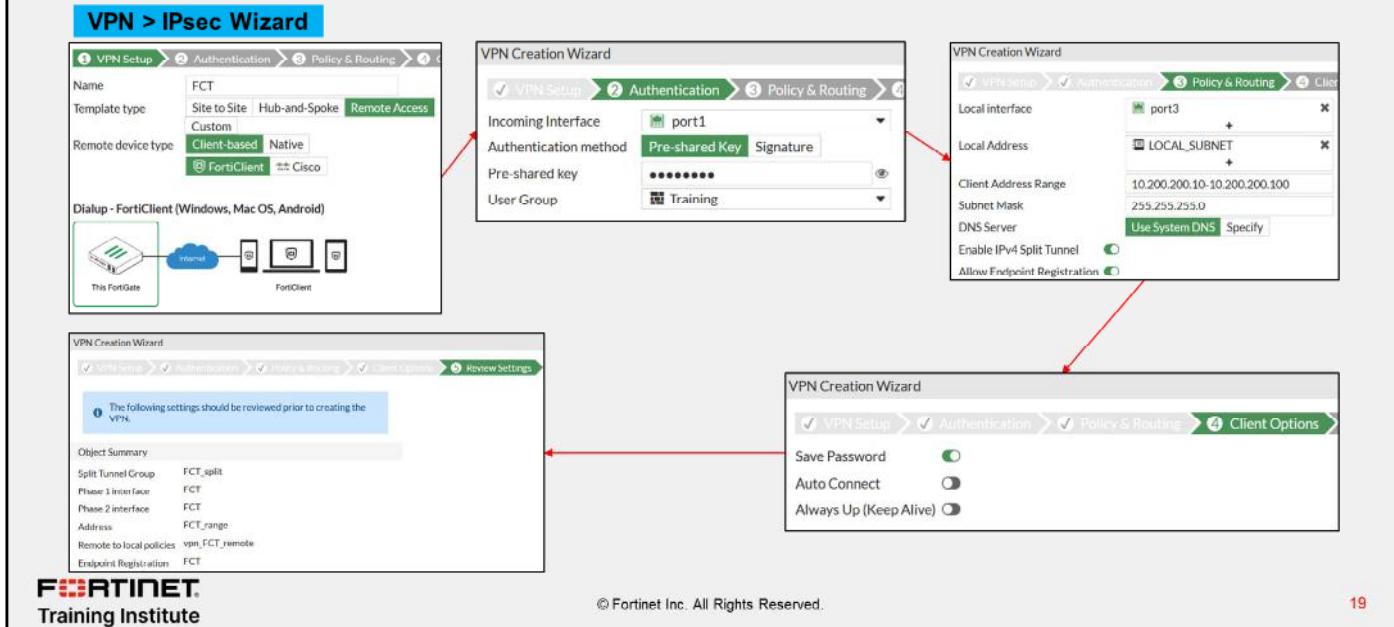
At the end of the wizard, the wizard provides a summary of the configuration changes made in the system, and that the administrator can review if needed.

If you are new to FortiGate, or don't have much experience with IPsec VPNs, using the IPsec wizard is recommended. You can later adjust the configuration applied by the wizard to match your specific needs.

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Using the IPsec Wizard for a FortiClient VPN

- Simplifies IPsec configuration for a FortiClient VPN



A common use of the IPsec wizard is for configuring a remote access VPN for FortiClient users. The wizard enables IKE mode config, XAuth, and other appropriate settings for FortiClient users. You will learn more about IKE mode config and XAuth in this lesson.

The images on this slide show the four-step process used by the IPsec wizard for assisting the administrator on the FortiClient VPN configuration.

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IPsec Tunnel Templates

VPN > IPsec Tunnel Template

Template	Description
Site to Site - FortiGate	Static tunnel between this FortiGate and a remote FortiGate.
Site to Site - FortiGate (SD-WAN)	Static tunnel between this FortiGate using SD-WAN and a remote FortiGate.
Dialup - FortiGate	On-demand tunnel between two FortiGate devices.
Site to Site - Cisco	Static tunnel between this FortiGate and a remote Cisco firewall.
Dialup - Cisco Firewall	On-demand tunnel between a FortiGate device and a Cisco Firewall.
Dialup - FortiClient (Windows, Mac OS, Android)	On-demand tunnel for users using the FortiClient software.
Dialup - iOS (Native)	On-demand tunnel for iPhone/iPad users using the native iOS IPsec client.
Dialup - Android (Native L2TP/IPsec)	On-demand tunnel for Android users using the native L2TP/IPsec client.
Dialup - Windows (Native L2TP/IPsec)	On-demand tunnel for Windows users using the native L2TP/IPsec client.
Dialup - Cisco IPsec Client	On-demand tunnel for users using the Cisco IPsec client.
Hub-and-Spoke - FortiGate (Spoke)	Spoke role in a Hub-and-Spoke auto-discovery VPN configuration.
Hub-and-Spoke - FortiGate (Hub)	Hub role in a Hub-and-Spoke auto-discovery VPN configuration.

Click **View** to review the template details

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The IPsec wizard uses one of the templates shown on this slide when applying the configuration for the new IPsec tunnel. You can review the settings of a template by selecting the template, and then clicking **View**. You cannot change the template settings.

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Phase 1—Overview

- Each peer of the tunnel—the initiator and the responder—connects and begins to set up the VPN
- On the first connection, the channel is not secure
 - Unencrypted keys can be intercepted
- To exchange sensitive private keys, both peers create a secure channel
 - Both peers negotiate the real keys for the tunnel later

Phase 1 takes place when each peer of the tunnel—the initiator and the responder—connects and begins to set up the VPN. The initiator is the peer that starts the phase 1 negotiation, while the responder is the peer that responds to the initiator request.

When the peers first connect, the channel is not secure. An attacker in the middle could intercept unencrypted keys. Neither peer has a strong guarantee of the other peer's identity, so how can they exchange sensitive private keys? They can't. First, both peers create a secure tunnel. Then, they use this secure tunnel to negotiate the real keys for the tunnel later.

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Phase 1—How it Works

1. Authenticate peers
 - PSK or digital signature
 - XAuth
2. Negotiate one bidirectional SA (called IKE SA)
 - In IKE v1, two possible ways:
 - Main mode
 - Aggressive mode
 - Not the same as IPsec SA
 - Encrypted tunnel for Diffie-Hellman (DH)
3. DH exchange for secret keys



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Now you'll examine how phase 1 works.

The purpose of phase 1 is to authenticate peers and set up a secure channel for negotiating the phase 2 SAs (or IPsec SAs) that are later used to encrypt and decrypt traffic between the peers. To establish this secure channel, the peers negotiate a phase 1 SA. This SA is called the IKE SA and is bidirectional.

To authenticate each other, the peers use two methods: pre-shared key or digital signature. You can also enable an additional authentication method, XAuth, to enhance authentication.

In IKEv1, there are two possible modes in which the IKE SA negotiation can take place: main, and aggressive mode. Settings on both ends must agree; otherwise, phase 1 negotiation fails and both IPsec peers are not able to establish a secure channel.

At the end of phase 1, the negotiated IKE SA is used to negotiate the DH keys that are used in phase 2. DH uses the public key (that both ends know) plus a mathematical factor called a nonce, in order to generate a common private key. With DH, even if an attacker can listen to the messages containing the public keys, they cannot determine the secret key.

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Phase 1—Network

New VPN Tunnel

Name: ToRemote

Comments: 0/255

Network

- IP Version: IPv4 (selected)
- Remote Gateway: Static IP Address
- IP Address: 10.200.3.1
- Interface: port1
- Local Gateway:
- Mode Config:
- NAT Traversal: Enable
- Keepalive Frequency: 10
- Dead Peer Detection: On Demand
- DPD retry count: 3
- DPD retry interval: 20 s
- Forward Error Correction: Egress, Ingress
- Advanced...

Remote Gateway: Static IP Address

IP Address: 10.200.3.1

Interface: port1

Local Gateway: Local Gateway

Local Gateway: Primary IP: 10.200.10.1

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Phase 1 configuration is broken down on the GUI into four sections: **Network**, **Authentication**, **Phase 1 Proposal**, and **XAUTH**. You will learn about the settings available on each section. You will learn about some of these settings in more detail on separate slides.

The section shown on this slide corresponds to the **Network** settings. The section includes the settings related to the connectivity of the IPsec tunnel:

- **IP Version:** select the IP version to use for the IPsec tunnel. Note that this defines only the IP version of the outer layer of the tunnel (after encapsulation). The packets being encapsulated (protected traffic) can be IPv4 or IPv6, and their IP version is defined in the phase 2 selectors.
- **Remote Gateway:** defines the type of the remote gateway. There are three types: **Static IP Address**, **Dialup User**, and **Dynamic DNS**. You will learn more about these types later in this lesson.
- **IP Address:** the IP address of the remote gateway. This field appears only when you select **Static IP Address** as **Remote Gateway**.
- **Interface:** refers to the interface where the IPsec tunnel terminates on the local FortiGate. Usually, this is the interface connected to the internet or the WAN. You need to make sure there is an active route to the remote gateway through this interface, otherwise the tunnel won't come up.
- **Local Gateway:** enable this setting when the interface where the tunnel terminates has multiple addresses assigned, and you want to specify which address to use for the tunnel. When you enable this setting, you see three options: **Primary IP**, **Secondary IP**, and **Specify**. Select **Specify** if you want to use an IP address different from the primary or secondary IP address.
- **Mode Config:** Enables automatic configuration through IKE. FortiGate acts as an *IKE mode config client* when you enable **Mode Config** and you set **Remote Gateway** to either **Static IP address** or **Dynamic DNS**. If you set **Remote Gateway** to **Dialup User**, FortiGate acts as an *IKE mode config server*, and more configuration options appear on the GUI. You will learn more about **Mode Config** in this lesson.

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Phase 1—Network (Contd)

The screenshot shows the 'New VPN Tunnel' configuration window. In the 'Network' section, 'IPv4' is selected for IP Version, 'Static IP Address' is chosen for Remote Gateway, and '10.200.3.1' is entered for IP Address. The Interface is set to 'port1'. Under 'Mode Config', 'NAT Traversal' is enabled. The 'Advanced...' button at the bottom left is highlighted with a red box and an arrow. On the right, a separate 'Advanced...' section is shown with various options like 'Add route', 'Auto discovery sender', and 'Device creation', each with an 'Enabled' or 'Disabled' checkbox.

Network

- IP Version: IPv4
- Remote Gateway: Static IP Address
- IP Address: 10.200.3.1
- Interface: port1

Mode Config

- NAT Traversal: Enabled
- Keepalive Frequency: 10
- Dead Peer Detection: On Demand
- DPD retry count: 3
- DPD retry interval: 20
- Forward Error Correction: Egress, Ingress

Advanced...

Add route	<input checked="" type="checkbox"/> Enabled	<input type="checkbox"/> Disabled
Auto discovery sender	<input checked="" type="checkbox"/> Enabled	<input type="checkbox"/> Disabled
Auto discovery receiver	<input checked="" type="checkbox"/> Enabled	<input type="checkbox"/> Disabled
Exchange interface IP	<input checked="" type="checkbox"/> Enabled	<input type="checkbox"/> Disabled
Device creation	<input checked="" type="checkbox"/> Enabled	<input type="checkbox"/> Disabled
Aggregate member	<input checked="" type="checkbox"/> Enabled	<input type="checkbox"/> Disabled

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The following are the other options available on the GUI in the **Network** section:

- NAT Traversal:** The option controls the behavior for NAT traversal. You will learn more about NAT traversal later in this lesson.
- Keepalive Frequency:** When you enable NAT traversal, FortiGate sends keepalive probes at the configured frequency.
- Dead Peer Detection:** Use dead peer detection (DPD) to detect dead tunnels. There are three DPD modes. **On Demand** is the default mode. You will learn more about DPD later in this lesson.
- Forward Error Correction:** Forward error correction (FEC) is a technique that you can use to reduce the number of retransmissions in IPsec tunnels established over noisy links, at the expense of using more bandwidth. You can enable FEC on egress and ingress, and it is only supported when you disable IPsec hardware offloading. You will learn more about IPsec hardware offloading later in this lesson.
- Advanced:**
 - Add route:** Disable this setting if you are using a dynamic routing protocol over IPsec and do not want FortiGate to automatically add static routes.
 - Auto discovery sender:** Enable this setting on a hub if you want the hub to facilitate ADVPN shortcut negotiation for spokes. When enabled, the hub sends a shortcut offer to the spoke to indicate that it can establish a shortcut to the remote spoke.
 - Auto discovery receiver:** Enable this setting on a spoke if you want the spoke to negotiate an ADVPN shortcut.
 - Exchange interface IP:** Enable this setting to allow the exchange of IPsec interface IP addresses. This allows a point-to-multipoint connection between the hub and spokes..
 - Device creation:** Enable this setting to instruct FortiOS to create an interface for every dial-up client. To increase performance, disable this setting in dial-up servers with many dial-up clients.
 - Aggregate member:** FortiGate allows you to aggregate multiple IPsec tunnels into a single interface. Enable this option if you want the tunnel to become an aggregate member.

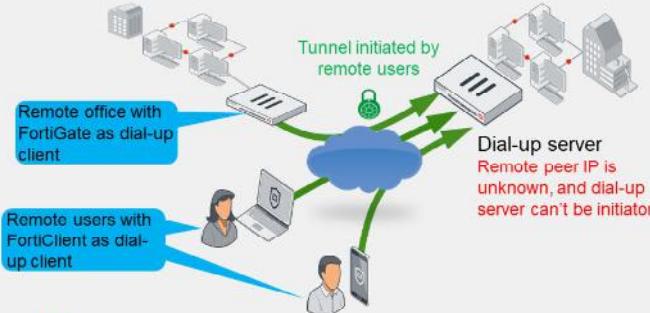
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Phase 1—Network—Remote Gateway

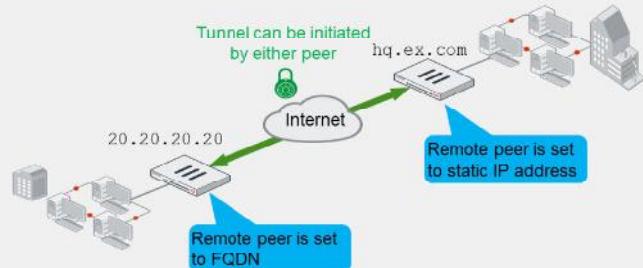
Dial-up user

- Two roles: dial-up server and client
- Dial-up server doesn't know client address
 - Dial-up client is always the initiator
- VPN peers:
 - FortiGate to FortiClient (or third-party client)
 - FortiGate to FortiGate (or third-party gateway)



Static IP address / dynamic DNS

- Dynamic DNS uses FQDN
- The address of the remote peer is known
 - Local peer can be initiator or responder
- VPN peers:
 - FortiGate to FortiGate (or third-party gateway)



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You have three options when configuring the remote gateway type of your VPN: **Dialup User**, **Static IP Address**, and **Dynamic DNS**.

Use **Dialup User** when the remote peer IP address is unknown. The remote peer whose IP address is unknown acts as the dial-up client, and this is often the case for branch offices and mobile VPN clients that use dynamic IP addresses, and no dynamic DNS. The dial-up client must know the IP address or FQDN of the remote gateway, which acts as the dial-up server. Because the dial-up server doesn't know the remote peer address, only the dial-up client can initiate the VPN tunnel.

Usually, dial-up clients are remote and mobile employees with FortiClient on their computer or handheld devices. You can also have a FortiGate device acting as a dial-up client for a remote office. One dial-up server configuration on FortiGate can be used for multiple IPsec tunnels from many remote offices or users.

Use **Static IP Address** or **Dynamic DNS** when you know the remote peer address. If you select **Static IP Address**, then you need to provide an IP address. If you select **Dynamic DNS**, then you need to provide a fully qualified domain name (FQDN), and make sure FortiGate can resolve that FQDN. When both peers know the remote peer address, that is, the remote gateway on both peers is set to **Static IP Address** or **Dynamic DNS**, then any peer can initiate the VPN tunnel.

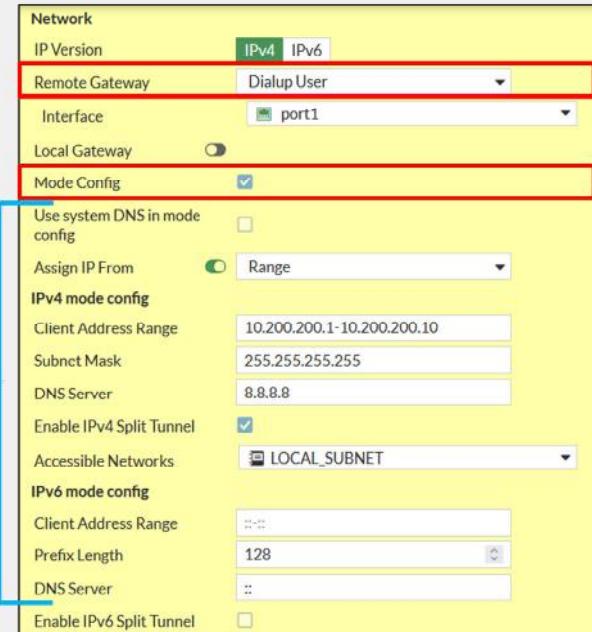
Note that in a dial-up setup, the dial-up client is just a VPN peer with the remote gateway set to **static IP address** or **dynamic DNS**. When setting your VPN, you can combine different types of remote gateways. For obvious reasons, a tunnel in which both peers has the remote gateway set to **Dialup user** won't work.

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Phase 1—Network—IKE Mode Config

- Like DHCP, automatically configures VPN clients' virtual network settings
- By default, FortiClient VPNs use it to retrieve their VPN IP address settings from FortiGate
- You must enable **Mode Config** on both peers

IKE mode config settings are only displayed if Remote Gateway is set to Dialup User



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IKE Mode Config is similar to DHCP because a server assigns network settings such as IP address, netmask, and DNS servers, to clients. This assignment takes place over IKE messages.

When you enable **Mode Config** on a FortiGate device acting as dial-up server, it pushes network settings to dial-up clients. The dial-up clients are usually FortiClient peers, but they can also be FortiGate peers.

For IKE mode config to work, you must enable the feature on both peers. On FortiClient, **Mode Config** is enabled by default, but on FortiGate, you must manually enable it.

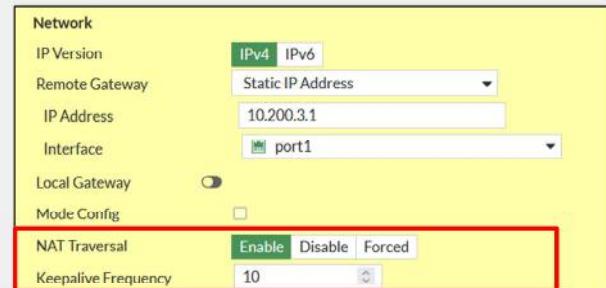
Note that the IKE **Mode Config** settings, are displayed on the GUI only when you set **Remote Gateway** to **Dialup User**. On the FortiGate device acting as dial-up client, you can select **Mode Config** on the GUI, but the additional settings are not displayed.

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Phase 1—Network—NAT Traversal (NAT-T)

- ESP can't support NAT because it has no port numbers
- If **NAT Traversal** is set to **Enable**, it detects whether NAT devices exist on the path
 - If yes, both ESP and IKE use UDP port 4500
 - Recommended if the initiator or responder is behind NAT
- If **NAT Traversal** is set to **Forced**:
 - ESP and IKE always use UDP port 4500, even when there are no NAT devices on the path
- Keepalive probes are sent frequently to keep the connection across the routers active



The ESP protocol usually has problems crossing devices that are performing NAT. One of the reasons is that ESP does not use port numbers, like TCP and UDP do, to differentiate one tunnel from another.

To solve this, NAT transversal (NAT-T) was added to the IPsec specifications. When NAT-T is enabled on both ends, peers can detect any NAT device along the path. If NAT is found, then the following occurs on both peers:

- IKE negotiation switches to using UDP port 4500.
- ESP packets are encapsulated in UDP port 4500.

So, if you have two FortiGate devices that are behind, for example, an ISP modem that performs NAT, you will probably need to enable this setting.

When you set the **NAT Traversal** setting to **Forced**, UDP port 4500 is always used, even when there is no NAT device along the path.

When you enable NAT-T, the **Keepalive Frequency** option shows the interval (in seconds) at which FortiGate sends keepalive probes. You need NAT-T when there is one or more routers along the path performing NAT. The purpose of the keepalive probes is to keep the IPsec connection active across those routers along the path.

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Phase 1—Network—Dead Peer Detection (DPD)

- Mechanism to detect a dead tunnel
- Useful in redundant VPNs, where multiple paths are available
- Three modes:
 - **On Demand:** DPD probes are sent when there is no inbound traffic
 - **On Idle:** DPD probes are sent when there is no traffic
 - **Disabled:** only reply to DPD probes—don't send probes

The screenshot shows the 'Network' configuration page in the FortiGate management interface. The 'IPv4' tab is selected. Under 'Dead Peer Detection', the mode is set to 'On Demand'. Other visible settings include 'Remote Gateway' (Static IP Address: 10.200.3.1), 'Interface' (port1), 'NAT Traversal' (Enable), 'Keepalive Frequency' (10), 'DPD retry count' (3), 'DPD retry interval' (20 seconds), and 'Forward Error Correction' (Egress and Ingress).

After the peers negotiate the IPsec SAs of a tunnel and, therefore, the tunnel is considered up, the peers usually don't negotiate another IPsec SA until it expires. In most cases, the IPsec SA expires every few hours. This means that if there is a network disruption along the path of the tunnel before the IPsec SA expires, the peers will continue to send traffic through the tunnel even though the communication between the sites is disrupted.

When you enable DPD, DPD probes are sent to detect a failed (or dead) tunnel and bring it down before its IPsec SAs expire. This failure detection mechanism is very useful when you have redundant paths to the same destination, and you want to fail over to a backup connection when the primary connection fails to keep the connectivity between the sites up.

FortiGate supports three DPD modes:

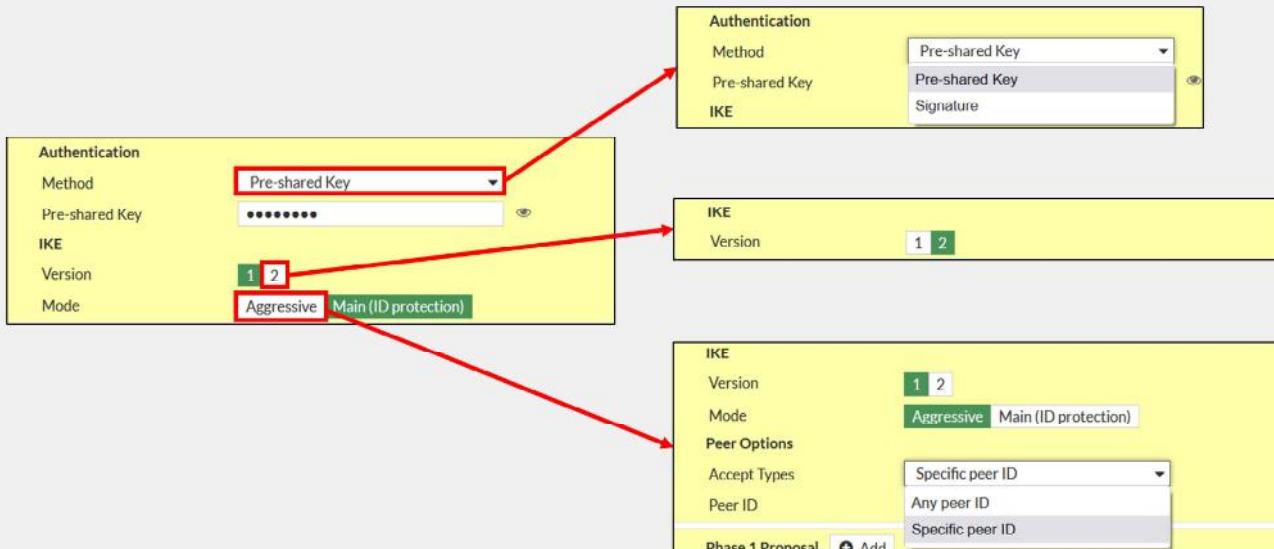
- **On Demand:** FortiGate sends DPD probes if there is only outbound traffic through the tunnel, but no inbound. Because network applications are usually bidirectional, observing only traffic on the outbound direction could be an indication of a network failure.
- **On Idle:** FortiGate sends DPD probes when no traffic is observed in the tunnel. An idle tunnel does not necessarily mean the tunnel is dead. Avoid this mode if you have many tunnels, because the overhead introduced by DPD can be very resource intensive.
- **Disabled:** FortiGate replies only to DPD probes received. FortiGate never sends DPD probes to the remote peer and therefore cannot detect a dead tunnel.

The default DPD mode is **On Demand**. In terms of scalability, **On Demand** is a better option than **On Idle**.

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Phase 1—Authentication



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Now, you will learn about the **Authentication** section in phase 1 configuration:

- Method:** FortiGate supports two authentication methods: **Pre-shared Key** and **Signature**. When you select **Pre-shared Key**, you must configure both peers with the same pre-shared key. When you select **Signature**, phase 1 authentication is based on digital certificate signatures. Under this method, the digital signature on one peer is validated by the presence of the CA certificate installed on the other peer. That is, on the local peer, you need to install both the local peer's certificate and the CA certificate that issued the remote peer certificate.
- Version:** allows you to select the IKE version to use. When selecting version **2**, aggressive and main modes disappear because they don't apply to IKEv2.
- Mode:** refers to the IKEv1 mode. Two options are available: **Aggressive** and **Main (ID protection)**. You will learn more about these modes in this lesson.

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Phase 1—Authentication—Modes

Aggressive

- Not as secure as main mode
- Faster negotiation (three packets exchanged)
- Required when peer ID check is needed

Main

- More secure
- Slower negotiation (six packets exchanged)
- Often used when peer ID check is not needed



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IKE supports two different negotiation modes: main and aggressive. Which one should you use?

To answer that question, we can analyze three categories: security, performance, and deployment.

Security wise, main mode is considered more secure because the pre-shared key hash is exchanged encrypted, whereas in aggressive mode, the hash is exchanged unencrypted. Although the attacker would still have to guess the cleartext pre-shared key for the attack to be successful, the fact that the pre-shared key hash has been encrypted in main mode reduces considerably the chances of a successful attack.

In terms of performance, aggressive mode may be a better option. This is because the negotiation is completed after only three packets are exchanged, whereas in main mode, six packets are exchanged. For this reason, you may want to use aggressive mode when a great number of tunnels terminate on the same FortiGate device, and performance is a concern.

Another use case for aggressive mode, is when there is more than one dial-up tunnel terminating on the same FortiGate IP address, and the remote peer is authenticated using a peer ID because its IP address is dynamic. Because peer ID information is sent in the first packet in an aggressive mode negotiation, then FortiGate can match the remote peer with the correct dial-up tunnel. The latter is not possible in main mode because the peer ID information is sent in the last packet, and after the tunnel has been identified.

When both peers know each other's IP address or FQDN, you may want to use main mode to take advantage of its more secure negotiation. In this case, FortiGate can identify the remote peer by its IP address and, as a result, associate it with the correct IPsec tunnel.

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Phase 1—Phase 1 Proposal

Encryption	Authentication
AES128	SHA256
AES256	SHA256
AES128	SHA1
AES256	SHA1

Diffie-Hellman Groups
<input type="checkbox"/> 32 <input type="checkbox"/> 31 <input type="checkbox"/> 30 <input type="checkbox"/> 29 <input type="checkbox"/> 28 <input type="checkbox"/> 27 <input type="checkbox"/> 21 <input type="checkbox"/> 20 <input type="checkbox"/> 19 <input type="checkbox"/> 18 <input type="checkbox"/> 17 <input type="checkbox"/> 16 <input checked="" type="checkbox"/> 15 <input checked="" type="checkbox"/> 14 <input checked="" type="checkbox"/> 5 <input type="checkbox"/> 2 <input type="checkbox"/> 1

Key Lifetime (seconds)
86400

Local ID
[Redacted]

Phase 1 Proposal	Add
Encryption	AES128
Encryption	DES
Encryption	3DES
Encryption	AES128
Encryption	AES192
Encryption	AES256

Diffie-Hellman Groups
<input type="checkbox"/> 31 <input type="checkbox"/> 30 <input type="checkbox"/> 1

Authentication
SHA256
MD5
SHA256
SHA384
SHA512

Now, you will learn about the **Phase 1 Proposal** section of phase 1 configuration. This section allows you to enable the different proposals that FortiGate supports when negotiating the IKE SA (or phase 1 SA). You can combine different parameters to suit your security needs. You must at least configure one combination of encryption and authentication algorithms, or several.

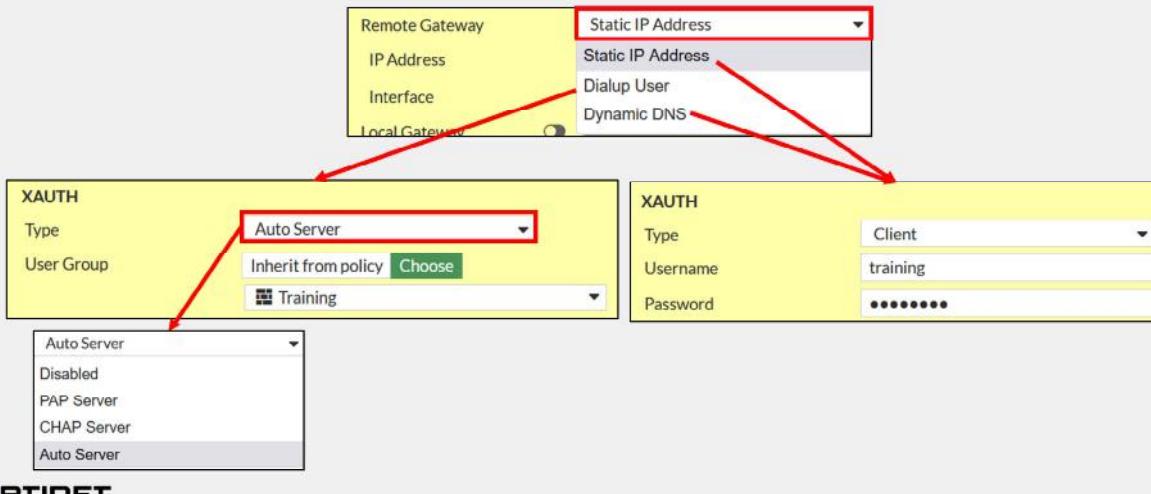
- **Encryption:** select the algorithm to use for encrypting and decrypting the data.
- **Authentication:** select the authentication algorithm to use for verifying the integrity and authenticity of the data.
- **Diffie-Hellman Groups:** The Diffie-Hellman (DH) algorithm is used during IKE SA negotiation. The use of DH in phase 1 is mandatory and can't be disabled. You must select at least one DH group. The higher the DH group number, the more secure the phase 1 negotiation is. However, a higher DH group number also results in a longer compute time.
- **Key Lifetime:** defines the lifetime of the IKE SA. At the end of the lifetime, a new IKE SA is negotiated.
- **Local ID:** if the peer accepts a specific peer ID, type that same peer ID in this field.

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Phase 1—Extended Authentication (XAuth)

- XAuth adds stronger authentication: username + password
- You can authorize all users who belong to a specific user group or inherit it from the matching policy



Phase 1 supports two types of authentication: pre-shared keys and digital signatures. The XAuth extension, sometimes called phase 1.5, forces remote users to authenticate additionally with their credentials (username and password). So, additional authentication packets are exchanged if you enable it. What is the benefit? Stronger authentication.

When you set **Remote Gateway** to **Dialup User**, FortiGate acts as the authentication server. The **XAUTH** section shows the authentication server type options: **PAP Server**, **CHAP Server**, and **Auto Server**. In the example shown on this slide, **Auto Server** is selected, which means that FortiGate automatically detects the authentication protocol used by the client.

After you select the authentication server type, you configure how user group matching is performed. There are two options: **Inherit from policy** and **Choose**. The latter is used in the example on this slide, and allows you to select one of the user groups available on FortiGate. Note that, when you select **Choose**, you must configure a separate dial-up VPN for every group of users that require a different network access policy.

The other way to authenticate VPN users with XAuth is by selecting **Inherit from policy**. When you select this option, FortiGate authenticates users based on their matching IPsec policy and, as a result, the configuration for controlling network access is simpler. That is, you control network access by configuring multiple policies for different user groups, instead of configuring multiple tunnels for different user groups. The **Inherit from policy** option follows a similar authentication approach used for SSL VPN remote users. You will learn more about SSL VPN in another lesson.

When **Remote Gateway** is set to **Static IP Address** or **Dynamic DNS**, FortiGate acts as the client, and the **XAUTH** section shows the **Client** option as **Type**. You can then set the credentials that FortiGate uses to authenticate against the remote peer through XAuth.

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Phase 2—How it Works

- Negotiates two unidirectional IPsec SAs for ESP
 - Protected by phase 1 IKE SA
- When IPsec SAs are about to expire, it renegotiates
 - Optionally, if **Perfect Forward Secrecy** is enabled, FortiGate uses DH to generate new keys each time phase 2 expires
- Each phase 1 can have multiple phase 2s
 - High security subnets can have stronger ESP



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After phase 1 has established a secure channel to exchange data, phase 2 begins.

Phase 2 negotiates security parameters for two IPsec SAs over the secure channel established during phase 1. ESP uses IPsec SAs to encrypt and decrypt the traffic exchanged between sites.

Phase 2 does not end when ESP begins. Phase 2 periodically renegotiates IPsec SAs to maintain security. If you enable **Perfect Forward Secrecy**, each time phase 2 expires, FortiGate uses DH to recalculate new secret keys. In this way, new keys are not derived from older keys, making it much harder for an attacker to crack the tunnel.

Each phase 1 can have multiple phase 2s. When would this happen? For example, you may want to use different encryption keys for each subnet whose traffic is crossing the tunnel. How does FortiGate select which phase 2 to use? By checking which phase 2 selector (or quick mode selector) matches the traffic.

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Phase 2—Phase 2 Selectors

- Determines the encryption domain
 - You can configure multiple selectors for granular control
 - If traffic does not match a selector, it is dropped
 - In point-to-point VPNs, selectors must match
 - The source on one FortiGate is the destination setting on the other
- Select which selector to use using:
 - Local Address** and **Remote Address**
 - Protocol** number
 - Local Port** and **Remote Port**

Phase 2 Selectors		
Name	Local Address	Remote Address
ToRemote	0.0.0/0.0.0	0.0.0/0.0.0

New Phase 2	
Name	Comments
ToRemote	Comments
Local Address	Subnet
Remote Address	Subnet

Advanced...	
Local Port	All <input checked="" type="checkbox"/>
Remote Port	All <input checked="" type="checkbox"/>
Protocol	All <input checked="" type="checkbox"/>

Subnet	
IP Range	<input type="checkbox"/>
IP Address	<input type="checkbox"/>
Named Address	<input type="checkbox"/>
IPv6 Subnet	<input type="checkbox"/>
IPv6 Range	<input type="checkbox"/>
IPv6 Address	<input type="checkbox"/>
Named IPv6 Address	<input type="checkbox"/>

In phase 2, you must define the encryption domain (or interesting traffic) of your IPsec tunnel. The encryption domain refers to the traffic that you want to protect with IPsec, and it is determined by your phase 2 selector configuration.

You can configure multiple selectors to have more granular control over traffic. When you configure a phase 2 selector, you specify the encryption domain by indicating the following network parameters:

- Local Address** and **Remote Address**: as seen in the example shown on this slide, you can define IPv4 or IPv6 addresses using different address scopes. When selecting **Named Address** or **Named IPv6 Address**, FortiGate allows you to select an IPv4 or IPv6 firewall address object, respectively, configured in the system.
- Protocol**: is in the **Advanced** section, and is set to **All** by default.
- Local Port** and **Remote Port**: are also shown in the **Advanced** section, and are set to **All** by default. This applies only to port-based traffic such as TCP or UDP. You will learn more about the **Advanced** section later in this lesson.

Note that after the traffic is accepted by a firewall policy, traffic is dropped before entering the IPsec tunnel if the traffic does not match any of the phase 2 selectors configured. For this reason, usually, it's more intuitive to filter traffic with firewall policies. So, if you don't want to use phase 2 selector filtering, you can just create one phase 2 selector with both the local and remote addresses set to any subnet, like in the example shown on this slide, and then use firewall policies to control which traffic is accepted on the IPsec tunnel.

In addition, the phase 2 selector network parameters on both peers must match if the tunnel is point-to-point, that is, when the remote gateway is *not* set to dial-up user.

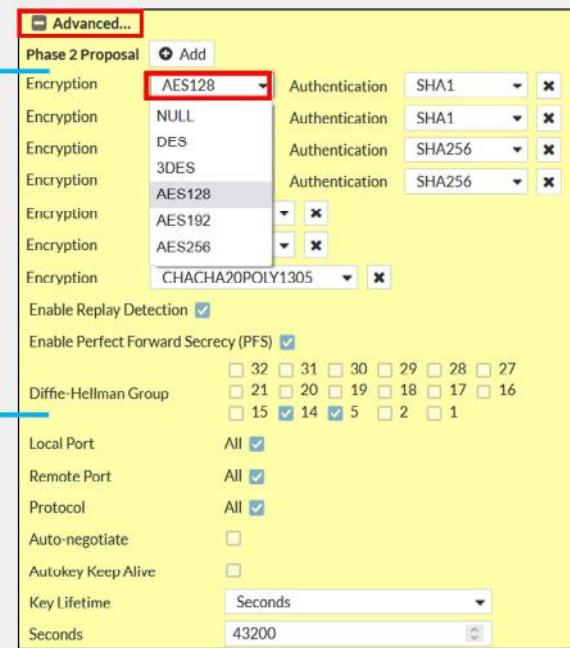
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Phase 2—Phase 2 Proposal

- Determines the encryption algorithms
 - You can configure multiple proposals for added flexibility
 - Impacts performance and hardware offloading
- You can enable replay detection to protect against ESP replay attacks
 - Local setting

Encryption and authentication algorithms for IPsec encryption



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For every phase 2 selector, you need to configure one or more phase 2 proposals. A phase 2 proposal defines the algorithms supported by the peer for encrypting and decrypting the data over the tunnel. You can configure multiple proposals to offer more options to the remote peer when negotiating the IPsec SAs.

Like in phase 1, you need to select a combination of encryption and authentication algorithms. Some algorithms are considered more secure than others, so make sure to select the algorithms that conform with your security policy. However, note that the selection of the algorithms has a direct impact on FortiGate IPsec performance. For example, **3DES** is known to be a much more resource-intensive encryption algorithm than **DES** and **AES**, which means that your IPsec throughput could be negatively impacted if you select **3DES** as the encryption algorithm. Also, note that if you select **NULL** as the encryption algorithm, traffic is not encrypted.

In addition, some encryption algorithms, such as **CHACHA20POLY1305**, are not supported for hardware offload. That is, if you have a FortiGate device that contains network processor (NP) units, you can achieve higher IPsec performance if you select an algorithm that is supported for IPsec offload by your NP unit model, such as AES or DES. For a list of supported encryption algorithms for IPsec hardware offloading, refer to <https://docs.fortinet.com>.

When configuring the phase 2 proposal, you can select **Enable Replay Detection** to detect antireplay attacks on ESP packets. Note that this is a local setting and, therefore, it is not included as part of the proposals presented by the peer during phase 2 negotiation.

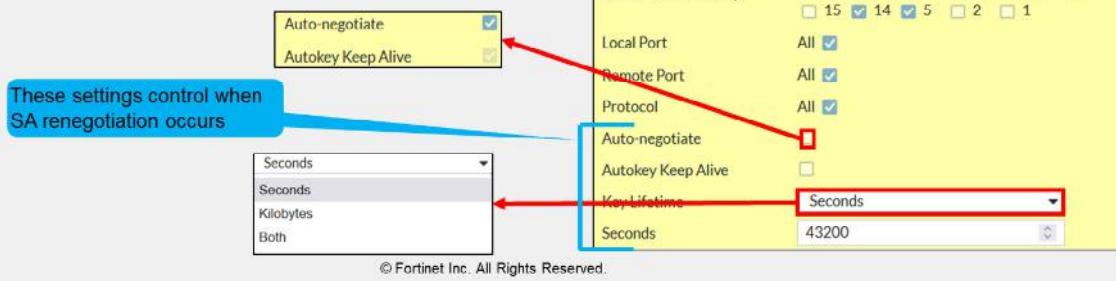
Also, if you enable **Perfect Forward Secrecy**, FortiGate uses DH to enhance security during the negotiation of IPsec SAs.

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Phase 2—Phase 2 Proposal (Contd)

- IPsec SA expires based on the number of:
 - **Seconds** (time-based)
 - **Kilobytes** (volume-based)
 - **Both** (whichever expires first)
- Key lifetime thresholds do not have to match for tunnel to come up
- **Auto-negotiate** prevents disruption caused by SA renegotiation
- **Autokey Keep Alive** keeps the tunnel up



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IPsec SAs are periodically renegotiated to improve security, but when does that happen? It depends on the key lifetime settings configured on the phase 2 proposal.

The expiration of an IPsec SA is determined by the lifetime type and threshold configured. By default, **Key Lifetime** is set to **Seconds** (time-based). This means that when the SA duration reaches the number of seconds set as **Seconds**, the SA is considered expired. You can also set the key lifetime to **Kilobytes** (volume-based), upon which the SA expires after the amount of traffic encrypted and decrypted using that SA reaches the threshold set. Alternatively, you can select **Both** as the key lifetime type, upon which FortiGate tracks both the duration of the SA and the amount of traffic. Then, when any of the two thresholds is reached, the SA is considered expired. Note that the key lifetime thresholds do not have to match for the tunnel to come up. When thresholds are different, the peers agree on using the lowest threshold value offered between the two.

When IPsec SAs expire, FortiGate needs to negotiate new SAs to continue sending and receiving traffic over the IPsec tunnel. Technically, FortiGate deletes the expired SAs from the respective phase 2 selectors, and installs new ones. If IPsec SA renegotiation takes too much time, then FortiGate might drop interesting traffic because of the absence of active SAs. To prevent this, you can enable **Auto-negotiate**. When you do this, FortiGate not only negotiates new SAs before the current SAs expire, but it also starts using the new SAs right away. The latter prevents traffic disruption by IPsec SA renegotiation.

Another benefit of enabling **Auto-negotiate** is that the tunnel comes up and stays up automatically, even when there is no interesting traffic. When you enable **Autokey Keep Alive** and keep **Auto-negotiate** disabled, the tunnel does not come up automatically unless there is interesting traffic. However, after the tunnel is up, it stays that way because FortiGate periodically sends keep alive packets over the tunnel. Note that when you enable **Auto-negotiate**, **Autokey Keep Alive** is implicitly enabled.

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IPsec Hardware Offloading

- On some FortiGate models, you can offload IPsec encryption and decryption to hardware
- Hardware offloading capabilities and supported algorithms vary by processor type and model
- By default, offloading is enabled for supported algorithms
 - You can manually disable offloading:

```
config vpn ipsec phasel-interface
    edit ToRemote
        set npu-offload disable
    next
end
```



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On some FortiGate models, you can offload the encryption and decryption of IPsec traffic to hardware. The algorithms that are supported depend on the NP unit model present on FortiGate. For a list of supported encryption algorithms for IPsec hardware offloading, refer to <https://docs.fortinet.com>.

By default, hardware offloading is enabled for the supported algorithms. This slide shows the commands you can use to disable hardware offloading per tunnel, if necessary.

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Knowledge Check

1. Which type of VPN peer can initiate a VPN tunnel?
 A. Dial-up server
 B. Dial-up client

2. On which phase do you configure the algorithms used for traffic encryption?
 A. Phase 1
 B. Phase 2

3. Which IKEv1 negotiation mode is faster?
 A. Aggressive
 B. Main

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Lesson Progress



IPsec Introduction



IPsec Configuration



Routing and Firewall Policies



Redundant VPNs



Monitoring and Logs

Good job! You now understand IPsec configuration.

Now, you will learn about routing and firewall policies for IPsec traffic.

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Routing and Firewall Policies

Objectives

- Understand route-based IPsec VPNs
- Learn how to configure routing and firewall policies for IPsec traffic

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

By demonstrating competence in routing and firewall policies for IPsec VPNs, you will be able to set up appropriate routing and firewall policies for your IPsec VPN deployment.

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Route-Based IPsec VPNs

- Types of IPsec VPNs:
 - Route-based
 - Virtual interface for each VPN: VPN matching based on routing
 - Policy-based
 - Legacy: VPN matching based on policy. Not recommended.
- Route-based VPNs benefits:
 - Simpler operation and configuration
 - Redundancy
 - Support for:
 - L2TP-over-IPsec
 - GRE-over-IPsec
 - Dynamic routing protocols



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FortiGate supports two types of IPsec VPNs: route-based and policy-based. Policy-based is a legacy IPsec VPN that is supported only for backward compatibility reasons, and its use *is not recommended* for new deployments. Unless otherwise stated, all IPsec VPN references in this lesson are for route-based IPsec VPNs.

In a route-based IPsec VPN, FortiGate automatically adds a virtual interface with the VPN name. This means that not only can you configure routing and firewall policies for IPsec traffic in the same way you do for non-IPsec traffic, but you also can leverage the presence of multiple connections to the same destination to achieve redundancy.

Another benefit of route-based IPsec VPNs is that you can deploy variations of IPsec VPNs such as L2TP-over-IPsec and GRE-over-IPsec. In addition, you can also enable dynamic routing protocols for scalability purposes and best path selection.

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Routes for IPsec VPNs

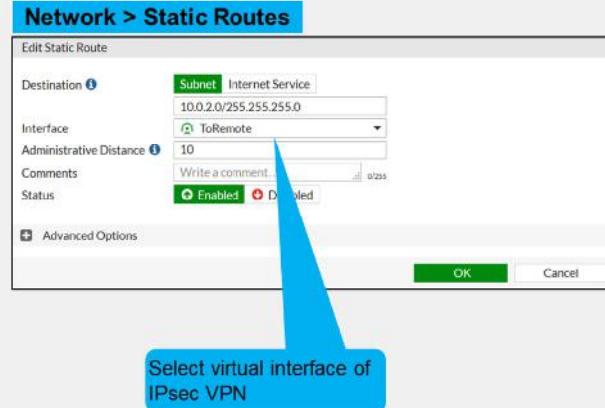
Dial-up user

```
config vpn ipsec phasel-interface
    edit "Dialup"
        set add-route enable | disable
    next
end
```

- **add-route is enabled (default)**
 - No need to configure static routes
 - Static routes are added after phase 2 is up
 - The destination is the local network presented by the dial-up client during phase 2 negotiation
 - The default route distance is 15
 - Static routes are deleted after phase 2 is down
- **add-route is disabled**
 - Useful when dynamic routing protocol is used
 - Dynamic routing protocol takes care of routing updates

Static IP address / dynamic DNS

- Static routes are needed



Although you can use dynamic routing protocols for IPsec VPNs, this lesson covers only the use of static routes.

The routing configuration needed for your IPsec VPN depends on the type of remote gateway configured. When you set the remote gateway to **Dialup User** and enable **add-route**, FortiGate automatically adds a static route for the local network presented by the remote peer during phase 2 negotiation. In addition, the route is added to the routing table only after phase 2 is up. If phase 2 goes down, the static route is removed from the routing table.

When you set the remote gateway to **Dialup User** and disable **add-route**, FortiGate does not add static routes automatically. In this case, a dynamic routing protocol is used between the remote peers to exchange routing information.

When the remote gateway is set to **Static IP Address** or **Dynamic DNS**, you must configure static routes. When you configure a static route, you select the virtual interface of the IPsec tunnel as the outgoing interface.

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Firewall Policies for IPsec VPNs

- At least one firewall policy is needed for a tunnel to come up
- Usually two firewall policies are configured for every tunnel

Policy & Objects > Firewall Policy

New Policy

Name: Traffic to Remote
Incoming Interface: port3
Outgoing Interface: ToRemote
Source: LOCAL_SUBNET
Destination: REMOTE_SUBNET
Schedule: always
Service: ALL
Action: ✓ ACCEPT, ✘ DENY
Inspection Mode: Flow-based, Proxy-based
Firewall / Network Options
NAT:

Virtual interface matches phase 1 name

Policy & Objects > Firewall Policy

New Policy

Name: Traffic from Remote
Incoming Interface: ToRemote
Outgoing Interface: port3
Source: REMOTE_SUBNET
Destination: LOCAL_SUBNET
Schedule: always
Service: ALL
Action: ✓ ACCEPT, ✘ DENY
Inspection Mode: Flow-based, Proxy-based
Firewall / Network Options
NAT:

Allow and inspect the traffic coming from/going to the IPsec virtual interface

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You must configure at least one firewall policy that accepts traffic on your IPsec tunnel. Otherwise, the tunnel will not come up.

When you configure firewall policies for non-IPsec traffic, the policy determines the direction of the traffic that initiates sessions. The same applies to IPsec traffic. For this reason, you usually want to configure at least two firewall policies for your IPsec VPN: one incoming policy and one outgoing policy. The incoming policy allows traffic initiated from the remote site, while the outgoing policy allows traffic to be initiated from the local network.

Note that the policies are configured with the virtual tunnel interface (or phase 1 name) as the incoming or outgoing interface.

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Knowledge Check

1. Which IPsec VPN type is legacy and not recommended for new deployments?
A. Route-based IPsec VPN
 B. Policy-based IPsec VPN

2. What is a configuration requirement for an IPsec tunnel to come up?
 A. A firewall policy accepting traffic on the IPsec tunnel
B. A route for IPsec traffic

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Lesson Progress



IPsec Introduction



IPsec Configuration



Routing and Firewall Policies



Redundant VPNs



Monitoring and Logs

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Good job! You now understand routing and firewall policies for IPsec traffic.

Now, you will learn about redundant VPNs.

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Redundant VPNs

Objectives

- Learn about redundant VPNs
- Understand redundant VPN configuration between two FortiGate devices

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

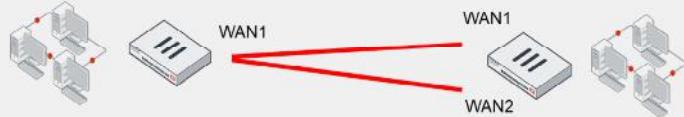
By demonstrating competence in redundant VPNs, you will be able to add redundancy to your IPsec VPN deployment.

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Redundant VPNs

- If the primary VPN tunnel fails, FortiGate then routes traffic through the backup VPN
- *Partially redundant*: one peer has two connections



- *Fully redundant*: both peers have two connections



How can you make your IPsec VPN deployment more resilient? Provide a second ISP connection to your site and configure two IPsec VPNs. If the primary IPsec VPN fails, another tunnel can be used instead.

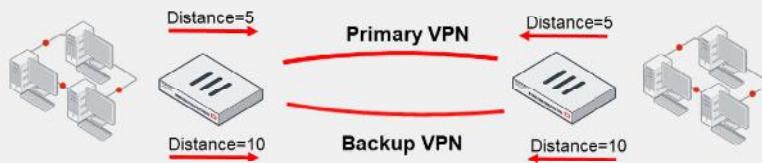
There are two types of redundant VPNs:

- Partially redundant: on one peer (usually the hub, where a backup ISP is available if the main ISP is down), each VPN terminates on *different* physical ports. That way, FortiGate can use an alternative VPN. On the other peer, each VPN terminates on the *same* physical port—so the spoke is not fault tolerant.
- Fully-redundant: both peers terminate their VPNs on different physical ports, so they are both fault tolerant.

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Redundant VPN Configuration

- Add one phase 1 configuration for each tunnel. You should enable DPD on both ends.
- Add at least one phase 2 definition for each phase 1
- Add one static route for each path
 - Use distance or priority to select primary routes over backup routes
 - Alternatively, use dynamic routing
- Configure firewall policies for each IPsec interface



So, how do you configure a partially or fully redundant VPN?

First, create one phase 1 for each path—one phase 1 for the primary VPN and one for the backup VPN. You should also enable DPD on both ends.

Second, create at least one phase 2 definition for each phase 1.

Third, you must add at least one static route for each VPN. Routes for the primary VPN must have a lower distance (or lower priority) than the backup. This causes FortiGate to use the primary VPN while it's available. If the primary VPN fails, then FortiGate automatically uses the backup route. Alternatively, you could use a dynamic routing protocol, such as OSPF or BGP.

Finally, configure firewall policies to allow traffic through both the primary and backup VPNs.

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Knowledge Check

1. Which feature should be enabled in a redundant IPsec VPN deployment?

- A. DPD
- B. XAuth

2. Which setting determines whether a tunnel is used as primary or backup?

- A. Routing
- B. Firewall policies

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Lesson Progress



IPsec Introduction



IPsec Configuration



Routing and Firewall Policies



Redundant VPNs



Monitoring and Logs

Good job! You now understand redundant VPNs.

Now, you will learn about monitoring IPsec VPNs and reviewing their logs.

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Monitoring and Logs

Objectives

- Learn how to monitor an IPsec VPN status
- Check IPsec VPN logs

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

By demonstrating competence in monitoring and logs, you will be able to monitor IPsec VPN and review past events.

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IPsec VPN Status—IPsec Monitor Widget

- Monitor IPsec VPN tunnels
 - Display status and statistics
 - Bring up or bring down VPNs

Dashboard > Network > IPsec

IPsec

Name Remote Gateway Peer ID Incoming Data Outgoing Data Phase 1 Phase 2 Selectors

ToRemote 10.200.1.1 2.18 kB 2.18 kB ToRemote ToRemote1 ToRemote2

Custom 1

VPN status

Bring down the entire tunnel or the phase 2 only

Data received Data sent

Phase 1 name and status Phase 2 name and status

Select Columns

Outgoing Data Phase 1 Phase 2 Selectors

Comments Created Phase 2 Protocols Proxy Destination Ports Proxy ID Destination Proxy ID Source Proxy Source Ports Remote Port Status Timeout XAUTH User

Apply Cancel

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On the GUI dashboard, you can use the IPsec widget to monitor the status of your IPsec VPNs. The widget shows the phase 1 and phase 2 status of an IPsec VPN.

You can also bring up or bring down individual VPNs, and get additional details. When you bring up an IPsec VPN using the IPsec widget, you can choose between bringing up a particular phase 2 selector or all phase 2 selectors in that VPN. Because bringing up a phase 2 selector requires bringing up its phase 1 first, then bringing up a phase 2 selector results in its phase 1 also coming up.

To bring down the VPN, you can choose between bringing down a particular phase 2 selector, all selectors, or the entire tunnel. When you bring down the entire tunnel, you bring down all phase 2 selectors as well as the phase 1.

The **Name** column indicates the VPN status. The VPN is up when at least one of its phase 2 selectors is up. If all phase 2 selectors are down, the VPN status is also down. The **Phase 1** and **Phase 2 Selectors** columns indicate the status of phase 1 and phase 2 selectors, respectively.

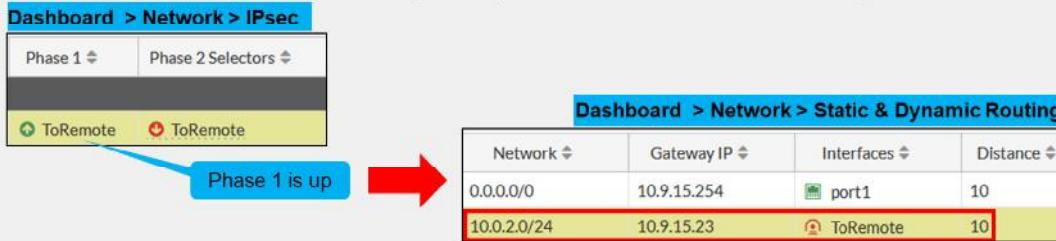
The IPsec widget also displays the amount of data sent and received through the tunnel. When you right-click any of the columns, a menu opens with a list of all the columns available. You can enable additional columns to get further details about the IPsec tunnels.

In the example shown on this slide, the **ToRemote** VPN is up because at least one of its phase 2 selectors (**ToRemote1**) is up.

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Monitor IPsec Routes

- IPsec routes appear in the routing table after:
 - Phase 1 comes up, if the remote gateway is set to static IP address or dynamic DNS



- Phase 2 comes up, if the remote gateway is set to dial-up user



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If you set the remote gateway to **Static IP Address** or **Dynamic DNS**, the static routes for these tunnels become active in the routing table after phase 1 comes up. Phase 1 negotiation is started automatically because automatic negotiation is enabled on phase 1 by default. This behavior allows FortiGate to match interesting traffic to the right tunnel. Moreover, if phase 2 is not up, traffic matching the static route triggers a phase 2 negotiation, which eventually results in the tunnel (or phase 2) to come up.

When you set the remote gateway to **Dialup User**, by default, a static route for the destination network is added after phase 2 comes up. The distance set for the static route is 15. If phase 2 goes down, the route is removed from the routing table.

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IPsec Logs

Log & Report > System Events > VPN Events

Date/Time	Level	Action	Message	VPN Tunnel
Yesterday	INFO	negotiate	success	progress IPsec phase 2
Yesterday	INFO	negotiate	success	progress IPsec phase 2
Yesterday	INFO	phase2-up		IPsec phase 2 status change
Yesterday	INFO	install_sa		install IPsec SA
Yesterday	INFO	phase2-down		IPsec phase 2 status change
Yesterday	INFO	tunnel-stats		IPsec tunnel statistics
Yesterday	INFO	negotiate	success	negotiate IPsec phase 2
Yesterday	INFO	negotiate	success	progress IPsec phase 2
Yesterday	INFO	tunnel-up		IPsec connection status change
Yesterday	INFO	phase2-up		IPsec phase 2 status change
Yesterday	INFO	Install_sa		Install IPsec SA
Yesterday	INFO	negotiate	success	progress IPsec phase 2
Yesterday	INFO	negotiate	success	progress IPsec phase 1
Yesterday	INFO	negotiate	success	progress IPsec phase 1
Yesterday	INFO	negotiate	success	progress IPsec phase 1
Yesterday	INFO	negotiate	success	progress IPsec phase 1
Yesterday	INFO	negotiate	failure	progress IPsec phase 1

Double-click any log to get more details

Phase 1 is DONE (up)

FortiGate logs IPsec VPN events by default. To view IPsec VPN event logs, click **Log & Report > System Events > VPN Events**.

The logs track the progress of phase 1 and phase 2 negotiations, and report on tunnel up and down events and DPD failures, among other events. For more information about IPsec logs, visit <https://docs.fortinet.com>.

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Knowledge Check

1. The IPsec monitor widget enables you to bring down the _____ of an IPsec VPN.
 A. Phase 1
 B. Entire tunnel

2. When the remote gateway is set to dial-up user, a static route to the remote network is added to the routing table after _____.
 A. Phase 1 comes up
 B. Phase 2 comes up

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Lesson Progress



IPsec Introduction



IPsec Configuration



Routing and Firewall Policies



Redundant VPNs



Monitoring and Logs

Congratulations! You have completed this lesson.

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

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Review

- ✓ Describe the benefits of IPsec VPN
- ✓ Understand how IPsec works
- ✓ Learn about the IPsec wizard
- ✓ Identify and understand the phases of IKEv1
- ✓ Understand phase 1 and phase 2 settings
- ✓ Understand redundant VPN configuration between two FortiGate devices
- ✓ Monitor IPsec VPNs and review logs



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

By mastering the objectives covered in this lesson, you learned how the IPsec protocol works, and how to configure and monitor IPsec VPNs on FortiGate.

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FortiGate Infrastructure

High Availability



FortiOS 7.2

Last Modified: 30 August 2022

In this lesson, you will learn about the fundamentals of FortiGate high availability (HA) and how to configure it. FortiGate HA provides a solution for enhanced reliability and increased performance.

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Lesson Overview



HA Operation Modes



HA Cluster Synchronization



HA Failover and Workload



Monitoring and Troubleshooting

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

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HA Operation Modes

Objectives

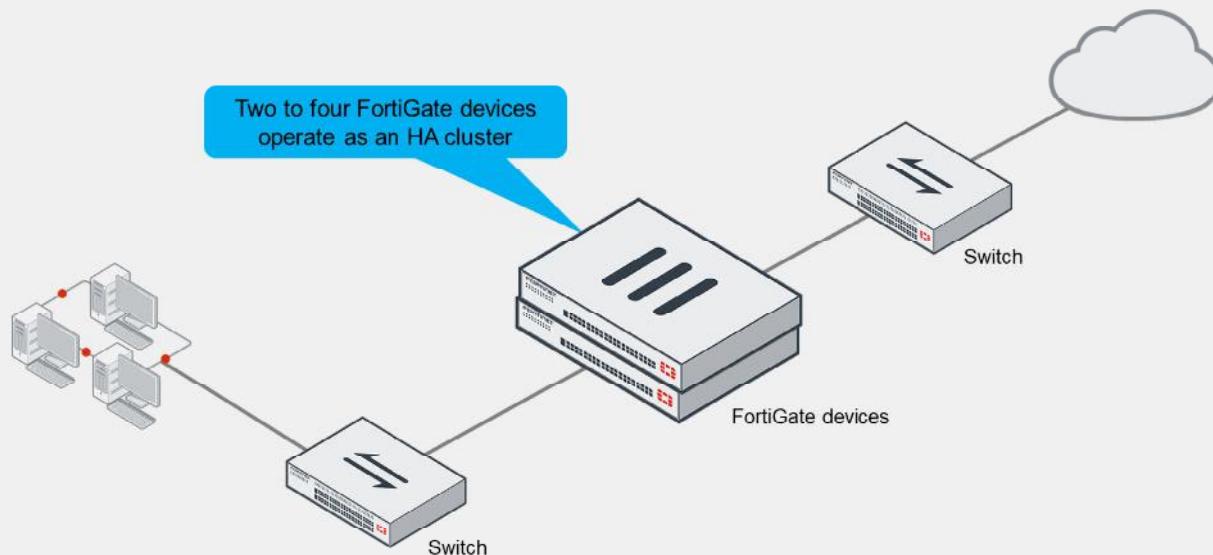
- Identify the different operation modes for HA
- Understand the primary FortiGate election in an HA cluster

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

By demonstrating competence in HA operation modes and primary FortiGate election, you will be able to choose and implement the right HA operation mode in your network based on your requirements. You will be able to use FortiGate devices effectively in your network.

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What Is FortiGate HA?



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The idea of HA is simple. HA links and synchronizes two to four FortiGate devices to form a cluster for redundancy and performance purposes.

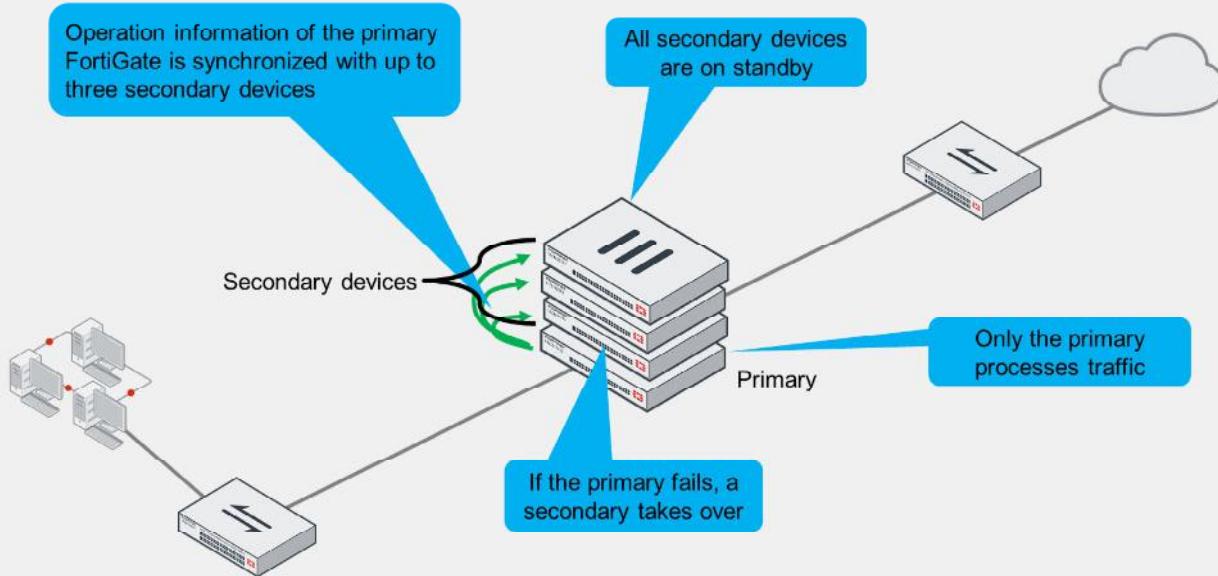
A cluster includes one device that acts as the primary FortiGate (also called the active FortiGate). The primary synchronizes its configuration, session information, FIB entries, FortiGuard definitions, and other operation-related information to the secondary devices, which are also known as standby devices.

The cluster shares one or more heartbeat interfaces among all devices—also known as members—for synchronizing data and monitoring the health of each member.

There are currently two HA operation modes available: active-active (A-A) and active-passive (A-P). Now, you will examine the differences.

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Active-Passive HA

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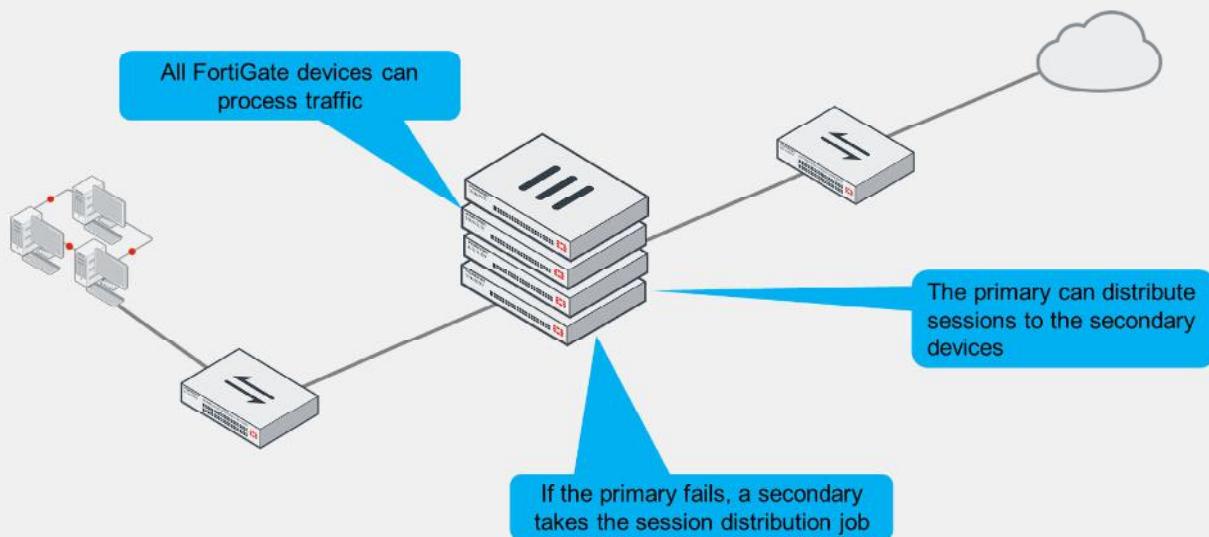
First, take a look at active-passive mode. In either of the two HA operation modes, the operation information (configuration, sessions, FIB entries, and so on) of the primary FortiGate is synchronized with secondary devices.

In active-passive mode, the primary FortiGate is the only FortiGate that actively processes traffic. Secondary FortiGate devices remain in passive mode, monitoring the status of the primary device.

If a problem is detected on the primary FortiGate, one of the secondary devices takes over the primary role. This event is called an *HA failover*.

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Active-Active HA

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The other HA mode is active-active.

Like active-passive HA, in active-active HA, the operation-related data of the primary FortiGate is synchronized to the secondary FortiGate devices. Also, if a problem is detected on the primary device, one of the secondary devices takes over the role of the primary, to process the traffic.

However, one of the main differences from active-passive mode is that in active-active mode, all cluster members can process traffic. That is, based on the HA settings and traffic type, the primary FortiGate can distribute sessions to the secondary devices.

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FortiGate Clustering Protocol

- Used for:
 - Member discovery
 - Primary election
 - Data synchronization
 - Member health monitoring
- Failover trigger events:
 - Dead member
 - Failed link
 - Failed remote link (link health monitoring)
 - High memory usage
 - Failed solid state disk (SSD)
 - Admin-triggered
- Ethernet types and ports:
 - Heartbeat:
 - Ethernet type 0x8890 (NAT mode)
 - Ethernet type 0x8891 (Transparent mode)
 - Data synchronization, logging, and CLI management:
 - Frame: Ethernet type 0x8893
 - Inner packet:
 - TCP/703 and UDP/703 (data sync)
 - TCP/700 (logging and alert emails)
 - TCP/22 (CLI management)
 - A-A load balancing (first packet only):
 - Frame: Ethernet type 0x8891
 - Inner packet: Original packet (MAC rewrite)



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FortiGate HA uses the Fortinet-proprietary FortiGate Clustering Protocol (FGCP) to discover members, elect the primary FortiGate, synchronize data among members, and monitor the health of members.

To discover and monitor members, the members broadcast heartbeat packets over all configured heartbeat interfaces. If the cluster operates in NAT mode, the heartbeat frames are type 8890. In transparent mode, the heartbeat frames are type 8891. If the cluster operates in active-active mode, the first packet of a session distributed to the secondary is encapsulated in Ethernet frames type 8891.

The members also exchange frames type 8893 for data synchronization, local CLI management, and logging purposes. For data synchronization, the inner packet can be TCP port 703 or UDP port 703, depending on the type of data to synchronize. The primary also relays logs and alert emails from secondary devices over TCP port 700. For local HA management using the CLI, the inner packet is SSH.

You can configure the cluster to perform HA failover based on the following events:

- Dead member: The primary FortiGate is unresponsive.
- Failed link: The link of one or more monitored interfaces on the primary FortiGate goes down.
- Failed remote link: FortiGate uses the link health monitor feature to monitor the health of one or more interfaces. The primary fails if the accumulated penalty of all failed interfaces reaches the set threshold.
- High memory usage: The primary fails if its memory utilization reaches the configured threshold.
- Failed SSD: FortiOS detects a failure in an SSD. Only available for devices with SSDs.
- Admin-triggered: The administrator issues a manual failover.

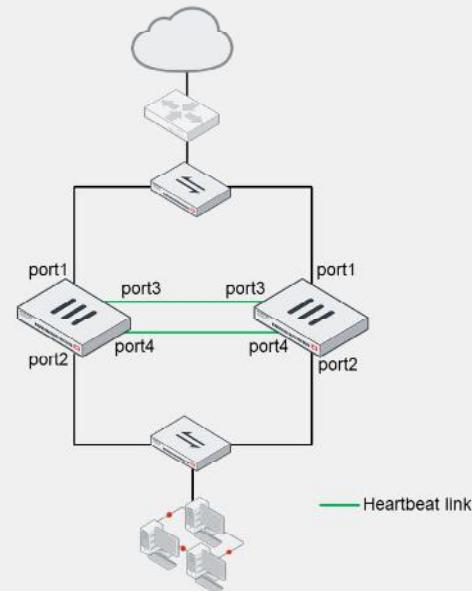
For any of the failover trigger events, the result is that the cluster promotes one of the secondary devices to the new primary FortiGate role.

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HA Requirements

- All members must have the same:
 - Firmware version
 - Model
 - Licensing
 - If different, the cluster uses the lowest-level license
 - Hard drive configuration
 - Operating mode (management VDOM)
- Setup:
 - Same HA group ID, group name, password, and heartbeat interface settings
 - Heartbeat interfaces can see each other
- Best practice:
 - Use at least two heartbeat interfaces (maximum 8)
 - Initially, switch DHCP and PPPoE interfaces to static configuration



To successfully form an HA cluster, you must ensure that the members have the same:

- Firmware version
- Model: the same hardware model or VM model
- Licensing: includes the FortiGuard license, VDOM license, FortiClient license, and so on
- Hard drive configuration: the same number and size of drives and partitions
- Operating mode: the operating mode—NAT mode or transparent mode—of the management VDOM

If the licensing level among members isn't the same, the cluster resolves to use the lowest licensing level among all members. For example, if you purchase FortiGuard Web Filtering for only one of the members in a cluster, none of the members will support FortiGuard Web Filtering when they form the cluster.

From a configuration and setup point of view, you must also make sure that:

- The HA settings on each member have the same group ID, group name, password, and heartbeat interface settings.
- The heartbeat interfaces on each member can see each other. This usually means placing all heartbeat interfaces in the same broadcast domain, or for two-member clusters, connecting them directly.

It's also a best practice to:

- Configure at least two heartbeat interfaces for redundancy purposes. This way, if one heartbeat link fails, the cluster uses the next one, as indicated by the priority and position in the heartbeat interface list.
- If using DHCP or PPPoE interfaces, use static configuration during the cluster initial setup to prevent incorrect address assignment. After the cluster is formed, you can put back the original interface settings.

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Primary FortiGate Election—Override Disabled

- Override disabled (default)
 - Force a failover

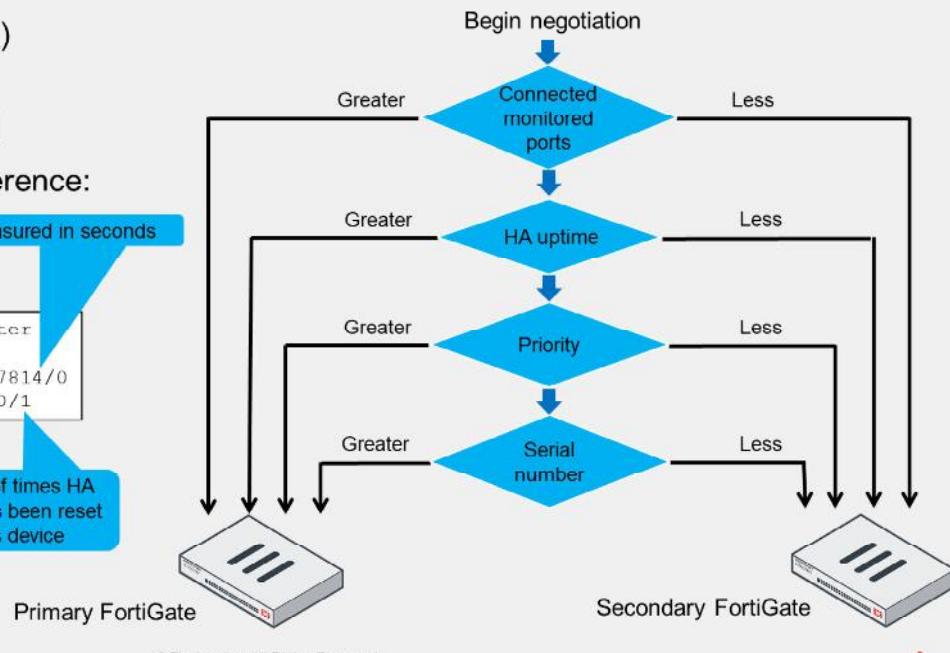
```
# diagnose sys ha reset-upptime
```

 - Check the HA uptime difference:

Difference measured in seconds

```
# diagnose sys ha dump-by vcluster  
...  
FGVMxxxx92:...uptime/reset_cnt=7814/0  
FGVMxxxx36:...uptime/reset_cnt=0/1
```

0 is for the device with the lowest HA uptime



This slide shows the different criteria that a cluster considers during the primary FortiGate election process. The criteria order evaluation depends on the HA override setting. This slide shows the order when the HA override setting is disabled, which is the default behavior. Note that the election process stops at the first matching criteria that successfully selects a primary FortiGate in a cluster.

1. The cluster compares the number of monitored interfaces that have a status of up. The member with the most available monitored interfaces becomes the primary.
 2. The cluster compares the HA uptime of each member. The member with the highest HA uptime, by at least five minutes, becomes the primary.
 3. The member with the highest priority becomes the primary.
 4. The member with the lowest serial number becomes the primary.

When HA override is disabled, the HA uptime has precedence over the priority setting. This means that if you must manually fail over to a secondary device, you can do so by reducing HA uptime of the primary FortiGate. You can do this by running the `diagnose sys ha reset-uptime` command on the primary FortiGate, which resets its HA uptime to 0.

Note that the `diagnose sys ha reset-uptime` command resets the HA uptime and not the system uptime. Also, note that if a monitoring interface fails, or a member reboots, the HA uptime for that member is reset to 0.

This slide also shows how to identify the HA uptime difference between members. The member with 0 in the uptime column indicates the device with the lowest uptime. The example shows that the device with the serial number ending in 92 has an HA uptime that is 7814 seconds higher than the other device in the HA cluster. The `reset cnt` column indicates the number of times the HA uptime has been reset for that device.

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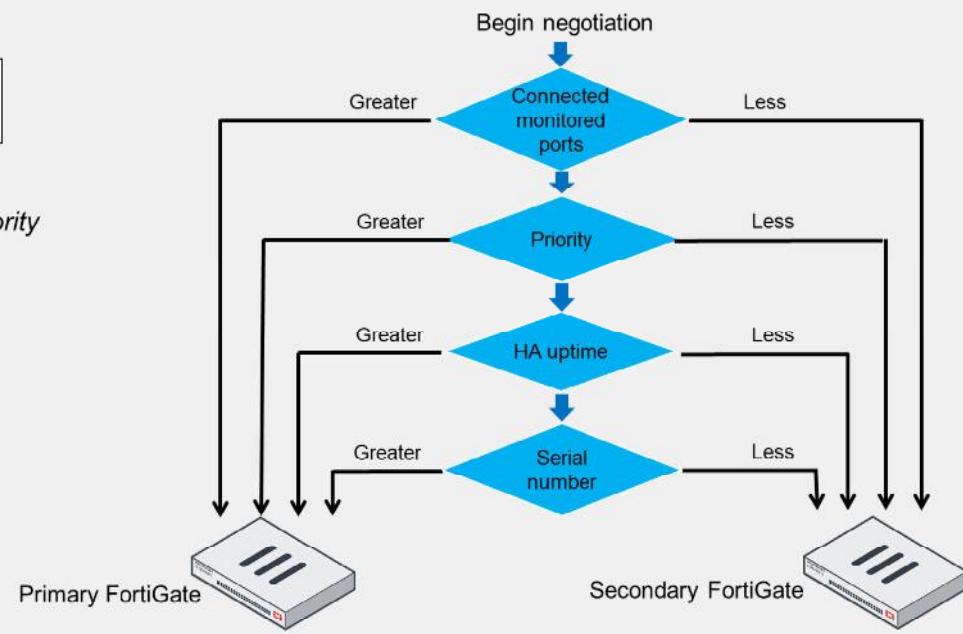
Primary FortiGate Election—Override Enabled

- Override enabled

```
config system ha
  set override enable
end
```

- Force a failover

- Change the HA priority



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If the HA override setting is enabled, the priority is considered before the HA uptime.

The advantage of this method is that you can specify which device is the preferred primary every time (as long as it is up and running) by configuring it with the highest HA priority value. The disadvantage is that a failover event is triggered not only when the primary fails, but also when the primary is available again. That is, when the primary becomes available again, it takes its primary role back from the secondary FortiGate that temporarily replaced it.

When override is enabled, the easiest way of triggering a failover is to change the HA priorities. For example, you can either increase the priority of one of the secondary devices, or decrease the priority of the primary.

The override setting and device priority values are not synchronized to cluster members. That is, on each member, you must manually enable override and adjust the priority.

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Knowledge Check

1. What is a requirement for members to form an HA cluster?
 - A. They must have same host name
 - B. They must run the same firmware version

2. What is the default order criteria (override disabled) for selecting the primary in an HA cluster?
 - A. Connected monitored ports > HA uptime > priority > serial number
 - B. Priority > HA uptime > connected monitored ports > serial number

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Lesson Progress



HA Operation Modes



HA Cluster Synchronization



HA Failover and Workload



Monitoring and Troubleshooting

Good job! You now understand HA operation modes and the election of the primary FortiGate in an HA cluster.

Now, you will learn about HA cluster synchronization.

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HA Cluster Synchronization

Objectives

- Identify the primary and secondary device tasks in an HA cluster
- Identify what is synchronized between HA cluster members
- Configure session synchronization for seamless failover

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

By demonstrating competence in cluster synchronization, you will be able to identify the tasks assigned to members based on their roles, as well as what information is synchronized between members. You will also learn how to configure session synchronization to perform session failover to specific types of traffic.

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Primary FortiGate Tasks

- Broadcasts hello packets for member discovery and monitoring
- Synchronizes operation-related data such as:
 - Configuration (some settings are not synchronized)
 - FIB entries
 - DHCP leases
 - ARP table
 - FortiGuard definitions
 - IPsec tunnel SAs
 - Sessions (must be enabled)
- In active-active mode only:
 - Distributes sessions to secondary members



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So, what are the tasks of a primary FortiGate?

It monitors the cluster by broadcasting hello packets and listening for hello packets from other members in the cluster. The members use the hello packets to identify if other FortiGate devices are alive and available.

The primary FortiGate also synchronizes its operation-related data to the secondary members. Some of the data synchronized includes its configuration, FIB entries, DHCP leases, ARP table, FortiGuard definitions, and IPsec tunnel security associations (SAs). Note that some parts of the configuration are not synchronized because they are device-specific. For example, the host name, HA priority, and HA override settings are not synchronized.

Optionally, you can configure the primary FortiGate to synchronize qualifying sessions to all the secondary devices. When you enable session synchronization, the new primary can resume communication for sessions after a failover event. The goal is for existing sessions to continue flowing through the new primary FortiGate with minimal or no interruption. You will learn which types of sessions you can enable synchronization for later in the lesson.

In active-active mode only, a primary FortiGate is also responsible for distributing sessions to secondary members.

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Secondary FortiGate Tasks

- Broadcasts hello packets for member discovery and monitoring
- Synchronizes data from the primary
- Monitors the health of the primary
 - If the primary fails, the secondary devices elect a new primary
- In active-active mode only:
 - Processes traffic distributed by the primary



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Now, take a look at the tasks of secondary FortiGate devices.

Like the primary, secondary members also broadcast hello packets for discovery and monitoring purposes.

In addition, in active-passive mode, the secondary devices act as a standby device, receiving synchronization data but not actually processing any traffic. If the primary FortiGate fails, the secondary devices elect a new primary.

In active-active mode, the secondary devices don't wait passively. They process all traffic assigned to them by the primary device.