CCIE Security Certification

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Agenda

Session	Topic
1	CCIE® Program Overview
2	CCIE® Security Overview
3	Firewall (Cisco PIX/ASA)
4	VPN
5	Cisco Intrusion Prevention System (IPS)
6	Identity Management
7	Advanced Security
8	Network Attacks
9	Preparation Resources and Test-Taking Tips

Disclaimer

- Not all the topics discussed today appear on every exam
- For time reasons, we’re unable to discuss every feature and topic possible on the exam

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2009

Session 1

CCIE Program Overview

Welcome to the Human Network.

CISCO

Overview: CCIE Certification

- Highest regarded IT certification for over 15 years
- Industry standard for validating expert level skills and experience
- Exams continually updated and revised with new technologies
- Theoretical and intensive hands-on lab examination requirements
- Demonstrate strong commitment and investment in networking career, life-long learning, and dedication to remaining an active CCIE

CCIE Roadmap and Exam Basics

Overview: CCIE Tracks

Routing and Switching

- Core networking cert
- 74% of all bookings
- Labs in all regions, all worldwide locations

Security

- Introduced 2002
- Fastest growing cert; 13% of bookings
- Labs in Beijing, Brussels, RTP, San Jose, Sydney, Dubai, Bangalore and Tokyo

Voice over IP

- Introduced 2003
- 10% of bookings
- Labs in Brussels, San Jose, RTP and Sydney

Storage Networking

- Introduced Nov. 2004
- Labs in Brussels, RTP, San Jose

Service Provider Networks

- Introduced 2002
- 3% of bookings
- Labs in Brussels, Beijing, Hong Kong, RTP, Sao Paulo, Sydney

Wireless

- Introduced 2009
- X% of bookings
- Labs in Brussels, San Jose, Sydney

Available in Six Technical Specialties

CCIE Information Worldwide

Total of Worldwide CCIEs:	**18,674***
Total of Routing and Switching CCIEs:	16,399
Total of Security CCIEs:	2,007
Total of Service Provider CCIEs:	1,120
Total of Storage Networking CCIEs:	140
Total of Voice CCIEs:	872

***Updated 6-Jan-2009**

Multiple Certifications

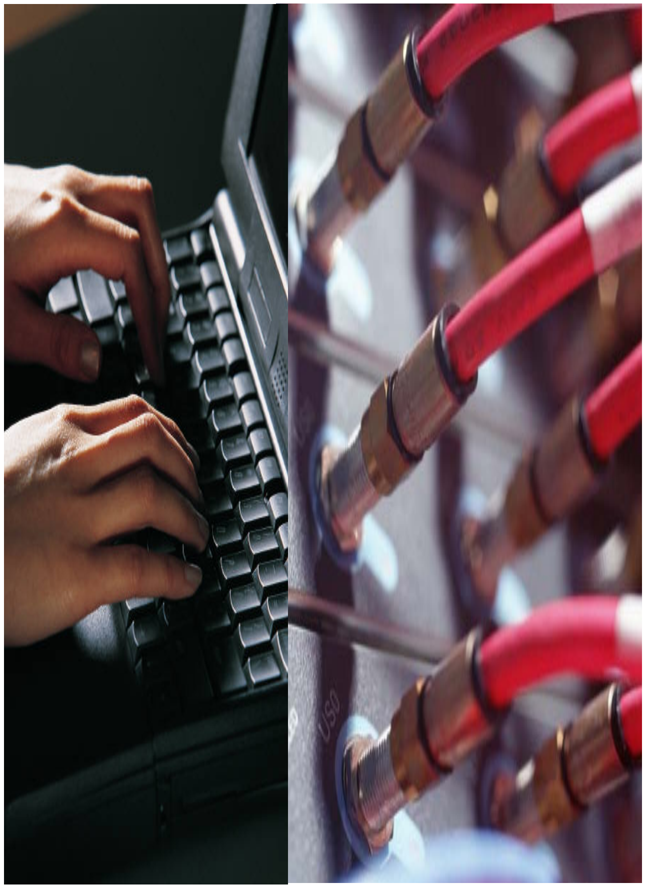
Many CCIEs Have Gone on to Pass the Certification Exams In Additional Tracks, Becoming a “Multiple CCIE.” Below Are Selected Statistics on CCIEs Who Are Certified in More Than One Track

Total with Multiple Certifications Worldwide:	1,885
Total of Routing and Switching and Security CCIEs:	706
Total of Routing and Switching and Service Provider CCIEs:	472
Total of Routing and Switching and Storage Networking CCIEs:	35
Total of Routing and Switching and Voice CCIEs:	250
Total with 3 or More Certifications	302

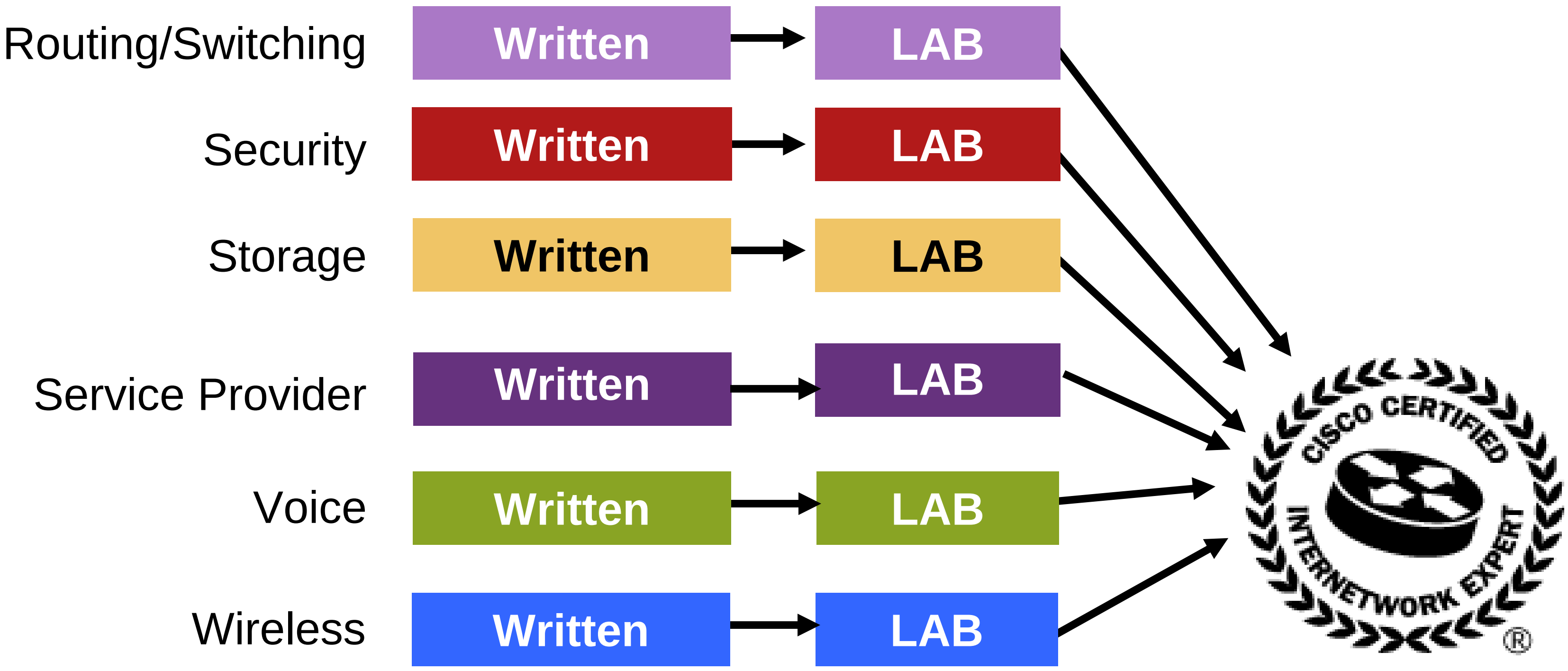
http://www.cisco.com/web/learning/le3/ccie/certified_ccies/worldwide.html

Certification Process

- CCIEs must pass two exams
- The written qualification exam has 100 multiple-choice questions
- The lab exam is what makes CCIE different. The full-day, hands-on lab exam tests the ability to configure and troubleshoot equipment
- Not all lab exams are offered at all lab locations



Process: Steps to CCIE Certification



Routing/Switching	Written	LAB
Security	Written	LAB
Storage	Written	LAB
Service Provider	Written	LAB
Voice	Written	LAB
Wireless	Written	LAB

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Session 2

CCIE Security Overview

Welcome to the Human Network.

CCIE Security Overview

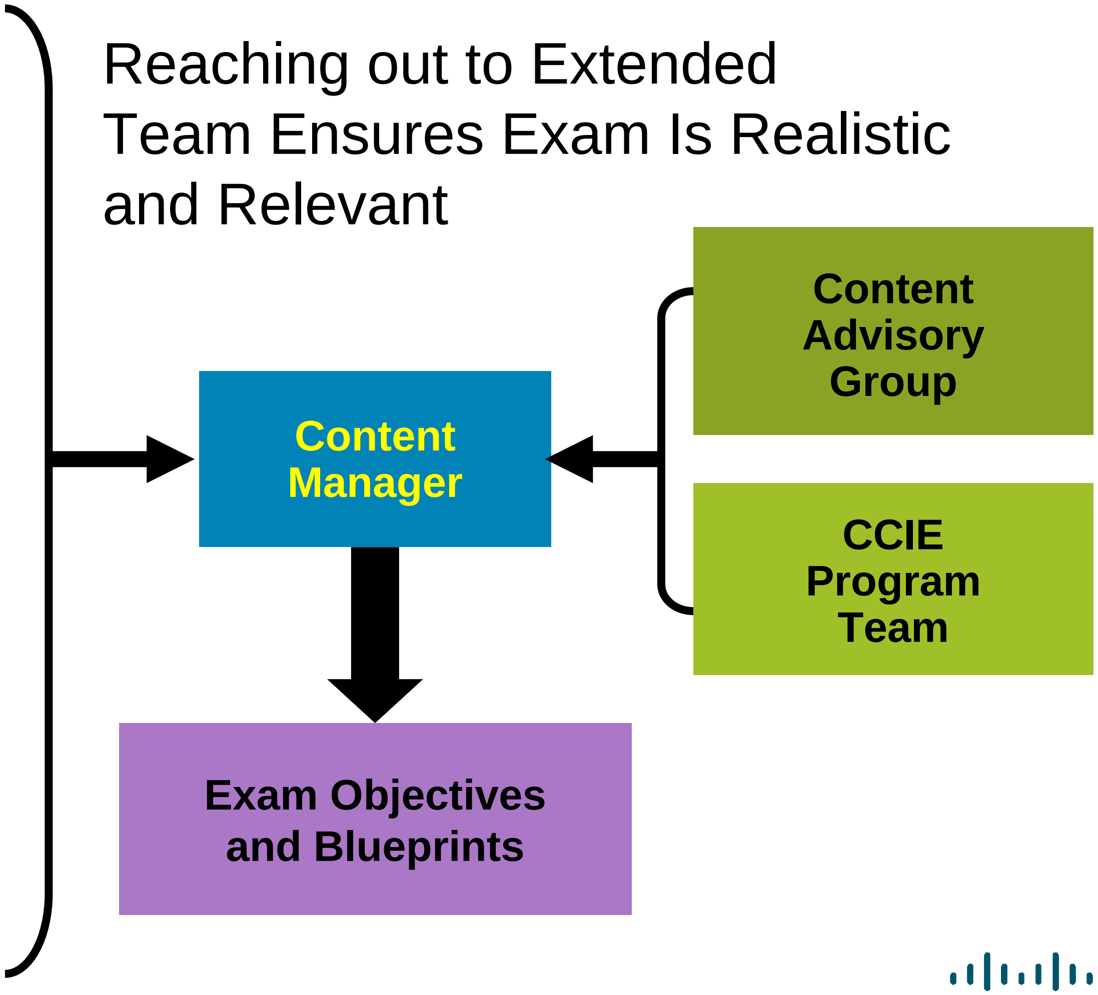
- Security is one of the fastest-growing areas in the industry
- Information security is on top agenda to all organizations
- There is an ever-growing demand for Security professionals in the industry
- The CCIE Security certification was introduced in 2001 and has evolved into one of the industry’s most respected high-level security certifications
- Just around 2,000 CCIE Security worldwide

CCIE Exam Content and Advisory Sources

Input Sought From:

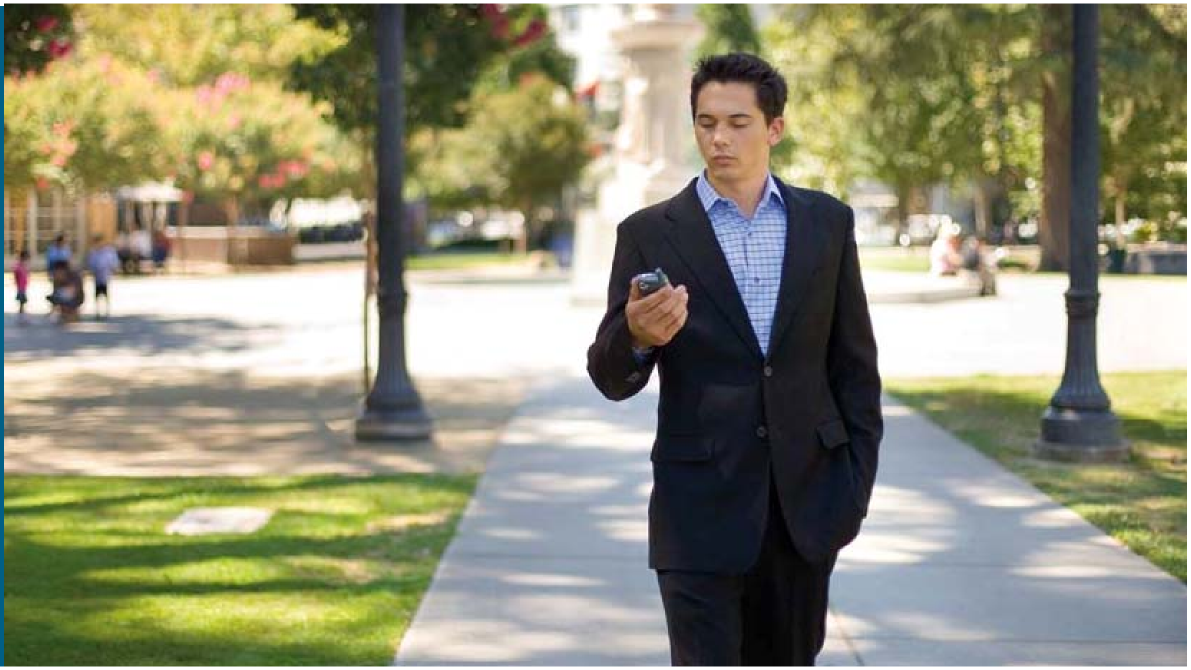
- Cisco Business Units/ Technology Groups
  - Cisco Standard Architectures (AVVID, SAFE)
- Advisory Subject Matter Experts
- Technical Support
  - TAC Cases
  - Technical Bulletins, Best Practices, Whitepapers
- Enterprise Technical Advisory Board
- Focus Groups/Customer Sessions
- CCIE Field Surveys

Reaching out to Extended Team Ensures Exam Is Realistic and Relevant



Welcome to the Human Network.

CCIE Security Written Exam



Welcome to the Human Network.

CCIE Security Written Exam

v2.0

- Covers networking theory related to:

    General Networking

    Security Protocols

    Application Protocols

    Security Technologies

    Cisco Security Appliances and Apps

    Cisco Security Management

    Cisco Security General

    Security Solutions

    Security General

- Lays foundation for Security lab exam

CCIE Security Written Exam

v2.0

- The CCIE Security v2.0 written exam strengthens coverage of technologies critical to highly-secure enterprise networks
- New topics such as ASA, IPS, NAC/ATD, CS-MARS, IPv6, security policies and standards are added to test candidates on the security technologies and best practices in use today

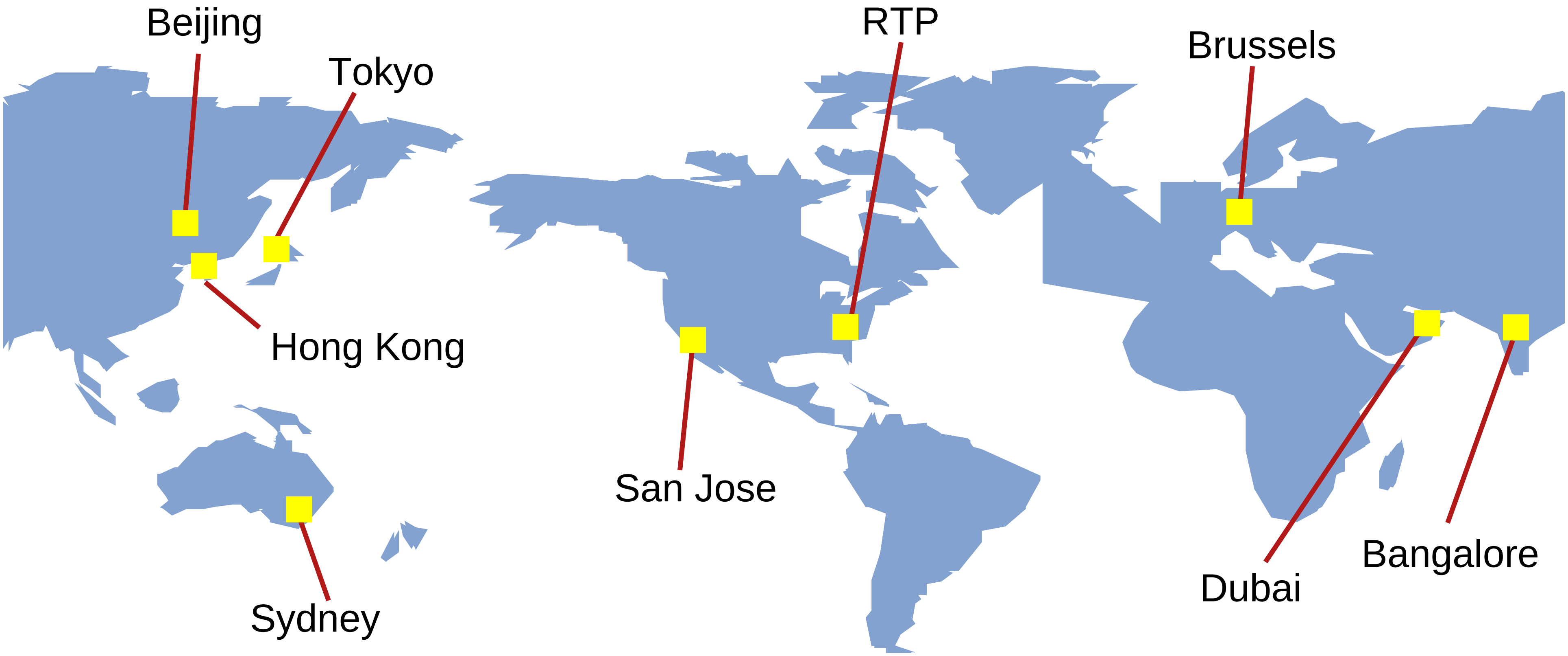
CCIE Security Lab Exam

Welcome to the Human Network.

CCIE Security Lab Exam

- Candidates build a network to a series of supplied specifications
- The point values for each question are shown on the exam
- Some questions depend upon completion of previous parts of the network
- Report any suspected equipment issues to the proctor as soon as possible; adjustments cannot be made once the exam is over

Security Lab Exam: Locations



Nine Worldwide CCIE Lab Locations for Security

CCIE Security Lab Exam

v2.0

- The CCIE Security lab exam content was revised and new exam format delivery started on January 2nd 2007, to include some of the current trends and technologies in the security industry
- New topics on security appliances such as PIX, IPS and VPN3000 were introduced
- In addition, the ASA5500 security appliance was added, and CiscoSecure ACS Configuration is now also required, along with other items added to test candidates on the security technologies and best practices in use today

Security Lab Exam: Equipment and Cisco IOS Versions

v2.0

Lab May Test Any Feature that Can Be Configured on the Equipment and Cisco IOS Versions Listed Below, or on the CCIE Website; More Recent Versions **May** Be Installed in the Lab, But You Won’t Be Tested on Them

- Six Routers (26xx/36xx/37xx) running Cisco IOS version 12.2T
- Two Cisco Catalyst 3550 Series switches running 12.2SEE
- Two ASA5500 Series Firewalls running version 7.2.x
- One PIX 500 Series Firewall running version 7.2.x
- One VPN 3000 Series Concentrator running version 4.7.x
- One IPS 4200 Series Sensor Appliance running version 5.1.x
- One Cisco Secure ACS version 4.x
- One Test PC for Testing and Troubleshooting
- One Candidate PC for rack access

Cisco Expo 2009

v2.0

Security Lab Exam: Blueprint

Section 1	Firewall
Section 2	VPN
Section 3	IPS
Section 4	Identity Management
Section 5	Advanced Security
Section 6	Network Attacks

Security Lab Exam: Pre-Configuration

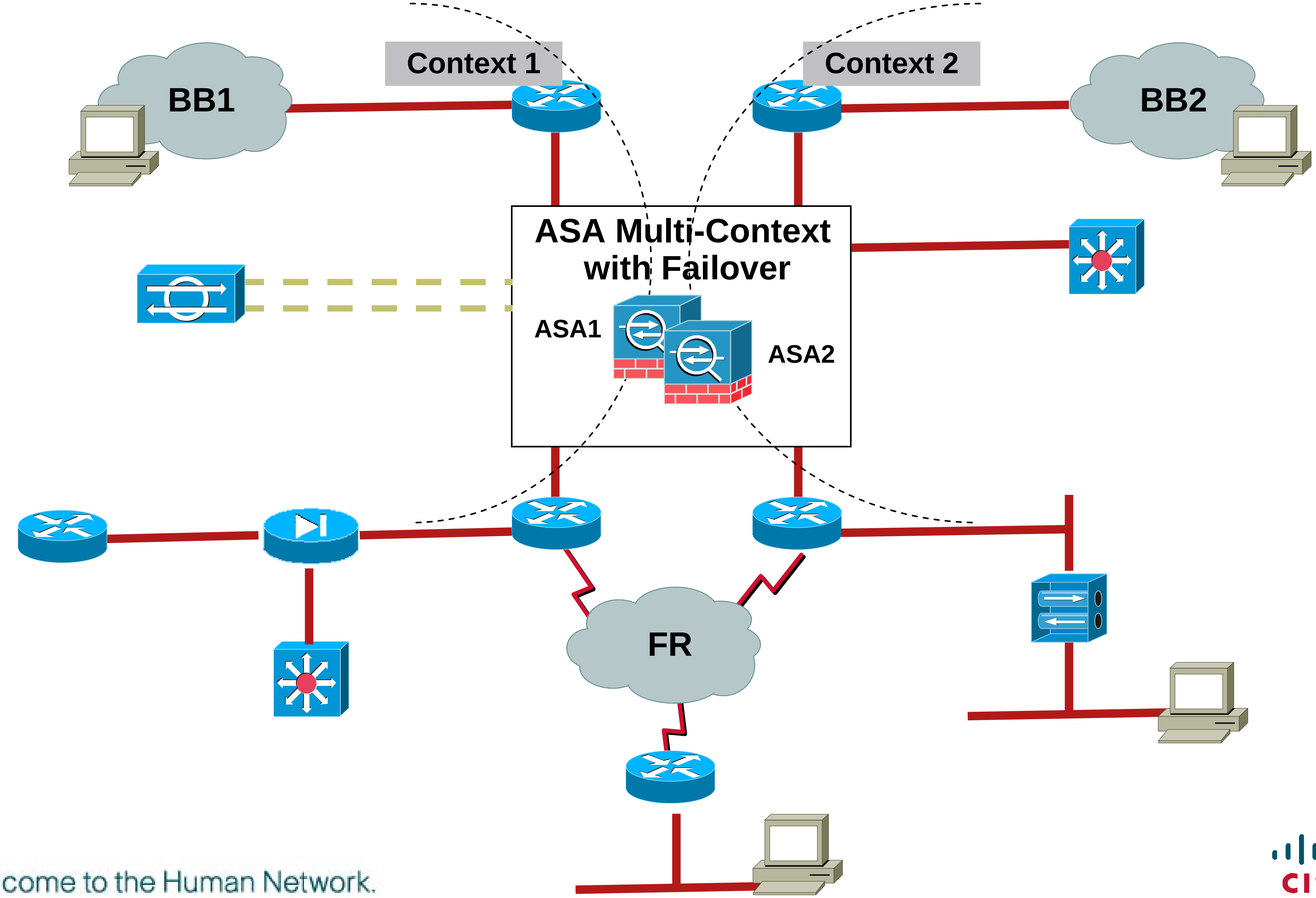
The Routers and Switches in Your Topology Are Preconfigured with:

- Basic IP addressing, hostname, passwords
- Switching: Trunking, VTP, VLANs
- Frame Relay: DLCI mapping (static/dynamic)
- Core Routing: OSPF, RIP, EIGRP, BGP
- All pre-configured passwords are ‘cisco’

Security Devices (PIX, VPN3000, IDS) Are Not Initialized. Candidate Is Required to Do So

Do Not Change Any Pre-Configuration on Any Devices Unless Explicitly Stated in a Question

Security Lab Exam: Sample Topology



Security Lab Exam: Grading

- Proctors grade all lab exams
- Automatic tools aid proctors with simple grading tasks
- Automatic tools are never solely responsible for lab exam grading—proctors are
- Proctors complete grading of the exam and submits the final score within 48 hours
- Partial credit is not awarded on questions
- Points are awarded for working solutions only
- Some questions have multiple solutions

v2.0

Summary

Topics Covered More Heavily in the Exams:

- Firewalls (hardware and software)
- VPNs
- Intrusion protection
- Identity authentication
- Advanced security technologies
- Mitigation techniques to respond to network attacks

New v3.0

CCIE Security Lab Exam Revision

Welcome to the Human Network.

Security Lab Exam: Changes

New v3.0

- The CCIE Security Lab exam content is scheduled to be revised, to include some of the current trends and technologies in the security industry
- New topics and hardware & software upgrades will be introduced
- End-of-Life devices will be removed;

  PIX500 and VPN3000 will be removed

  Routers will be replaced with new ISR series

  3550 Switches will be replaced with new 3560

Security Lab Exam: Equipment and Software Versions

New v3.0

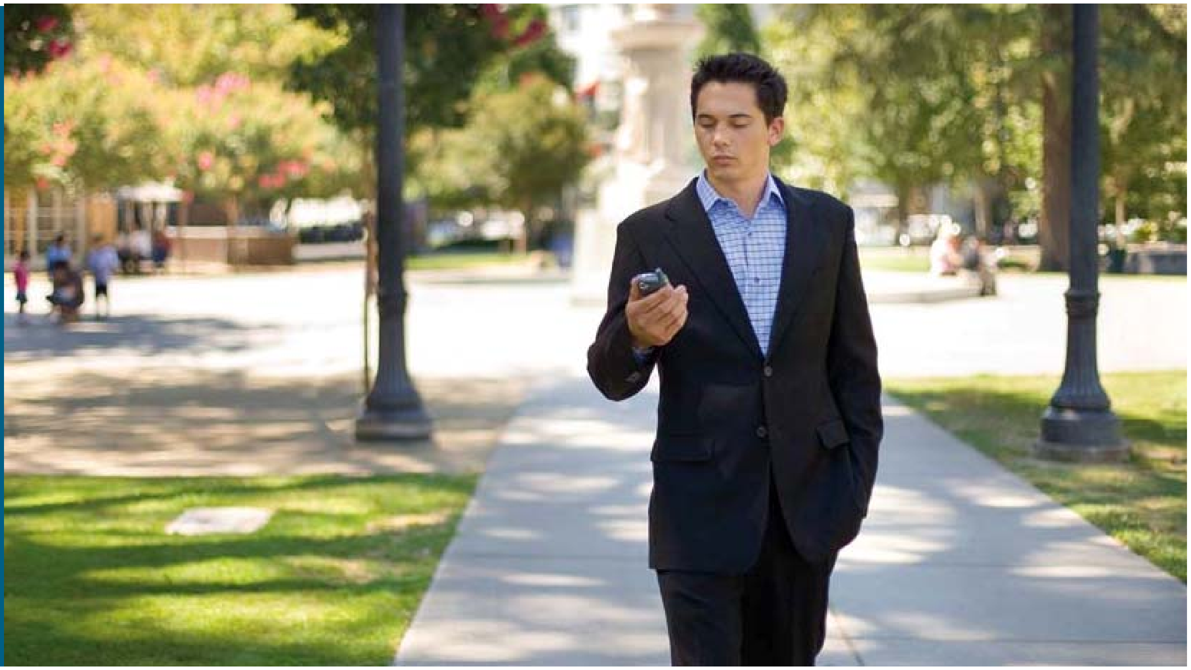
- Cisco Integrated Services Routers (ISR) series running Cisco IOS version 12.4T
- Cisco Catalyst 3560 series switches running 12.2(x)SE
- Cisco ASA 5500 series Firewalls running version 8.x
- Cisco IPS 4240 Appliance Sensor running version 6.x
- Cisco Secure ACS version 4.1
- Test PC for Testing and Troubleshooting
- Candidate PC for rack access

Security Lab Exam: Blueprint

New v3.0

- Implement secure networks using Cisco ASA Firewalls and Cisco IOS Firewalls
- Implement secure networks using Cisco VPN solutions
- Configure Cisco IPS to mitigate network threats
- Implement Identity Management solutions
- Implement Control Plane and Management Plane Security
- Configure Advanced IOS Security
- Identify and Mitigate Network Attacks

Session 3



Firewall (Cisco PIX/ASA)

Cisco Firewalls

- Cisco PIX Firewall

  Firewall Appliance

- Cisco IOS Firewall (CBAC)

  Router integrated Firewall

- Firewall Service Module (FWSM)—(Not in Lab exam)

  Switch integrated Firewall

- Adaptive Security Appliance (ASA)

  Multi-function (FW, VPN, IPS) Security Appliance

Cisco PIX 7.0 and ASA 7.0

- Same Binary image file supports both platform
- Same ASDM image file supports both platform

  (ASDM is not allowed in the Lab Exam, only CLI)

- 501/506E are NOT supported under 7.0
- PIX 7.0 does not support following features but offered by ASA 7.0

  Web VPN

  VPN LB

  SSM related (IPS)

  CF card support

  AUX port support

Cisco PIX/ASA Firewalls

What Is a Firewall?

- A system that implements a network security policy between segments of a network
  - Firewalls are security policy enforcement points
- Without a security policy, the availability of your network can be compromised
  - And it is very difficult to configure your firewall

Stateful Firewall Algorithms

- Recognizes the “stateful” nature of TCP/IP protocols
- Using a state table the firewall can track:
  - Source and destination IP addresses and ports
  - TCP sequence numbers
  - The state of each TCP and UDP session
  - Additional flags and fields
- But isn’t UDP a “stateless” protocol?
  - Builds artificial connection state for UDP and tracks traffic timeouts
- Supports authentication, authorization, syslog

Interface and Security Levels

- Inside Interface always has a security level of 100. Most Secure level
- Outside Interface always has a security level of 0. Least Secure level
- Multiple perimeter networks can exist. Use DMZ Interface. Security levels between 1–99

Initializing Cisco PIX/ASA

- Firewall Mode (Router/Transparent)
- Single/Multiple Context
- Enable/Allocate interfaces
- Assign IP address for each active Interface
- Un-shut Interfaces
- Configure Address Translation (optional)
- Configure Routing

Address Translation

Subject to NAT-Control

- Dynamic translations are built using:

  Network Address Translation (NAT)
  (one-to-one mapping)

  or

  Port Address Translation (PAT)
  (many-to-one mapping)

- Static translations are built using:

  Static command
  (create permanent mapping between a local IP address and a global IP address)

Policy NAT

- Policy NAT lets you identify local traffic for address translation by specifying the source and destination addresses (or ports) in an access list
- Regular NAT uses source addresses/ports only, whereas policy NAT uses both source and destination addresses/ports
- With policy NAT, you can create multiple static statements that identify the same local address as long as the source/port and destination/port combination is unique for each statement
- Use an access list with the static command to enable policy NAT

Object Grouping

- Used for simplifying complex access control policies. Object grouping provides a way to reduce the number of access rule entries required to describe complex security policies
- Following types of objects:

Protocol—group of IP protocols. It can be one of the following keywords; icmp, ip, tcp, or udp, or an integer in the range 1 to 254 representing an IP protocol number. To match any Internet protocol, including ICMP, TCP, and UDP, use the keyword ip.

Service—group of TCP or UDP port numbers assigned to different services

icmp-type—group of ICMP message types to which you permit or deny access

Network—group of hosts or subnets

Routing

- PIX/ASA supports RIP and OSPF routing protocols
- Both protocols support clear text and MD5 authentication
- Practice route filtering and summarization for both protocols
- Running both OSPF and RIP concurrently on the same Firewall is **now** supported

VLAN

- Virtual LANs (VLANs) are used to create separate broadcast domains within a single switched network
- You can configure multiple logical interfaces on a single physical interface and assign each logical interface to a specific VLAN
- PIX/ASA supports 802.1q, allowing it to send and receive traffic for multiple VLANs on a single interface

Basic Feature Summary: Practice Them All

- Address Translation
- AAA
- VPN IPsec
- PPTP
- TCP Intercept
- RIP
- OSPF
- Syslog
- Failover
- Java Filtering
- ActiveX Filtering

- Packet Capture
- VLAN
- Object Grouping
- DHCP
- PPPoE
- URL Filtering
- IDS
- SSH
- SNMP
- NTP
- Policy NAT

New Firewall Features in v7.0

- Virtual Firewall (Security Contexts)
- Transparent Firewall
- Modular Policy Framework (MPF)
- Application Firewall
- High Availability FO
- No NAT-Control
- Access-Group Keyword: OUT
- Access-List Keyword: TIME-RANGE
- VPN Hub-and-Spoke/Spoke-to-Spoke Enhancement

Troubleshooting Firewall

Welcome to the Human Network.

Firewall Troubleshooting Tools

- Understanding the packet flow
- Syslog
- Debug commands
- Show commands
- Packet capture

Understanding the Packet Flow

- To effectively troubleshoot a problem, one must first understand the packet path through the network
- Attempt to isolate the problem down to a single device
- Then perform a systematic walk of the packet path through the device to determine where the problem could be
- For problems relating to the PIX, always:

  Determine the flow: SRC IP, DST IP, SRC port, DST port, and protocol

  Determine the interfaces through which the flow passes

Note: All Firewall Issues Can Be Simplified to Two Interfaces (Ingress and Egress) and the Rules Tied to Both

Example Flow

- Flow

  SRC IP: 10.1.1.9 SRC Port: 11030

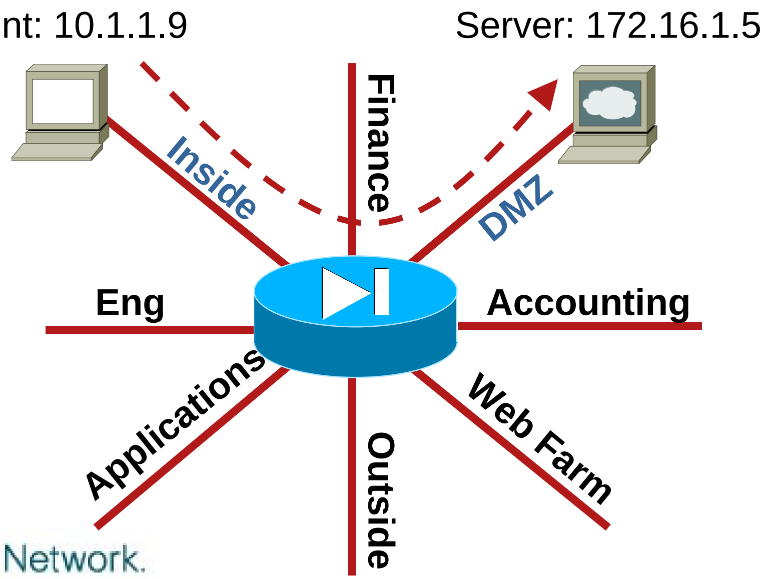
  DST IP: 172.16.1.5 DST Port: 8080

  Protocol: TCP

- Interfaces

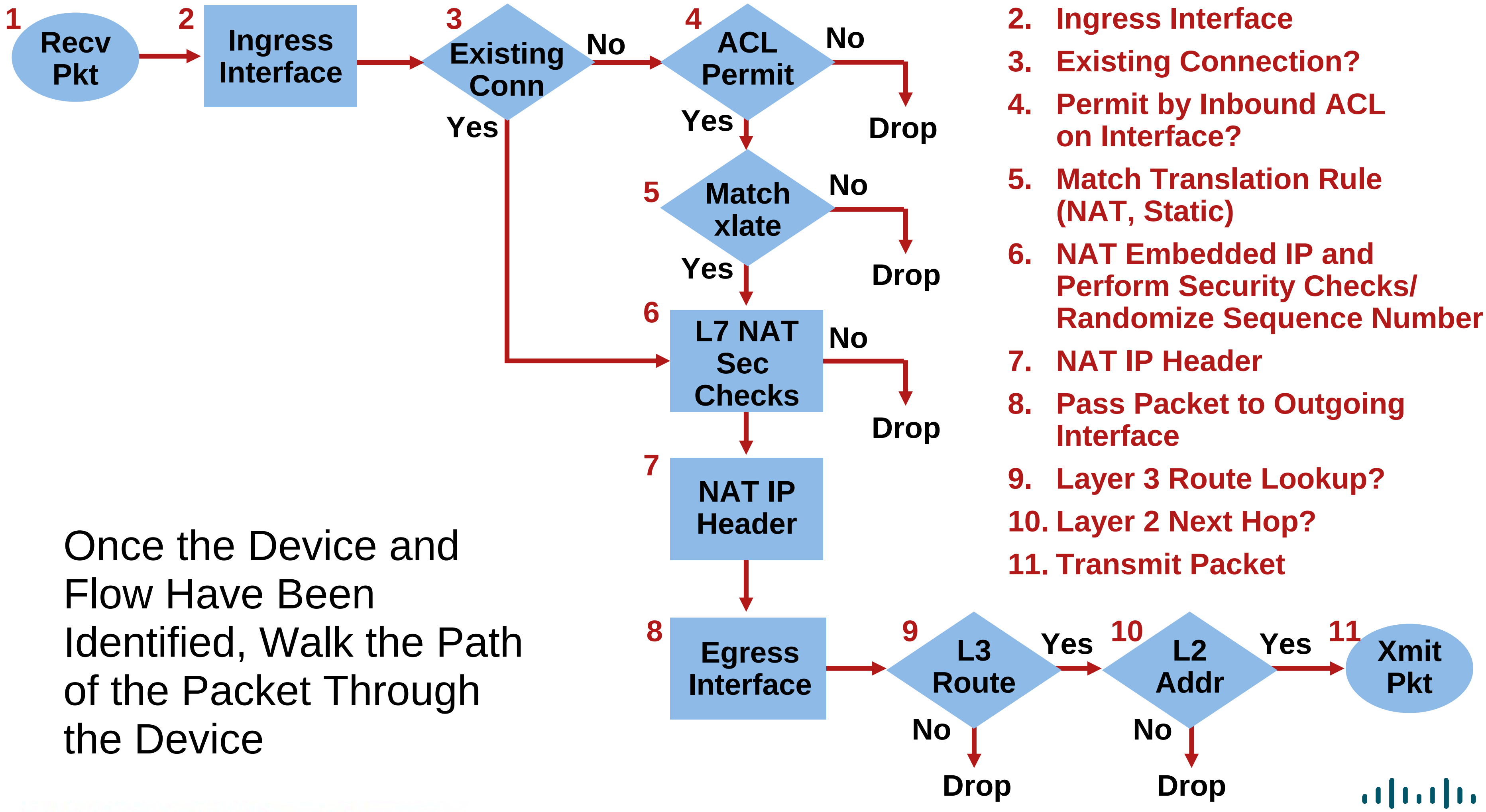
  SRC Interface: Inside DST Interface: DMZ

Packet Flow



With the Flow Defined, Examination of Config Issues Boils Down to Just the Two Interfaces: Inside and DMZ

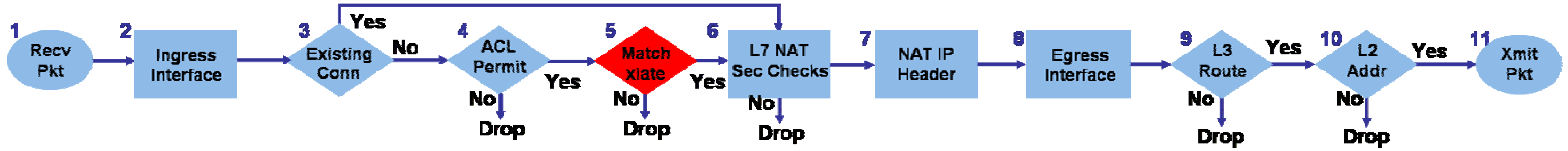
Packet Processing Flow Diagram



1. Receive Packet
2. Ingress Interface
3. Existing Connection?
4. Permit by Inbound ACL on Interface?
5. Match Translation Rule (NAT, Static)
6. NAT Embedded IP and Perform Security Checks/ Randomize Sequence Number
7. NAT IP Header
8. Pass Packet to Outgoing Interface
9. Layer 3 Route Lookup?
10. Layer 2 Next Hop?
11. Transmit Packet

Once the Device and Flow Have Been Identified, Walk the Path of the Packet Through the Device

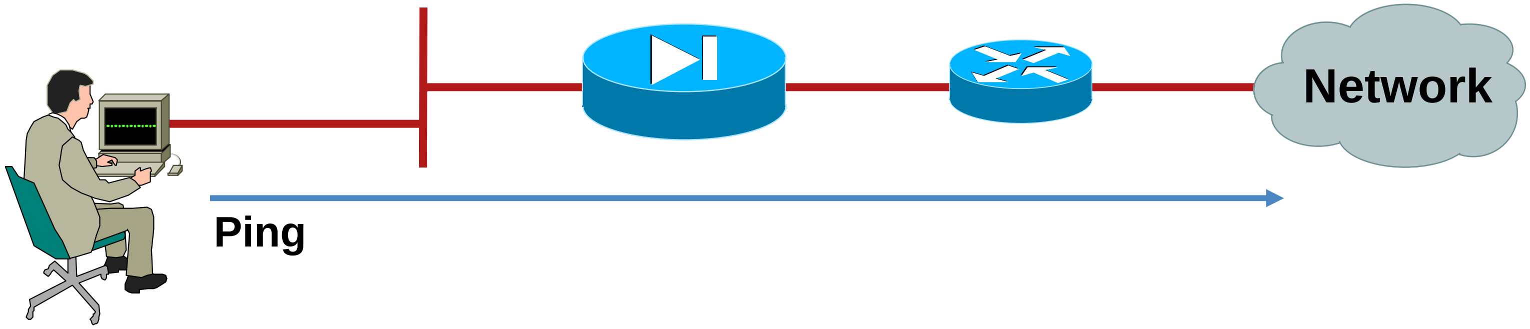
Translation and NAT Order of Operations



First Match

1. nat 0 access-list (nat-exempt)
2. Match existing xlates
3. Match static commands (first match)
   a. Static NAT with and without access-list
   b. Static PAT with and without access-list
4. Match nat commands
   a. nat <id> access-list (first match)
   b. nat <id> <address> <mask> (best match)
      i. If the ID is 0, create an identity xlate
      ii. Use global pool for dynamic NAT
      iii. Use global pool for dynamic PAT

Debug ICMP Trace



- Valuable tool used to troubleshoot connectivity issues
- Provides interface and translation information to quickly determine flow
- Echo-replies must be explicitly permitted through ACL

Example `debug icmp trace` output

```
ICMP echo-request from inside:10.1.1.2 to 198.133.219.25 ID=3239 seq=4369 length=80
ICMP echo-request: translating inside:10.1.1.2 to outside:209.165.201.22

ICMP echo-reply from outside:198.133.219.25 to 209.165.201.22 ID=3239 seq=4369 length=80
ICMP echo-reply: untranslating outside:209.165.201.22 to inside:10.1.1.2
```

Show Traffic

The Show Traffic Command Displays the Traffic Received and Transmitted out Each Interface of the PIX

```
pixfirewall# show traffic
outside:
        received (in 124.650 secs):
                295468 packets  167218253 bytes
                2370 pkts/sec   1341502 bytes/sec
        transmitted (in 124.650 secs):
                260901 packets  120467981 bytes
                2093 pkts/sec   966449 bytes/sec
<..>
inside:
        received (in 124.650 secs):
                261478 packets  120145678 bytes
                2097 pkts/sec   963864 bytes/sec
        transmitted (in 124.650 secs):
                294649 packets  167380042 bytes
                2363 pkts/sec   1342800 bytes/sec
```

Show Local-Host

- A local-host entry is created for any source IP on a higher security level interface
- It groups the xlates, connections, and AAA information together
- Very useful for seeing the connections terminating on servers

```
PIX# show local-host
Interface inside: 1131 active, 2042 maximum active, 0 denied
local host: <10.1.1.9>,
    TCP connection count/limit = 1/unlimited
    TCP embryonic count = 0
    TCP intercept watermark = 50
    UDP connection count/limit = 0/unlimited
  AAA:
    user 'cisco' at 10.1.1.9, authenticated (idle for 00:00:10)
       absolute   timeout: 0:05:00
       inactivity timeout: 0:00:00
  Xlate(s):
    Global 172.18.124.69 Local 10.1.1.9
  Conn(s):
    TCP out 198.133.219.25:80 in 10.1.1.9:11055 idle 0:00:10 Bytes 127 flags UIO
```

Show Xlate and Show Xlate Debug

```
show xlate [global|local <ip1[-ip2]> [netmask <mask>]]
[gport |lport <port1[-port2]>] [debug]
```

```
PIX# show xlate
2 in use, 2381 most used
Global 172.18.124.68 Local 10.1.1.9
PAT Global 172.18.124.65(1024) Local 10.9.9.3(11066)
```

```
PIX# show xlate debug
2 in use, 2381 most used
Flags: D - DNS, d - dump, I - identity, i - inside, n - no random,
       o - outside, r - portmap, s - static

NAT from inside:10.1.1.9 to outside:172.18.124.68
    flags - idle 0:02:03 timeout 3:00:00

TCP PAT from inside:10.9.9.3/11066 to outside:172.18.124.65/1024
    flags r idle 0:00:08 timeout 0:00:30
```

Show Conn and Show Conn Detail

Idle Time, Bytes Transferred

Connection Flags

```
PIX# show conn
2 in use, 64511 most used

TCP out 198.133.219.25:23 in 10.9.9.3:11068 idle 0:00:06 Bytes 127 flags UIO
UDP out 172.18.124.1:123 in 10.1.1.9:123 idle 0:00:13 flags –
```

“detail” Adds Interface Names

```
PIX# show conn detail
2 in use, 64511 most used
Flags: A - awaiting inside ACK to SYN, a - awaiting outside ACK to SYN,
       B - initial SYN from outside, C - CTIQBE media, D - DNS, d - dump,
       E - outside back connection, F - outside FIN, f - inside FIN,
       G - group, g - MGCP, H - H.323, h - H.225.0, I - inbound data,
       i - incomplete, J - GTP, j - GTP data, K - GTP t3-response
       k - Skinny media, M - SMTP data, m - SIP media, O - outbound data,
       P - inside back connection, q - SQL*Net data, R - outside acknowledged FIN,
       R - UDP SUNRPC, r - inside acknowledged FIN, S - awaiting inside SYN,
       s - awaiting outside SYN, T - SIP, t - SIP transient, U - up
TCP outside:198.133.219.25/23 inside:10.9.9.3/11068 flags UO
UDP outside:172.18.124.1/123 inside:10.1.1.9/123 flags -
```

Packet Capture

```
capture <capture-name> [access-list <acl-name>] [buffer <buf-size>]
[ethernet-type <type>] [interface <if-name>] [packet-length <bytes>]
```

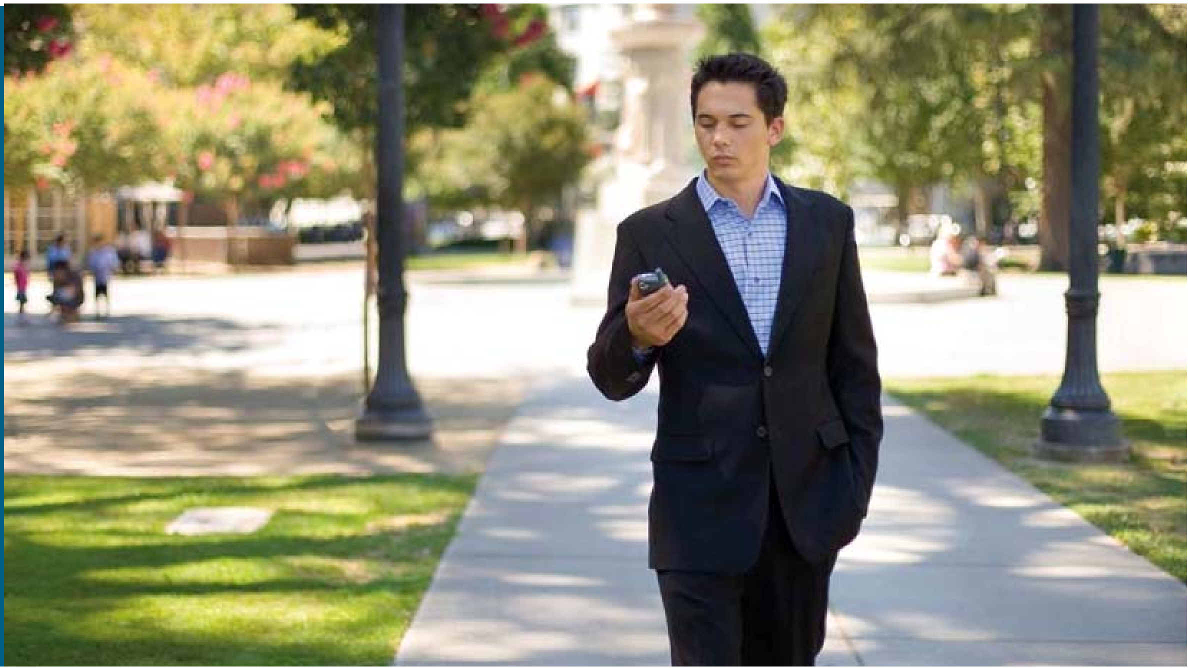
- Capture command first introduced in PIX 6.2; it deprecates the “debug packet” command
- Capture sniffs packets on an interface that match an ACL
- Key steps:

  Create an ACL that will match interesting traffic

  Define the capture and bind it to an access-list and interface

  View the capture on the PIX, or copy it off in pcap format

Session 4



VPN

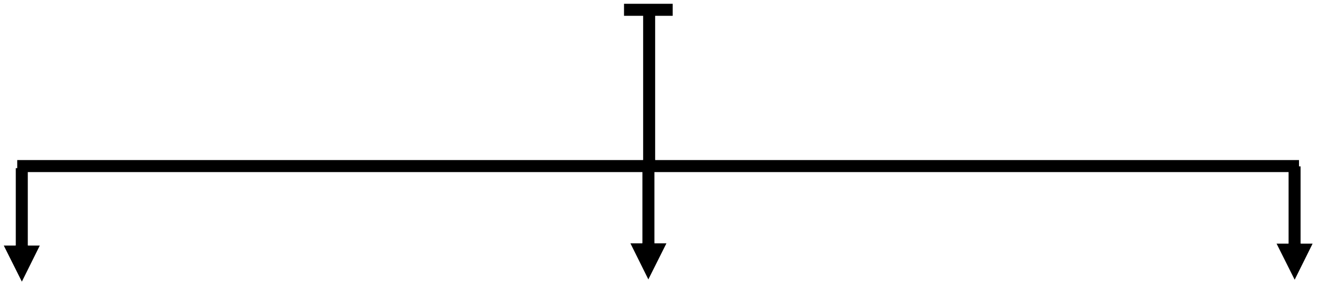
Welcome to the Human Network.

Virtual Private Network (VPN) Defined

"A Virtual Private Network carries private traffic over public network."

Network Security

Data Security Assurance Model (CIA)



Confidentiality

Benefit

- Ensures data privacy

Shuns

- Sniffing
- Replay

Integrity

Benefit

- Ensures data is unaltered during transit

Shuns

- Alteration
- Replay

Authentication

Benefit

- Ensures identity of originator or recipient of data

Shuns

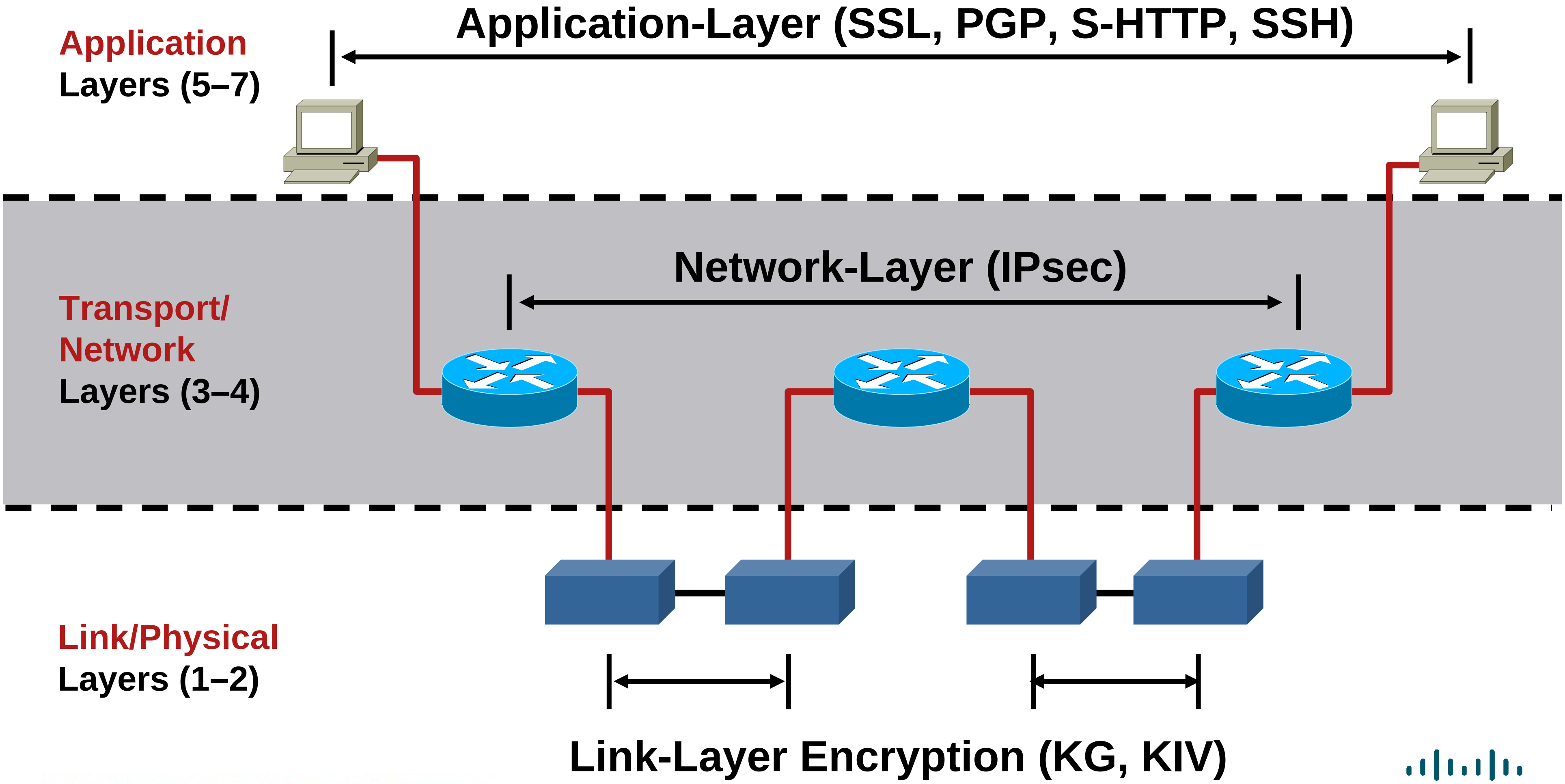
- Impersonation
- Replay

What Is IPsec?

Internet Protocol Security

- A set of security protocols and algorithms used to secure IP data at the network layer
- IPsec provides data confidentiality (encryption), integrity (hash), authentication (signature/certificates) of IP packets while maintaining the ability to route them through existing IP networks

Encryption Layers

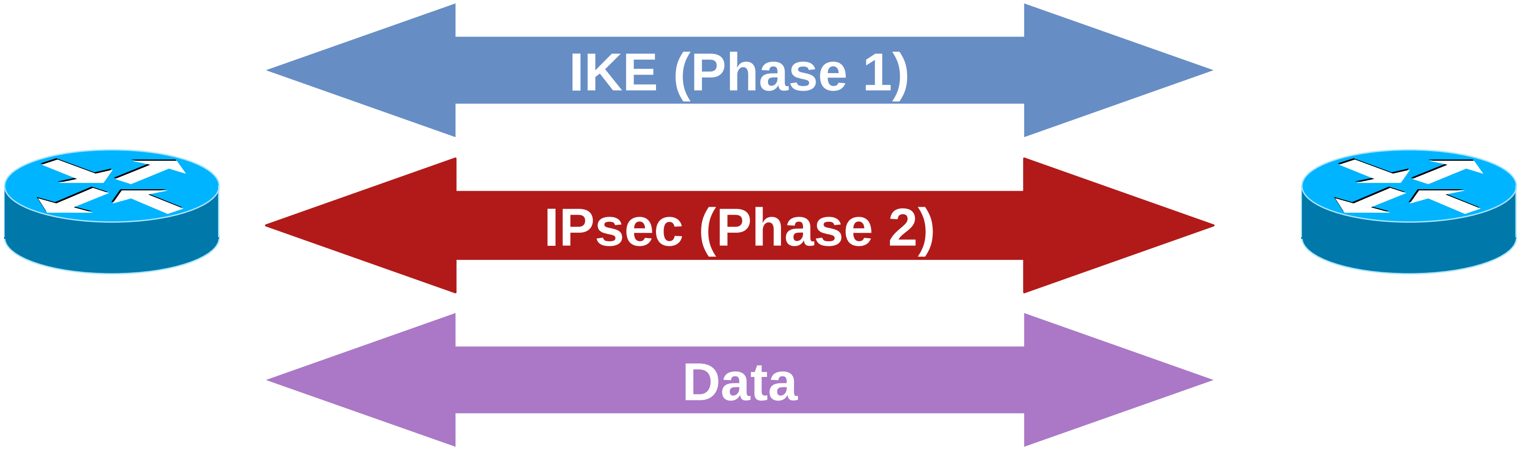


Understanding IPsec

IPsec

- IPsec can ensure the confidentiality and/or the authenticity of IP packets
- The key points are
  - Two modes of propagation (transport and tunnel)
  - Security associations (SAs)
  - Two types of header (ESP and AH)
- IPsec does not provide a key exchange mechanism

IPsec: Building a Connection



- Two-phase protocol:

  Phase 1 exchange: two peers establish a secure, authenticated channel with which to communicate; Main mode or Aggressive mode accomplishes a Phase 1 exchange

  There is also a Transaction Mode in between which is used for EzVPN client scenario performing XAUTH and/or Client attributes (Mode Config)

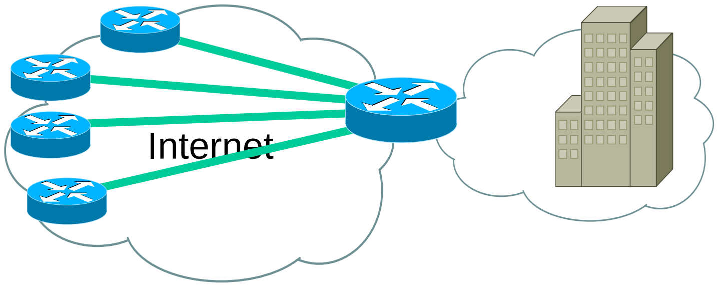
  Phase 2 exchange: security associations are negotiated on behalf of IPsec services; Quick mode accomplishes a Phase 2 exchange

- Each phase has its SAs: ISAKMP SA (Phase 1) and IPsec SA (Phase 2)

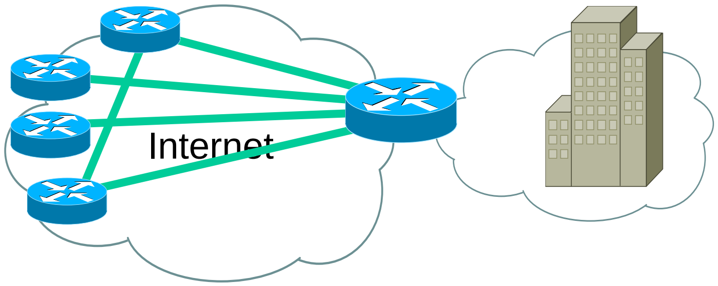
Implementing IPsec

IPsec Scenarios

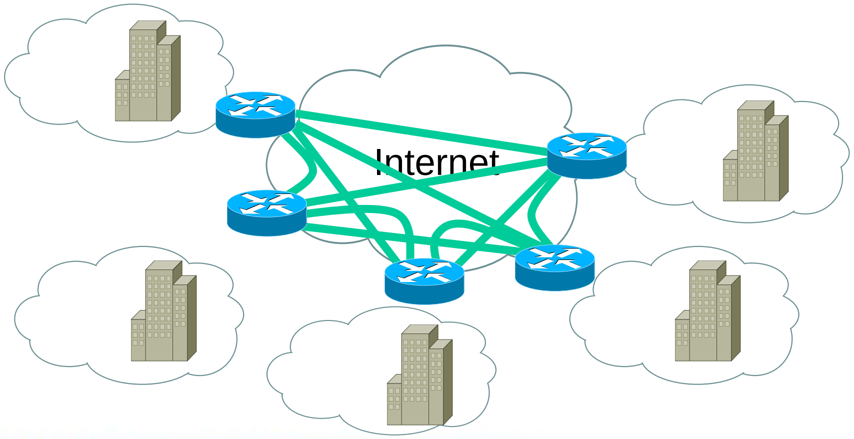
Site-to-Site Hub-and-Spoke



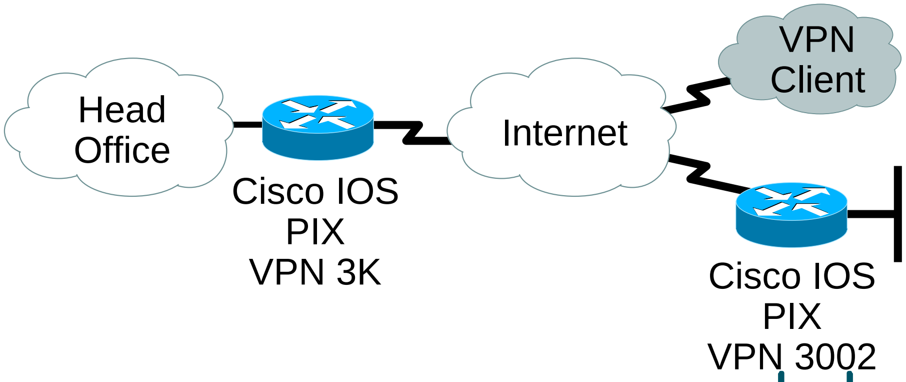
Site-to-Site Partial Mesh



Site-to-Site Full Mesh

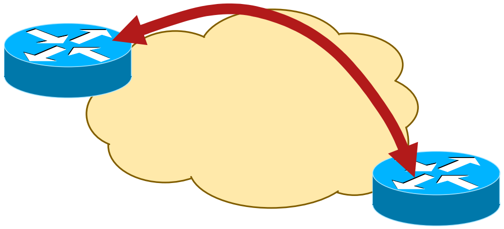


Remote Access



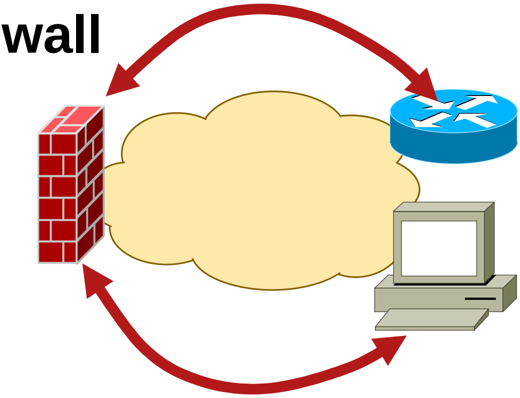
Welcome to the Human Network.

IPsec Scenarios

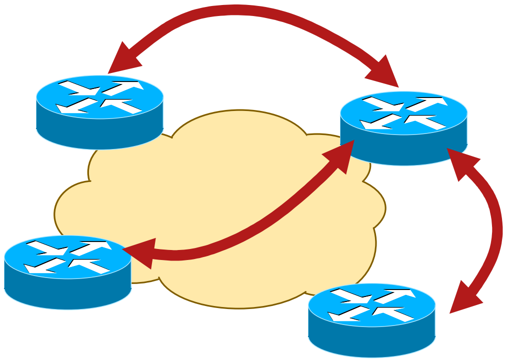


Router to Router

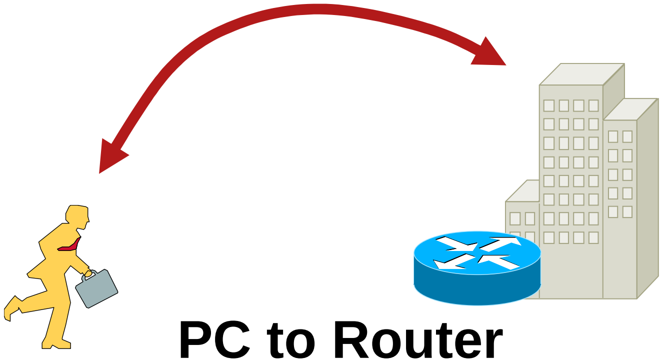
Router to Firewall



PC to Firewall

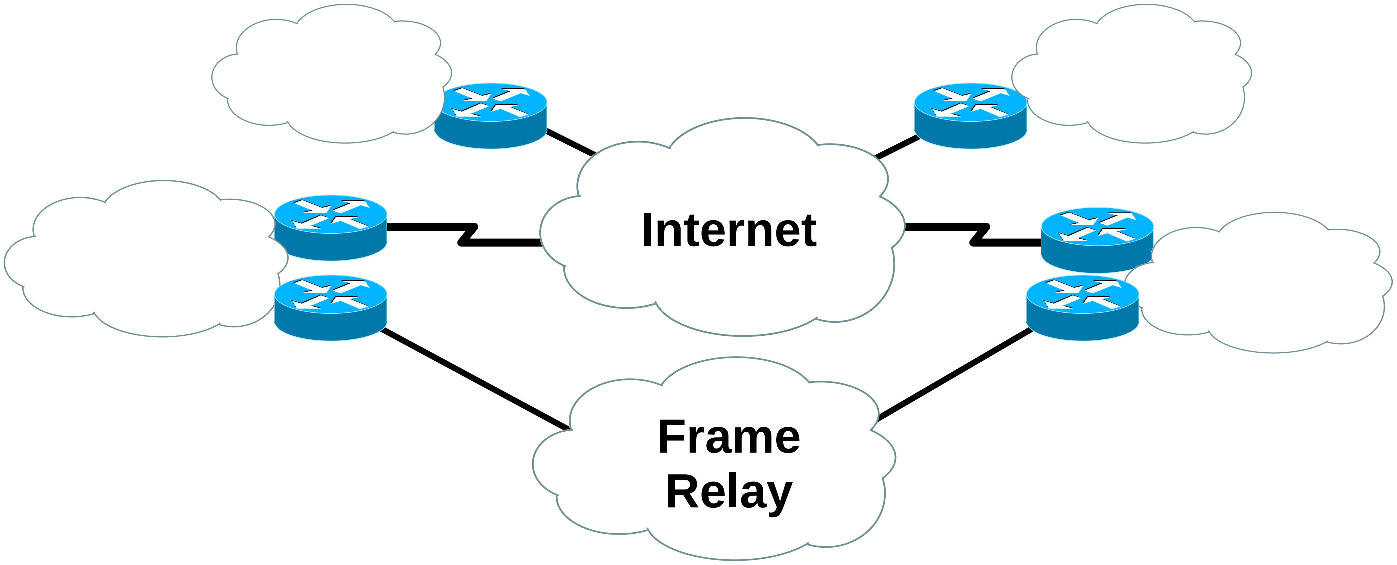


One Router (or Firewall) to Many



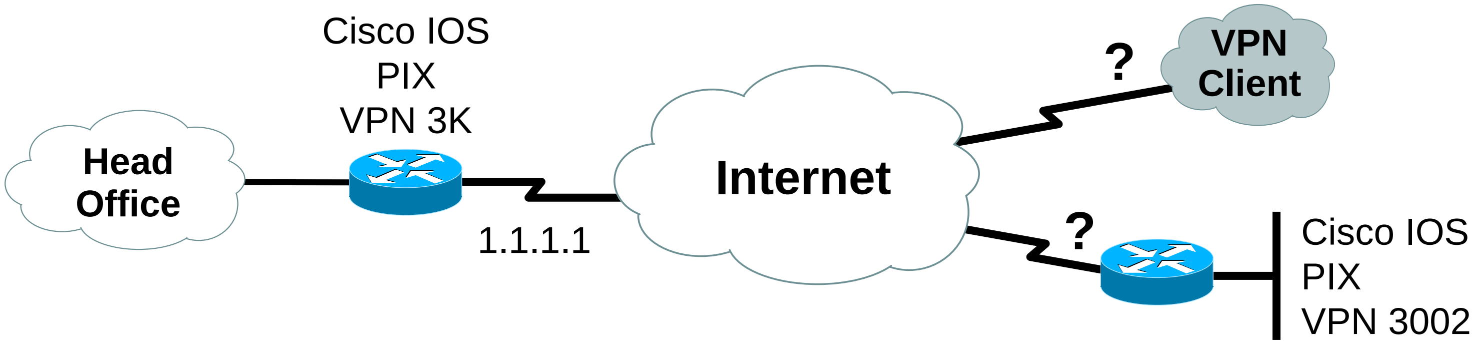
PC to Router

IPsec/GRE: Scalable Site-to-Site VPNs



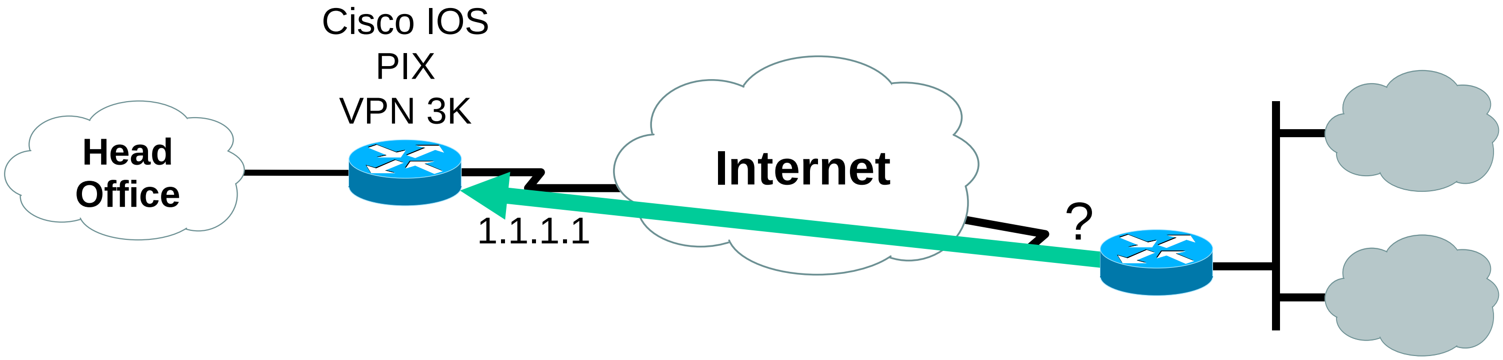
- Routing Protocol (OSPF, EIGRP…) necessary
- Routing (or multicast) not specified by IPsec
- Supported in Cisco IOS using GRE/IPSec

IPsec Remote Access (EzVPN)



- Client-server architecture
- Client always initiates IPsec connection
- Client may have dynamic IP address
- Very easy to configure
- Very scalable, no routing expertise required

IPsec Remote Access (EzVPN) (Cont.)



- Client extension mode:

  Packets from all devices behind EzVPN Client are PATed to one ip address (then tunneled in IPsec)

- Network extension mode:

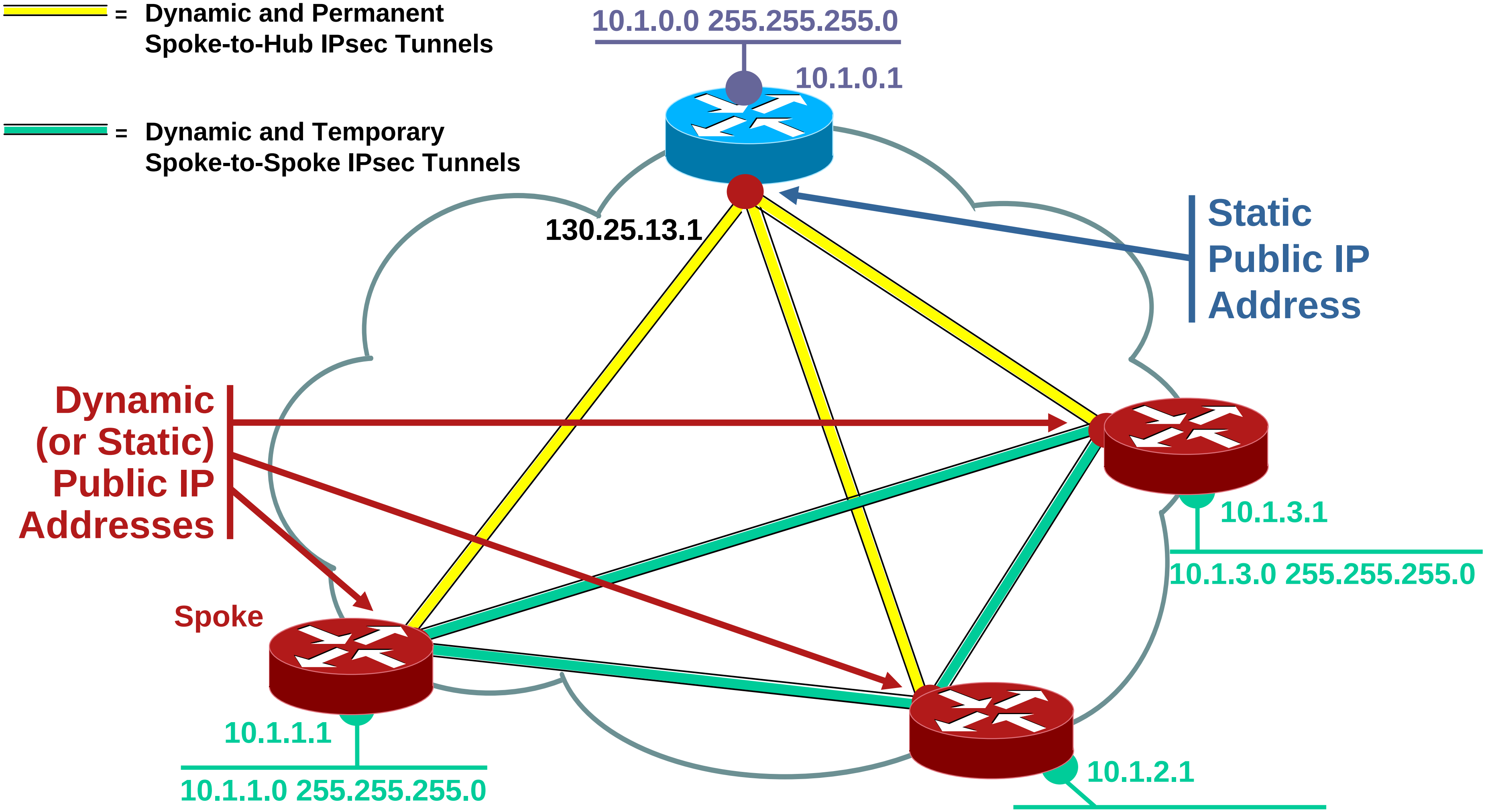
  Packets from all devices behind EzVPN client are tunneled in IPsec (no PAT before IPsec)

Dynamic Multipoint VPN (DMVPN)

What Is DMVPN?

- It is GRE, NHRP and IPsec mix
- NHRP allows the peers to have dynamic addresses (Dial, DSL, …) with GRE/IPSec tunnels
- The backbone is a hub and spoke topology
- It allows direct spoke to spoke tunneling by auto leveling to a partial mesh

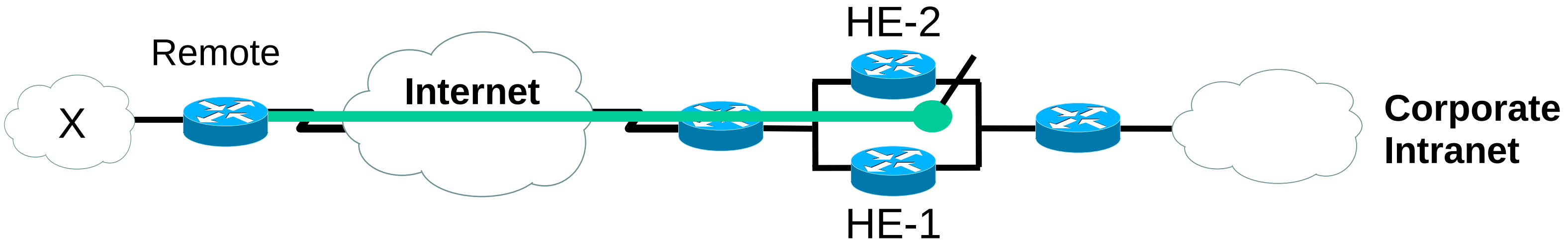
Dynamic Multipoint VPN (DMVPN)



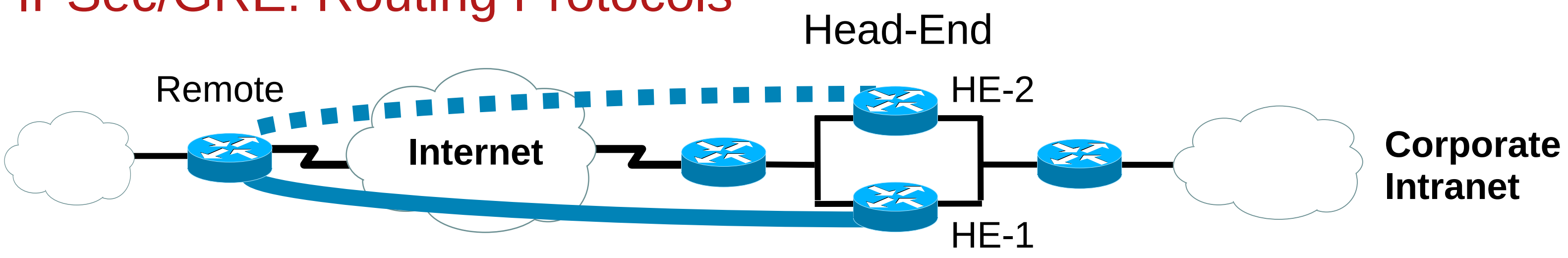
Welcome to the Human Network.

High-Availability Designs: Stateless Options

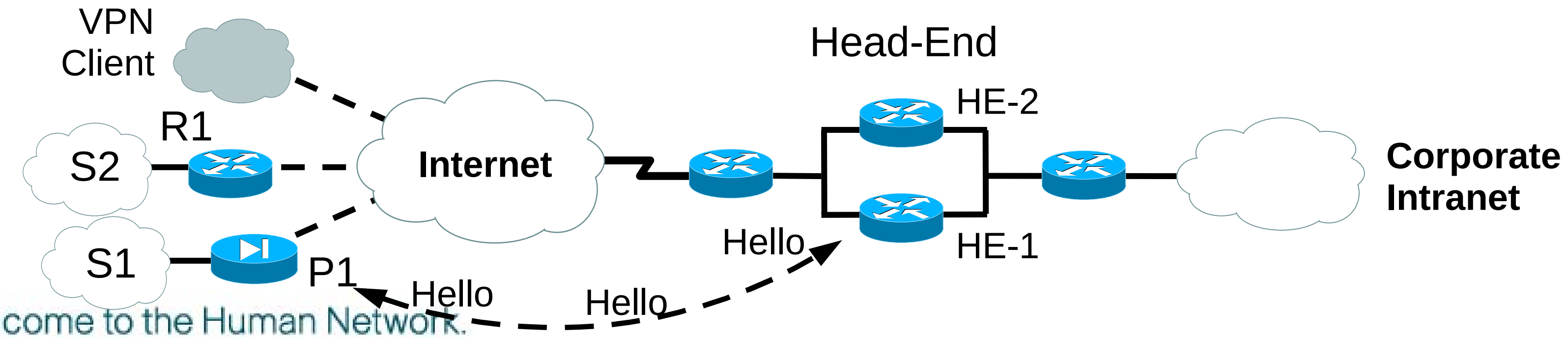
IPsec and HSRP + with Reverse Route Inj. (RRI)



IPSec/GRE: Routing Protocols



IPsec and Dead Peer Detection (DPD)



Practice IPsec

Practice Every Possible Scenario and Combination

- IPsec LAN-to-LAN using pre-shared and certificates
  - Cisco IOS
  - PIX/ASA
  - VPN 3000
- IPsec remote access using pre-shared and certificates
  - Cisco IOS
  - PIX/ASA
  - VPN 3000

Practice IPsec Features

- Reverse Route Injection (RRI)
- Split Tunnel
- Xauth/Mode config
- RADIUS
- NAT-T (IPsec over TCP/UDP)
- IPsec and NAT
- SSL VPN
- Fragmentation and PMTU Discovery
- QoS
- DMVPN/mGRE/NHRP
- High Availability scenarios

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Troubleshooting IPsec

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Troubleshooting IPsec

Determine the Problem Characteristics

- Is the problem in connection establishment?
  - Phase 1 failure
  - Transaction Mode/XAUTH
  - Phase 2 failure
- Is the problem in passing traffic?
  - All traffic
  - Specific traffic

Always Use Show Command Before Debug

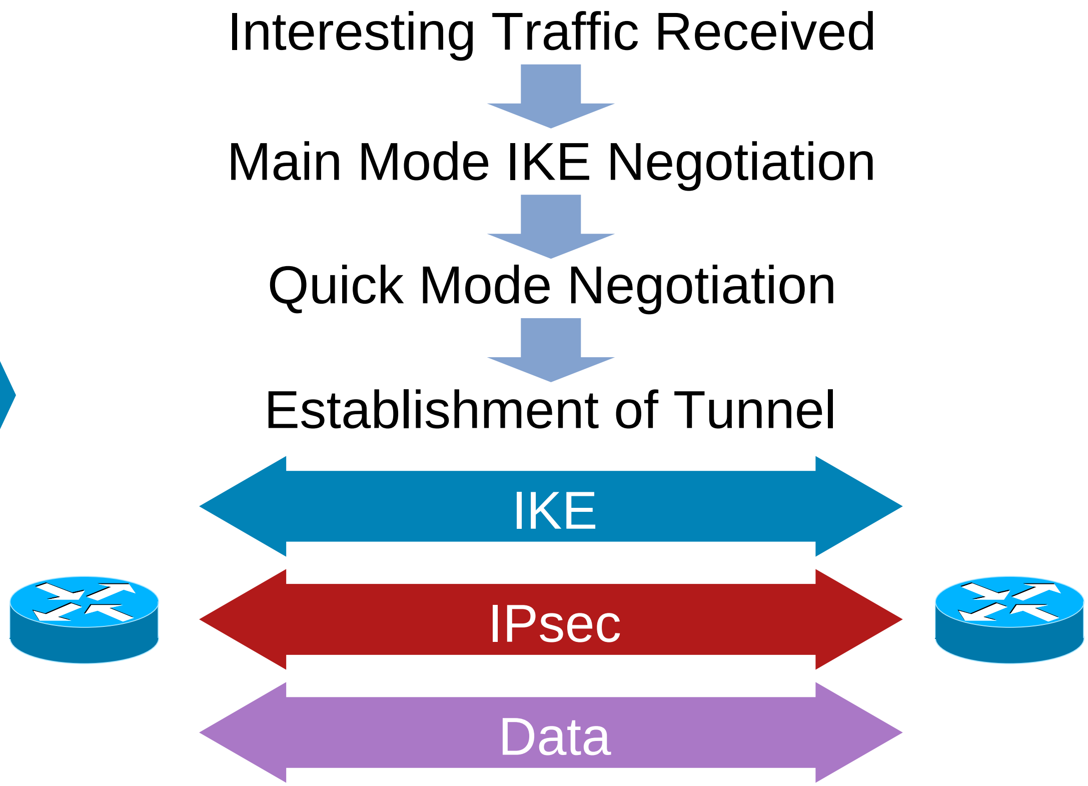
Important Show

```
show crypto isakmp sa

show crypto ipsec sa

show crypto engine connection active
```

Show Functionality Flowchart



Interesting Traffic Received

Main Mode IKE Negotiation

Quick Mode Negotiation

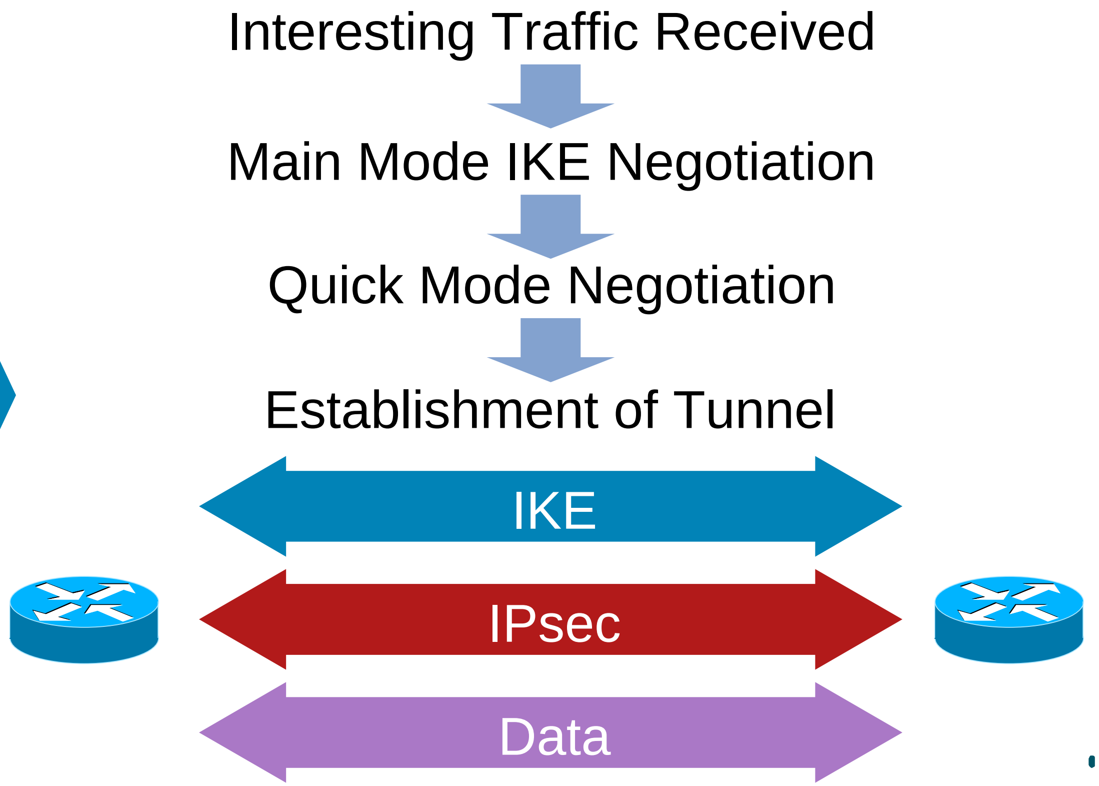
Establishment of Tunnel

Debug Commands

Important Debugs

```
debug crypto isakmp
debug crypto ipsec
debug crypto engine
```

Debug Functionality Flowchart



Interesting Traffic Received

Main Mode IKE Negotiation

Quick Mode Negotiation

Establishment of Tunnel

Welcome to the Human Network.

Common Mistakes

Common Mistakes

- Incompatible ISAKMP Policy
- Incompatible Preshared Secrets
- Incompatible Transform Sets
- Incompatible or Incorrect Access Lists
- Crypto Map on the Wrong Interface
- Incorrect SA Selection by the Router
- Routing Issues
- NAT with IPsec
- Firewall and ACLs

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Session 5

Intrusion Prevention Systems (IPS)

Welcome to the Human Network.

IPS Terminology:
The Marketing of IPS/IDS

- IDS Intrusion Detection System—Typically limited to promiscuous sensors (out of packet stream)
- IPS Intrusion Prevention/Protection System—The term most commonly applied to a sensor that sits inline (in the packet stream) and can drop malicious packets, flows or attackers
- IDP Intrusion Detection and Prevention—Marketing term coined by a vendor for product differentiation

IPS Terminology: What Is IPS?

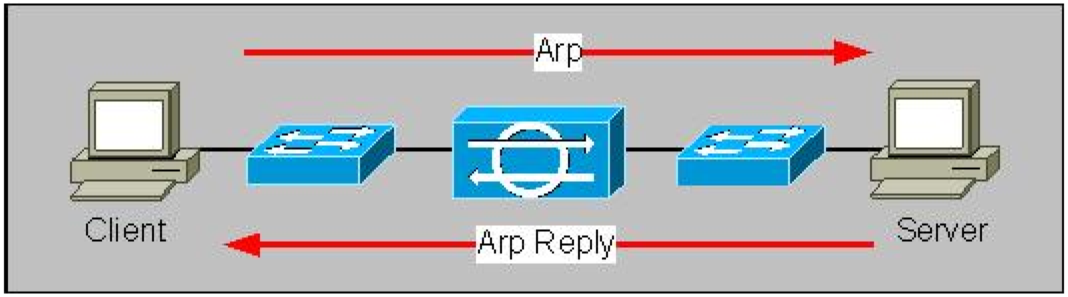
Different Understandings of “What Is IPS?”

- IPS feature vs. IDS feature—The IPS feature is specifically inline monitoring with “deny packet” capability (but not necessarily used) while IDS feature is promiscuous-only monitoring with post attack response actions (TCP reset or block on external device)
- Cisco IPS software vs. Cisco IDS software—IPS software is usually capable of both inline (IPS feature) and promiscuous (IDS feature) monitoring while IDS software is only capable of promiscuous (IDS feature) monitoring; Cisco v5.0 vs v4.x software versions
- Cisco IPS hardware vs. Cisco IDS hardware—IDS hardware is generally designed with only one port for promiscuous monitoring; to get inline monitoring typically requires addition of an interface card; IPS hardware is designed for inline operations; typically two or more sensing ports by default

IPS Terminology: What Is IPS? (Cont.)

IPS Closely Resembles a Layer 2 Bridge or Repeater

- "Identical to a wire" is the closest analogy
- Inline interfaces have no MAC or IP and cannot be detected directly
- Network IPS passes all packets without directly participating in any communications including spanning tree (but spanning tree packets are passed)
- Default behavior is to pass all packets even if unknown, (i.e. IPX, Appletalk, etc.) unless specifically denied by policy or detection



IPS Terminology: Signatures and Anomalies

- Signatures explicitly define what activity should be considered malicious
  - Simple pattern matching
  - Stateful pattern matching
  - Protocol decode-based analysis (including protocol anomalies)
  - Heuristic-based analysis
- Anomaly detection involves defining or learning “normal” activity and looking for deviations from this baseline

IPS Terminology:
Signature Implementations and Structures

- Signature implementation

  Context—trigger data contained in packet header

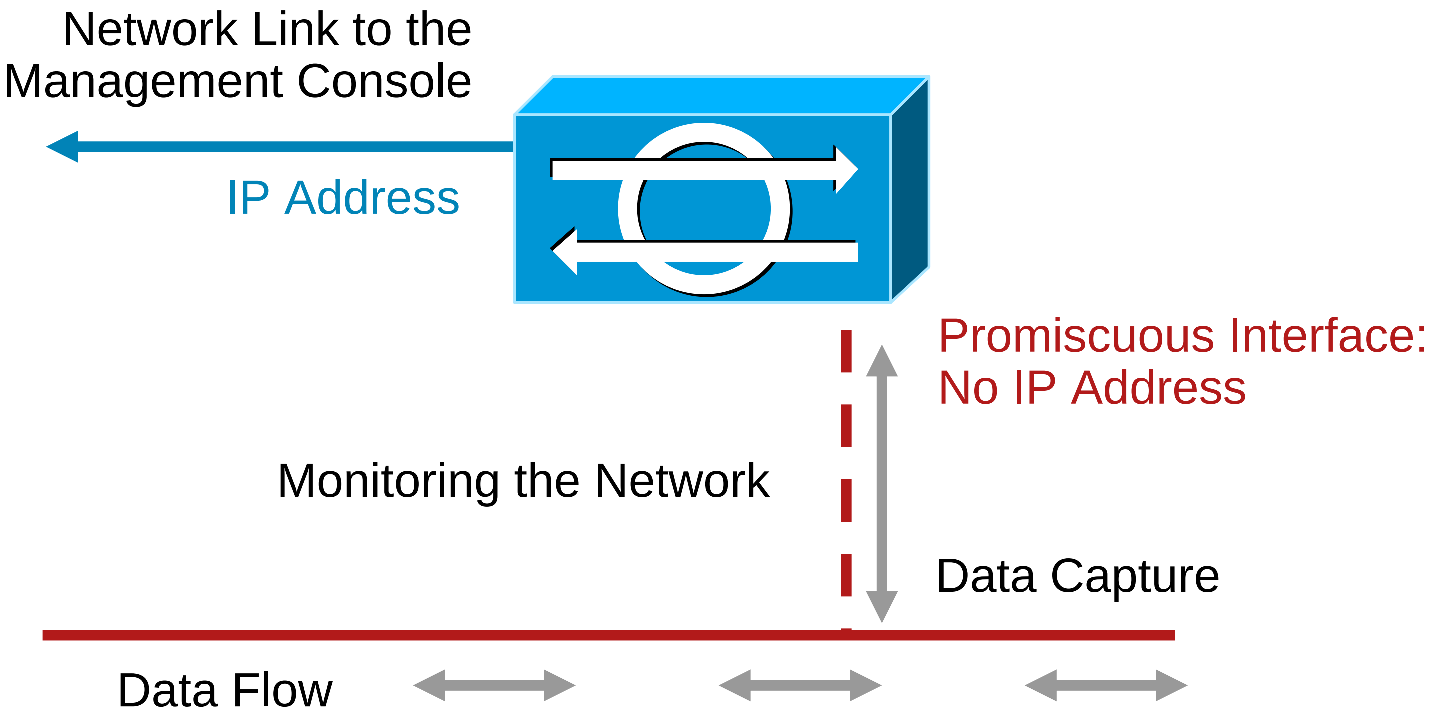
  Content—trigger data contained in packet payload

- Signature structure

  Atomic—trigger contained in a single packet

  Composite—trigger contained in a series of multiple packets

Network-Based IDS: The Sensor



Network Link to the
Management Console

IP Address

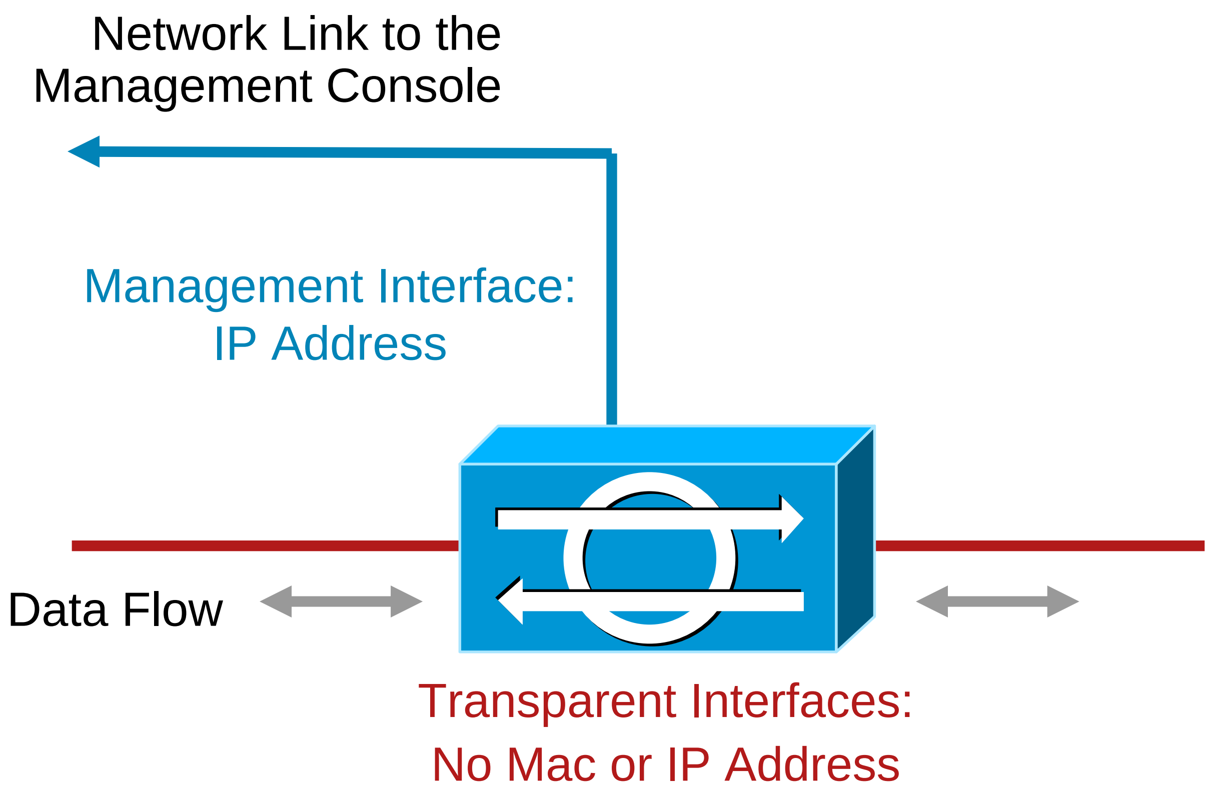
Promiscuous Interface:
No IP Address

Monitoring the Network

Data Capture

Data Flow

Network-Based IPS: The Sensor



Network Link to the Management Console

Management Interface: IP Address

Data Flow

Transparent Interfaces: No Mac or IP Address

Initializing the Sensor

- Default username/password will be changed in the lab exam. Follow the instructions/guidelines in your workbook. In most cases, username and password will be set to `cisco/123cisco123`. Do not change this user credentials, else; you will lose all points
- Configure basic parameters such as the host name, IP address, netmask, gateway and communications options
- Use IDS Device Manager (IDM) to browse the sensor management IP address to complete remaining exam

Scaling Analysis: Signature Engines

- Cisco IPS analysis implemented with a series of engines that each inspect for a specific type of activity
- Signature engine types:
  - Atomic
  - Meta
  - State
  - Sweep
  - Flood
  - Service
  - String
  - Trojan
  - Traffic
  - Normalizer
  - AIC
  - Other

Signature Tuning

- Sensors are shipped with default signature configuration
- Signature specific:
  - Ports, protocols, services, analysis length, etc.
- Filtering: what networks to alarm on
- Event count: number of events to see before alarm
- Severity: what level of alarm to send
- Alarm aggregation: how many alarms to send
  - Summary mode: fire all, summarize, global summarize
  - Summary interval: summarization window
  - Summary threshold: high water mark to change summarization
- Event action: what to do following when the sig is triggered (includes producing an alert)

Custom Signatures

- Customize vendor-provided signatures

  For example, if a web signature is set to watch TCP 80, and you're running a web server on TCP8080, you can change the signature to also watch that port

- New environment specific signatures can be created
- Custom signature configuration tasks:

  1. Select the signature micro-engine that best meets your requirements
  2. Enter values for the signature parameters that are required and meet your requirements
  3. Save and apply the custom signature to the sensor

Active Response: IPS

- A sensor deployed in IPS mode operates on the actual network packets instead of copies
  - Multiple different deny actions are possible in addition to all actions supported in IDS mode
    - Deny attacker
    - Deny connection
    - Deny packet
- Actions configurable per signature

TCP Resets

- For TCP applications, connection is prematurely terminated by a RST sent from “sensing” interface
- Must guess correct TCP sequence number and successfully insert RST into session
  - Makes TCP resets somewhat unreliable especially when source and destination are “close”
- Certain applications will automatically reconnect and resend (e.g., SMTP), making this less effective
- Note that initial trigger packet will make it to its destination, so can’t necessarily stop event
  - Code red 1 was a single packet attack and couldn’t be reset
- Conclusion: TCP resets are a temporary solution while you readjust your security posture

Blocking (Shunning)

- When signature fires, sensor inserts ACL on router/issues shun command on firewall

  Deny subsequent traffic from that source IP address or associated with that specific connection

  Note that initial trigger packets will make it to the destination because of the time required to establish the block

- Sensor connects to firewall and/or router from management interface

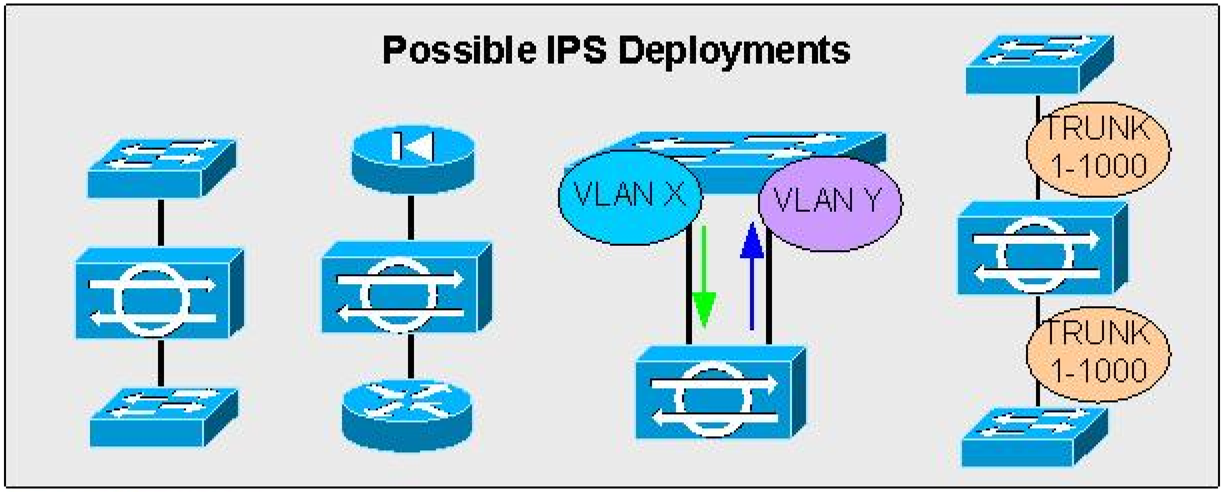
  Need to configure authentication credentials for firewall/router

- Conclusion: Blocking can be effective at stopping an infected host but can't stop first attack

IPS Appliance Deployment Examples

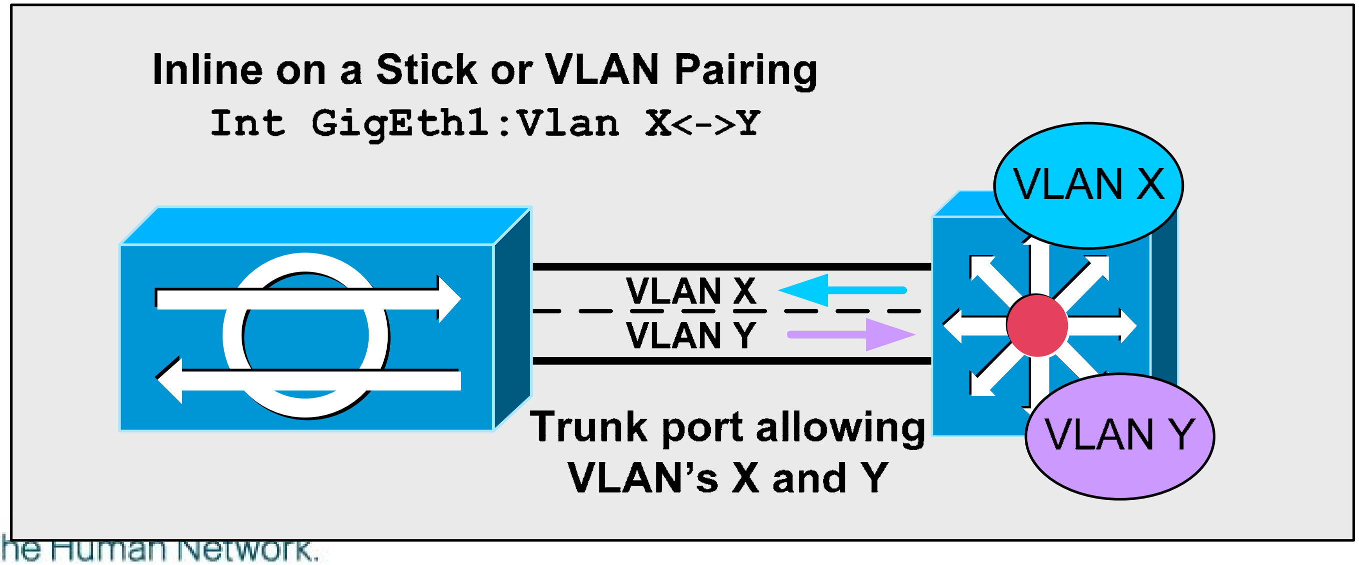
IPS Appliance Sensor Deployment Examples:

- Two L2 devices (non trunk)
- Two L3 devices
- Bridging 2 VLANs on same switch
- Two L2 devices (trunked; 802.1q)



Inline-on-a-Stick or VLAN Pairing

- VLAN pairing allows a sensor to bridge VLANs together on the same physical interface by creating, in effect, sub-interfaces that allow the sensor to bring packets in on VLAN X and out on VLAN Y
- Multiple VLAN pairs per physical interface reduces the need to have many physical interfaces per chassis



Inline on a Stick or VLAN Pairing

```
Int GigEth1:Vlan X<->Y
```

Trunk port allowing VLAN’s X and Y

Useful Show Commands on IDS Console

- show statistics eventStore
- show events alert {high|medium|low}
- show events status
- show interface
- show configuration
- show version
- show statistics

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Session 6

Identity Management (AAA)

Welcome to the Human Network.

AAA Overview

- Authentication, Authorization, and Accounting (AAA) network security services provide the primary framework through which you set up access control
- The CiscoSecure ACS uses authentication, authorization, and accounting (AAA) to provide network security. Each facet of AAA significantly contributes to the overall security of your network:

  Authentication determines the identity of users and whether they should be allowed access to the network

  Authorization determines the level of network services available to authenticated users after they are connected

  Accounting keeps track of each user's network activity

RADIUS vs. TACACS+

RADIUS

- RADIUS uses UDP port 1645/1646 and as per RFC 2138; 1812/1813
- RADIUS encrypts only the password in the packet
- Single challenge response
- Combines authentication and authorization
- Industry standard (created by Livingston)
- Does not support command authorization

TACACS+

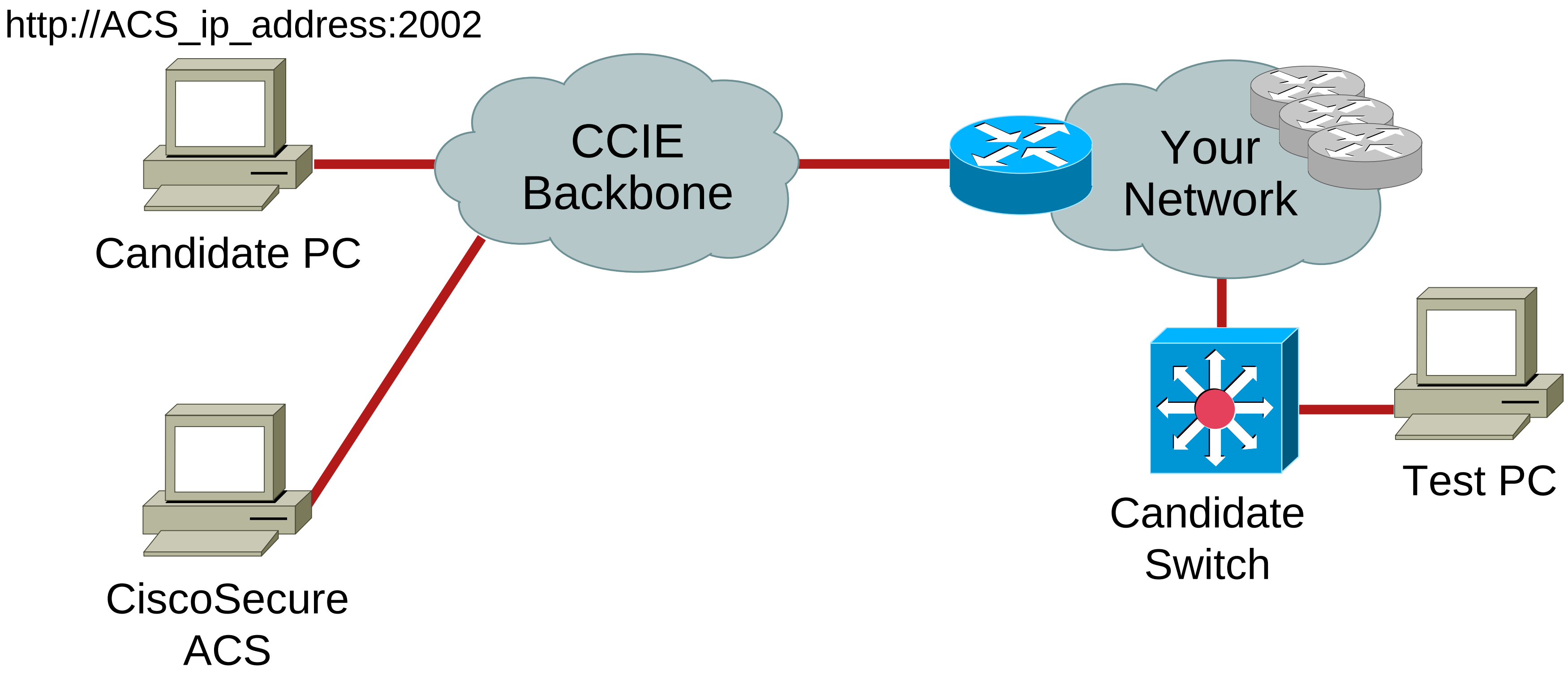
- TACACS+ uses TCP port 49
- TACACS+ encrypts entire packet
- Multiple challenge response
- Uses the AAA architecture and separates each process
- Cisco proprietary
- Supports command authorization

CiscoSecure ACS

- CiscoSecure ACS Server supports both; RADIUS and TACACS+ protocols
- ACS is **not** pre-configured in the lab exam; candidates are required to configure all aspects of ACS system.
- Full access will be provided for configuration, verification and troubleshooting purpose
- How to bring up ACS GUI remotely?

  http://ip_address:2002

CiscoSecure ACS: Connection Method



Device Management

- Practice device management using AAA on router and Cisco Catalyst switches equally
- Device management via Telnet, SSH, HTTP/HTTPS are the most commonly authenticated protocols
- Console/Aux port should not be affected by any AAA commands unless otherwise specified
- Device management can be performed on all devices such as routers, Cisco Catalyst switches, PIX and VPN3000 (IDS does not support AAA)
- TACACS+ gives you the best control for managing a device by allowing you to restrict commands used while on the device using various privilege levels

Command Authorization

- A device can be configured to authorize commands through a AAA server at all or specific levels
- The following router configuration allows all users to have per-command authorization set up on the server
- Here we authorize all commands through CiscoSecure ACS using TACACS+; but if the AAA server is down, fallback authorization is set to local database
- Example:

```
aaa authorization commands 1 default group tacacs+ local
aaa authorization commands 15 default group tacacs+ local
```

VPN3000 Management

- Configure AAA servers to authenticate administrators. VPN3000 can be configured to govern the level of access for administrators authenticated by a TACACS+ server (be sure that any servers you reference are properly configured)
- Authentication is performed when a user browses via HTTP/HTTPS
- This method does not provide security for console access of the VPN3000 concentrator. Console port is not affected and is your backdoor if the AAA does not respond
- Default username and password is admin/admin

PIX/ASA Management

- AAA support is available to authenticate Telnet, SSH and Console access on PIX/ASA using TACACS+ and RADIUS
- Make sure you can Telnet from the inside network to the inside interface of the PIX/ASA without any AAA authentication
- PIX/ASA command authorization and expansion of local authentication was introduced in version 6.2
- Commands performed may be controlled locally on the firewall or remotely through TACACS+

Cisco PIX/ASA Service Authentication

- RADIUS and TACACS+ **authentication** can be done for HTTP, HTTPS, FTP, Telnet, SSH, and ICMP connections through the Firewall using AAA
- Authentication for other less common protocols, non-standard services and/or other TCP/UDP ports can also be made to work using tcp/<port> and udp/<port>
- Note that TACACS+ **authorization** is supported, however, RADIUS authorization is not

AAA Test Command

- AAA test command provides protocol connectivity test from the NAS to the RADIUS/TACACS+ server. It validates if the NAS can establish connectivity with the server using RADIUS/TACACS+ ports
- At times, the 'test aaa' may yield a failed result even if the ping (ip connectivity) is successful. Why?
- Example:

```
Router# test aaa group tacacs+ testuser mypassword legacy
Attempting authentication test to server-group tacacs+ using tacacs+
User was successfully authenticated
```

or

```
Router# test aaa group radius testuser mypassword legacy
Attempting authentication test to server-group radius using radius
User was successfully authenticated
```

Troubleshooting AAA

- debug aaa authentication
- debug aaa authorization
- debug aaa accounting
- debug radius
- debug tacacs
- test aaa group radius|tacacs+ username pwd legacy

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Session 7

Advanced Security

Welcome to the Human Network.

Disable Ports Not Used on the Router?

- show ip sockets—show some of the UDP ports opened
- Two steps required for TCP ports:
    - show tcp brief all
    - show tcp tcb

Global Services That Should Be Disabled

Some Services, Turned On by Default, Should Be Turned Off to Save Memory and Prevent Security Breaches/Attacks

```
no service finger

no service pad

no service udp-small-servers

no service tcp-small-servers

no ip bootp server
```

Interface Services You Turn Off

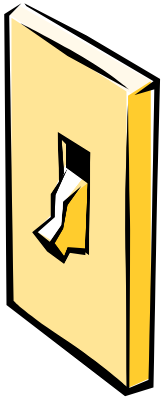
All Interfaces on a Backbone Router Should Have the Following as a Default:

```
no ip redirects

no ip directed-broadcast

no ip proxy-arp

no ip source-routing
```



VTY Security

- Control is done via access lists
- Authentication: **local password, TACACS+, RADIUS**
- Transport mechanism should be SSH

  Need to run crypto image for SSH

SNMP

- Change your community strings; do not use public, private, secret
- Use different community strings for the RO and RW communities
- Use mixed alphanumeric characters in the community strings: SNMP community strings can be cracked, too
- Turn off SNMP if it isn't needed:

  Cisco IOS: `no snmp-server`

- Block SNMP access to outsiders

ICMP Message Types

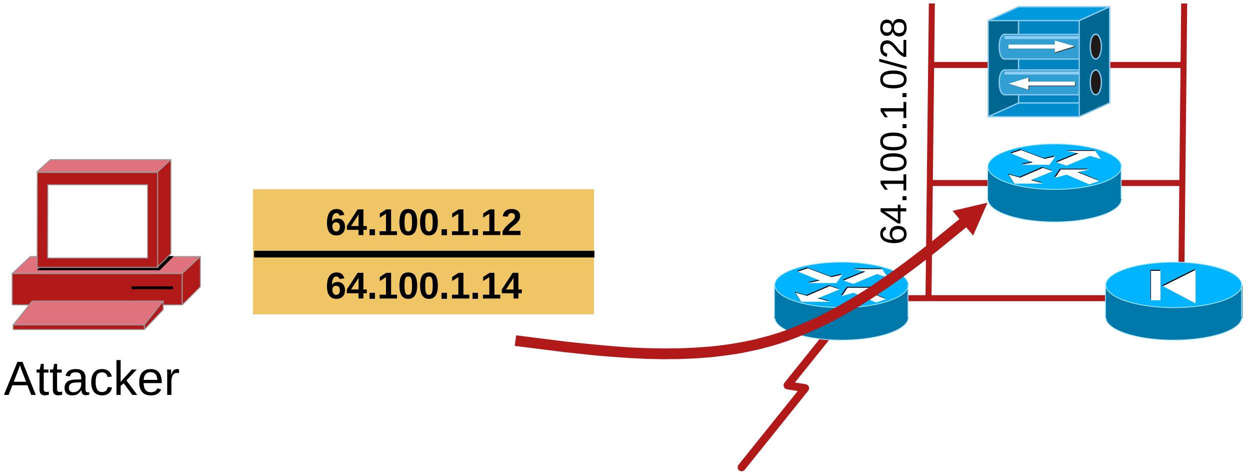
Control the Direction of a Ping

```
access-list 111 permit icmp any 10.1.1.0 0.0.0.255 echo-reply
!
interface Serial 0
   access-group 111 in
```

Summary of ICMP Message Types

0	Echo Reply
3	Destination Unreachable
4	Source Quench
5	Redirect
8	Echo
11	Time Exceeded
12	Parameter Problem
13	Timestamp
14	Timestamp Reply
15	Information Request
16	Information Reply

IP Spoofing



- Hacker claims he is one of the inside hosts
- Inside host may have a trust relationship with spoofed host

IP Spoofing: How to Avoid It

- Deny incoming packets if source address is one of yours
- Deny outbound packets if source address is not one of yours

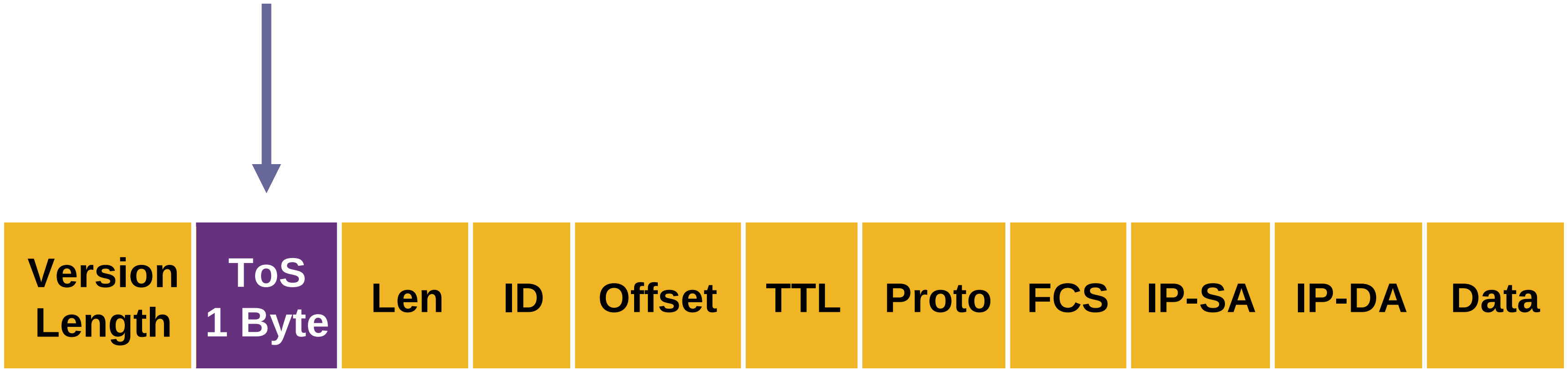
Unicast Reverse Path Forwarding (uRPF)

- Mitigates source address spoofing by checking that a packet’s return path uses the same interface it arrived on
- Source IP packets are checked to ensure that the route back to the source uses the same interface
- Requires CEF
- Not always appropriate where asymmetric paths exist

```
ip cef
!
interface Serial 0
 ip verify unicast (reverse-path | source reachable-via rx |
 source reachable-via any) <ACL_Number>
```

Packet-Marking and Classification

**Packets Are Marked at the Edge,
for Purposes of Classification in the Core**



Version Length	ToS 1 Byte	Len	ID	Offset	TTL	Proto	FCS	IP-SA	IP-DA	Data

The IPv4 Header and the Type of Service (ToS) Byte

Class-Based Weighted Fair Queuing (Modular QoS CLI—MQC)

- Traffic is queued by user defined classes
- A queue is reserved for each class
- Queue uses tail drop or WRED
- Unclassified traffic is flow-based

NBAR: Network-Based Application Recognition

- NBAR is used for classifying traffic
  - Classification of applications that dynamically assign TCP/UDP port numbers
  - Classification of HTTP traffic by URL, HOST, or Multipurpose Internet Mail Extension (MIME) type
  - Classification of application traffic using sub-port information
- Use the classification in conjunction with CAR or traffic policing

NetFlow

- Provides network administrators with “packet flow” information
- Allows for:

  Traffic flow analysis

  Security monitoring

  Anomaly detection

Enabling NetFlow

- Receive NetFlow information only on the specific interface(s) of interest
- Typical use case for NetFlow: Accounting, Security and Capacity Planning

```
Router(config-if)# ip flow ingress
```

- Starting Cisco IOS v12.2(15)T a simple “ip flow ingress” interface command starts collecting NetFlow data on that interface

This New Command Was Added in Cisco IOS v12.2(15)T Older Command “ip route-cache flow” Also Enables Ingress NetFlow on the Interface but Should No Longer Be Used

Cisco Catalyst Security and Advance Features

Practice Cisco Catalyst Security Features; Some Examples Are:

- Port Security
- BPDU/Root Guard
- 802.1x
- Router ACLs, Port ACLs, VLAN ACLs
- AAA on Switch
- Traffic Control
- EtherChannels
- 802.1Q and Layer 2 Protocol Tunneling
- SPAN, RSPAN

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Session 8

Network Attacks

Welcome to the Human Network.

Proactive vs. Reactive

The Questions in this Section of the Exam Are Mainly Focused on Reactive Measures

- Focus on techniques used to mitigate network attacks
- Same tools and techniques are used as discussed in previous section “Advanced Security”
- Questions will also test knowledge of protocols, e.g. TCP, HTTP, ICMP
- Questions will also test knowledge of Headers and standard packet format, e.g. TCP Header
- Questions will also test knowledge of reading packet captures and various show and debug outputs

Common Attacks

- Network reconnaissance
- Denial of Service (DoS)
- IP spoofing
- DHCP snooping
- DNS spoofing
- MAC spoofing
- ARP snooping
- Fragment attack
- Smurf attack
- TCP SYN attack

Knowledge of Protocols

- Traffic Characterization
- Packet Classification
- Marking Techniques
- Identifying Attack Patterns
- Understanding Attack Vectors

  Example: SYN, TCP/UDP options, ICMP Type/Code
- Common Protocol and Port Numbers

Understanding Protocol Headers

- Understanding & Interpreting ARP Header Structure
- Understanding & Interpreting IP Header Structure
- Understanding & Interpreting TCP Header Structure
- Understanding & Interpreting UDP Header Structure
- Understanding & Interpreting ICMP Header Structure
- Understanding & Interpreting ICMP Type/Code
- Understanding & Interpreting SYSLOG Messages
- Understanding & Interpreting Sniffer Capture Outputs

Mitigation Using Various Techniques

- Preventing SYN Attack using ACL
- Preventing SYN Attack using NBAR
- Preventing SYN Attack using Policing
- Preventing SYN Attack using CBAC
- Preventing SYN Attack using CAR
- Preventing SYN Attack using TCP Intercept
- Preventing SYN Attack using MPF

Mitigation Using Various Techniques

- Preventing IP Spoofing Attack using anti-spoofing ACLs
- Preventing IP Spoofing Attack using uRPF
- Preventing IP Spoofing Attack using IP Source Guard

Mitigation Using Various Techniques

- Preventing MAC Spoofing Attack using Port Security
- Preventing ARP Spoofing Attack using DAI
- Preventing STP Attack using Root/BPDU Guard
- Preventing DHCP Spoofing Attack using Port Security
- Preventing DHCP Spoofing Attack using DAI
- Preventing Fragment Attack using ACL

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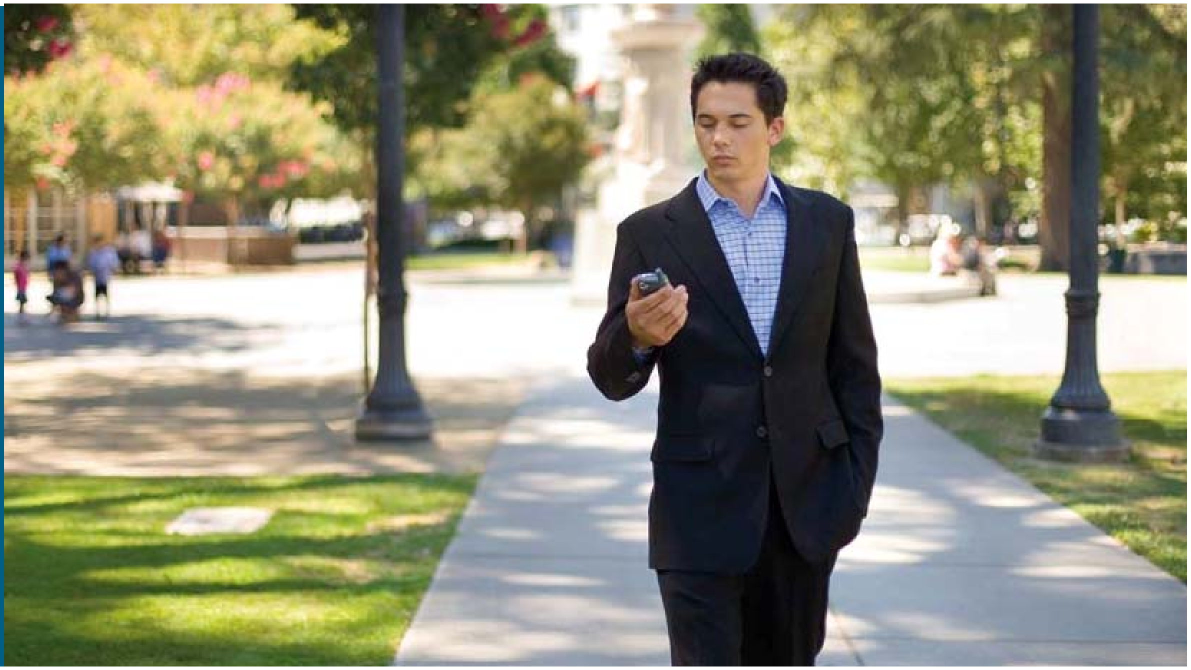
Session 9

Preparation Resources and Test-Taking Tips

Welcome to the Human Network.

Preparation Resources



Planning Resources

- There is an abundance of material available to prepare for the CCIE certification. However, you have to be very selective of the material you choose to use
- Choose materials that offer configuration examples and take a “hands-on” approach
- Look for materials approved or provided by Cisco and its Learning Partners
- Customize your study plan to reflect your own personal strengths and weaknesses

A Good Study Plan Is Key to Your Success

Assessing Strengths

- Evaluate your experience and knowledge in the major topic areas listed on blueprint
- Using the content blueprint, determine your experience and knowledge level in the major topic areas
- For areas of strength: practice for speed
- For weaker areas: boost knowledge with training or book study first, then practice

Trainings

Although No Formal Training Is Required for the CCIE Security Certification, Cisco Recommends the Following Training Courses, Which Are Described Further on the Cisco Website at:

http://www.cisco.com/web/learning/le3/ccie/security/training.html

Books

- Many Cisco Press® and other vendor books are available to assist in preparing for CCIE exams
- A current list can be found on the CCIE website at

  http://www.cisco.com/web/learning/le3/ccie/security/book_list.html

- No single resource is uniformly great; you will likely need to add multiple books to your collection

Trainings

- Securing Networks with Cisco Routers and Switches (SNRS)
- Securing Networks with PIX and ASA (SNPA)
- Cisco Secure Virtual Networks (CSVPN)
- Implementing Cisco Intrusion Prevention System (IPS)
- Securing Cisco Network Devices (SND)

Free Online Cisco Quick Learning Web-Based Modules:

- Securing Cisco Routers (SECR)
- Configuring ASA and PIX Security Appliances
- Configuring IPS 4200 Series Sensors
- Security and VPN Quick Learning Modules
- Cisco IOS and IP Routing Quick Learning Modules

Bootcamp

- Many candidates ask if I can recommend a Security boot camp?
- In my opinion, bootcamps are intended to give an overview of the lab, offer tips-and-tricks for exam taking, and provide mock scenarios which help you gauge your readiness
- Therefore, to gain the most benefit, I recommend you study the technologies involved before attending any boot camp

Cisco Website CCO

- Many candidates overlook one of the best resources for useful material and technical information—the Cisco website
- There are many sample scenarios available on the Tech Support pages for each Cisco product and technology. For instance, the Tech Support page for IPsec has more than 150 samples and tips available
- These articles are written to reflect current trends and demands and include sample diagrams, configurations, and invaluable show and debug command outputs

Forums

Forums Can Play an Essential Role for a Candidate During Preparation; You Can Generally Find Qualified CCIEs and Other Security Engineers Available 24x7 to Answer Your Queries and Work Through Your Technical Problems

- Cisco's Networking Professional Connection

  http://www.cisco.com/go/netpro

  Networking Professionals can post questions for technical assistance, seek suggestions or share experiences at NetPro

- Cisco Learning Network (CLN)

  http://www.cisco.com/go/learnnetspace

  Offers online learning network to enhance and advance your IT career. Browse technical content and connect and share insights, opinions, and knowledge with the community.

- Cisco's Certification Online Support

  http://www.cisco.com/go/certsupport

  Q and A on certification related topics such as exam info, books, trainings, requirements, resources, tools and utilities and much more

Documentation CD (Your Lifeline)

- You need to be able to navigate the Cisco documentation CD with confidence
- This is the only resource you are allowed during the exam and you will need to be able to look up anything you need with speed and confidence
- Make it part of your regular practice; if you are familiar with it, it can save you time during the exam

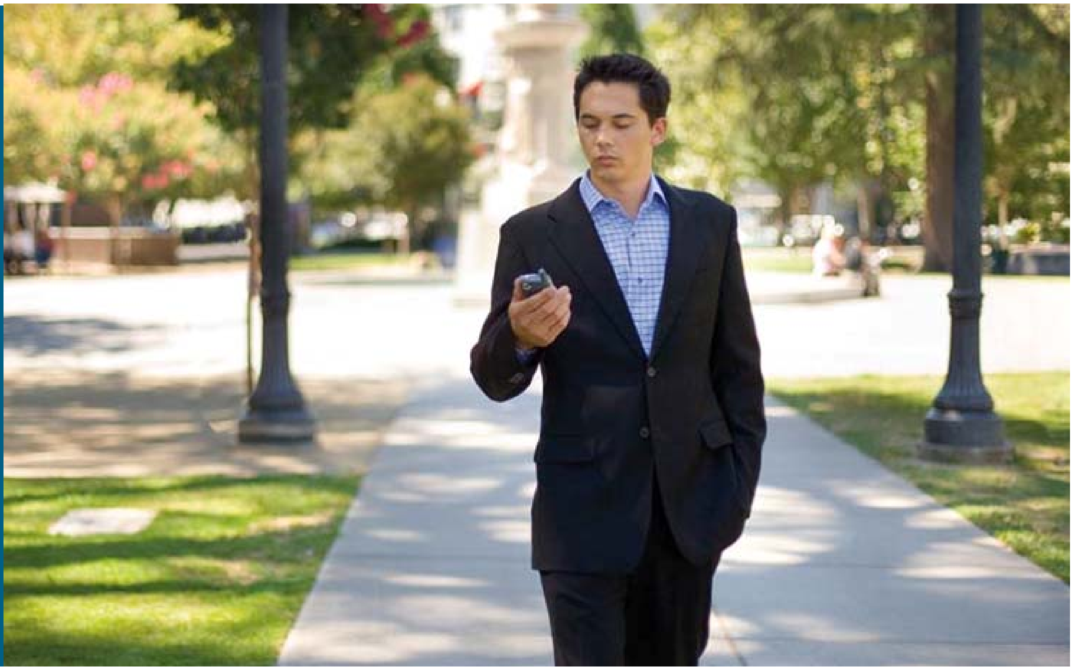
Practice Labs

- Practice lab exercises with a high level of complexity will assist you in making improvements in your exam strategy and identifying areas requiring extra study. Practice labs can be used to gauge your readiness and help identify your strengths and weaknesses. This will help you refocus and revise your study plan and adjust it according to your findings
- Technical skill is not the only thing you need to work on; time management and your exam-taking strategy is also important to succeed in the CCIE exam. Practice labs also assist you in improving your time management and test-taking approach

Equipment (Home Lab vs. Rental Racks)

- Although acquiring a personal home lab is an ideal scenario, it can be costly to gather all the equipment to build a security rack. You can start with just a few devices—three to four routers, a switch and a PIX firewall. The goal is to obtain a thorough understanding of the technologies and the architecture and also know how they integrate with each other
- For the hardware devices which are more costly to obtain, such as the IDS Sensor or VPN3000 concentrator, I would advise looking at renting the equipment online. There are many vendors who provide such services. This is far less expensive than purchasing a home security rack

Test-Taking Tips



Lab Preparation: Hands-On Practice

- Essential for passing lab
- Borrow or rent equipment you can practice on
- Two or three routers will support most scenarios
- Build and practice scenarios for each topic
- Go beyond the basics—practice additional features
- If a technology has multiple configurations—practice all of them
- Learn show and debug commands for each topic

Lab Exam Tips

- Reduce stress—arrive early
- Leave yourself time—exam can run over
- Read entire exam
- Redraw topology to clarify scenario
- Manage your time
- Make no assumptions
- Keep a list
- Work questions as a unit
- Test your work
- Save configurations often
- Minimize last-minute changes

Troubleshooting

- Know how to troubleshoot using tools available
- Verify each question before moving on. Work the simple or basic questions first and then the complex ones
- Check for typos when configuring maps, network statements, IP addresses, etc.
- Keep in mind the point value; don’t lose too much time working on a two or three point question
- Save your configurations. If necessary, you can reload a device and work on something else while it comes back up in a known state

Lab Exam Proctors

Ask the Proctor Questions

- Proctor’s role is to keep exam fair
- Talk to proctor if you don’t understand question
- Ask the proctor clarifying questions
- Report any equipment or technical problems to proctor as soon as it occurs

For More Information

- Beware of rumors
- Visit the CCIE web page

  http://www.cisco.com/go/ccie

- Online Support

  www.cisco.com/go/certsupport

- E-mail

  ccie-lab@cisco.com

- Cheating

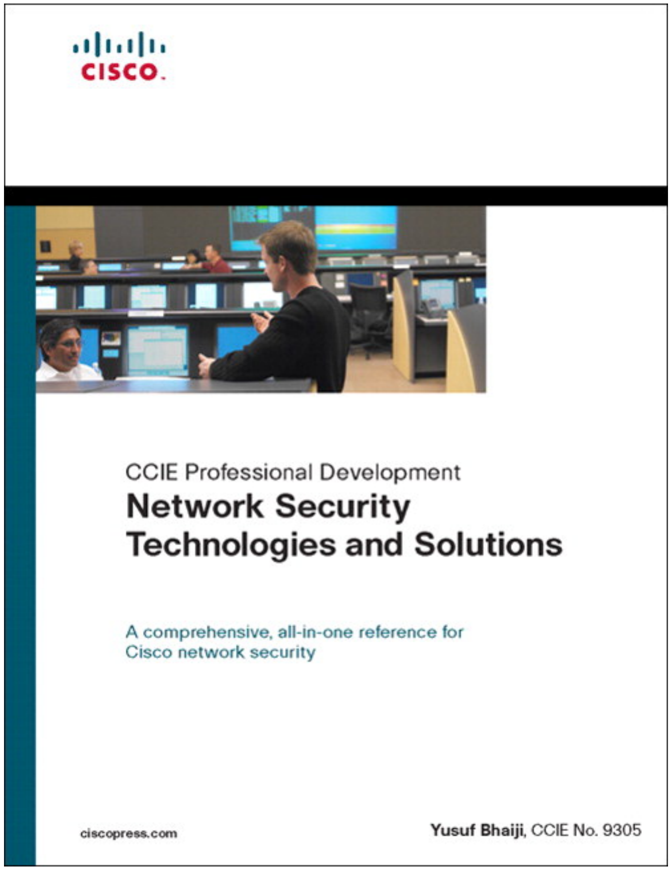
  ccie-nda-enforcement@cisco.com

Recommended Reading

Network Security Technologies and Solutions (CCIE Professional Development Series)

ISBN: 1587052466

By Yusuf Bhaiji



CCIE Professional Development

Network Security Technologies and Solutions

A comprehensive, all-in-one reference for Cisco network security

ciscopress.com

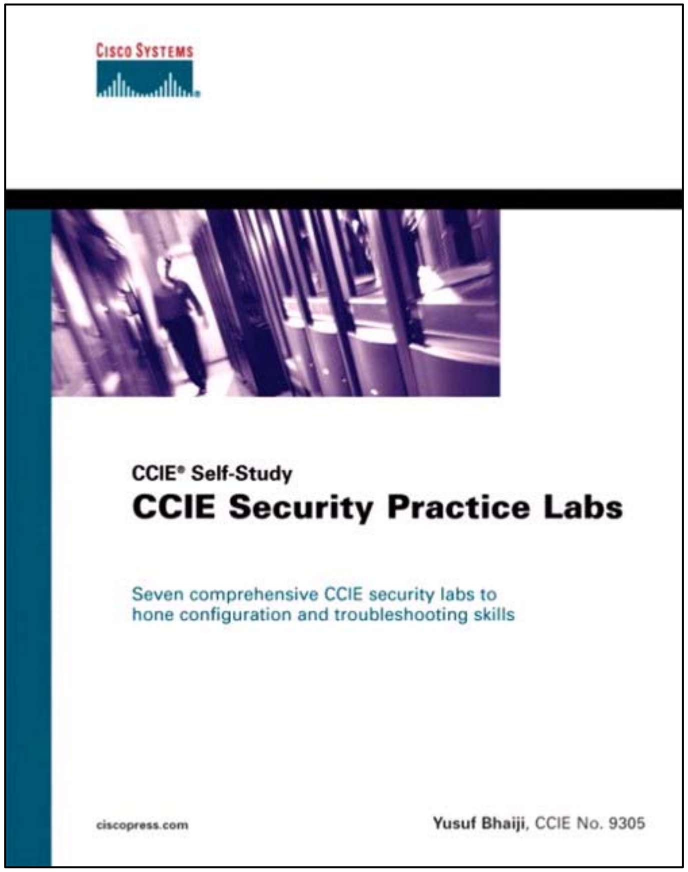
Yusuf Bhaiji, CCIE No. 9305

Recommended Reading (Cont.)

CCIE Security Practice Labs
(CCIE Self-Study)

ISBN: 1587051346

By Yusuf Bhaiji



Cisco Systems

CCIE® Self-Study

CCIE Security Practice Labs

Seven comprehensive CCIE security labs to
hone configuration and troubleshooting skills

ciscopress.com

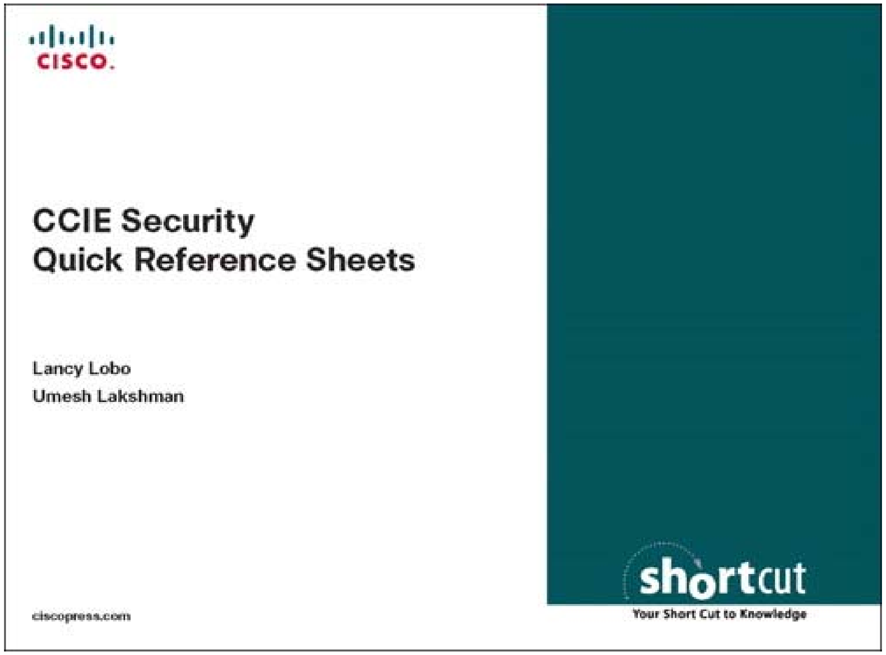
Yusuf Bhaiji, CCIE No. 9305

Recommended Reading (Cont.)

CCIE Security Exam
Quick Reference Sheets

ISBN: 1587053349

By Lancy Lobo, Umesh Lakshman



CCIE Security
Quick Reference Sheets

Lancy Lobo
Umesh Lakshman

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