Troubleshooting Network Security

CCNP TSHOOT: Maintaining and Troubleshooting IP Networks

Chapter 9 Objectives

- Management Plane Security
- Control Plane Security
- Data Plane Security

Security Features Review

- **Management plane:**
  - Represents functions and protocols involved in managing the device.
  - Provides access for device configuration, device operation, and statistics.
  - If the management plane is compromised, other planes are also exposed.
  - Protocols include Telnet, AAA, SSH, FTP, TFTP, SNMP, syslog, TACACS+, RADIUS, DNS, NetFlow and ROMMON.
- **Control plane:**
  - Represents functions and protocols between network devices to control the operation of the network.
  - Layer 3 protocols include routing protocols and HSRP.
  - Layer 2 protocols and functions include ARP, STP and VLANs.
- **Data plane:**
  - Represents functions involved in forwarding traffic through the device.
  - Traffic is between endpoints such as workstations, servers and printers.
  - Routers and switches can inspect and filter traffic as part of the implementation of a security policy.
  - All management and control plane traffic flows through the data plane.
  - Security features on the data plane can cause failures on the management and control plane.

Management Plane Security

Management Plane Security

Three methods of accessing management functions of a router or switch::

- The Cisco IOS command-line interface (CLI)
- Web-based device management
- A network management platform based on Simple Network Management Protocol (SNMP)

CLI

- The CLI is the most common and powerful method to manage routers and switches.
- Commands are entered through a console connection or remotely through Telnet or SSH.
- Authentication ensures that only authorized personnel can access and configure the network devices.
- Restrict the network locations that devices can be accessed from and use SSH instead of Telnet.
- Physical security is vital to the security of the management plane.
  - The CLI can always be accessed through the serial console.
  - An unauthorized user could power cycle the device and use password recovery to gain control of the device.

Management Plane Security – Cont.

Web-based Management Access

- A web-based device manager can provide an alternative method to manage routers and switches.
- Examples include:
  - Cisco Configuration Professional (CCP)
  - Security Device Manager (SDM)
- The protocol used is either HTTP or HTTPS (preferred).

SNMP Management Access

- Primarily used to access operational parameters and statistics of the device, not to change the configuration.
- If a device is configured for read-access the configuration cannot be changed.
- If a device is configured for read-write access, apply the same level of security as for command-line or web-based access.

Management Plane Security: AAA

- Authentication, authorization, and accounting (AAA) is a major component of network security.
- A centralized security server contains security policies that define the list of users and what they are allowed to do.
- Cisco Secure Access Control Server (ACS) is an example of a AAA server.
- Network devices can access the centralized security server using protocols such as TACACS+ and RADIUS.

Management Plane Security: RADIUS & TACACS+

	RADIUS	TACACS+
Standard	IETF	Cisco proprietary
Architecture	Combines authentication and authorization	Uses AAA architecture which decouples authentication and authorization
Transport protocol	UDP port 1812 (or 1645) for authentication, and UDP port 1813 (or 1646) for accounting	TCP (port 49)
Encryption	Password only	Entire packet body
Authorization of specific commands	Not on per-user basis	Two methods provided
Suitability for router management	Less flexible	More flexible
Accounting capabilities	Extensive	Limited

Securing the Management Plane

From a troubleshooting standpoint, it is important to know the answer to the following questions:

- What security policies have been implemented for management access to the devices?
- From which IP addresses or networks can the network devices be accessed?
- What type of authentication, authorization, and accounting is used on the network?
- If centralized AAA services are deployed, what happens when these servers fail or become unreachable?
- Are there any backdoors or fallback mechanisms to access the devices?

AAA models

- Old model
  - Authentication and authorization only against local database
  - No accounting
- New model
  - AAA service can be connected to external databases
  - Allows accounting, authentication and authorization

New AAA model

- Assumption for AAA model
  - Services need to be authenticated via a mechanism (dot1x, enable, login, ppp)
  - Databases with user credentials used for authentication and authorization (RADIUS, TACACS, local database)
  - AAA model tells a service which authentication database should use
- Examples:
  - CLI login is verified against local database
  - SSH login is verified against RADIUS with IP 1.2.3.4
  - PPP login is verified against RADIUS with IP 5.6.7.8
  - Ethernet clients are verified against RADIUS with IP 9.8.7.6

AAA authentication

- AAA activation:

```
Router(config)# aaa new-model
```

- Create authentification database for authentication:

```
Router(config)# aaa authentication { ppp | dot1x | enable
  | login } MENO db [ db … ]
```

- Example:

```
Router(config)# aaa new-model
Router(config)# aaa authentication login L_LOCAL local
Router(config)# line vty 0 15
Router(config-line)# login authentication L_LOCAL
```

AAA Authorization

- Authentication and authorization are separated In the new AAA model
  - Login is allowed but without any privilege
- Create a list of authorization methods (databases) :

```
Router(config)# aaa authorization { exec | network | … }
  DB_NAME db [ db … ]
```

- Example:

```
Router(config)# aaa new-model
Router(config)# aaa authorization exec E_LOCAL local
Router(config)# line vty 0 15
Router(config-line)# authorization exec E_LOCAL
```

Examples:

- Local database:

```
aaa new-model
aaa authentication login L_LOCAL local
aaa authorization exec E_LOCAL local
line vty 0 15
 login authentication L_LOCAL
 authorization exec E_LOCAL
```

- RADIUS server and local database:

```
aaa new-model
aaa authentication login L_RAD+L group radius local
aaa authorization exec E_RAD+L group radius local
radius-server host 1.2.3.4 auth-port 1812 acct-port 1813 key HESLO
line vty 0 15
 login authentication L_RAD+L
 authorization exec E_RAD+L
```

Management Plane: Common RADIUS Issues

- The RADIUS server's failure or loss of network connectivity
- Mismatch of the shared key between the RADIUS server and the network device (RADIUS client)
- User authorization failure (incorrect username, password, or both)
- Mismatch of RADIUS port numbers between the router and RADIUS server

Management Plane: RADIUS Issues

```
Router# debug radius
Router# debug aaa authentication
! The RADIUS server is down or the device has no connectivity to the server:
As1 CHAP: I RESPONSE id 12 len 28 from “chapadd”
RADIUS: id 15, requestor hung up.
RADIUS: No response for id 15
RADIUS: No response from server
AAA/AUTHEN (1866705040): status = ERROR
AAA/AUTHEN/START (1866705040): Method=LOCAL
AAA/AUTHEN (1866705040): status = FAIL
As1 CHAP: Unable to validate Response. Username chapadd: Authentication failure
As1 CHAP: 0 FAILURE id 13 len 26 msg is “Authentication failure”

! The key on the device and RADIUS server do not match:
RADIUS: received from id 21 171.68.118.101:1645, Access-Reject, len 20
RADIUS: Reply for 21 fails decrypt
NT client sends ‘DOMAIN\user’ and Radius server expects ‘user’:
RADIUS: received from id 16 171.68.118.101:1645, Access-Reject, len 20
AAA/AUTHEN (2974782384): status = FAIL
As1 CHAP: Unable to validate Response. Username CISCO\chapadd: Authentication
failure
As1 CHAP: 0 FAILURE id 13 len 26 msg is “Authentication failure”

! Username and password are correct, but authorization failed:
RADIUS: received from id 19 171.68.118.101:1645, Access-Accept, len 20
RADIUS: no appropriate authorization type for user
AAA/AUTHOR (2370106832): Post authorization status = FAIL
AAA/AUTHOR/LCP As1: Denied

! Bad username, bad password, or both:
RADIUS: received from id 17 171.68.118.101:1645, Access-Reject, len 20
AAA/AUTHEN (3898168391): status = FAIL
As1 CHAP: Unable to validate Response. Username ddunlap: Authentication failure
As1 CHAP: 0 FAILURE id 14 len 26 msg is “Authentication failure”
As1 PPP: Phase is TERMINATING
```

Control Plane Security

Control Plane Security ①

- Control plane traffic is handled by the system's route processor.
- Packets that traverse the control plane are those destined for that router's CPU, as opposed to network endpoints.
- Examples include routing protocols, keepalives, first-hop redundancy protocols (FHRP), DHCP, STP and ARP.
- All packets entering the control plane are redirected by the data (forwarding) plane.
- Denial-of-service (DoS) attacks on the control plane can overburdened router CPU.
- Unauthorized participation in any of these protocols should be prevented to secure the network.

Control Plane Security ②

- Most routing protocols support neighbor authentication based on MD5 hashes.
- Authentication is also supported by first-hop redundancy protocols:
  - Hot Standby Router Protocol (HSRP)
  - Virtual Router Redundancy Protocol (VRRP)
  - Gateway Load Balancing Protocol (GLBP)
- Using an authentication mechanism prevents unauthorized devices from and misdirecting or black-holing application traffic.
- The IEEE 802.1D STP does not have an authentication mechanism.
- Cisco switches support features such as BPDU guard and Root Guard to help prevent unauthorized interaction with Spanning Tree Protocol.
- The DHCP and ARP protocols can be secured by enabling the DHCP snooping and dynamic ARP inspection (DAI) features.
- Control plane and control plane protection can use the Cisco Modular QoS CLI (MQC) to protect the infrastructure from DoS attacks.

Securing the Control Plane: Overview – Cont.

- It is important to know which control plane security features have been implemented in the network and on which devices.
- Misconfiguration can cause the operation of a control plane protocol between devices to fail.
- Ask the following questions to help troubleshoot control plane security implementations:
  - Are routing protocols or FHRPs set up for authentication properly?
  - Are STP security features such as BPDU Guard, BDPU Filter, Loop Guard, or Root Guard enabled correctly?
  - Is DHCP snooping configured properly?
  - Is the configuration of DAI correct?
  - Are the configurations for control plane policing or control plane protection done appropriately?

DHCP Snooping

```
Sw# show ip dhcp snooping
Switch DHCP snooping is enabled
DHCP snooping is configured on following VLANs:
1
DHCP snooping is operational on following VLANs:
1
DHCP snooping is configured on the following L3 Interfaces:

Insertion of option 82 is enabled
   circuit-id default format: vlan-mod-port
   remote-id: 001d.e5be.e380 (MAC)
Option 82 on untrusted port is not allowed
Verification of hwaddr field is enabled
Verification of giaddr field is enabled
DHCP snooping trust/rate is configured on the following Interfaces:

Interface                  Trusted    Allow option    Rate limit (pps)
-----------------------    -------    ------------    ----------------
FastEthernet0/24           yes        yes             unlimited
  Custom circuit-ids:
```

DHCP Snooping binding

```
Sw# show ip dhcp snooping binding
MacAddress          IpAddress    Lease(sec)  Type            VLAN  Interface
------------------  -----------  ----------- --------------  ----  ---------
00:E0:4C:41:3C:E9  10.0.0.4     84960       dhcp-snooping    1      Fa0/11
00:E0:4C:3B:B7:87  10.0.0.6     85042       dhcp-snooping    1      Fa0/1
Total number of bindings: 2
```

DHCP Snooping problem

- DHCP server is in the same VLAN as a client
  - DHCP server does not assign IP, debug log on DHCP server shows following info:

```
Router# debug ip dhcp server packet
*Sep 9 01:59:40: DHCPD: inconsistent relay information.
*Sep 9 01:59:40: DHCPD: relay information option exists, but giaddr is zero
```

- Reason: Switch insert Option-82 in a DHCP message but does not include IP address of relay agent
- Solution: Allows to the switch to accept these DHCP messages, either globally or per interface

```
Router(config)# ip dhcp relay information trust-all ! Globally…
Router(config)# int fa0/1
Router(config-if)# ip dhcp relay information trusted ! … per interface
```

Data Plane Security

Data Plane Security

- Routers and switches process and forwarding network traffic and can play an effective role in inspecting and filtering traffic as it flows through the network.
- The Cisco IOS firewall software provides enhanced security functions for the data plane.
- There are two types of Cisco IOS firewall:
  - **Classic Cisco IOS firewall** (stateful packet inspection)
  - **Zone-based policy firewall**

IOS Stateful Packet Inspection (SPI)

- Cisco IOS stateful packet inspection (SPI) is a component of the Cisco IOS firewall.
- Formerly known as context-based access control (CBAC)
- Cisco SPI allows certain incoming flows by first inspecting and recording flows initiated from the trusted network.
- It is configured per interface and operates by dynamically modifying access list entries based on traffic flows.
- IOS SPI can inspect to the application layer

IOS SPI

- The combination of the inspection policy and the ACL-based policy defines the overall firewall policy.
- To protect a trusted (internal) network from an untrusted (external) network using a router with two interfaces, the router can be placed between the two networks. There will be four logical points at which the router can inspect traffic:
  - Inbound on the internal interface
  - Outbound on the external interface
  - Inbound on the external interface
  - Outbound on the internal interface
- **Beware of performance issues and Single Point of Failure!**

IOS SPI Example

- First apply a simple access list to deny all IP traffic for the inbound direction of the external interface (Fa 0/0). In this example an ACL Denying All Inbound Traffic Is Created and Applied to Fa 0/0.

```
Router(config)# ip access-list extended DENY_ALL
Router(config-ext-nacl)# deny ip any any
Router(config-ext-nacl)# exit
Router(config)# interface fa0/0
Router(config-if)# ip access-group DENY_ALL in
Router(config-if)# exit
```

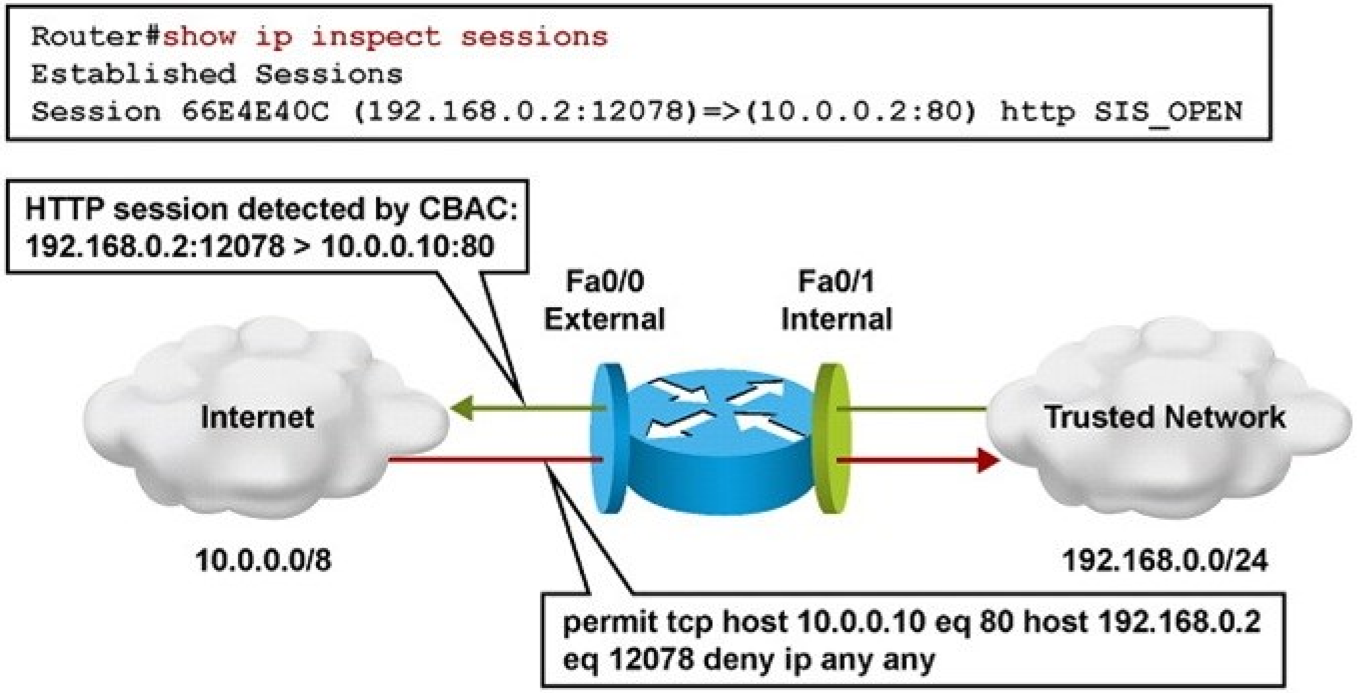
IOS SPI Example – Cont.

- To allow responses to return from the Internet for internal client web requests, define an inspection rule to track HTTP sessions.
- Create an inspection rule called **inshttp** to monitor HTTP and apply it outbound on the external interface (Fa0/0).
- The router will inspect traffic originating from the trusted network, and dynamically adjust the ACL restricting traffic inbound on the external interface.

```
Router(config)# ip inspect name inshttp http
Router(config)# interface fa0/0
Router(config-if)# ip inspect inshttp out
Router(config-if)# end
Router#
```

IOS SPI Example – Cont.

The output of the **`show ip inspect sessions`** in the figure shows that trusted host 192.168.0.2 has opened an HTTP connection to external web server 10.0.0.2



```
Router#show ip inspect sessions
Established Sessions
Session 66E4E40C (192.168.0.2:12078)=>(10.0.0.2:80) http SIS_OPEN
```

HTTP session detected by CBAC:
192.168.0.2:12078 > 10.0.0.10:80

permit tcp host 10.0.0.10 eq 80 host 192.168.0.2
eq 12078 deny ip any any

IOS SPI Example – Cont.

Use the **`show ip inspect all`** command to display the SPI configuration and session information.

```
Router# show ip inspect all
Session audit trail is enabled
Session alert is enabled
<output omitted>
Inspection Rule Configuration
 Inspection name inshttp
    http alert is on audit-trail is on timeout 3600
    https alert is on audit-trail is on timeout 3600
Interface Configuration
 Interface FastEthernet0/0
  Inbound inspection rule is not set
  Outgoing inspection rule is inshttp
    http alert is on audit-trail is on timeout 3600
    https alert is on audit-trail is on timeout 3600

  Outing access list is not set
<output omitted>
```

IOS SPI Example – Cont.

An audit trail can be enabled to generate syslog messages for each SPI session creation and deletion using the **ip inspect audit-trail** command. The output of the **debug ip inspect** command provides greater detail.

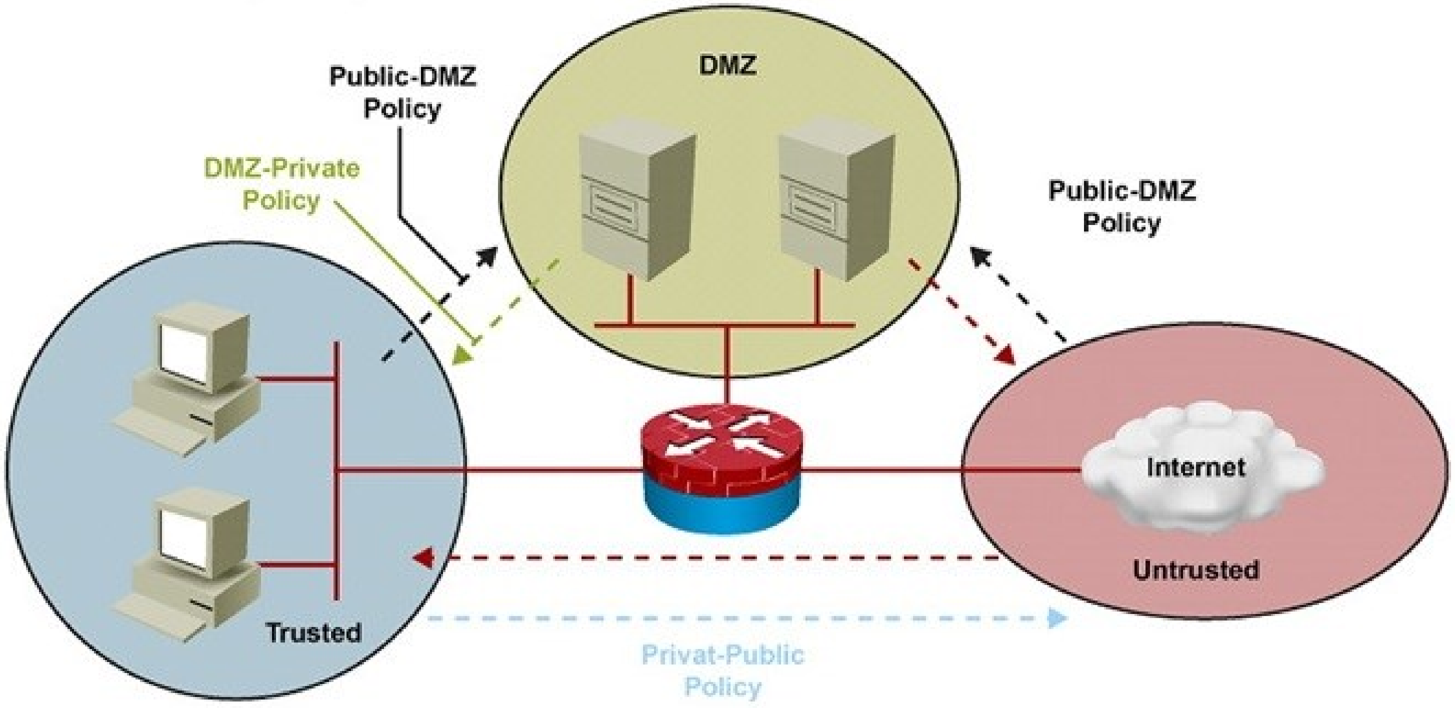
```
Router(config)# ip inspect audit-trail
Router(config)#
%FW-6-SESS_AUDIT_TRAIL_START: Start http session: initiator
(192.168.0.2:10032) -- responder (10.0.0.10:80)

Router# debug ip inspect
Object-creation INSPECT Object Creations debugging is on
Router#
CBAC* OBJ_CREATE: Pak 6621F7A0 sis 66E4E154 initiator_addr
(192.168.0.2:10032) responder_addr (10.0.0.10:80) initiator_alt_addr
(192.168.0.2:10032) responder_alt_addr (10.0.0.2:80)
CBAC OBJ-CREATE: sid 66E684B0 acl DENY_ALL Prot: tcp
Src 10.0.0.10 Port [80:80]
Dst 192.168.0.2 Port [10032:10032]
CBAC OBJ_CREATE: create host entry 66E568DC addr 10.0.0.10 bucket 8
(vrf 0:0) insp_cb 0x66B61C0C
```

Zone-Based Policy Firewall Overview

- The zone-based policy firewall (ZPF) is the most current Cisco firewall technology.
- ZPF allows grouping of physical and virtual interfaces.
- Firewall policies are configured on traffic moving between zones.
- ZPF simplifies firewall policy troubleshooting by applying explicit policy on interzone traffic.
- Firewall policy configuration is very flexible.
- Varying policies can be applied to different host groups, based on ACL configuration.
- ZPF supports the following functionalities:
  - Stateful inspection
  - Application inspection: IM, POP, IMAP, SMTP/ESMTP, HTTP URL filtering
  - Per-policy parameter
  - Transparent firewall
  - Virtual Routing and Forwarding (VRF)-aware firewall

ZPF Example Topology

Zone-Based Policy firewall application with private, public and DMZ zones controlled by multiple policies .



ZPF Configuration Example: Process

The following steps describe an example process for configuring a simple ZPF between the private and public zones.

1. Create an inspect class map called MY-CLASS for all TCP-based traffic that matches an ACL (Telnet, SMTP, FTP, and HTTP).
2. Create a policy map called MY-POLICY which defines the action to perform on the traffic matching the class map MY-CLASS. In this example, the action is to inspect the traffic to create dynamic inspection objects.
3. Define the two security zones, in this case PRIVATE and PUBLIC.
4. Create a corresponding zone pair called PRIV-PUB to represent the direction of the traffic to which the policy will be applied.
5. Apply the policy MY-POLICY to the zone pair to control the traffic.
6. Zone pair PRIV-PUB states that all traffic sourced from zone PRIVATE and destined for zone PUBLIC will be processed according to policy map MY-POLICY.
7. Assign each interfaces to an appropriate zone. Interface Fa0/0 is in zone PRIVATE, and interface Fa0/1 is in zone PUBLIC.
8. Define the ACL to be used by class map MY-CLASS.

ZPF Configuration Example: Commands

```
! Define inspect class-maps:
class-map type inspect match-any TCP
 match protocol tcp
class-map type inpsect match-all MY-CLASS
 match access-group 102
 match class-map TCP

! Define inspect policy-map:
policy-map type inspect MY-POLICY
 class type inspect MY-CLASS
 inspect

! Define zones:
zone security PRIVATE
zone security PUBLIC

! Establish zone pair, apply policy:
zone-pair security PRIV-PUB source PRIVATE destination PUBLIC
 service-policy type inspect MY-POLICY

! Assign interfaces to zones:
interface FastEthernet0/0
 zone-member security PRIVATE
interface FastEthernet0/1
 zone-member security PUBLIC

! Define ACL
access-list 102 permit tcp any any eq telnet
access-list 102 permit tcp any any eq smtp
access-list 102 permit tcp any any eq ftp
access-list 102 permit tcp any any eq www
```

Other Methods of Securing the Data Plane

- Unauthorized or unwanted traffic can be blocked by implementing traffic-filtering and other security features such as:
  - Standalone Access Control Lists (ACLs)
  - VLAN access maps (on LAN switches)
  - Cisco IOS firewall (SPI or ZPF)
  - Intrusion Prevention System (IPS)
  - Unicast Reverse Path Forwarding (uRPF).
  - IP Security (IPsec)
  - IEEE 802.1X
  - Network Admission Control (NAC)

Troubleshooting Data Plane Security – Cont.

- Knowledge of which security features are implemented and where is critical.
- Misconfigured security features can cause valid traffic to be dropped.
- Security features should always be considered as a possible cause of network connectivity problems.
- If there is network layer connectivity between two hosts, but upper layers are not functioning as expected, packet filtering may be a factor.
- Management and control traffic also passes through the data plane and data plane security features could be the cause of the failure.
- The troubleshooting tools for the ZPF are similar to the tools used for classic Cisco IOS firewall:
  - When audit trails are enabled, syslog messages are generated for each stateful inspection session.
  - Debugging can be used to obtain more detailed information in either case

Troubleshooting ZPF Using Syslog - Example

- A user complains that he is unable to browse to a web server with the IP address 172.16.1.100.
- An administrator searches the syslog for the string 172.16.1.100 and realizes that a Java applet reset option was configured on the ZPF.
- The class map is myClassMap, and the appl-class is HttpAic.
- The administrator corrects this problem by allowing the embedded Java applet to the server in the HTTP AIC policy (HttpAic).
- Syslog is an effective troubleshooting tool available for ZPF. It captures alert, audit trail, and **debug** command output.

```
May 31 18:02:34.739 UTC: %FW-6-SESS_AUDIT_TRAIL_START: (target:class)-
publicPrivateOut:myClassMap:Start http session: initiator (10.1.1.100:3372)
-- responder (172.16.1.100:80)
May 31 18:02:34.907 UTC: %APPFW-4-HTTP_JAVA_APPLET: HTTP Java Applet
detected - resetting session 172.16.1.100:80 10.1.1.100:3372 on zone-pair
publicPrivateOut class myClassMap appl-class HttpAic
May 31 18:02:34.919 UTC: %FW-6_SESS_AUDIT_TRAIL: (target:class)-
(publicPrivateOut:myClassMap):Stop http session: initiator
(10.1.1.100:3372) sent 297 bytes -- responder (172.16.1.100:80) sent 0 bytes
```

Troubleshooting ZPF Using show Commands

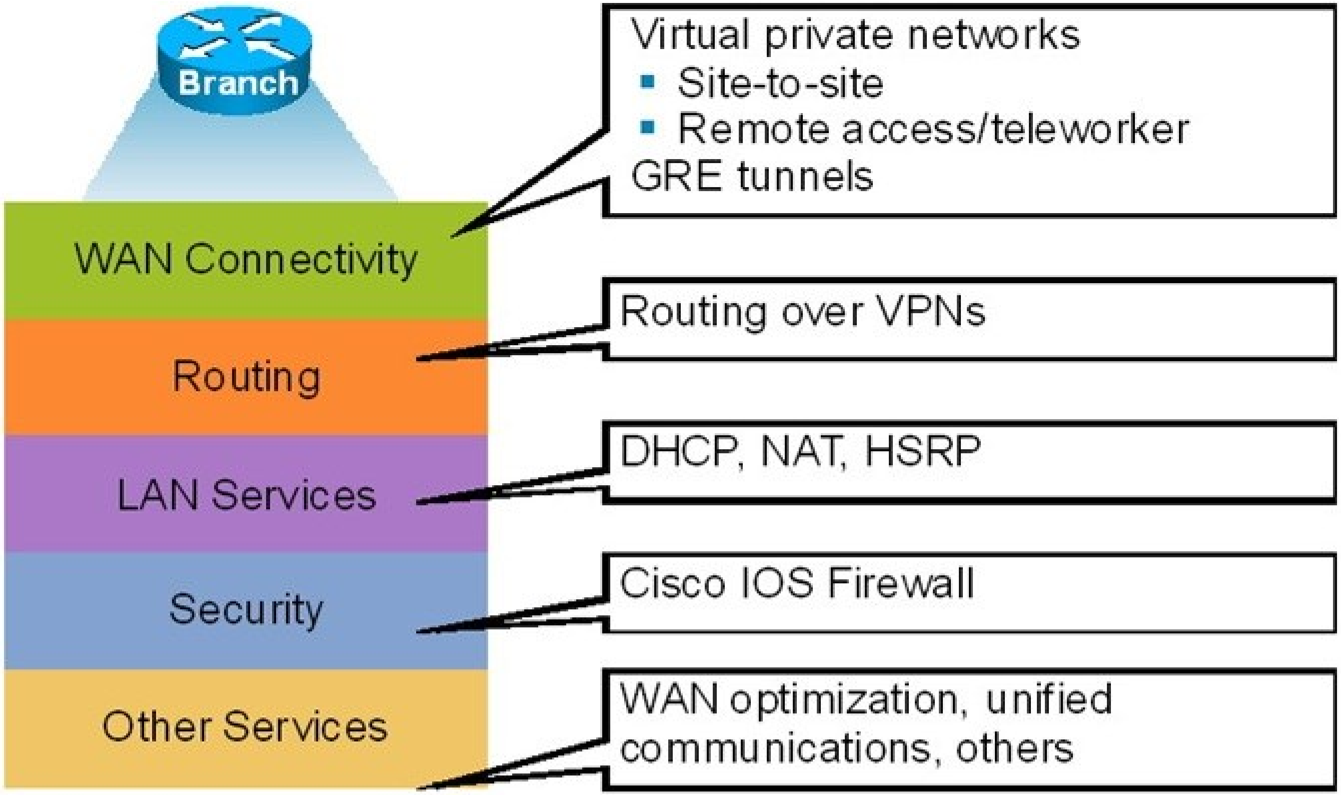
- **`show zone security`**: Displays information for all zones configured and corresponding member interfaces. Verifies zone configuration and assignment.
- **`show zone-pair security`** (See example): Provides information about how zones are paired including Zone-pair direction (with respect to the traffic flow) and policy applied to zone-pair traffic.
- **`show policy-map type inspect`**: Displays relevant information for the policy including what traffic is matched to which class and what action is applied to each class of traffic. Also displays the dynamically created session objects.

```
Router# show zone-pair security source PRIVATE destination PUBLIC
Zone-pair name PRIV-PUB
    Source-Zone PRIVATE Destination-Zone Public
    Service-policy MY-POLICY
```

Troubleshooting Branch Office and Remote Worker Connectivity

Branch Office and Remote Worker Connectivity

Branch office connectivity involves multiple topics and technologies such as WAN connectivity through VPNs, Generic Routing Encapsulation (GRE) tunnels, routing, LAN services and security



Virtual private networks
- Site-to-site
- Remote access/teleworker

GRE tunnels

Routing over VPNs

DHCP, NAT, HSRP

Cisco IOS Firewall

WAN optimization, unified communications, others

Branch Office & Remote Worker Connectivity Issues

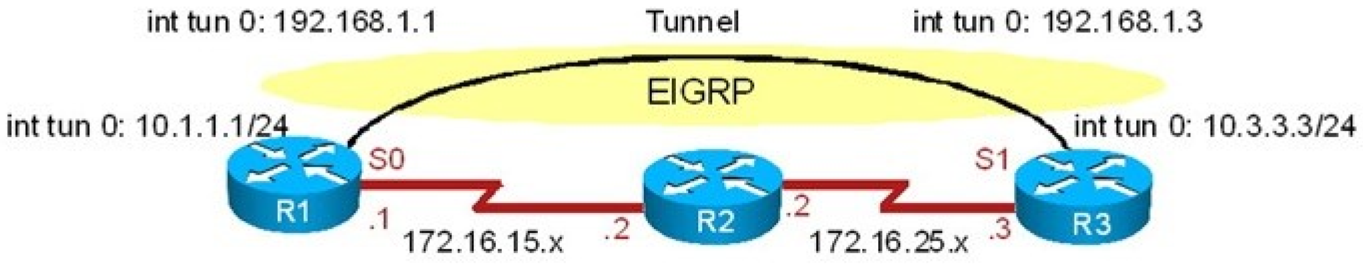
- Site-to-site VPN connectivity
  - Misconfigured parameters causing mismatches on the VPN-termination routers.
  - Overlapping IP subnets on the opposite sides of the tunnel which can require the use of NAT
- Remote-access VPNs
  - Host issues related to client configuration or antivirus software.
  - User authentication and authorization is also a critical function
- GRE tunnels
  - Misconfiguring tunnel source and destination can cause routing issues preventing the tunnel from forming.

Branch Office Connectivity Issues with GRE

- GRE tunnels are typically used to transport routing protocols across IPsec VPNs.
- Maximum transmission unit (MTU) and fragmentation are a common issue.
- Problems related to GRE tunnel establishment are usually due to configurations of tunnel sources and tunnel destinations, along with improper routing of loopbacks.
- Firewalls and traffic filters may block the IPsec traffic that carries the GRE tunnels.
- Multiple GRE point-to-point tunnels can saturate the physical link with routing information if the bandwidth is not adequately provisioned or configured on the tunnel interface.
- The point-to-point nature of traditional GRE tunnels makes a full-mesh solution a challenge because all routers have to terminate a high number of tunnels.
- Technologies that can alleviate the full-mesh requirement, making it dynamic, automatic, and efficient can be deployed. Examples include:
  - Virtual Tunnel Interface (VTI)
  - Dynamic Multipoint VPN (DMVPN)
  - Group-Encrypted Transport VPN (GET VPN).

Branch Office Connectivity Issues with GRE – Cont.

- Misconfiguration of routing over GRE tunnels can lead to recursive routing.
- In the example shown in the figure, the GRE tunnel is terminated at the loopback interfaces of the routers at each end.
- Those loopback interfaces are also injected into EIGRP, and they are advertised across the tunnel to the other side, from R3 to R1 and vice versa.
- The routing tables will show that the best path to the loopbacks, the source of the tunnel, is the tunnel itself. This causes the inconsistent routing that leads to the recursive routing problem.
- When the best path to the tunnel destination is through the tunnel itself, recursive routing causes the tunnel interface to flap.
- This mi the tunnel.



Branch Office Connectivity Issues – Cont.

- Other considerations with respect to troubleshooting branch connectivity include:
    - Are there firewalls or access lists blocking the VPN traffic?
    - Are there overlapping subnets at the opposite ends of the tunnel?
    - Is asymmetric routing causing VPN tunnels to fail?
    - Do we have HSRP aligned with VPN high-availability functions?
- These issues deal with the routing, addressing, and high-availability infrastructures present in the network.
- They are necessary for branch connectivity and require additional troubleshooting when they fail.
- Because branch connectivity touches so many areas, the tool box for troubleshooting its deployments include **`show`** and **`debug`** commands in many areas.

Remote Connectivity Troubleshooting Commands

Focus	Command

IPsec	`show crypto ipsec sa`
	`show crypto engine connections active`
	`show crypto map`

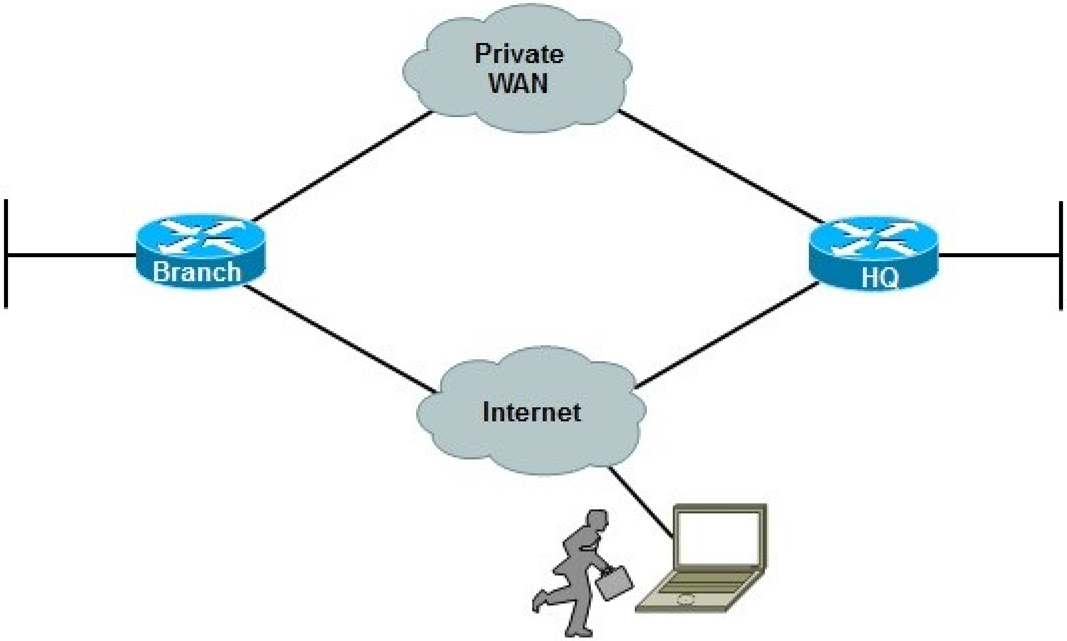
GRE	`show interfaces tunnel`
	`debug tunnel`

IP routing	`show ip route`
	`show ip protocols`
	`debug ip routing`

IP services	`show ip dhcp pool`
	`show ip dhcp bindings`
	`show ip nat statistics`
	`show ip nat translations`
	`show standby`
	`show standby brief`

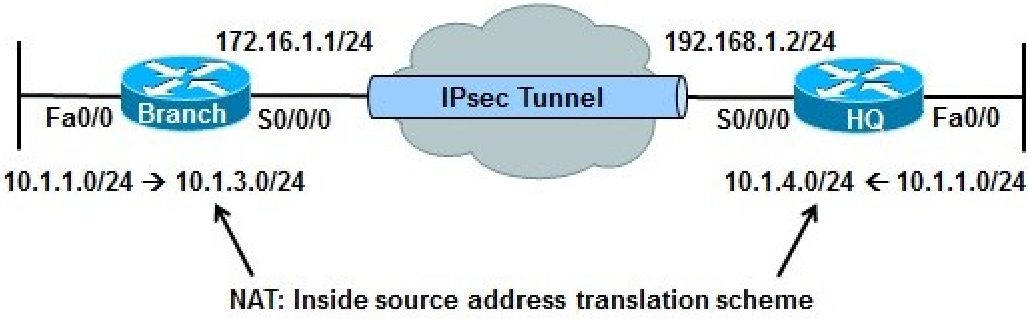
BO/RW Troubleshooting Example – Main Diag.

The troubleshooting examples presented in this section are all based on the network topology diagram shown here, with changes to accommodate for different scenarios. The diagram shows a private WAN and an Internet option for branch connectivity. There is also a remote-access service for mobile users and traveling users.



BO/RW TSHOOT Example 1: Address Translation Error

- The Branch router is using an IPsec tunnel to provide connectivity to headquarters for its LAN users.
- This deployment has been working for a while, but a recent change in NAT configuration has caused the tunnel to go down, not get reestablished, and VPN connectivity to fail.
- This is the only branch experiencing the problem.
- Regular Internet access, however, has been restored, and users are able to connect to websites normally.



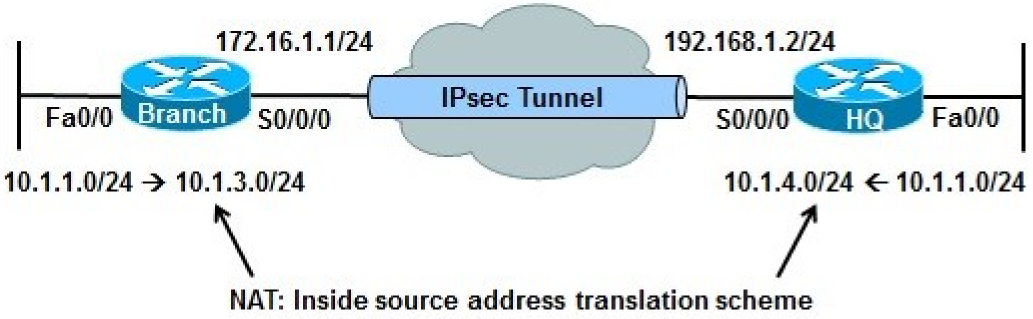
BO/RW TSHOOT Example 1 – Cont.

On the Branch router, use the **show ip nat statistics** command to display NAT information.

```
BRANCH# sh ip nat statistics
Total active translations: 1 (1 static, 0 dynamic, 0 extended)
Outside interfaces:
Serial0/0/0
Inside interfaces:
FastEthernet0/0
Hits: 0 Misses: 0
CEF Translated packets: 0, CEF Punted packets: 0
Expired translations: 0
Dynamic mappings:
-- Inside Source
[Id: 1] access-list 150 pool PUBLIC refcount 0
pool PUBLIC: netmask 255.255.255.0
start 172.16.1.100 end 172.16.1.200
type generic, total addresses 101, allocated 0 (0%), misses 0
[Id: 2] access-list VPN pool VPN_NAT refcount 0
start 10.1.10.10 end 10.1.10.200
type generic, total addresses 191, allocated 0 (0%), misses 0
Queued Packets: 0
```

BO/RW TSHOOT Example 1 – Cont.

- The output shows that the VPN traffic is exempted from “public” translation because it remains private as it goes through the tunnel.
- Based on the network topology diagram, the subnets on the opposite sides of the VPN are both using address 10.1.1.0/24 and are overlapping.
- NAT is needed to translate VPN traffic into something other than 10.1.1.0/24 on both sides.
- Traffic matching the VPN access list is being statically translated into an address from the range 10.1.10.10 to 10.1.10.200.
- Traffic from Branch to HQ (destination subnet 10.1.4.0/24), should have its source address translate to an address from the 10.1.3.0/24 subnet.
- The traffic leaving the headquarters network should have its source address translated to an address fron



BO/RW TSHOOT Example 1 – Cont.

- The translation done for the VPN traffic at the branch office is incorrect. The source address is being translated to 10.1.10.x rather than 10.1.3.x.
- The VPN traffic being translated will eventually go to the WAN interface to be tunneled through the IPsec VPN.
- The translated address must match the crypto access list; otherwise, it will not go through the VPN tunnel.
- Use the **`show crypto map`** command on the branch router to see the crypto ACL contained in the crypto map. This defines the traffic that will be accepted to the VPN tunnel.

```
BRANCH# show crypto map
Crypto Map “map1” 10 ipsec-isakmp
       Peer = 192.168.1.2
       Extended IP access list 106
          access-list 106 permit ip 10.1.3.0 0.0.0.255 10.1.4.0 0.0.0.255
       Current peer: 192.168.1.2
       Security association lifetime: 4608000 kilobytes/3600 seconds
       PFS (Y/N): N
       Transform sets={
                Ts1,
       }
       Interfaces using crypto map map1:
           Serial0/0/0
```

BO/RW TSHOOT Example 1 – Cont.

- The **`show crypto map`** command reveals that ACL 106 is used which only matches traffic with source address of 10.1.3.x and destination address of 10.1.4.x.
- If the source address of the traffic from the branch translates to anything other than 10.1.3.x, it will not go through the VPN tunnel.
- The NAT configuration is inconsistent with the crypto map (VPN) configuration.

```
BRANCH# show crypto map
Crypto Map “map1” 10 ipsec-isakmp
       Peer = 192.168.1.2
       Extended IP access list 106
          access-list 106 permit ip 10.1.3.0 0.0.0.255 10.1.4.0 0.0.0.255
       Current peer: 192.168.1.2
       Security association lifetime: 4608000 kilobytes/3600 seconds
       PFS (Y/N): N
       Transform sets={
                Ts1,
       }
       Interfaces using crypto map map1:
           Serial0/0/0
```

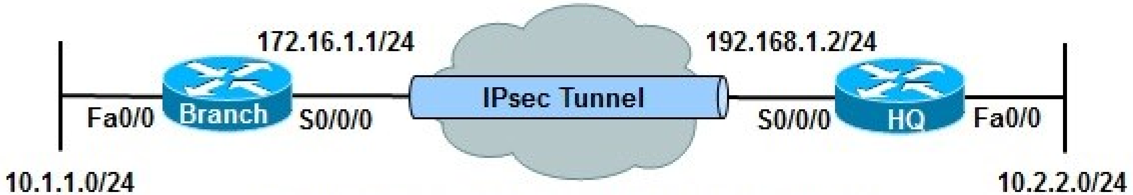
BO/RW TSHOOT Example 1 – Cont.

- Correct the VPN_NAT pool by removing the old definition and adding the new definition, as shown here.
- To test that the problem is solved, ping an address from the 10.1.4.0 pool (headquarters) with a source interface on the branch office LAN (Fa0/0) and the ping is successful.

```
BRANCH(config)# no ip nat pool VPN_NAT 10.1.10.10 10.1.10.200 netmask
255.255.255.0
BRANCH(config)#
BRANCH(config)# ip nat pool VPN_NAT 10.1.3.10 10.1.3.200 netmask 255.255.255.0
BRANCH(config)# end

BRANCH# ping 10.1.4.1 source fa0/0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.4.1, timeout is 2 seconds:
Packet sent with a source address of 10.1.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max - 56/57/60 ms
```

BO/RW TSHOOT Example 2: Crypto Map ACL Error

- The Branch router is using an IPsec tunnel to provide connectivity to headquarters for its LAN users.
- This time there is no subnet overlapping between the branch and headquarters networks.
- The VPN connection is down, but the Internet connection is working well.
- There have not been any recent documented configuration changes.
- This Branch router is providing DHCP services to LAN hosts.



Branch office serial interface (IP address: 172.16.1.1)
connects to the ISP router (IP address: 172.16.1.2)

BO/RW TSHOOT Example 2 – Cont.

- Start at the Branch router and use a bottom-up approach for each phase or step along the path.
- Use the **`show ip interfaces brief`** command to check the Layer 1 and Layer 2 status of the Branch router’s interfaces.
- As shown in the example, both the LAN and WAN interfaces are up.

```
BRANCH# sh ip int brief
Interface            IP-Address      OK?  Method    Status                 Protocol
FastEthernet0/0      10.1.1.1        YES  manual    up                     up
FastEthernet0/1      unassigned      YES  unset     administratively down  down
Serial0/0/0          172.16.1.1      YES  manual    up                     up
NVIO                 unassigned      NO   unset     up                     up
```

BO/RW TSHOOT Example 2 – Cont.

- Check whether the Branch router is providing IP address and related parameters through DHCP.
- The **`show ip dhcp pool`** command on the Branch router confirms that the address space 10.1.1.0/24 is being served to hosts through DHCP.

```
BRANCH# show ip dhcp pool

Pool LAN :
 Utilization mark (high/low)    : 100 / 0
 Subnet size (first/next)       : 0 / 0
 Total addresses                : 254
 Leased addresses               : 0
 Pending event                  : none
 1 subnet is currently in the pool :
Current index         IP address range               Leased addresses
10.1.1.1              10.1.1.1       - 10.1.1.254     0
```

BO/RW TSHOOT Example 2 – Cont.

- Check to see if there is a routing problem using the **`show ip route`** command.
- The output show what is expected for a small branch office: a static default pointing to a next hop on the WAN interface.

```
BRANCH# show ip route
<output omitted>

Gateway of last resort is 172.16.1.2 to network 0.0.0.0

     172.16.0.0 255.255.255.0 is subnetted, 1 subnets
C       172.16.1.0 is directly connected, Serial0/0/0
     10.0.0.0 255.255.255.0 is subnetted, 3 subnets
C       10.1.3.0 is directly connected, Loopback0
C       10.1.1.0 is directly connected, FastEthernet0/0
C       10.251.1.0 is directly connected, Loopback1
S*   0.0.0.0 0.0.0.0 [1/0] via 172.16.1.2
```

BO/RW TSHOOT Example 2 – Cont.

Next, check NAT with the **show ip nat statistics** command.

The output reveals that traffic matching ACL 107 will be translated.

```
BRANCH# show ip nat statistics
Total active translations: 1 (1 static, 0 dynamic, 0 extended)
Outside interfaces:
Serial0/0/0
Inside interfaces:
FastEthernet0/0
Hits: 60 Misses: 0
CEF Translated packets: 10, CEF Punted packets: 30
Expired translations: 7
Dynamic mappings:
-- Inside Source
[Id: 3] access-list 107 pool PUBLIC refcount 0
pool PUBLIC: netmask 255.255.255.0
start 172.16.1.100 end 172.16.1.200
type generic, total addresses 101, allocated 0 (0%), misses 0
```

BO/RW TSHOOT Example 2 – Cont.

- Display ACL 107 and the content looks correct because it denies traffic going from branch to headquarters.
- That means the traffic going from branch to headquarters will not be subjected to NAT.

```
BRANCH# show access-list 107
Extended IP access list 107
   10 deny ip 10.1.1.0 0.0.0.255 10.2.2.0 0.0.0.255
   20 permit ip 10.1.1.0 0.0.0.255 any
```

BO/RW TSHOOT Example 2 – Cont.

- Check the VPN configuration using the **`show crypto map`** on the Branch router.
- ACL 106 used in the crypto map states that only the traffic with source address 10.1.3.x and destination address 10.2.2.y will go through the VPN tunnel.
- That is incorrect because the traffic from the branch going to the headquarters (which is not subject to NAT) will have source address of 10.1.1.x, that is provided by the DHCP server.

```
BRANCH# show crypto map
Crypto Map "map1" 10 ipsec-isakmp
        Peer = 192.168.1.2
        Extended IP access list 106
            access-list 106 permit ip 10.1.3.0 0.0.0.255 10.2.2.0 0.0.0.255
        Current peer: 192.168.1.2
        Security association lifetime: 4608000 kilobytes/3600 seconds
        PFS (Y/N): N
        Transform sets={
                ts1,
        }
        Interfaces using crypto map map1:
                Serial0/0/0
```

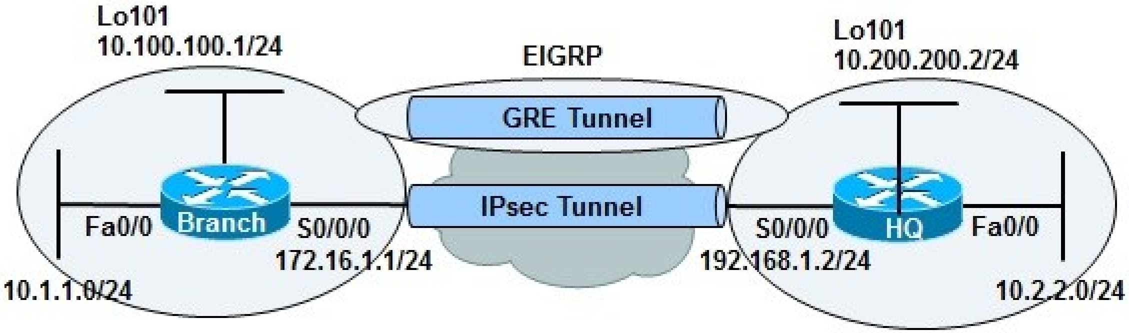
BO/RW TSHOOT Example 2 – Cont.

- The source IP addresses of the packets from the branch office are not matching the crypto ACL.
- Change the crypto ACL 106 on Branch to permit traffic sourced from network 10.1.1.0/24 destined for network 10.2.2.0/24 to be encrypted by the tunnel.
- Use the **`ping`** command to verify connectivity. The ping from branch to headquarters is successful.

```
BRANCH# conf t
Enter configuration commands, one per line. End with CNTL/Z
BRANCH(config)# no access-list 106
BRANCH(config)#
BRANCH(config)# access-list 106 permit ip 10.1.1.0 0.0.0.255 10.2.2.0 0.0.0.255

BRANCH# ping 10.2.2.1 source f0/0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.2.2.1, timeout is 2 seconds:
Packet sent with a source address of 10.1.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max - 88/89/92 ms
```

BO/RW TSHOOT Example 3: GRE Config. Error

- EIGRP is being routed across an IPsec VPN tunnel, using GRE.
- The GRE tunnel is sourced at the loopback interfaces on each router.
- EIGRP is used to advertise internal networks in the 10.0.0.0 address space, for branch-to-headquarters connectivity.
- The problem is that traffic is not reaching the headquarters network, which hosts multiple mission-critical servers.
- The support team does not have many details, just that connectivity is lost.



BO/RW TSHOOT Example 3 – Cont.

- At the Headquarters router check the status of the VPN tunnel and look for the IP address of the Branch router as a destination using the **`show crypto isakmp sa`** command.
- The status of the tunnel to branch at 172.16.1.1 is ACTIVE. The same command at the Branch router shows an ACTIVE status, too.

```
HQ# show crypto isakmp sa
IPv4 Crypto ISAKMP SA
dst             src             state          conn-id  slot  status
172.16.1.1      192.168.1.2     QM_IDLE           1002     0  ACTIVE

BRANCH# show crypto isakmp sa
IPv4 Crypto ISAKMP SA
dst             src             state          conn-id  slot  status
192.168.1.2     172.16.1.1      QM_IDLE           1001     0  ACTIVE
```

BO/RW TSHOOT Example 3 – Cont.

- The VPN tunnel is reported as active from both ends.
- Troubleshooting from the bottom up, determine whether the headquarters destinations can be found in the Branch router’s routing table.
- Use the **`show ip route`** command and search for network 10.2.2.0/24.
- This subnet is not present.

```
BRANCH# show ip route 10.2.2.0
% Subnet not in table
BRANCH#
```

BO/RW TSHOOT Example 3 – Cont.

- Routing (advertisement) is supposed to happen over GRE across the VPN tunnel.
- Examine the GRE (tunnel0) using the **`show interfaces tunnel 0`** command.
- The results show that the tunnel is up, but line protocol is down.
- The tunnel source at BRANCH is 10.100.100.1 (loopback101), and the tunnel destination is 10.200.200.22.

```
BRANCH# show interfaces tunnel 0
Tunnel0 is up, line protocol is down
  Hardware is Tunnel
  Internet address is 10.1.3.2 255.255.255.0
  MTU 1514 bytes, BW 9 Kbit, DLY 500000 usec,
    Reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation TUNNEL, loopback not set
  Keepalive not set
  Tunnel source 10.100.100.1 (Loopback101), destination 10.200.200.22
  Tunnel protocol/transport GRE/IP
    Key disabled, sequencing disabled
    Checksumming of packets disabled
  Tunnel TTL 255
  Fast tunneling enabled
<output omitted>
```

BO/RW TSHOOT Example 3 – Cont.

- Check the Headquarters router and see whether address 10.200.200.22 is a valid destination for this tunnel.
- The **`show interfaces tunnel 0`** command on the HQ router indicates the tunnel source at HQ is loopback101 with the IP address 10.200.200.2, not 10.200.200.22.
- It looks like a typing error has happened at the Branch router
- Notice that the tunnel interface at HQ is administratively down and that needs to be fixed, too.

```
HQ# show interfaces tunnel 0
Tunnel0 is administratively down, line protocol is down
  Hardware is Tunnel
  Internet address is 10.1.3.1 255.255.255.0
  MTU 1514 bytes, BW 9 Kbit, DLY 500000 usec,
    Reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation TUNNEL, loopback not set
  Keepalive not set
  Tunnel source 10.200.200.2 (Loopback101), destination 10.100.100.1
  Tunnel protocol/transport GRE/IP
<output omitted>
```

BO/RW TSHOOT Example 3 – Cont.

- Return to the Branch router to fix the tunnel destination address error.
- First enter the **`debug ip routing`** command to see the EIGRP routes appear in routing table as a result of repairing the tunnel.
- In interface configuration mode for the tunnel0 interface, remove the incorrect tunnel destination address, and enter the correct tunnel destination address (10.200.200.2).

```
BRANCH#
BRANCH# debug ip routing
IP routing debugging is on
BRANCH#

BRANCH# conf t
Enter configuration commands, one per line. End with CNTL/Z
BRANCH(config)# int tunnel0
BRANCH(config-if)# no tunnel destination 10.200.200.22
BRANCH(config-if)# tunnel destination 10.200.200.2
BRANCH(config-if)# end
```

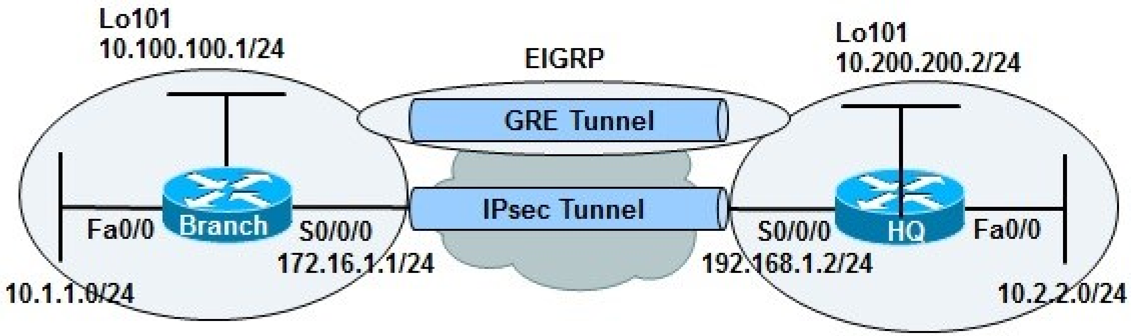
BO/RW TSHOOT Example 3 – Cont.

- Debug messages indicate the EIGRP neighbor session is established.
- The routing table is populated across the tunnel.
- Confirm end-to-end connectivity with an extended ping from the Branch router using its Fa0/0 interface as the source, to the address 10.2.2.1 at headquarters.
- The ping is successful.

```
BRANCH#
%SYS-5-CONFIG_I: Configured console by console
%DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 10.1.3.1 (Tunnel0) is up: new adjacency
BRANCH#
%LINK-3-UPDOWN: Interface Tunnel0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel0, changed state to up

BRANCH# ping 10.2.2.1 source f0/0
Type escape sequence to abort.
Sending 5 100-byte ICMP Echos to 10.2.2.1, timeout is 2 seconds:
Packet sent with a source address of 10.1.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 88/91/92 ms
BRANCH#
```

BO/RW TSHOOT Example 4: Recursive Routing Issue

- The IPsec tunnel was established and tested, and it was carrying user traffic with no problem.
- Suddenly the tunnel interface went down and EIGRP was no longer able to advertise routes.
- Level 1 operators tried resetting the interfaces, but that did not help.
- Tunnels get established and then go down after a few seconds every time.



BO/RW TSHOOT Example 4 – Cont.

GRE is being used to carry EIGRP advertisements across the VPN. Use the **`show ip protocols`** command to verify the EIGRP configuration. The output is shown here and looks correct.

```
BRANCH# show ip protocols
Routing Protocol is “eigrp 1”
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Default networks flagged in outgoing updates
  Default networks accepted from incoming updates
  EIGRP metric weight K1 =1, K2 = 0, K3 = 1, K4 = 0, K5 = 0
  EIGRP maximum hopcount 100
  EIGRP maximum metric variance 1
  Redistributing: eigrp 1
  EIGRP NSF-aware route hold timer is 240s
  Automatic network summarization is not in effect
  Maximum path: 4
  Routing for Networks:
    10.0.0.0
Routing Information Sources:
  Gateway Distance Last Update
  (this router) 90 00:38:11
Distance: internal 90 external 170
```

BO/RW TSHOOT Example 4 – Cont.

- Use the **`show interfaces tunnel`** command to determine the status of the tunnel on Branch.
- Interface Tunnel 0's line protocol is down
- The source and destination of the tunnel, based on the network diagram, are correct. No tunnel configuration error is apparent.
- The same command on the HQ router shows correct configuration, but the line protocol is down there, too.

```
BRANCH# show interface tunnel 0
Tunnel0 is up, line protocol is down
  Hardware is Tunnel
  Internet address is 10.1.3.2 255.255.255.0
  MTU 1514 bytes, BW 9 Kbit, DLY 500000 usec,
    Reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation TUNNEL, loopback not set
  Keepalive not set

  Tunnel protocol/transport GRE/IP
```

BO/RW TSHOOT Example 4 – Cont.

- Replicate the problem by shutting down the interfaces on HQ and bringing them back up. This will initiate establishment of the tunnel.
- An informational message on a new adjacency with the neighbor Branch across tunnel0 is reported.
- After a few seconds another message displays: “Tunnel0 temporarily disabled due to recursive routing.”
- The line protocol on interface tunnel0 changes state to down, and so does the neighbor.

```
HQ(config)# int tunnel0
HQ(config-if)# shutdown
HQ(config-if)# no shutdown
HQ(config-if)# end

%DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 10.1.3.2 (Tunnel0) is up: new
adjacency
HQ#
%TUN-5-RECURDOWN: Tunnel0 temporarily disabled due to recursive routing
%LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel0, changed state to down
%DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 10.1.3.2 (Tunnel0) is down:
interface
down
```

BO/RW TSHOOT Example 4 – Cont.

- Configure a path to the tunnel destination that is better than the EIGRP path through the tunnel itself using a static route.
- BRANCH address 172.16.1.1 (assumed to be a public address) is considered to be the address the ISP has assigned to the BRANCH router, and the HQ address 192.168.1.2 (assumed to be a public address) is considered to be the address that HQ’s ISP has assigned to the HQ router.
- The tunnel interface goes up and neighbor adjacency is established.

```
HQ(config)# interface tunnel0
HQ(config-if)# shutdown
HQ(config-if)# exit
HQ(config)# ip route 10.100.100.1 255.255.255.255 172.16.1.1
HQ(config)# interface tunnel0
HQ(config-if)# no shutdown
HQ
%LINK-3-UPDOWN: Interface Tunnel0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel0, changed state to up
HQ#
%DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 10.1.3.2 (Tunnel0) is up: new
Adjacency
```

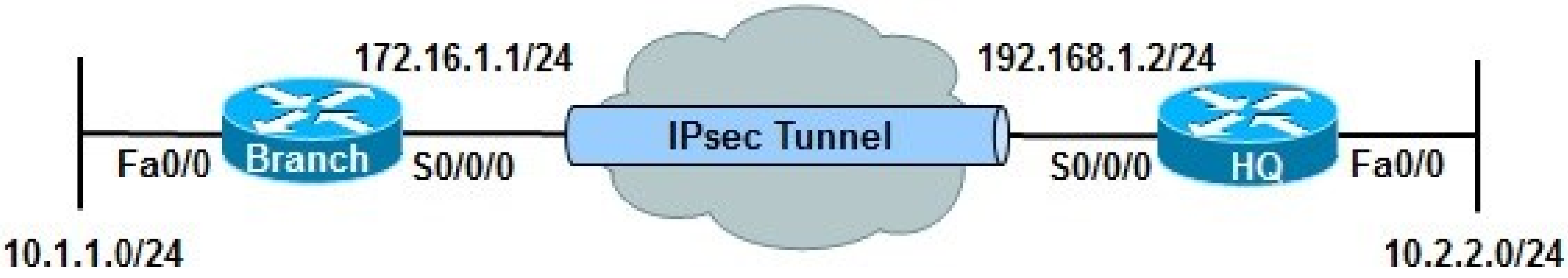
BO/RW TSHOOT Example 4 – Cont.

- A display of the HQ routing table using the **show ip route** command includes three paths to the tunnel0 destination (10.100.100.1):
- The gateway of last resort (0.0.0.0/0) through 192.168.1.1 (the ISP's IP address at HQ – not shown in the topology).
- The one is using the EIGRP route 10.100.100.0/24 through the tunnel0 interface.
- The one is using the static route entered to 10.100.100.1/32 through 172.16.1.1. This is the most specific one and will be used to reach the tunnel end.

```
HQ# show ip route
<output omitted>
Gateway of last resort is 192.168.1.1 to network 0.0.0.0

     10.0.0.0 255.0.0.0 is variably subnetted, 8 subnets, 2 masks
C       10.1.3.0 255.255.255.0 is directly connected, Tunnel0
C       10.200.200.0 255.255.255.0 is directly connected, Loopback101
D       10.100.100.0 255.255.255.0
           [90/297372416] via 10.1.3.2, 00:00:07, Tunnel0
C       10.2.2.0 255.255.255.0 is directly connected, FastEthernet0/0
D       10.1.1.0 255.255.255.0 [90/297372416] via 10.1.3.2, 00:00:07, Tunnel0
S       10.100.100.1 255.255.255.255 [1/0] via 172.16.1.1
C      192.168.1.0 255.255.255.0 is directly connected, serial0/0/0
S*   0.0.0.0 0.0.0.0 [1/0] via 192.168.1.1
```

BO/RW TSHOOT Example 5: ACL Denies IPsec

- A security auditor recently performed a security assessment and recommended a few improvements to the network policy.
- After the change, IPsec tunnels do not work and never get established. VPN connectivity is critical for branch services.
- All configurations have been reverted to their pre-audit state, except for the Branch router.
- Cisco IOS firewall services were installed in some important routers of the network.



BO/RW TSHOOT Example 5 – Cont.

- Use the **`show ip interfaces`** command to determine if ACLs are applied to any interface.
- The output shows that interface s0/0/0 is up/up and an ACL called FIREWALL-INBOUND is applied in the inbound direction.
- This interface is the one that terminates the IPsec tunnel.

```
BRANCH# show ip interface s0/0/0
Serial0/0/0 is up, line protocol is up
  Internet address is 172.16.1.1 255.255.255.0
  Broadcast address is 255.255.255.255
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is disabled
  Outgoing access list is not set
  Inbound access list is FIREWALL-INBOUND
  Proxy ARP
<output omitted>
```

BO/RW TSHOOT Example 5 – Cont.

- The ACL is allowing routing protocols and management protocols such as SSH.
- The ACL is missing statements that permit IPsec protocols and ISAKMP.
- IPsec requires ESP/AH (protocols 50/51) and ISAKMP (UDP Port 500) to be allowed by access lists.
- The ACL is blocking those ports.

```
BRANCH# show access-list FIREWALL-INBOUND
Extended IP access list FIREWALL-INBOUND
   10 permit tcp any 192.168.250.16 0.0.0.15 established
   20 permit tcp any host 192.168.250.16 eq www
   30 permit tcp any any eq 22
   40 permit tcp any any eq telnet
   50 permit tcp any host 192.168.250.16 eq ftp
   60 permit icmp any any
   70 permit eigrp any any (120 matches)
```

BO/RW TSHOOT Example 5 – Cont.

- Add the required lines to the ACL, and also add a remark indicating why you are making this change using the **`access-list remark`** command.
- Three IPsec protocols should be allowed:
  - ESP
  - AHP
  - ISAKMP
- Verify the solution by successfully pinging the HQ router (loopback interface), which is learned through the tunnel, from the Branch router.

```
BRANCH# configure terminal
Enter configuration commands, one per line. End with CNTL/Z
BRANCH(config)# ip access-list extended FIREWALL-INBOUND
BRANCH(config-ext-nacl)# remark —-additions for IPsec -—-
BRANCH(config-ext-nacl)# permit udp any any eq 500
BRANCH(config-ext-nacl)# permit esp any any
BRANCH(config-ext-nacl)# permit ahp any any
BRANCH(config-ext-nacl)# end
```

Chapter 9 Summary

- Security measures that affect troubleshooting can include:
  - Limiting access to network infrastructure devices
  - Control and management plane hardening
  - Packet filtering on routers and switches
  - Virtual private networks (VPN)
  - Intrusion prevention system (IPS) features.
- It is important to understand which features are deployed and how they operate.
- Most security features operate at the transport layer and above.
- A generic troubleshooting process can help to determine if problems are related to security features or caused by underlying Layer 1, 2, or 3 connectivity issues.
- Reported problems and possible solutions need to be validated against the organization’s security policy.
- Depending on the organization, it may be necessary to escalate the issue to a security specialist.

Chapter 9 Summary – Cont.

- Security features can affect router and switch operation on different planes. The three main functional planes are:
- **Management plane:**
  - Represents functions and protocols involved in managing the device.
  - Provides access for device configuration, device operation, and statistics.
  - If the management plane is compromised, other planes are also exposed.
  - Protocols include Telnet, AAA, SSH, FTP, TFTP, SNMP, syslog, TACACS+, RADIUS, DNS, NetFlow and ROMMON.
- **Control plane:**
  - Represents functions and protocols between network devices to control the operation of the network.
  - Layer 3 protocols include routing protocols and HSRP.
  - Layer 2 protocols and functions include ARP, STP and VLANs.
- **Data plane:**
  - Represents functions involved in forwarding traffic through the device. Traffic is between endpoints such as workstations, servers and printers.
  - Routers and switches can inspect and filter traffic as part of the implementation of a security policy.
  - All management and control plane traffic flows through the data plane.
  - Security features on the data plane can cause failures on the management and control plane.

Chapter 9 Summary: Management Plane

The management functions of a router or switch are commonly accessed using three methods:

- The Cisco IOS command-line interface (CLI)
- Web-based device management
- A network management platform based on Simple Network Management Protocol (SNMP)

CLI Management Access:

- The CLI is the most common and powerful method to manage routers and switches.
- Commands are entered through a console connection or remotely through Telnet or SSH.
- Authentication ensures that only authorized personnel can access and configure the network devices.
- Restrict the network locations that devices can be accessed from and use SSH instead of Telnet.
- Physical security is vital to the security of the management plane.
  - The CLI can always be accessed through the serial console.
  - An unauthorized user could power cycle the device and use password recovery to gain control of the device.

Chapter 9 Summary: Management Plane - Cont.

Web-based Management Access

- A web-based device manager can provide an alternative method to manage routers and switches. Examples include:
  - Cisco Configuration Professional (CCP)
  - Security Device Manager (SDM)
- The protocol used is either HTTP or HTTPS (preferred).

SNMP Management Access

- Primarily used to access operational parameters and statistics of the device, not to change the configuration.
- If a device is configured for read-access the configuration cannot be changed.
- If a device is configured for read-write access, apply the same level of security as for command-line or web-based access.

Chapter 9 Summary: Management Plane - Cont.

- Authentication, authorization, and accounting (AAA) is a major component of network security.
- A centralized security server contains security policies that define the list of users and what they are allowed to do.
- Cisco Secure Access Control Server (ACS) is an example of a AAA server.
- Network devices can access the centralized security server using protocols such as TACACS+ and RADIUS.
- The **`debug aaa authentication`** command is useful for troubleshooting AAA authentication problems.
- The **`debug aaa authorization`** command is useful for troubleshooting AAA authorization problems.
- The **`debug aaa accounting`** command is useful to troubleshoot AAA accounting problems.
- The most common problem occurring when centralized security servers are used is the server going down or becoming unreachable.

Chapter 9 Summary: Control Plane

- When troubleshooting control plane issues, first discover what protocols and features are enabled on the network devices.
- Next, for those protocols and features, you must consider possible configuration errors.
- Misconfiguration of any of the following can lead to control plane failures:
  - Routing protocol or FHRP authentication
  - STP options such as BPDU Guard, BPDU Filter, Root Guard, and Loop Guard
  - DHCP snooping
  - DAI
  - Control plane policing and control plane protection

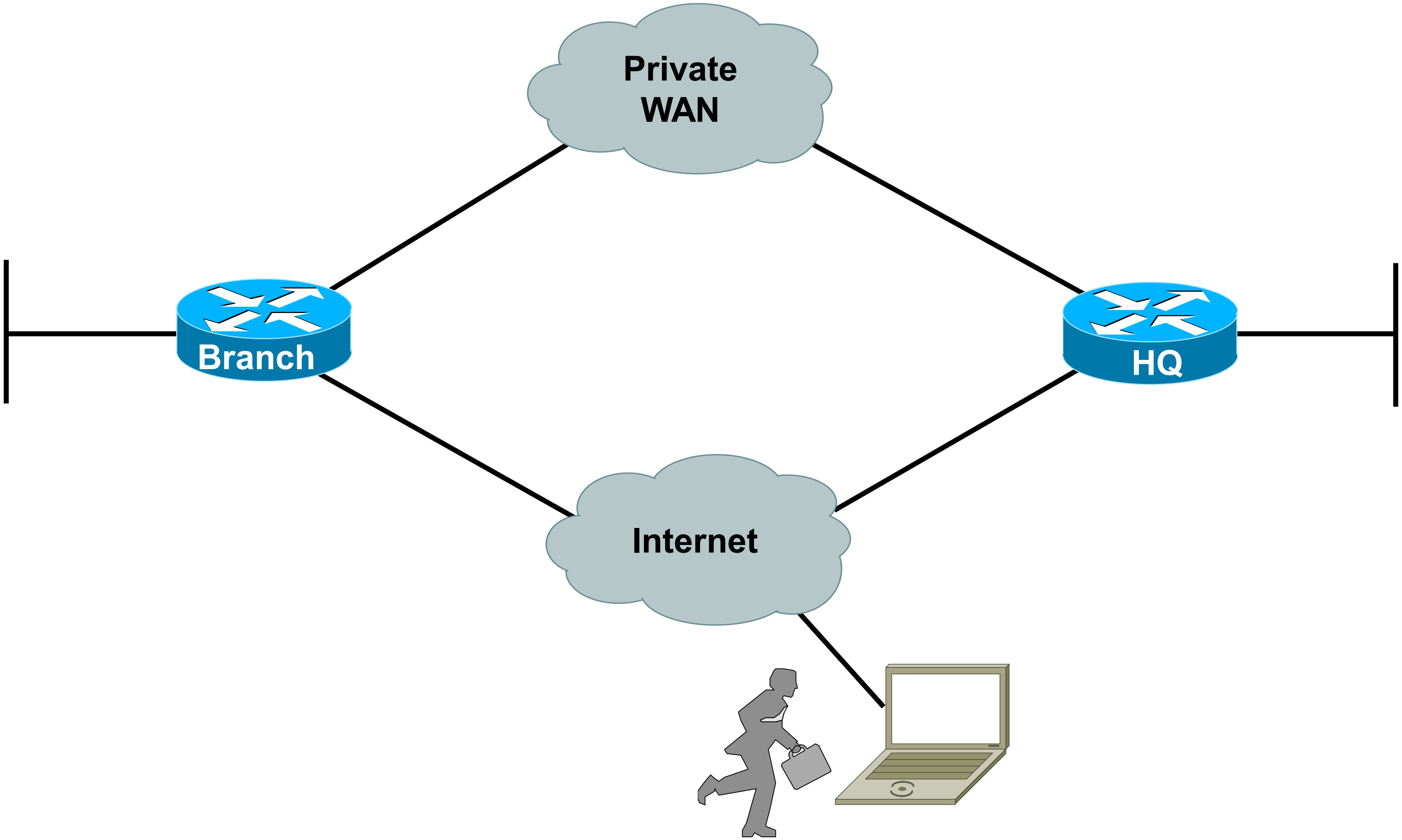
Chapter 9 Summary: Data Plane

- There are two types of Cisco IOS firewall:
  - Classic Cisco IOS firewall (AKA CBAC)
  - ZPF
- Tools for troubleshooting IP firewall (CBAC) configurations include:
  - The **`show ip inspect`** commands
  - Audit trails to generate syslog messages (using **`ip inspect audit-trail`** command)
  - The **`debug ip inspect`** commands.
- Commands for troubleshooting ZPF troubleshooting and verification include:
  - **`show zone security`**
  - **`show zone-pair security`**
  - **`show policy-map type inspect`**

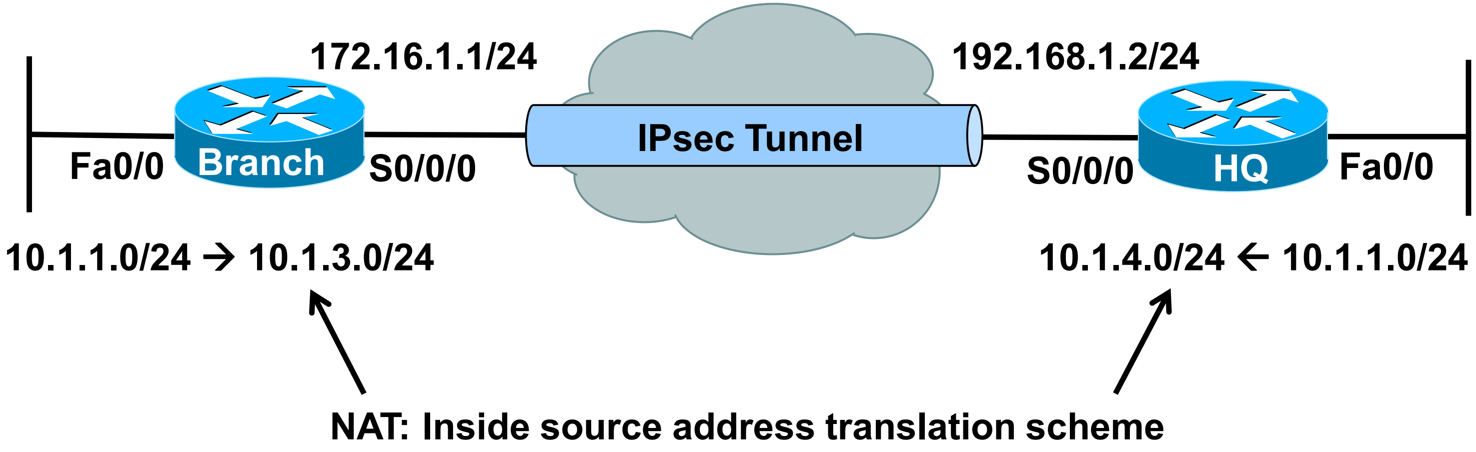
Chapter 9 Summary: Data Plane – Cont.

- Data plane security is accomplished using a variety of router and switch options such as uRPF, IPsec, NAC and 802.1X port authentication.
- The main considerations with respect to troubleshooting branch connectivity relate to network readiness and include the following:
  - Are firewalls or ACLs blocking crucial VPN traffic?
  - Are there overlapping subnets at the opposite ends of the tunnel?
  - Is asymmetric routing causing VPN tunnels to fail?
  - Do we have HSRP aligned with VPN high-availability functions?

RO & RW Troubleshooting Example - Main



RO & RW Troubleshooting Example 1



172.16.1.1/24

192.168.1.2/24

Fa0/0 Branch S0/0/0

IPsec Tunnel

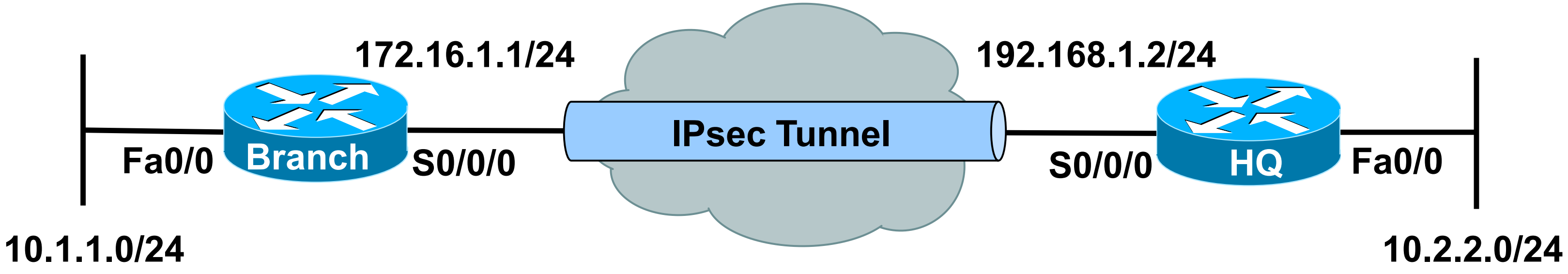
S0/0/0 HQ Fa0/0

10.1.1.0/24 → 10.1.3.0/24

10.1.4.0/24 ← 10.1.1.0/24

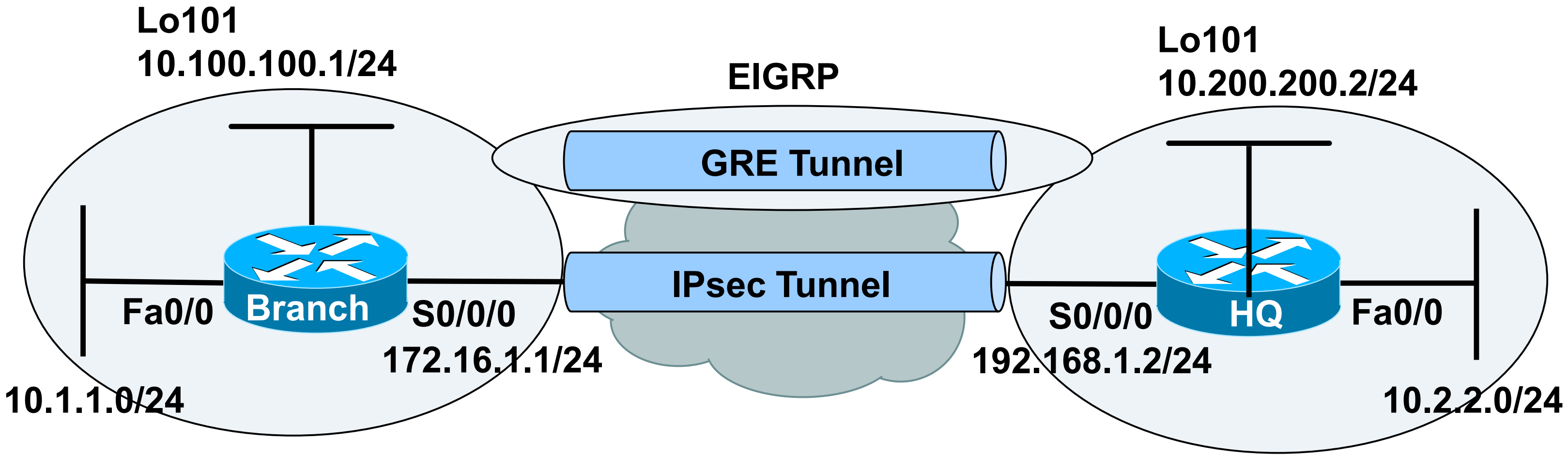
NAT: Inside source address translation scheme

RO & RW Troubleshooting Example 2

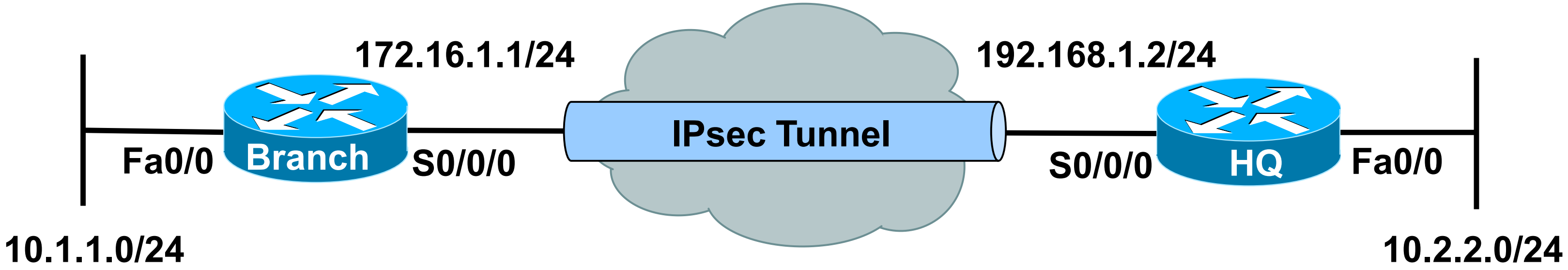


Branch office serial interface (IP address: 172.16.1.1) connects to the ISP router (IP address: 172.16.1.2)

RO & RW Troubleshooting Example 3 & 4



RO & RW Troubleshooting Example 5



Slides adapted by Vladimír Veselý and Matěj Grégr
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