Security Topics

Arquitetura de Redes

Mestrado Integrado
Engenharia de Computadores e Telemática
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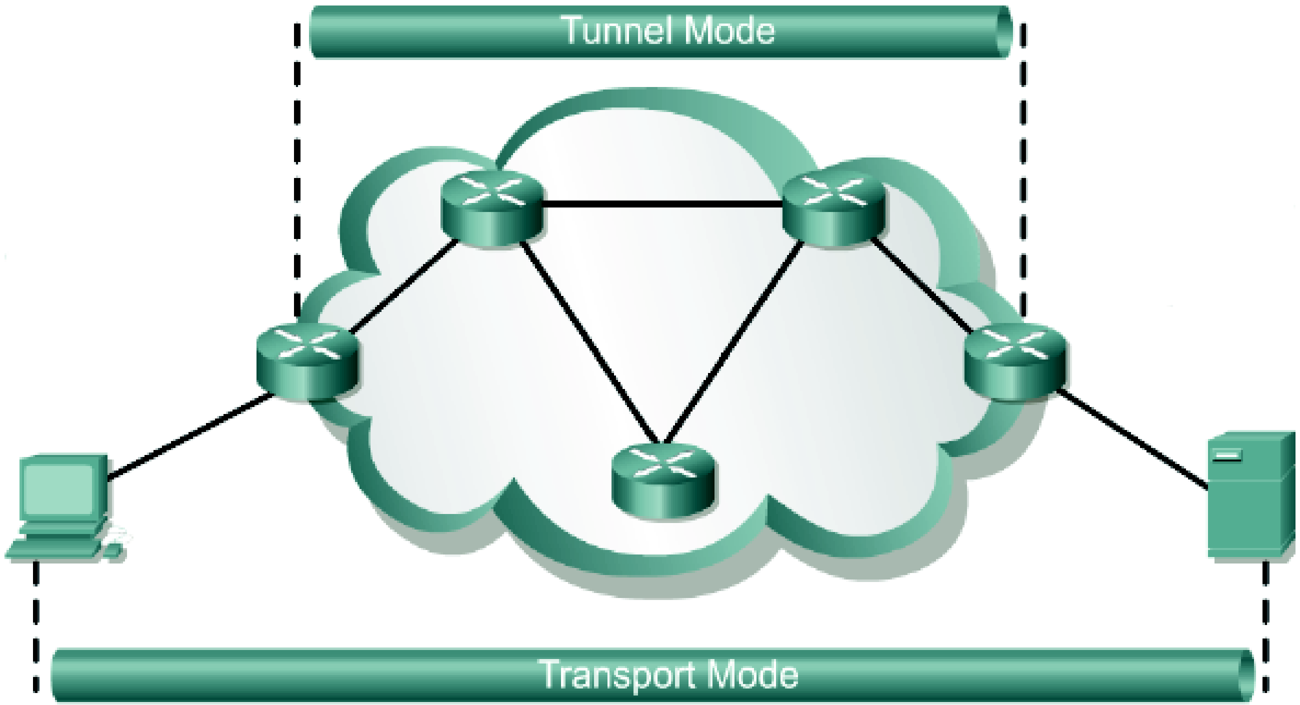
IP Secure Communications (IPsec Protocol)

IPSec

- Framework of security protocols and algorithms used to secure data at the network layer
- Authentication Header (AH)
  - Ensures data integrity
  - Does not provide confidentiality
  - Provides origin authentication
  - Uses Keyed-hash mechanisms
- Encapsulating Security Payload (ESP)
  - Provides data confidentiality (encryption)
  - Data Integrity
  - Does not protect IP header
- AH and ESP use symmetric secret key algorithms, although public key algorithms are feasible

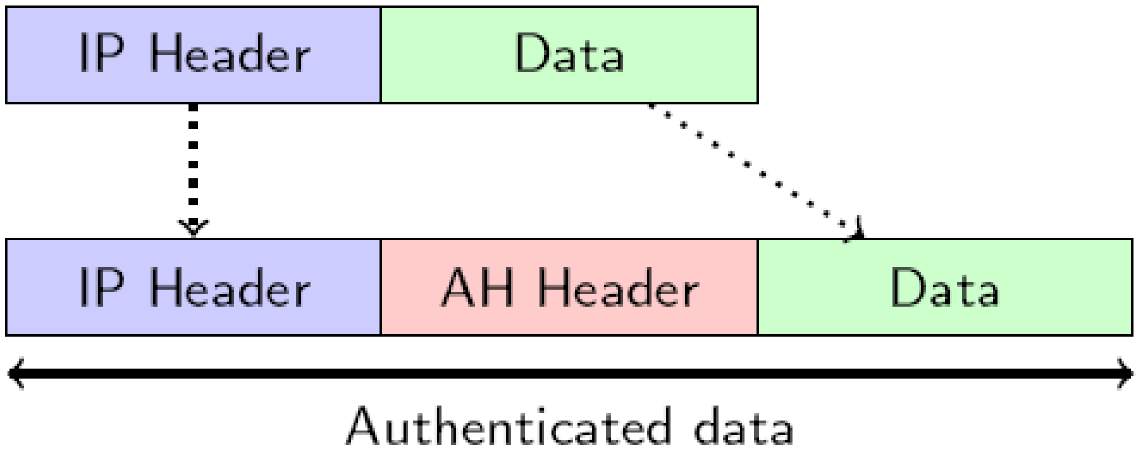
IPSec Modes

- Tunnel
  - IPSec gateways provide IPSec services to other hosts in peer-to-peer tunnels
  - End-hosts are not aware of IPSec being used to protect their traffic
  - IPSec gateways provide transparent protection over untrusted networks
- Transport
  - Each end host does IPSec encapsulation of its own data, host-to-host.
  - IPSec has to be implemented on end-hosts
  - The application endpoint must also be the IPSec endpoint

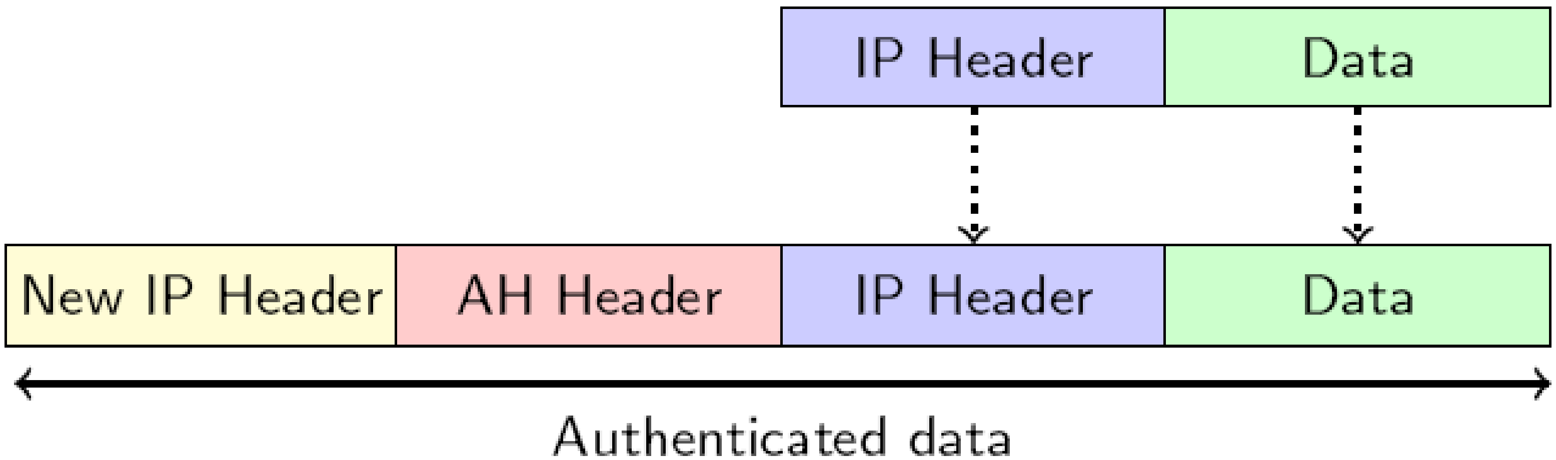


IPSec - AH header placement

- Transport mode

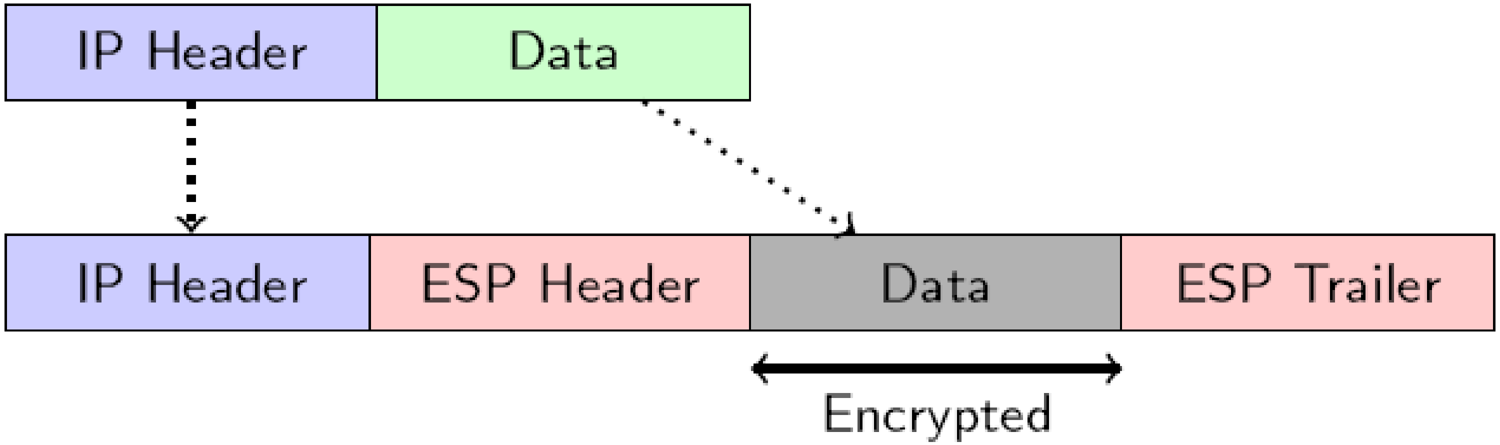


- Tunnel mode

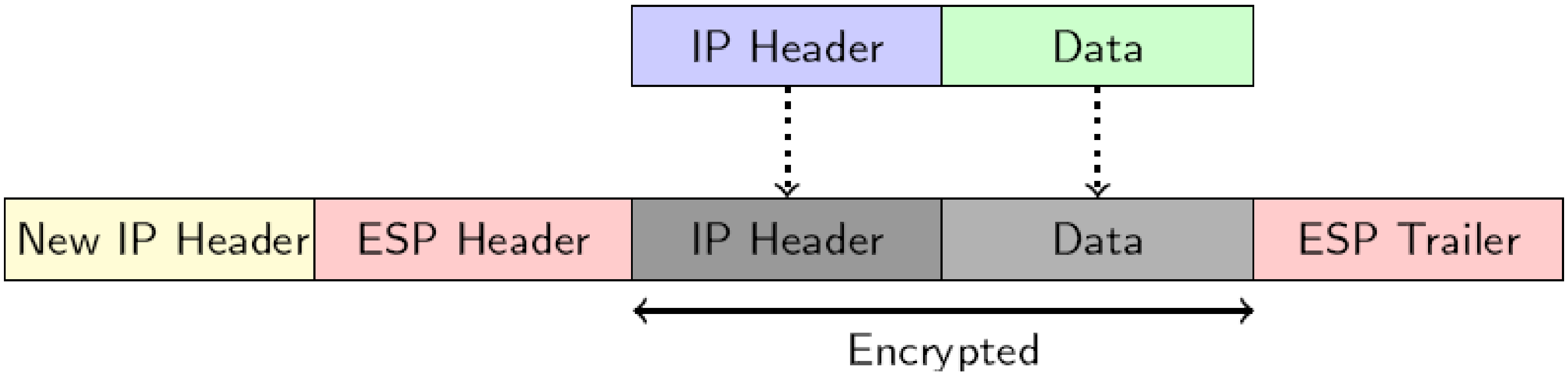


IPSec - ESP header placement

- Transport mode



- Tunnel mode



IPSec - Security Associations

- SAs represent a policy contract between two peers or hosts
- Describe how the peers will use IPSec security services to protect network traffic
- An SA contains the following security parameters:
  - Authentication/encryption algorithm, key length and other encryption parameters (e.g. key lifetime, ...)
  - Session keys for authentication, or HMACs, and encryption, which can be entered manually or negotiated automatically
  - A specification of network traffic to which the SA will be applied (e.g. IP traffic or only TELNET sessions)
  - IPSec AH or ESP encapsulation protocol and tunnel or transport mode

Establishing SA and Cryptographic Keys

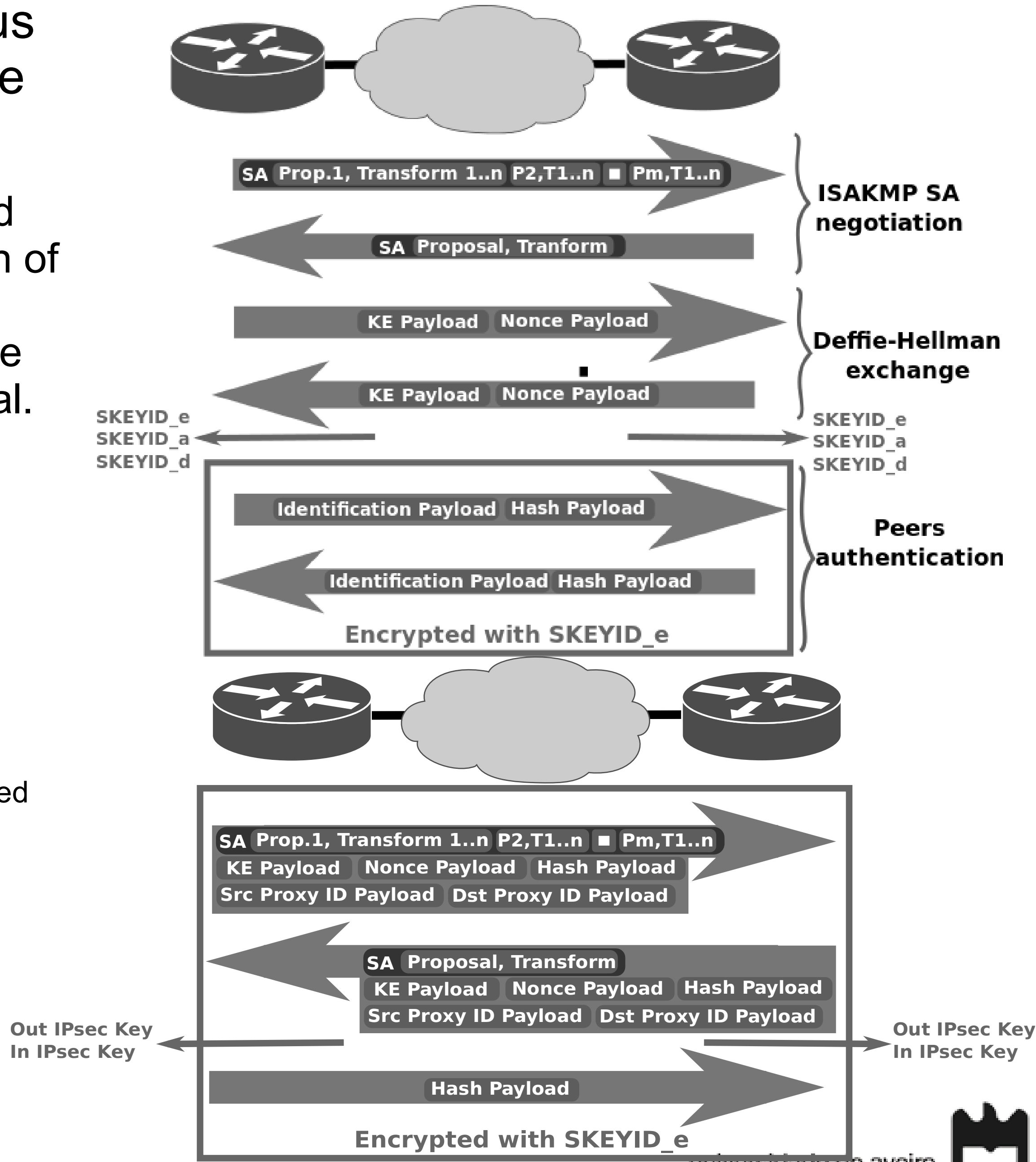
- ISAKMP - Internet Security Association and Key Management Protocol
  - Used to establishing Security Associations (SA) and cryptographic keys
  - Separate the details of security association management (and key management) from the details of key exchange
  - Provides a framework for authentication and key exchange but does not define them
- Oakley Key Determination Protocol
  - Key-agreement protocol
  - Allows authenticated peers to exchange keying material across an insecure connection
  - Uses Diffie-Hellman
- SKEME
  - Key exchange protocol
- IKE - Internet Key Exchange
  - Is a hybrid protocol
  - Uses part of Oakley and part of SKEME in conjunction with ISAKMP

IKE/ISAKMP and IPsec

- Enhances IPSec by providing additional features and flexibility
- Provides authentication of the IPSec peers, negotiates IPSec keys, and negotiates IPSec security associations
- The IKE tunnel protects the SA negotiations. After the SAs are in place, IPSec protects data transference
- Advantages
  - Eliminates the need to manually specify IPSec security parameters at both peers
  - Allows administrators to specify a lifetime for the IPSec security association
  - Allows encryption keys to change during IPSec sessions
  - Allows IPSec to provide anti-replay services
  - Permits certification authority (CA) support for a manageable, scalable IPSec implementation
  - Allows dynamic authentication of peers
- IKE/ISAKMP provides three methods for two-way authentication:
  - Pre-shared key (PSK),
  - Digital signatures (RSA-SIG),
  - Public key encryption (RSA-ENC).

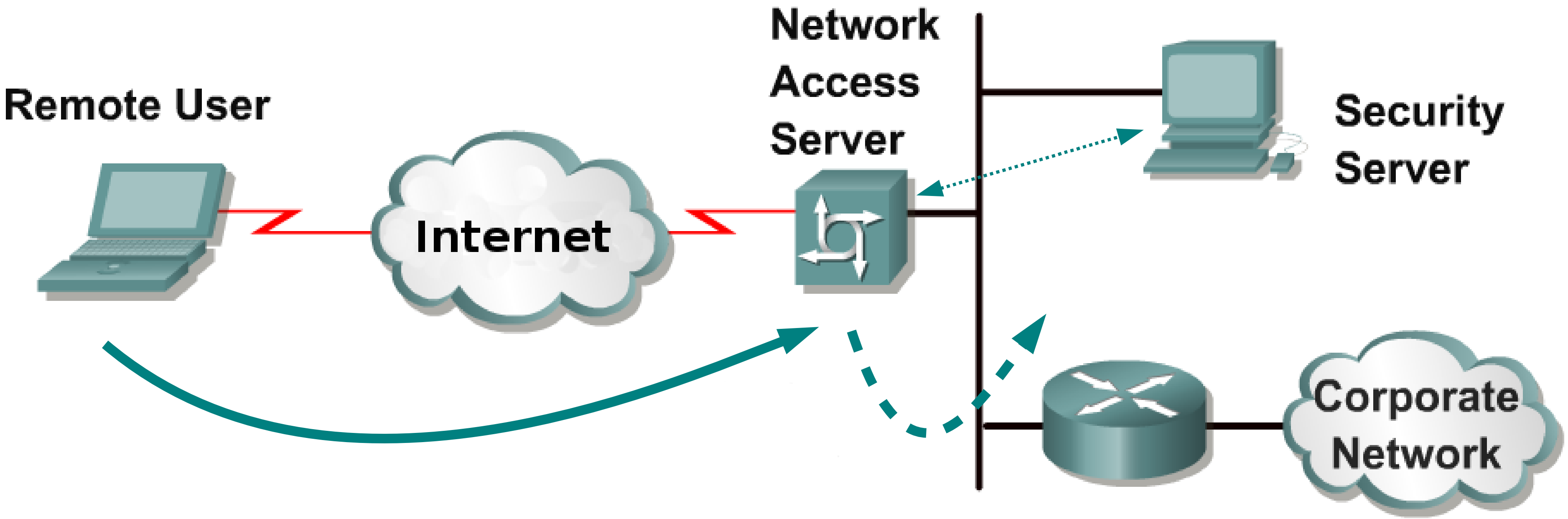
ISAKMP and IPsec – Phases/Modes

- ISAKMP modes control an efficiency versus security tradeoff during initial key exchange
- Phase 1
  - Peer agree on a set of parameters to be used to authenticate peers and to encrypt a portion of the phase 1 exchanges and all of phase 2 exchanges, authenticate peers, and generate keys to be used as generating keying material.
  - Main mode
    - Requires six packets back and forth
    - Provides complete security during the establishment of an IPsec connection
    - Aggressive mode is an alternative to main mode
      - Uses half the exchanges, but provides less security because some information is transmitted in cleartext
- Phase 2 - Quick mode
  - Peers negotiate and agree on parameters required to establish a fully functional IPsec communication service.



Authentication Protocols

Remote authentication



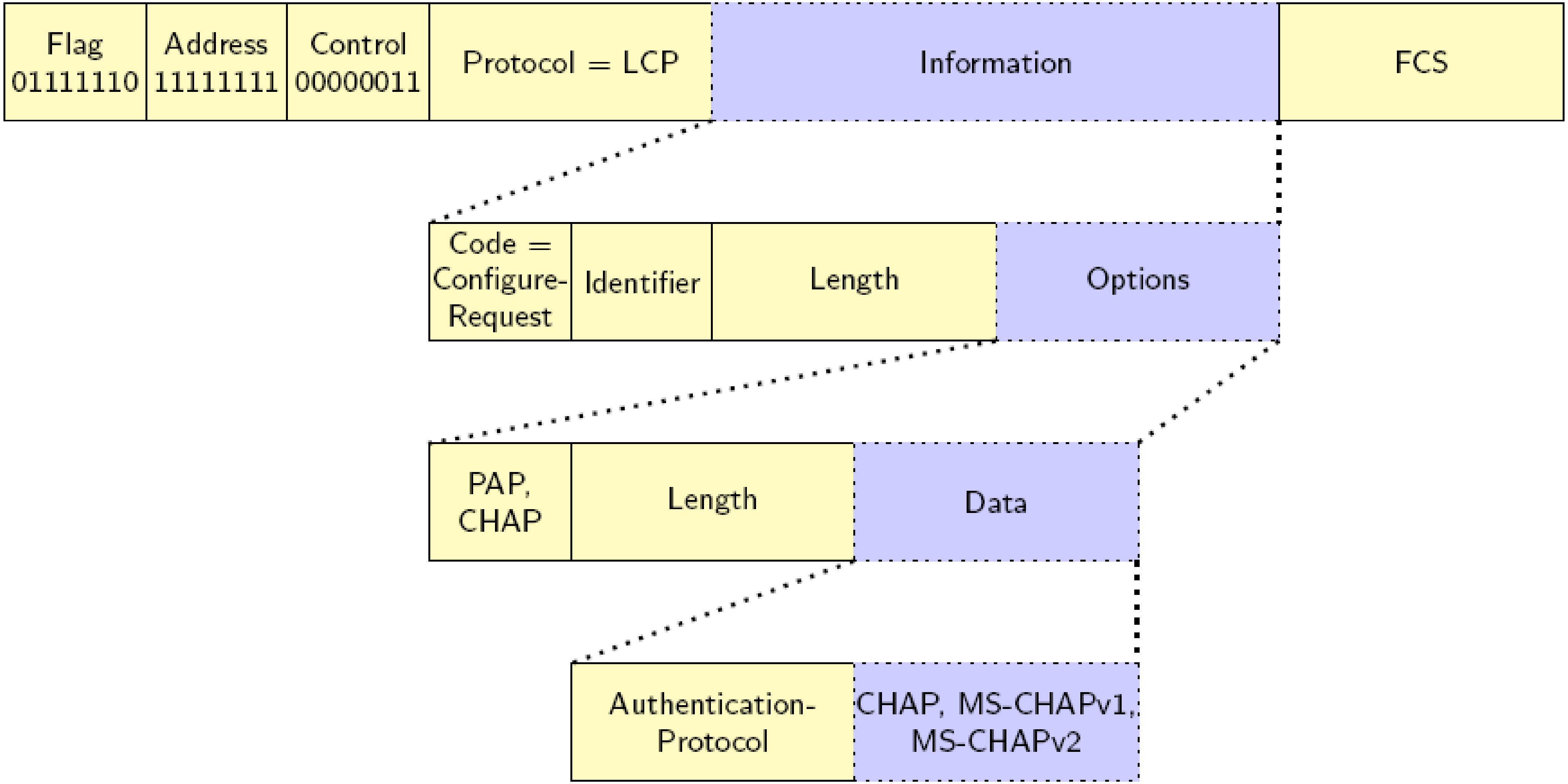
- Authentication is the security process that validates the claimed identity of an entity
  - Relying on one or more characteristics specific to that entity
- The authentication process involves at least two entities:
  - The one to be authenticated
  - The one requiring authentication (Network access server)

PPP - Point to Point Protocol

- The Point-to-Point Protocol (PPP) emerged as an encapsulation protocol for transporting IP traffic over point-to-point links
- Defines a virtual point-to-point connection
- In conjunction with the Link Control Protocol (LCP) and a family of Network Control Protocols (NCPs) supports
  - Link configuration, quality testing and error detection
  - Assignment and management of IP addresses
  - Network layer address negotiation
  - Network protocol multiplexing
  - Data-compression negotiation
  - Authentication configuration
- PPP Frame

Flag 01111110	Address 11111111	Control 00000011	Protocol	Information	FCS

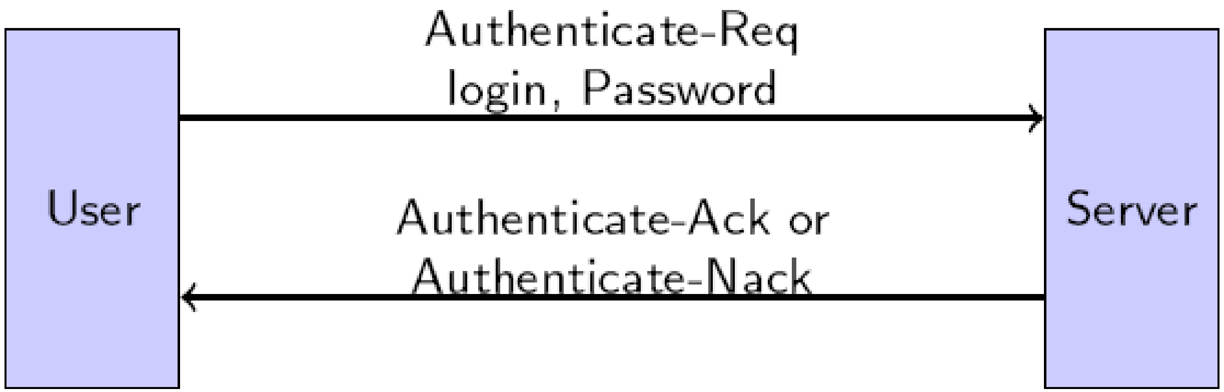
PPP - Authentication Configuration

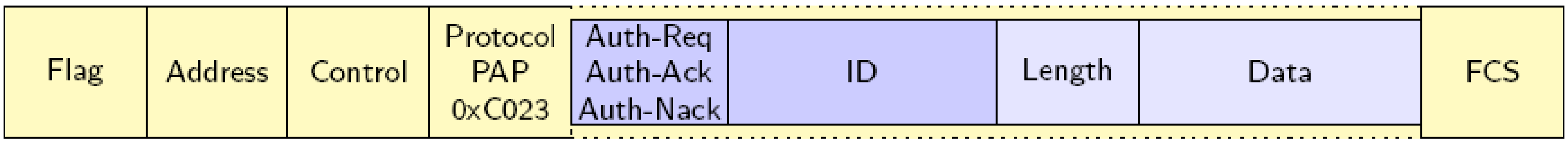


- Confirmation is made using a response with the code "Configure-Ack"

PAP - Password Authentication Protocol

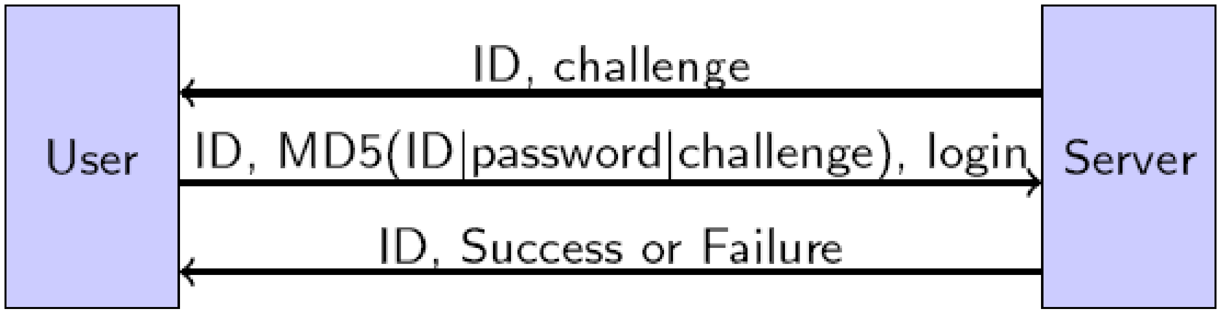
- Is a Link Control Protocol in the PPP suite
- Provides a basic method for peer authentication using a 2-way handshake
- PAP is not a strong authentication method passwords are transmitted "in the clear"
- After the link establishment phase is complete, the login and password are sent repeatedly by the peer to the authenticator until authentication is acknowledged or the connection is terminated

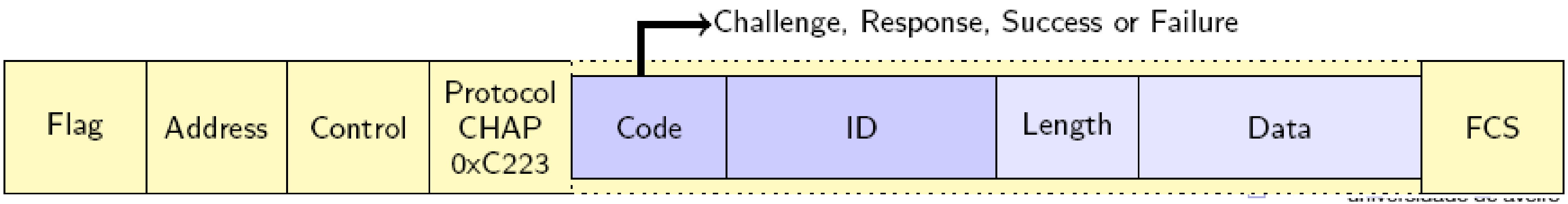




CHAP – Challenge-Handshake Authentication Protocol

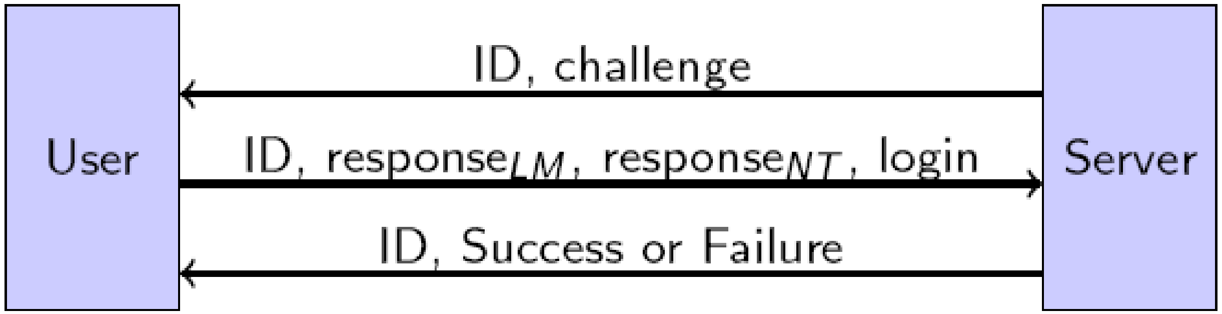
- Used to periodically verify the identity of a peer using a 3-way handshake
- After the Link Establishment phase is complete
  - The server sends a "challenge" message to the peer
  - The peer responds with an hash value (MD5)
  - The server checks the response against its own calculation of the expected hash value
- At random intervals, the server sends a new challenge to the peer





MS-CHAP version 1

- Microsoft version of the CHAP
- Differences from CHAP
  - Designed for compatibility with Microsoft's Windows NT 3.5, 3.51 and 4.0, and
  - Microsoft networking products (e.g LAN Manager)
  - Provides a password change mechanism
  - Provides an authentication retry mechanism
  - Defines a set of failure codes returned in the Failure packet Message field



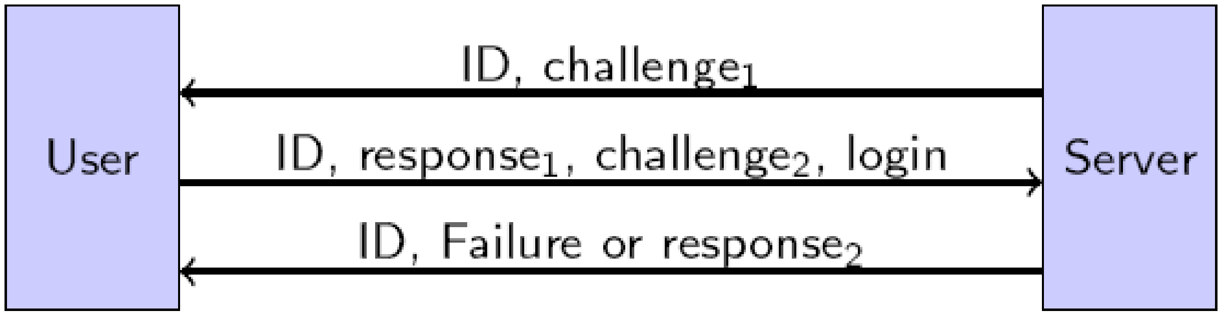
  - $response_{LM}$ = $DESkey_{LM}$ (challenge), key_{LM} = DES_{hash}(password)
  - $response_{NT}$ = $DESkey_{NT}$ (challenge), key_{NT} = MD4(password)

MS-CHAP version 1 - Issues

- LAN Manager encoding of the response used for backward compatibility is cryptographically weak
- Only one-way authentication is possible
- The key is based on the password. Each time the user connects with the same password, the same cryptographic key is generated

MS-CHAP version 2

- Diferences from MS-CHAPv1
  - MS-CHAPv2 no longer allows LAN Manager encoded responses or password changes
  - Provides two-way authentication (mutual authentication)



$response_1$ = DES_{keyNT} (SHA-1($challenge_2$|$challenge_1$|login))

key_{NT} =MD4(password)

$response_2$ = SHA-1 (SHA-1(H|response1|M_1)|D|M_2)

H=MD4(key_{NT})

D=SHA-1($challenge_2$|$challenge_1$|login)

M_1 and M_2 are constants

TLS - Transport Layer Security Protocol

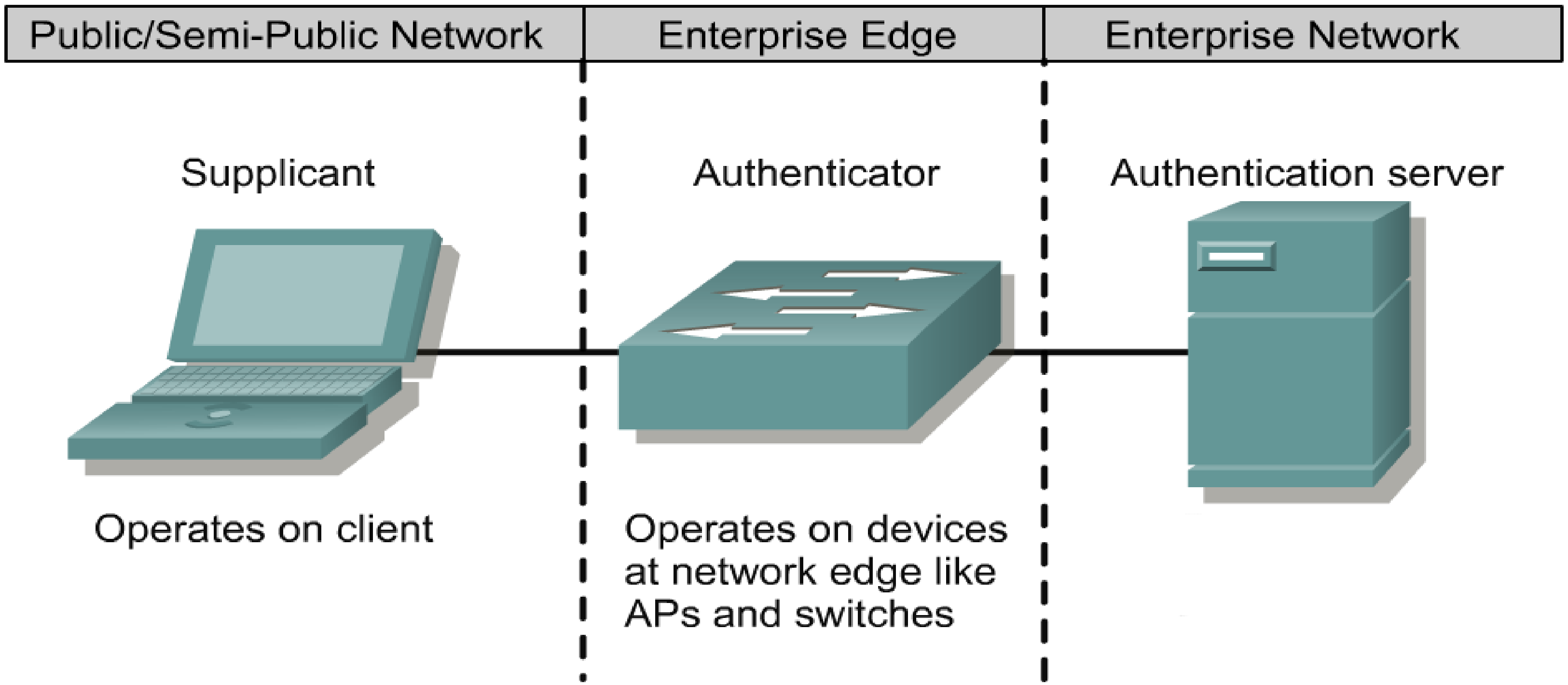
- Standardization of the SSL protocol proposed by Netscape
  - Added HMAC
- Provide privacy and data integrity between two communicating applications
- The protocol is composed of two layers
  - TLS Handshake Protocol
  - TLS Record Protocol
- TLS Handshake Protocol
  - Allows the server and client to authenticate each other and to negotiate an encryption algorithm and cryptographic keys
- TLS Record Protocol properties
  - The connection is private
  - The connection is reliable

EAP - Extensible Authentication Protocol

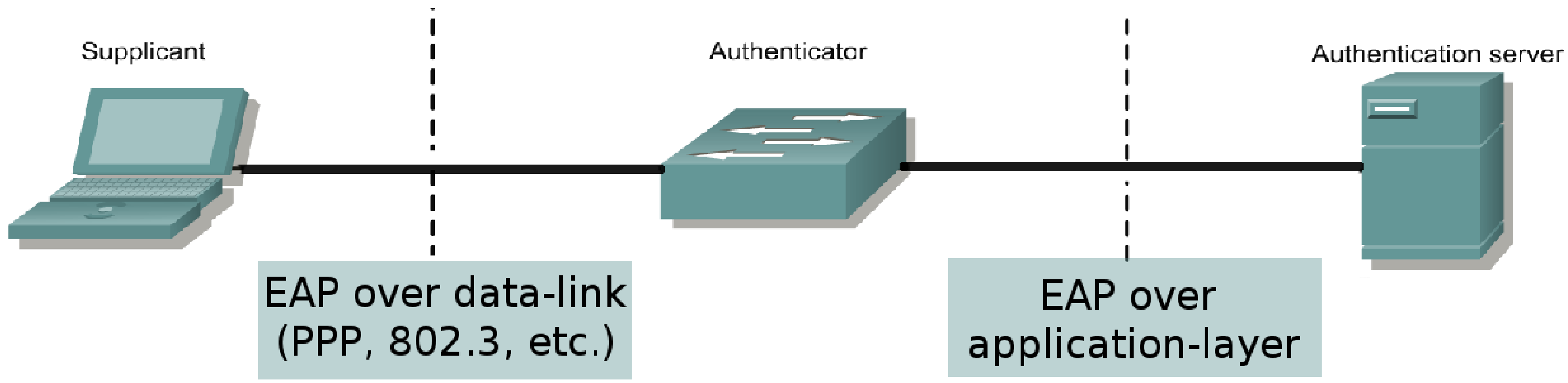
- Was designed to supplement PPP
- Provides a generalized framework for several different authentication methods
- More common methods:
  - EAP-PSK - Mutual authentication and session key derivation using a Pre-Shared Key (PSK)
  - EAP-TLS - Uses PKI to secure communication to authentication server
  - PEAP - Protected EAP (PEAP) allows hybrid authentication. PEAP employs server-side PKI authentication. For client-side authentication, PEAP can use any other EAP authentication type.
  - EAP-TTLS -Client does not need be authenticated via a PKI certificate to the server, but only the server to the client
  - LEAP - Cisco's proprietary EAP method. Uses a modified version of MS-CHAP
- EAP over LAN (EAPoL) used in 802.1x

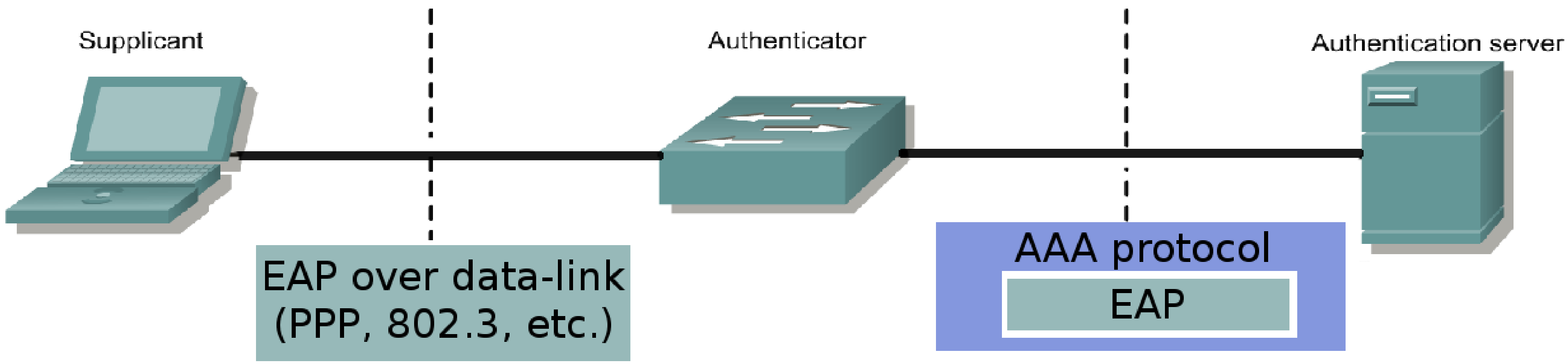
802.1x

- IEEE 802.1X is an IEEE Standard for Network Access Control (NAC)
- It provides an authentication mechanism to devices wishing to attach to a LAN
- It's based on the Extensible Authentication Protocol (EAP)



802.1x


Supplicant
Authenticator
Authentication server
EAP over data-link
(PPP, 802.3, etc.)
EAP over
application-layer


Supplicant
Authenticator
Authentication server
EAP over data-link
(PPP, 802.3, etc.)
AAA protocol
EAP

Authentication, Authorization and Accounting

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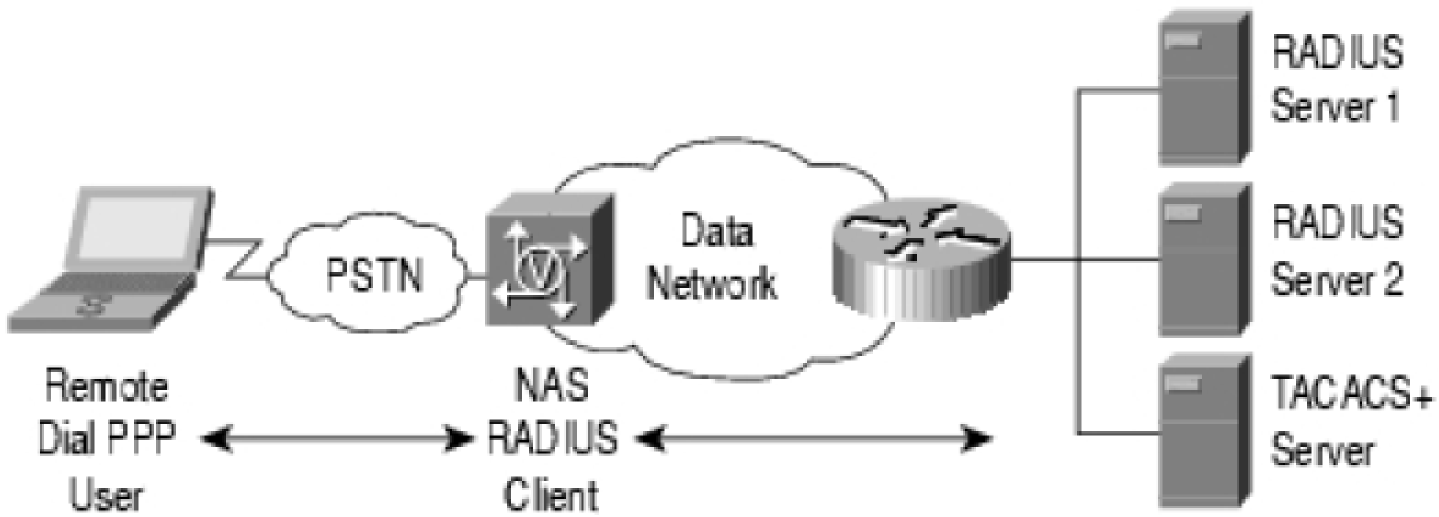
AAA Architecture

- Enables systematic access security
  - Authentication identies a user
  - Authorization determines what that user can do
  - Accounting monitors the network usage time for billing purposes
- Work with the network access server (NAS)
- AAA information is typically stored in an external database or remote server
- Traditional AAA Implementation



TACACS+

- Terminal Access Controller Access Control System Plus
- Forwards username and password information to a centralized security server
- Centralized server can be either a TACACS database or a database like the UNIX password le with TACACS support
- Features
  - Separates all AAA functionalities
  - Uses TCP
  - Bidirectional authentication
  - All packet is encrypted
  - Limited accounting customization

RADIUS

- Remote Authentication Dial-In User Service
- Network access server (NAS) operates as a client of RADIUS
- RADIUS servers are responsible for
  - Receiving user connection requests
  - Authenticating the user
  - Return all configuration information necessary for the client to deliver service to the user
- Transactions between the client and RADIUS server are authenticated using a shared secret
- Supports a variety of methods to authenticate a user
  - PAP, CHAP, or MS-CHAP, UNIX login, and other authentication mechanisms
- Combines Authentication and Authorization. Separates Accounting (less flexible than TACACS+)
- Uses UDP (less robust)
- Unidirectional authentication
- Only encrypts the password (less secure)
- RADIUS accounting can hold more information

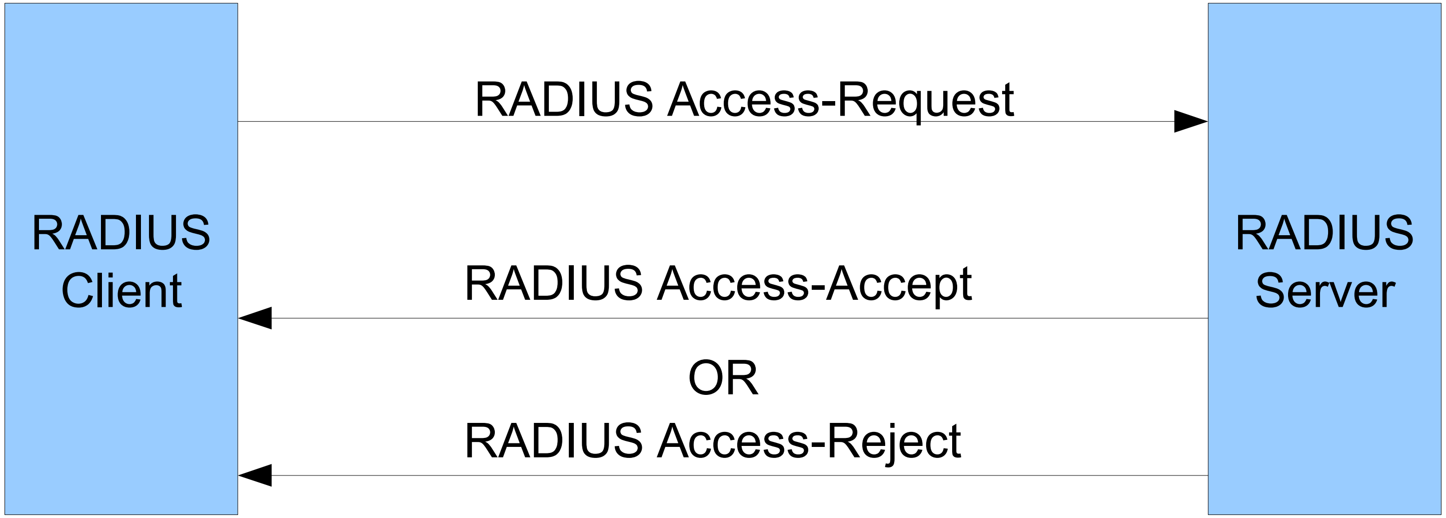
RADIUS Packet

Code (1 byte)	Identifier (1 byte)	Length (2 bytes)
Authenticator (16 bytes)		
Attributes		

- Code - Identifies the type of RADIUS packet
  - (1) Access-Request, (2) Access-Accept, (3) Access-Reject, (4) Accounting-Request, (5) Accounting-Response and (11) Access-Challenge
- Identifier - Allows the RADIUS client to match a RADIUS response with the correct pending request (usually is implemented as a counter)
- Authenticator
  - In client Requests – Random value
  - In server Responses - MD5 Hash function of (Code,ID,Length,Request Auth,Attributes,Shared Secret)
- Attributes - Section where an arbitrary number of attribute fields can be sent (e.g. User-Name and User-Password attributes)

RADIUS Protocol (1)

Example - RADIUS exchange involving just a username and user password:



- Only password is encrypted
  - The shared secret followed by the Request Authenticator is put through an MD5 hash to create a 16 octet value which is XORed with the password entered by the user
  - If the user password is greater than 16 octets, the password is broken into 16-octet blocks and additional MD5 calculations are performed

RADIUS Protocol (2)

- The RADIUS protocol has a set of vulnerabilities
  - The Access-Request packet is not authenticated at all.
  - Many client implementations do not create Request Authenticators that are sufficiently random.
  - Many administrators choose RADIUS shared secrets with insufficient information entropy and many implementations limit the shared secret key space.

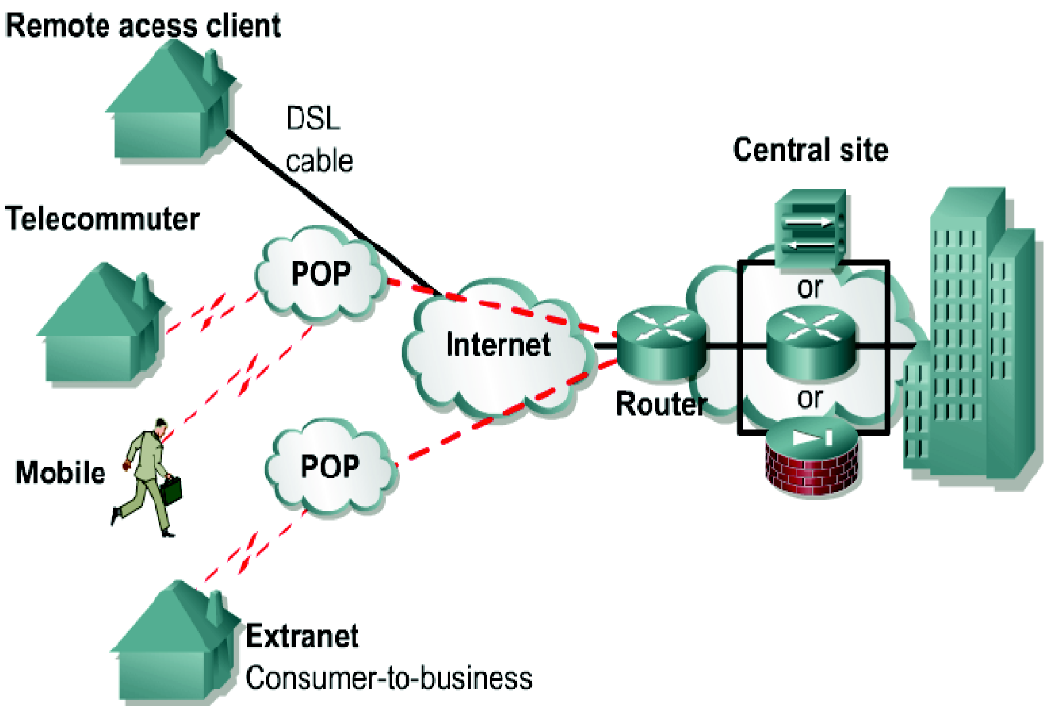
DIAMETER

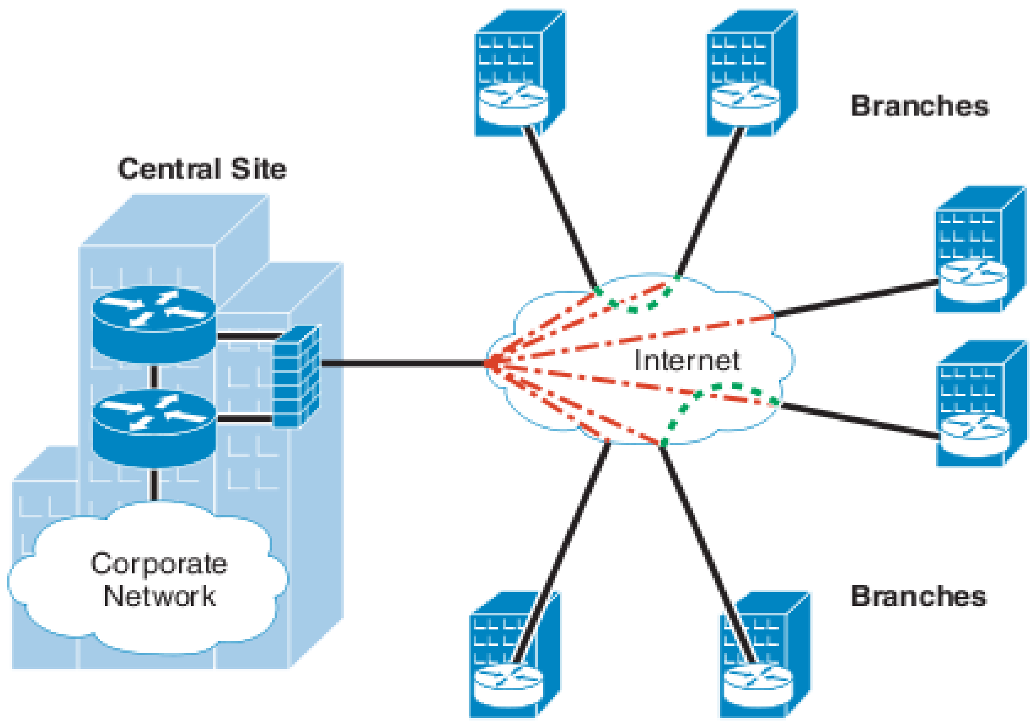
- DIAMETER is a newest framework in IETF for the next-generation AAA server
- Provides an AAA framework for Mobile-IP
- Does not use the same RADIUS protocol data unit, but is backward compatible with RADIUS to ease migration
- Bidirectional authentication
- It uses UDP but has a scheme that regulates the flow of packets
- Challenge/response attributes can be secured using end-to-end encryption and authentication
- Supports end-to-end security

Virtual Private Networks (VPN)

VPN - Virtual Private Networks

- Is an encrypted connection between private networks over a public network





- Remote Access VPN
- Site-to-Site VPN

VPN types

- Remote Access VPN
  - PPTP
  - L2TP/IPsec
  - SSL/TLS VPN
    - Web VPN (client-less SSL VPN) – VPN client can be a standard browser
  - SSH VPN
  - Open VPN
- Site-to-Site VPN
  - IPsec VPN
    - With static or dynamic configuration
  - IPsec + GRE VPN
    - Dynamic Multipoint VPN

Remote Access VPN - PPTP VPN

- Based on PPTP
  - PPTP packages data within PPP packets
  - Encapsulates the PPP packets within IP packets
- Uses a form of General Routing Encapsulation (GRE) to get data to and from its final destination
- Supports authentication based on protocols PAP, EAP, CHAP, MS-CHAPv1 and MS-CHAPv2
- Uses MPPE as cipher
  - Has two different keys (one for each direction)
  - Requires MS-CHAPv2 authentication
  - Keys derived from the MS-CHAPv2's password hash and challenges
- PPTP creates a TCP control connection between the VPN client and VPN server to establish a tunnel
  - Uses TCP port 1723 for these connections
- PPTP can support only one tunnel at a time for each user

Remote Access VPN - L2TP/IPSec VPN

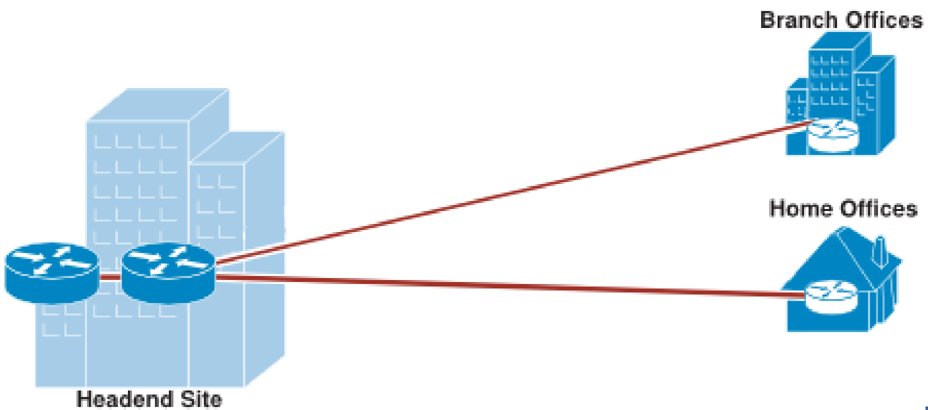
- Authentication can be performed with Digital Certificates (RSA) or with the same PPP authentication mechanisms as PPTP
- Provides data integrity, authentication of origin and replay protection
- Encryption provided by IPSec (ESP protocol)
- Can support multiple, simultaneous tunnels for each user
- Slower performance than PPTP

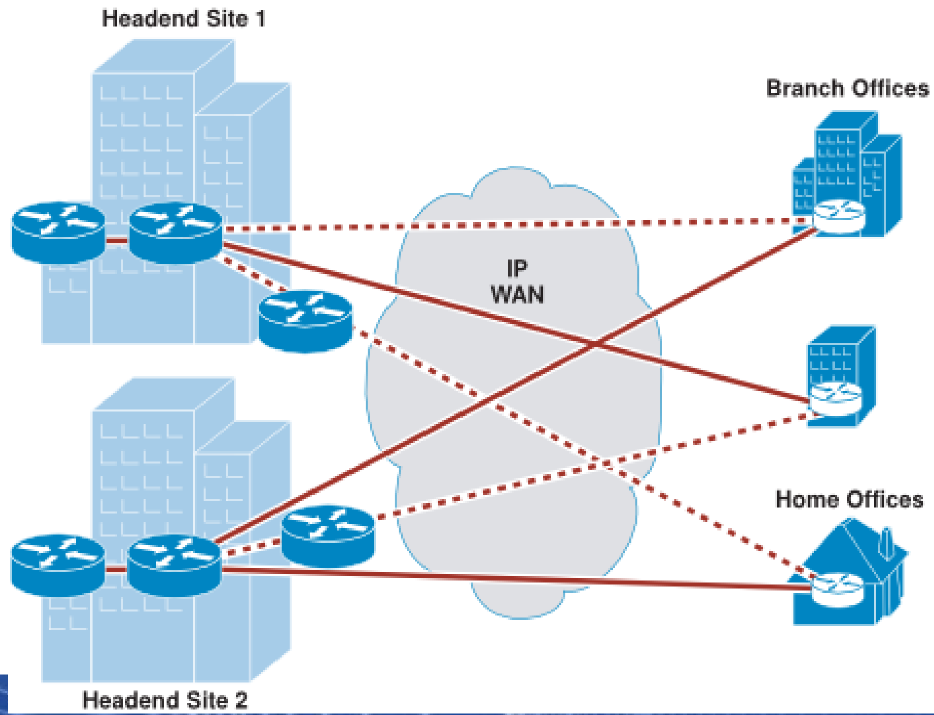
Other Remote Access VPN types

- SSL/TLS VPN
  - SSL/TLS protocol handles the VPN tunnel creation
  - SSL/TLS is much easier to implement than IPSec and provides a simple and well-tested platform
  - RSA handshake (or DH) is used exactly as IKE in IPSec
- SSH VPN
  - VPN over a SSH connection
  - SSH tunneling - port forwarding
- OpenVPN
  - Implements a SSL/TLS VPN
  - Allows PSK, certicate, and login/password based authentication
  - Encryption provided by OpenSSL (can use all ciphers available)
  - Compatible with dynamic and NAT addresses

Variants of Site-to-Site IPsec VPN

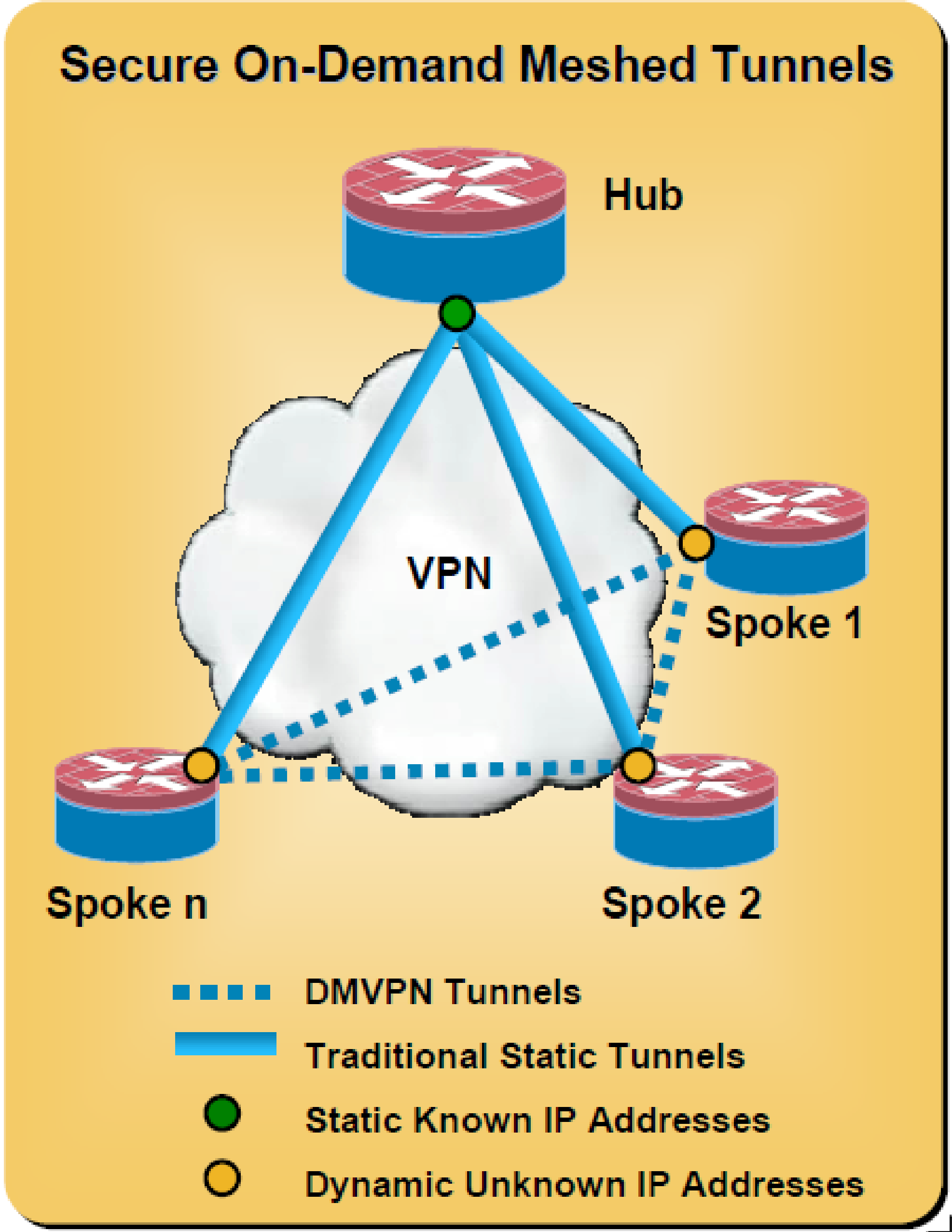
- IPsec tunnels with static configuration
  - Requires the knowledge of all peers (IP addresses and security parameters)
  - High configuration overhead
- IPsec tunnels with dynamic configuration (at the headend/hub)
  - Hub + spokes configuration
  - Generic configuration at the headend/hub
  - Easy to add new spokes
- → A basic IPsec tunnel can't protect multicast traffic.
- IPsec + GRE tunnels
  - Generic Routing Encapsulation (GRE) allows the protection of multicast traffic over IPsec
- Dynamic Multipoint VPN (DMVPN)





Dynamic Multipoint VPN

- Provides full meshed connectivity with simple configuration of hub and spoke
- Supports dynamically addressed spokes
- Facilitates zero-touch configuration for addition of new spokes
- Features automatic IPsec triggering for building an IPsec tunnel



Network Security Systems

Network Security Systems

- Firewall
- Intrusion Prevention System (IPS)
  - Performs deep-packet inspection
- Intrusion Detection Systems (IDS)
  - Performs deep-packet inspection
- Security Appliance
  - Unified communications security
  - Firewall services
  - Real-time threat defense
  - Secure remote access
  - Secure communications services
  - Content security

Firewalls

- A firewall provides a single point of defence between networks and protects one network from the others-
- It is a system or group of systems that enforces a control policy between two or more networks (access control, flow control and content control).
- It is a network gateway that enforces the rules of network security.
- Minimizes local vulnerabilities.
- Evaluates each network packet against the policies of network security.
- Can monitor all the network traffic and alert to any attempts to bypass security or to any patterns of inappropriate use.
- Can be hardware or software based.

Firewalls Security/Network Services

- NAT (Network Address Translation).
- Authorization
  - Flows (packet filtering).
  - Users (application and circuit level).
- Redirecting.
  - To specif machines.
  - Proxing.
- Content analysis.
- Secure communication.
  - Site-to-site VPN.
    - IPsec.
  - Remote-access VPN.
- DoS and DDoS detection and defense.

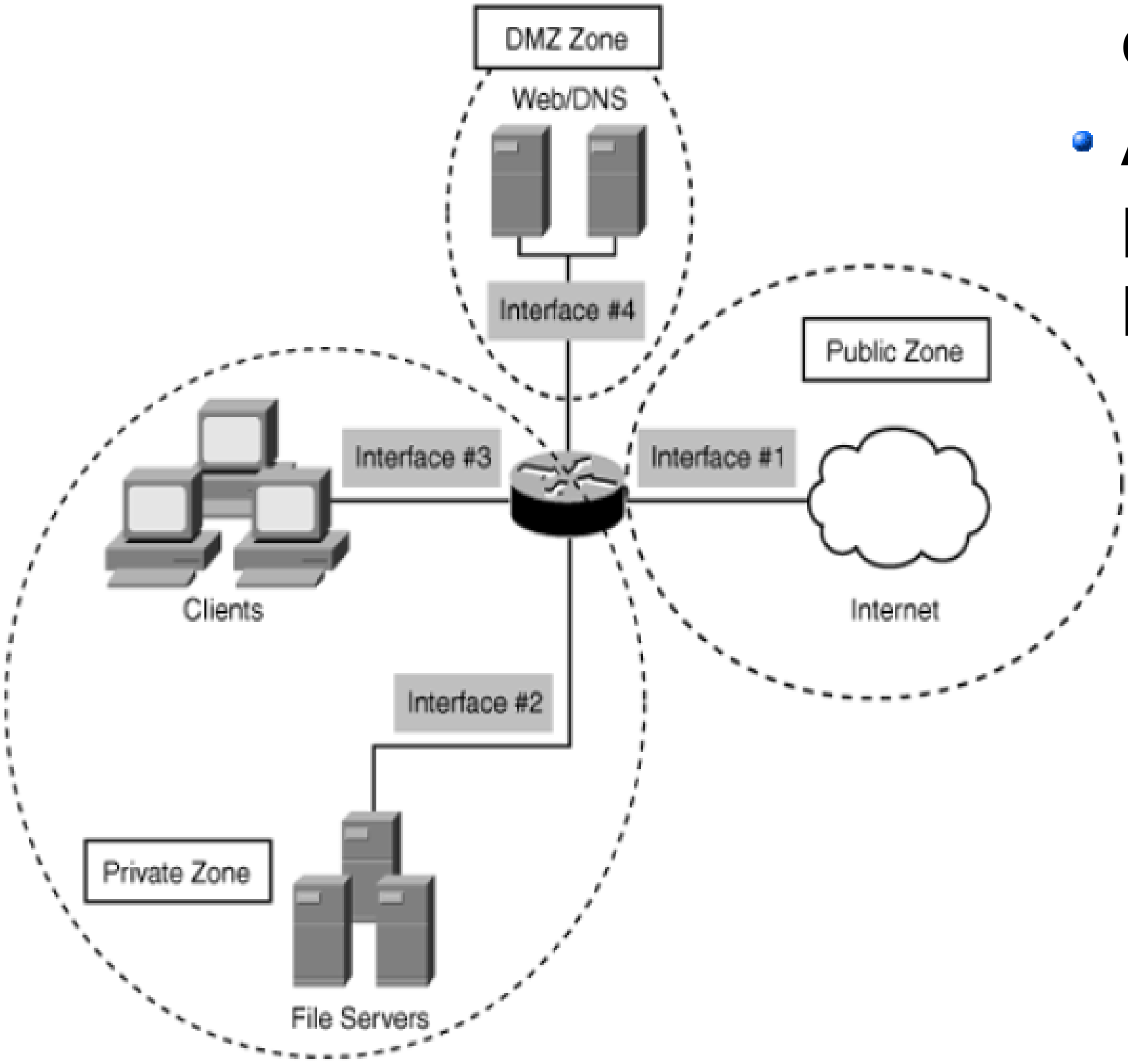
Types of Firewalls

- Network-Level Firewalls (L2/L3)
  - Packet filtering
  - Inspecting packet headers and filtering traffic based on
    - the IP address of the source and the destination, the port and the service (L3)
    - source and the destination MAC addresses (L2)
- Circuit-Level Firewalls (L4)
  - Monitor TCP handshaking between packets to make sure a session is legitimate
  - Traffic is filtered based on specified session rules
- Application-Level Firewalls (L4+)
  - Application-level firewalls are sometimes called proxies
  - Looking more deeply into the application data
  - Consider the context of client requests and application responses
  - Attempt to enforce correct application behavior and block malicious activity
  - Application-level filtering may include protection against Spam and viruses as well, and block undesirable Web sites based on content rather than just their IP address
  - Slow and resources consuming tasks
- Stateful Multi-level Firewalls (L*)
  - Filter packets at the network level and they recognize and process application-level data
  - Since they don't employ proxies, they have reasonably good performance even performing deep packet analysis
- Host Level / Personal Firewalls
  - Act only within a specif host
  - Filter all communication layers
  - Control OS processes/applications

Firewall Technologies (1)

- **Packet filtering systems** - Route packets between internal and external hosts, but do it selectively. The type of router used in a packet filtering firewall is known as a screening router.
- Problems:
  - Undesirable packets can be fitted to a packet rule criteria and, therefore, pass through the filter.
  - Packets can pass through the filter by being fragmented.
  - Complex rule sets are difficult to implement and maintain correctly.

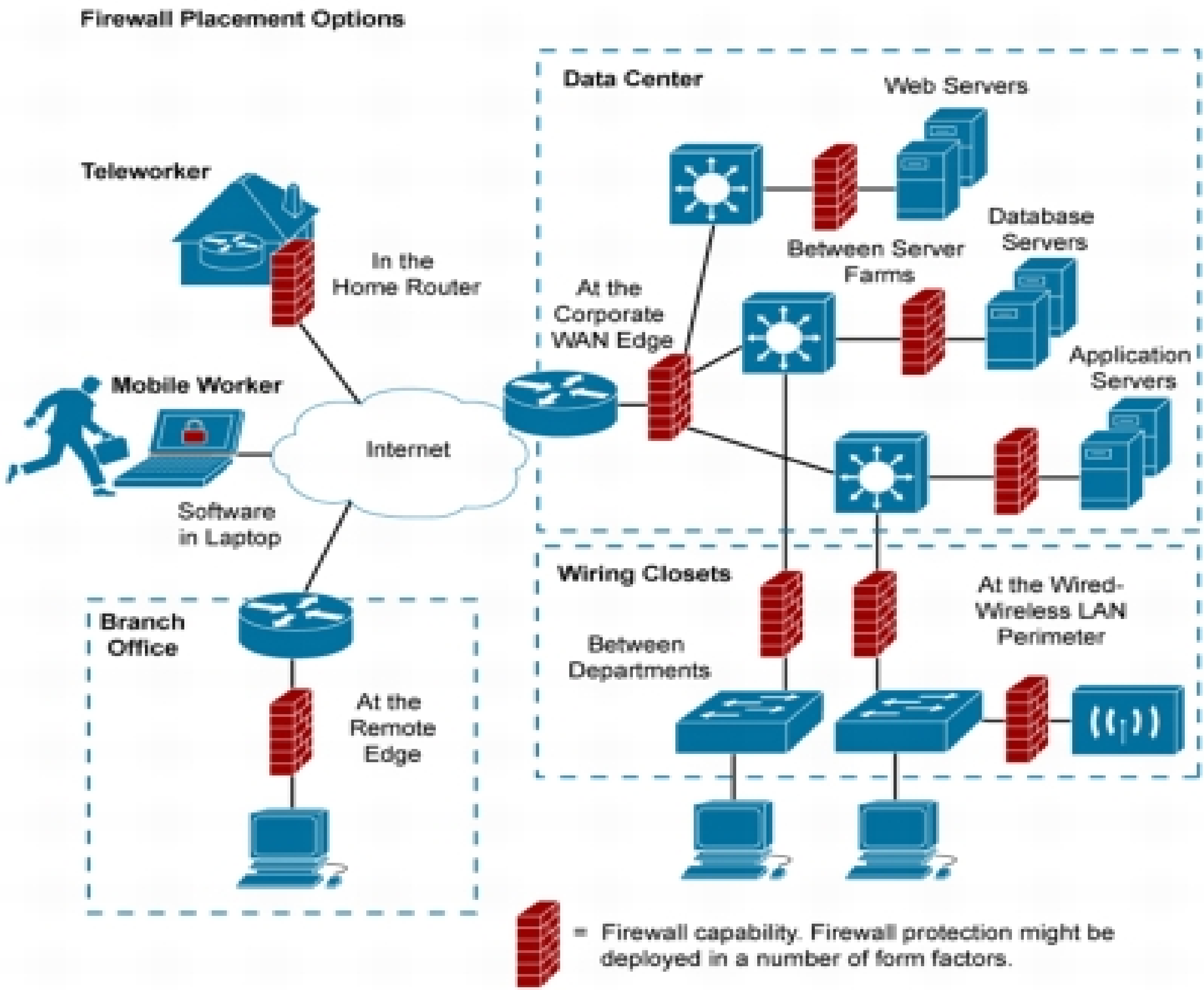
Secure Zones - Overview



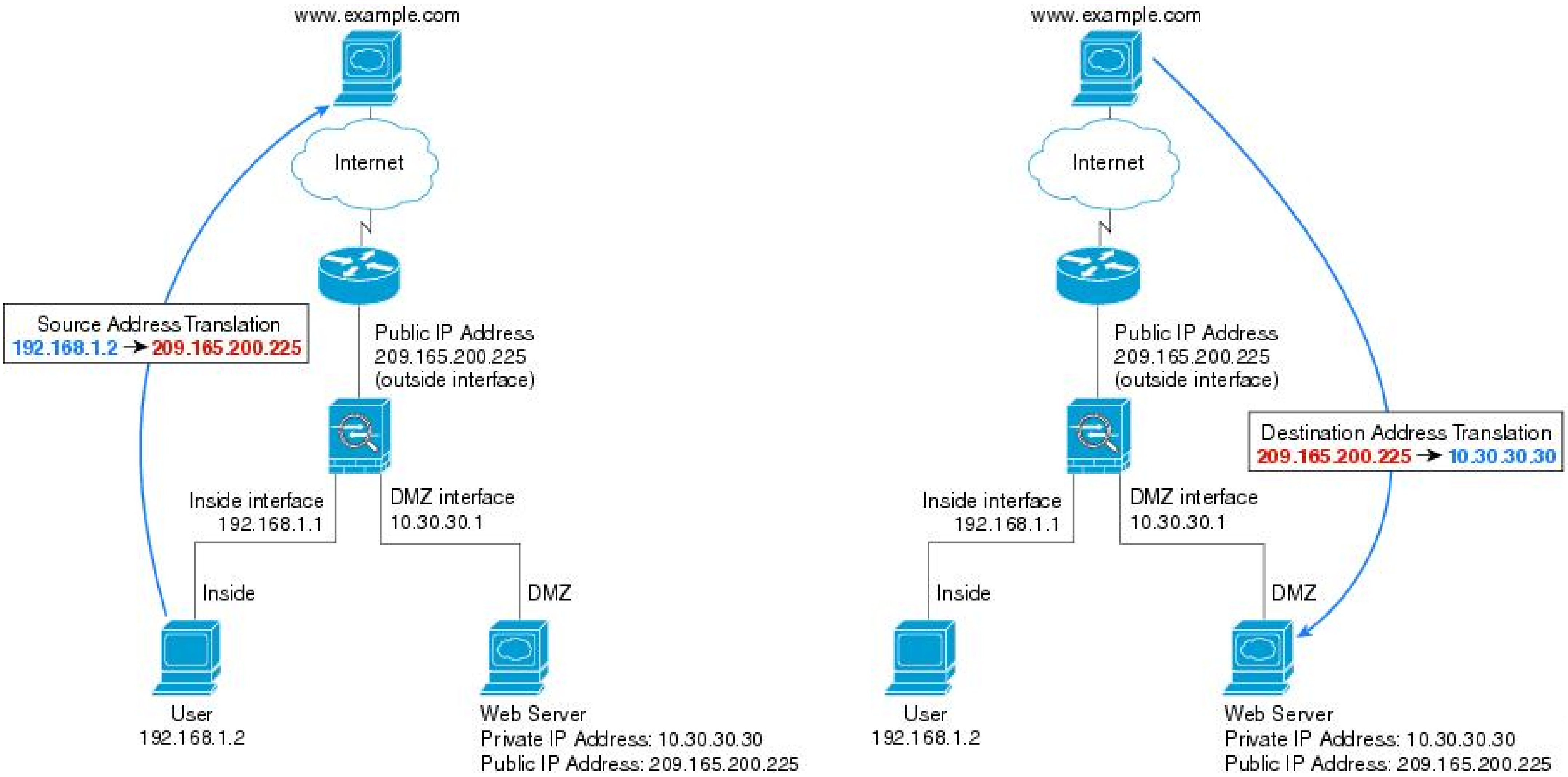
- A network can be divided in multiple secure zones with different security levels.
- A Demilitarized Zone (DMZ) is a perimeter network outside the protected internal/private network
  - Used to place public servers/services.
  - The DMZ is a "semi-protected" Zone.
    - It must be assumed that any machine placed on the DMZ is at risk.

Deploying Firewalls

- Network must be protected at multiple levels and locations



Example DMZ Network Topology

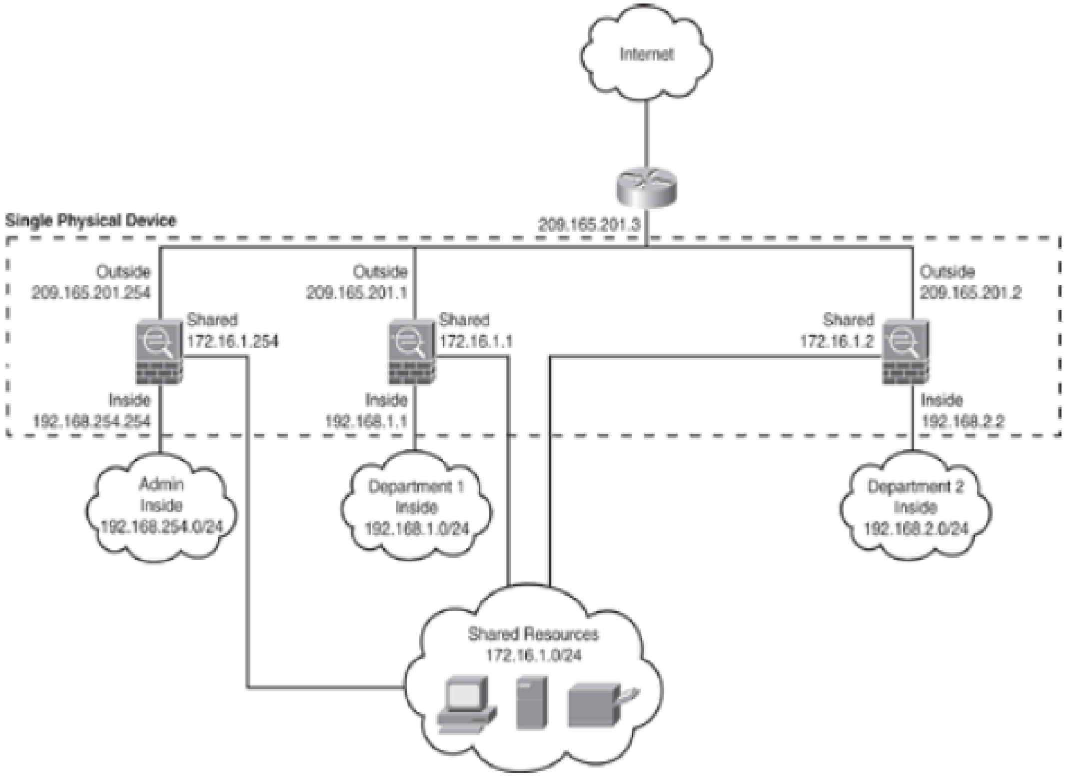


Multiple Security Contexts (1)

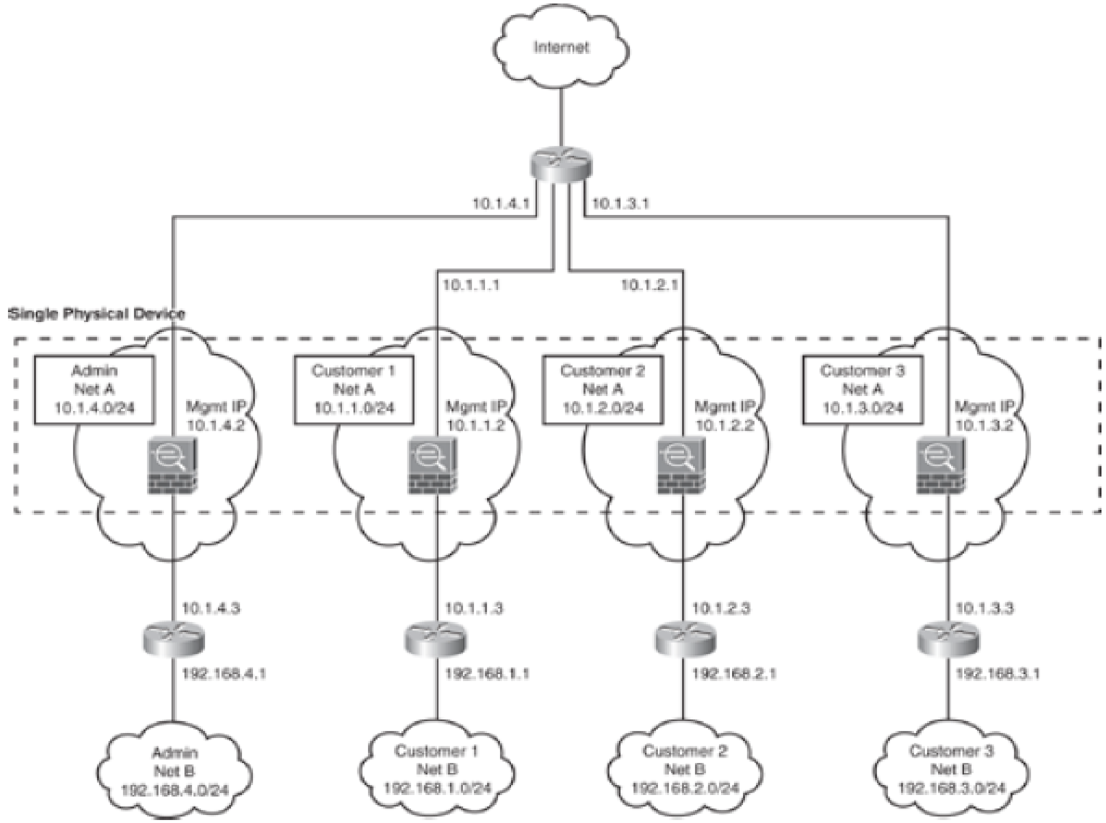
- Multiple security contexts can exist in these situations:
  - An ISP want to sell security services to many customers.
    - With multiple security contexts it is possible to an implement a cost-effective, space-saving solution that keeps all customer traffic separate and secure, and also eases configuration.
  - A large enterprise or a college campus want to keep departments completely separate.
  - An enterprise that wants to provide distinct security policies to different departments.
  - A network that requires more than one security appliance/firewall.

Multiple Security Contexts (2)

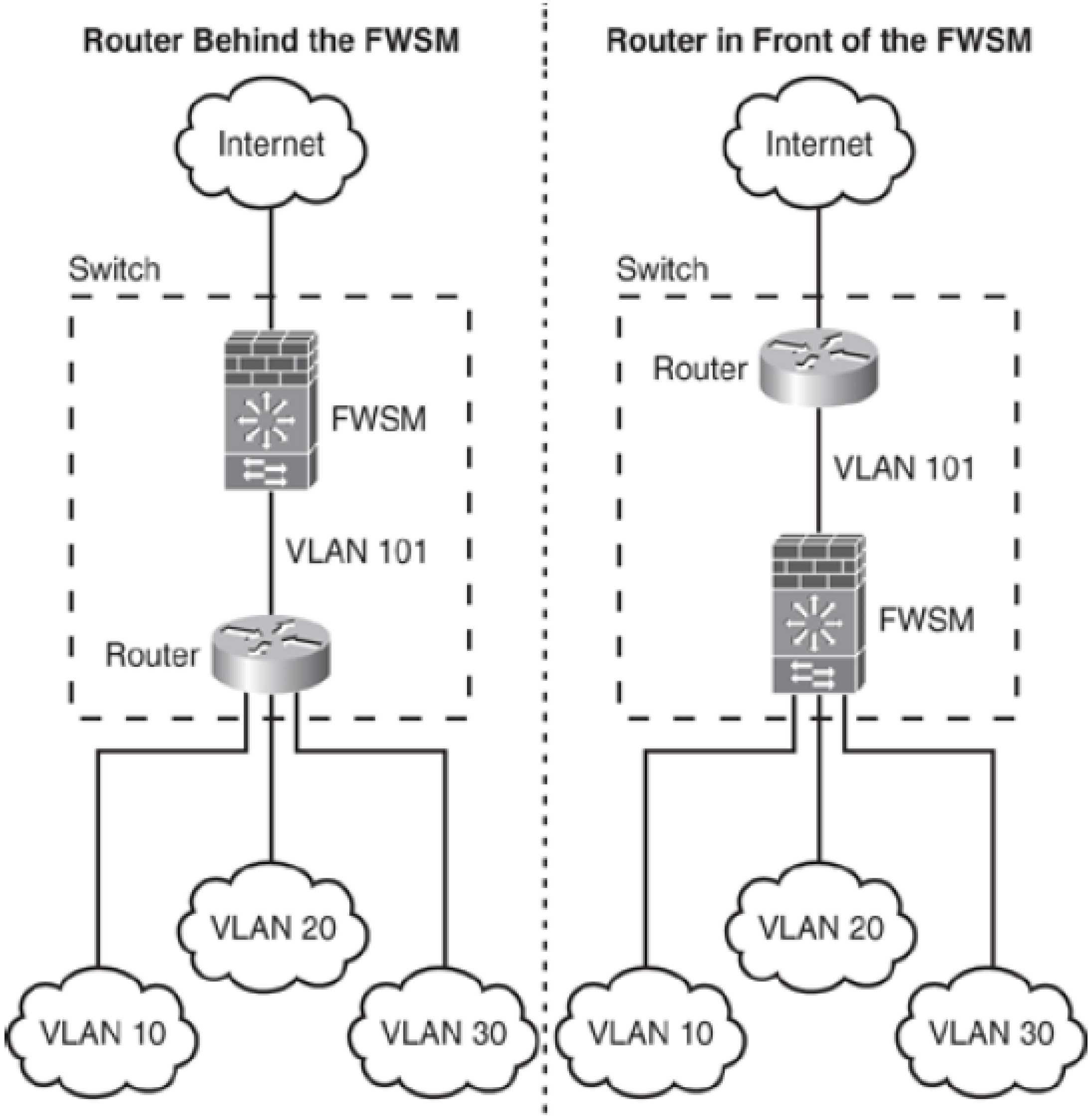
- Routed Mode
  (with Shared Resources)



- Transparent Mode

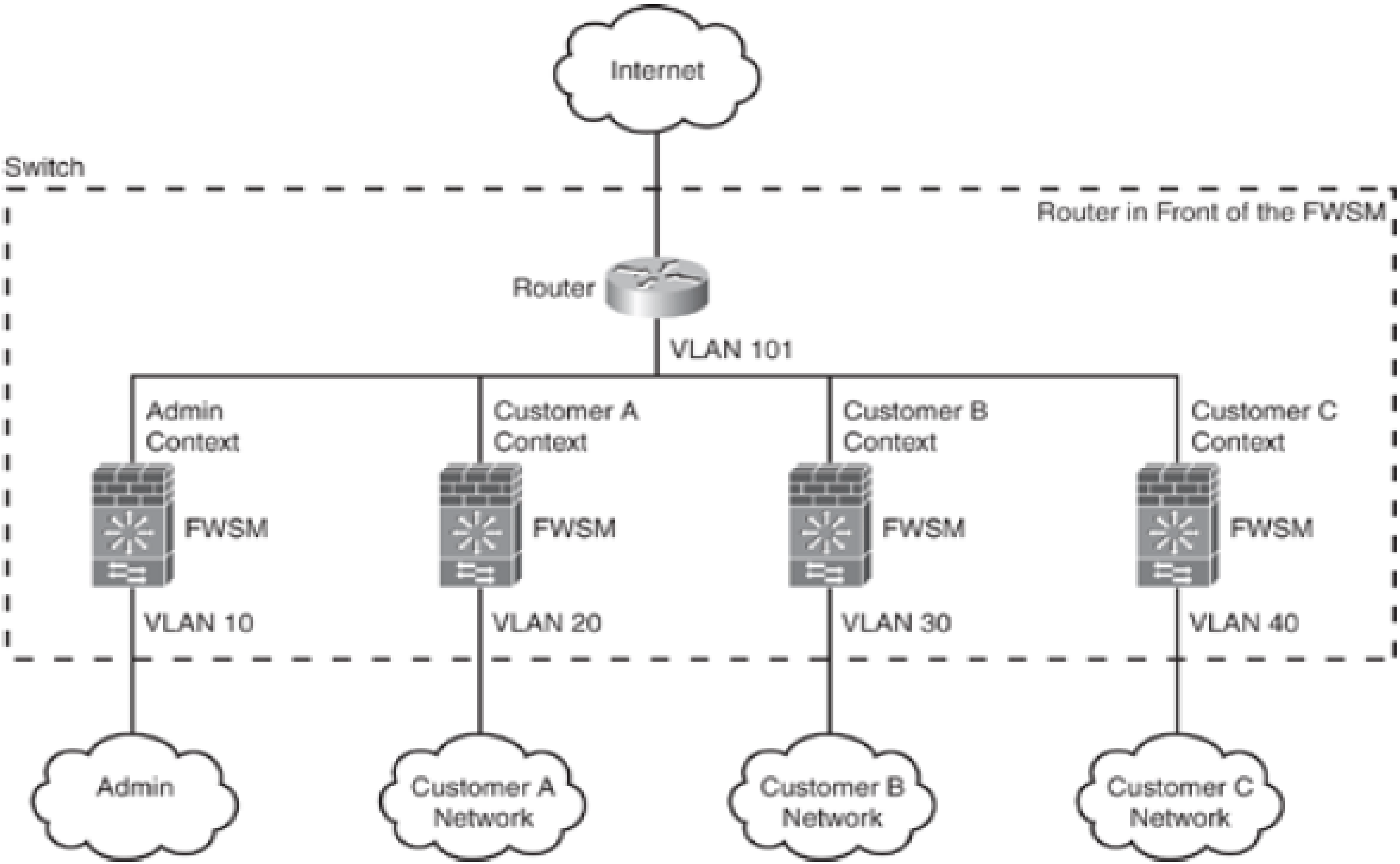


Firewall placement - In Single Context

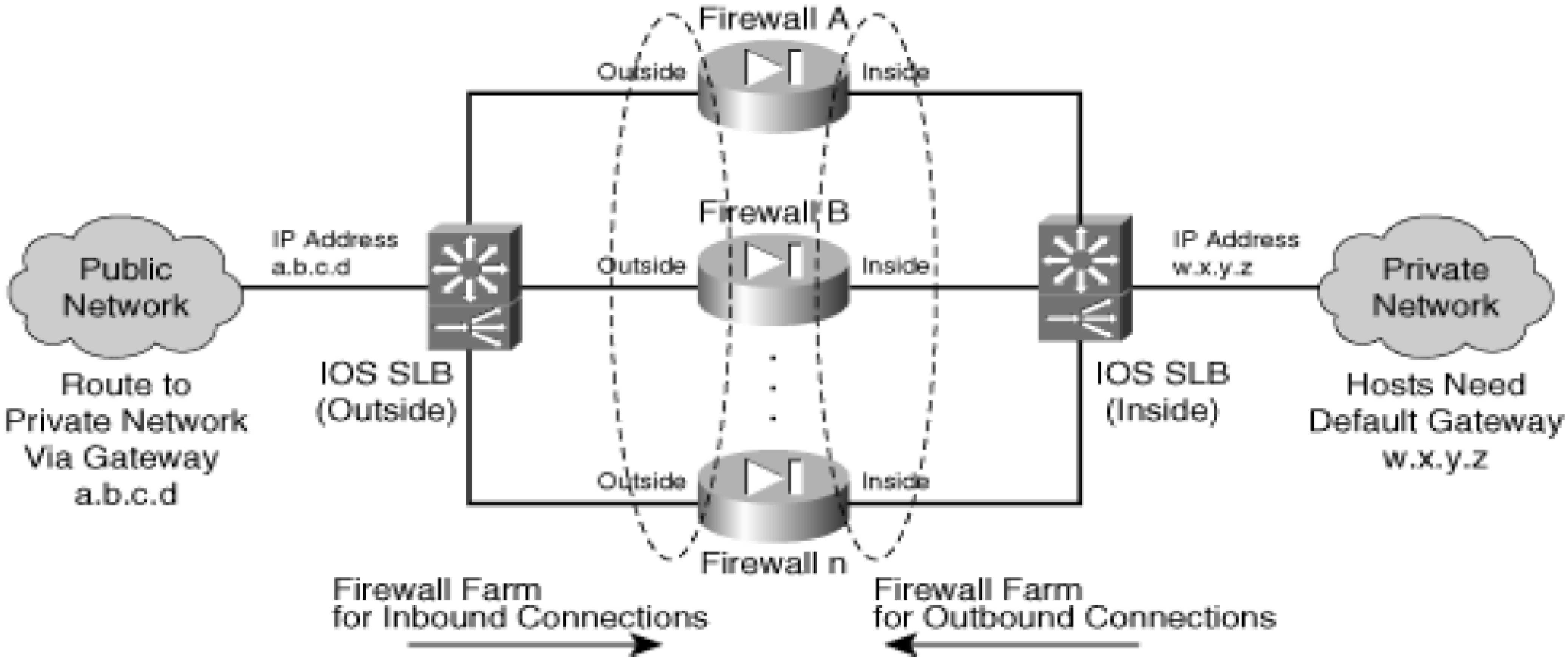


- Both solutions are acceptable!

Firewall placement - In Multiple Context



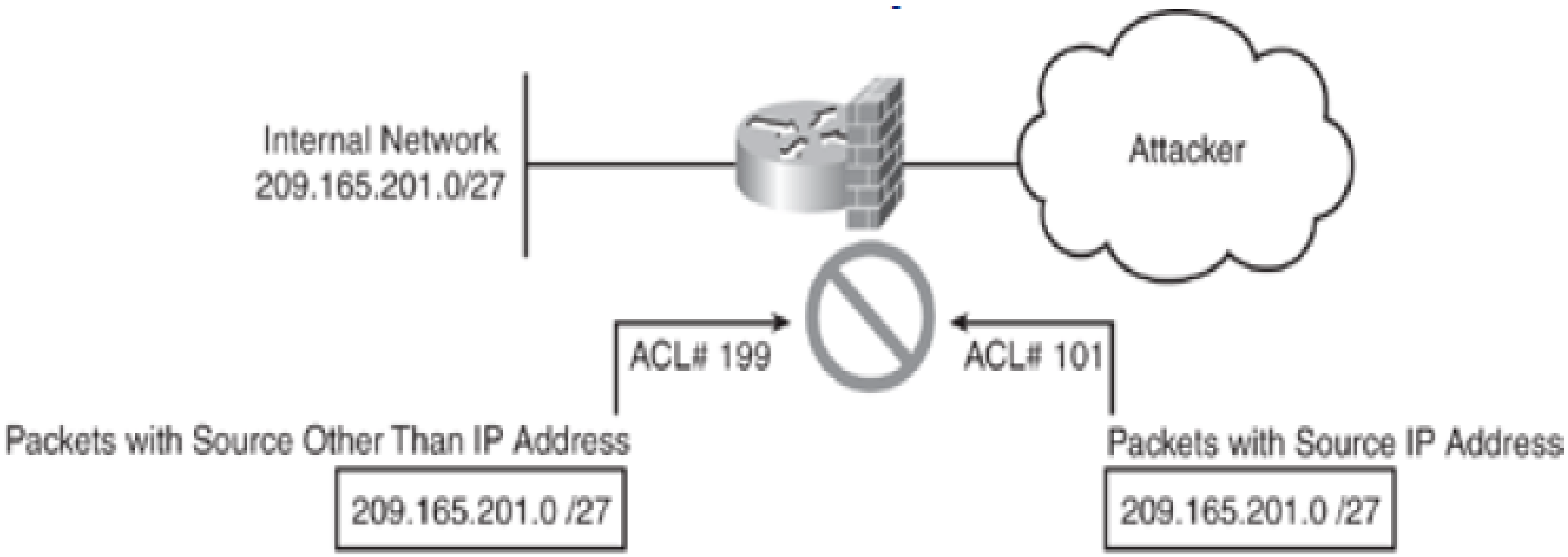
Firewall Load-Balancing Concept



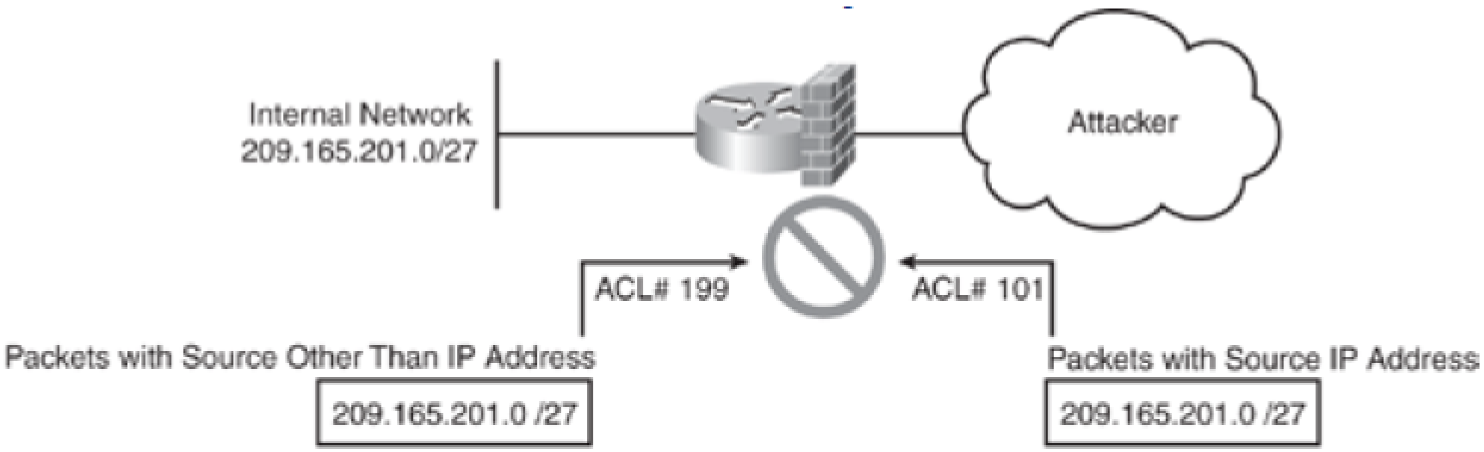
- Load-balancing equipments can distribute traffic by multiple firewalls.
  - Decrease processing and memory requirments of each firewall.
  - Makes the network less vulnerable to DoS attacks.

IP Spoofing

- IP spoofing refers to the creation of IP packets with a forged source IP address.
  - To hide the identity of the sender or impersonate another network system.
  - Spoofing IP datagrams is a well-known problem.
  - Most spoofing is done for illegitimate purposes.



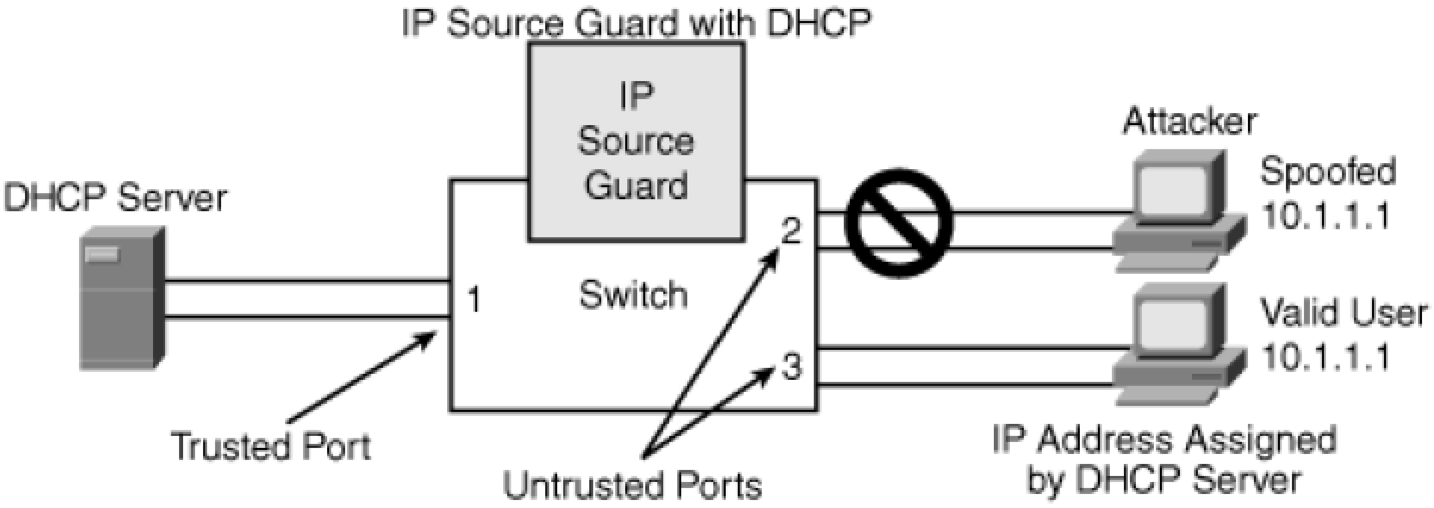
Preventing IP Spoofing



- Deny external traffic with
  - IP source equal to protected network IP ranges.
  - IP source equal to private addresses.
  - Multicast destinations.
- Reverse Path Verification
  - Deny traffic where the source IP network is not reachable using the interface where the packet arrived.

```
Interface interface-name
  ip access-group 101 in
  ip access-group 199 out
!
access-list 101 deny ip 209.165.201.0 0.0.0.31 any
access-list 101 deny icmp any any redirect
access-list 101 deny ip 224.0.0.0 31.255.255.255 any
access-list 101 deny ip 240.0.0.0 15.255.255.255 any
access-list 101 deny ip 127.0.0.0 0.255.255.255 any
access-list 101 deny ip host 0.0.0.0 any
access-list 101 deny ip 10.1.1.0 0.0.0.255 any
access-list 101 deny ip 172.16.0.0 0.15.255.255 any
access-list 101 deny ip 192.168.0.0 0.0.255.255 any
access-list 101 permit ip any any
!
access-list 199 permit ip 209.165.201.0 0.0.0.31 any
access-list 199 deny ip any any
```

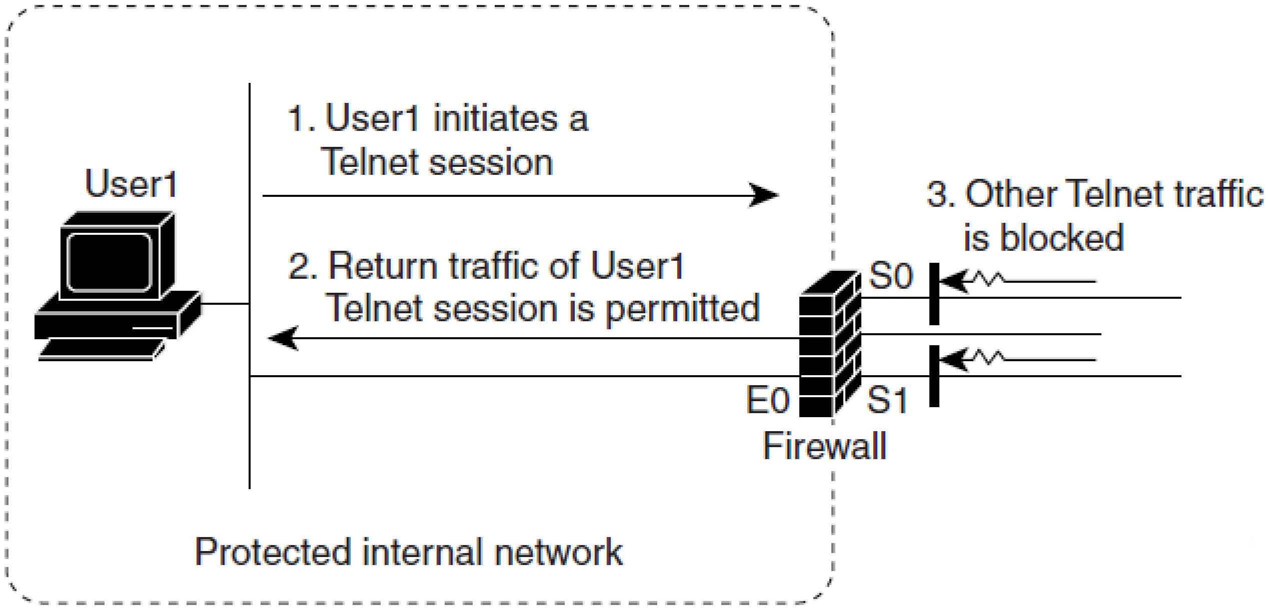
Preventing IP Spoofing with IP Source Guard



- IP Source Guard is a Layer 2 security feature that prevents IP spoofing attacks by restricting IP traffic on untrusted Layer 2 ports to clients with an assigned IP address.
- Works by filtering IP traffic with a source IP address other than that assigned via Dynamic Host Configuration Protocol (DHCP) or static configuration on the untrusted Layer 2 ports.
- Works in combination with the DHCP and is enabled on untrusted Layer 2 ports.

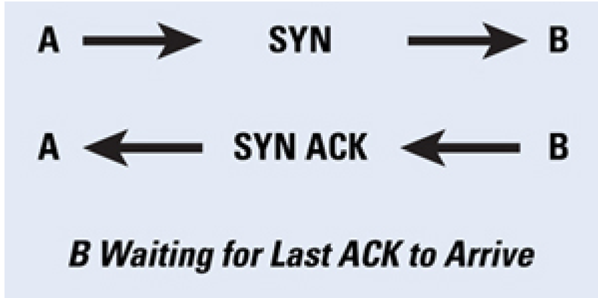
Context-Based Access Control (CBAC)

- CBAC intelligently filters TCP and UDP packets based on application-layer protocol session information
- Permit TCP and UDP traffic through a firewall only when the connection is initiated from within the network
- Without CBAC, traffic filtering is limited to implementations that examine packets only at the network layer and transport layer



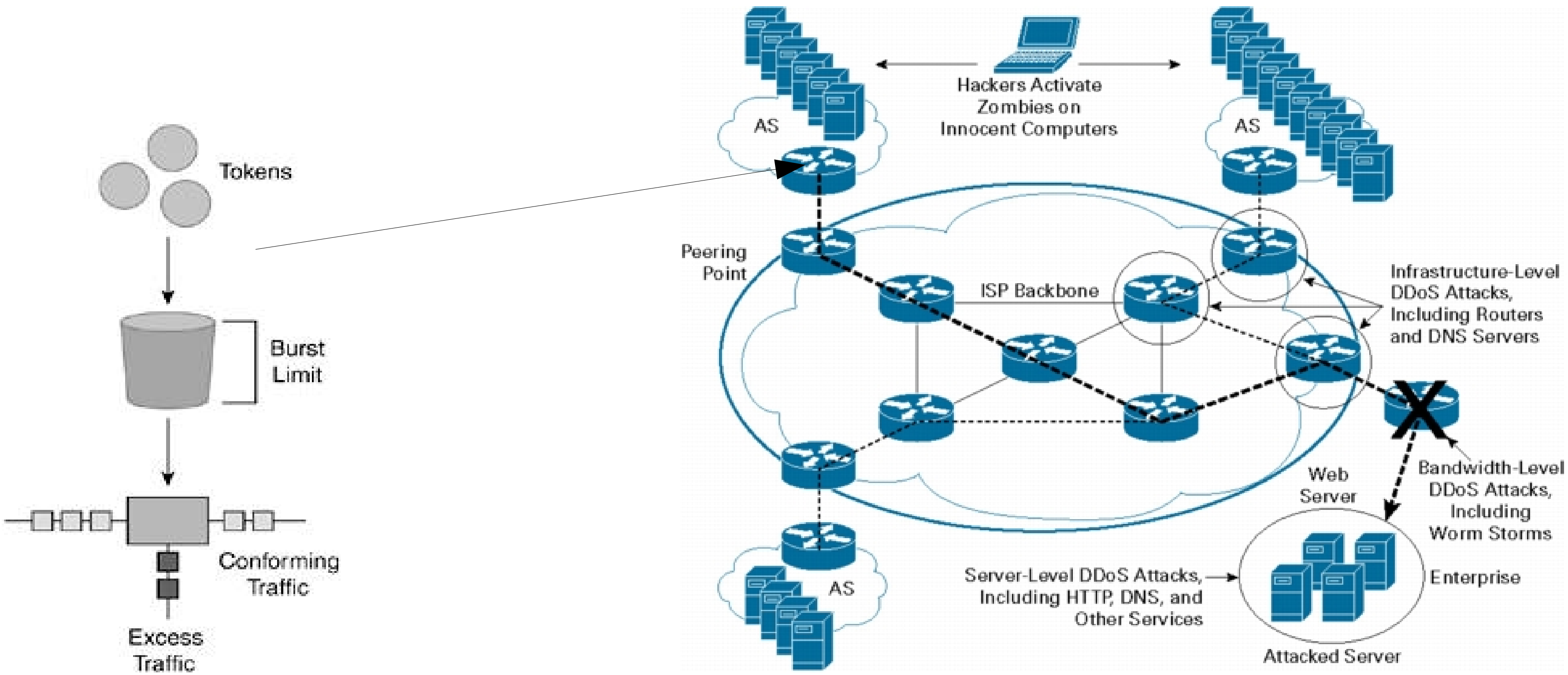
Half-Open TCP Connection Problem

- A DoS attack commonly uses half-open TCP connections.
  - Firewall keeps the state of the TCP session in memory.
  - Multiple half-open TCP connections can overrun firewalls.
    - Define timeout values for half-open TCP sessions:
      - Normal: small/medium values.
      - Under attack (based on traffic thresholds): very small values.
    - May be necessary to use external means to "clean" firewall.
      - Reseting (half-open) connections from the internal servers.



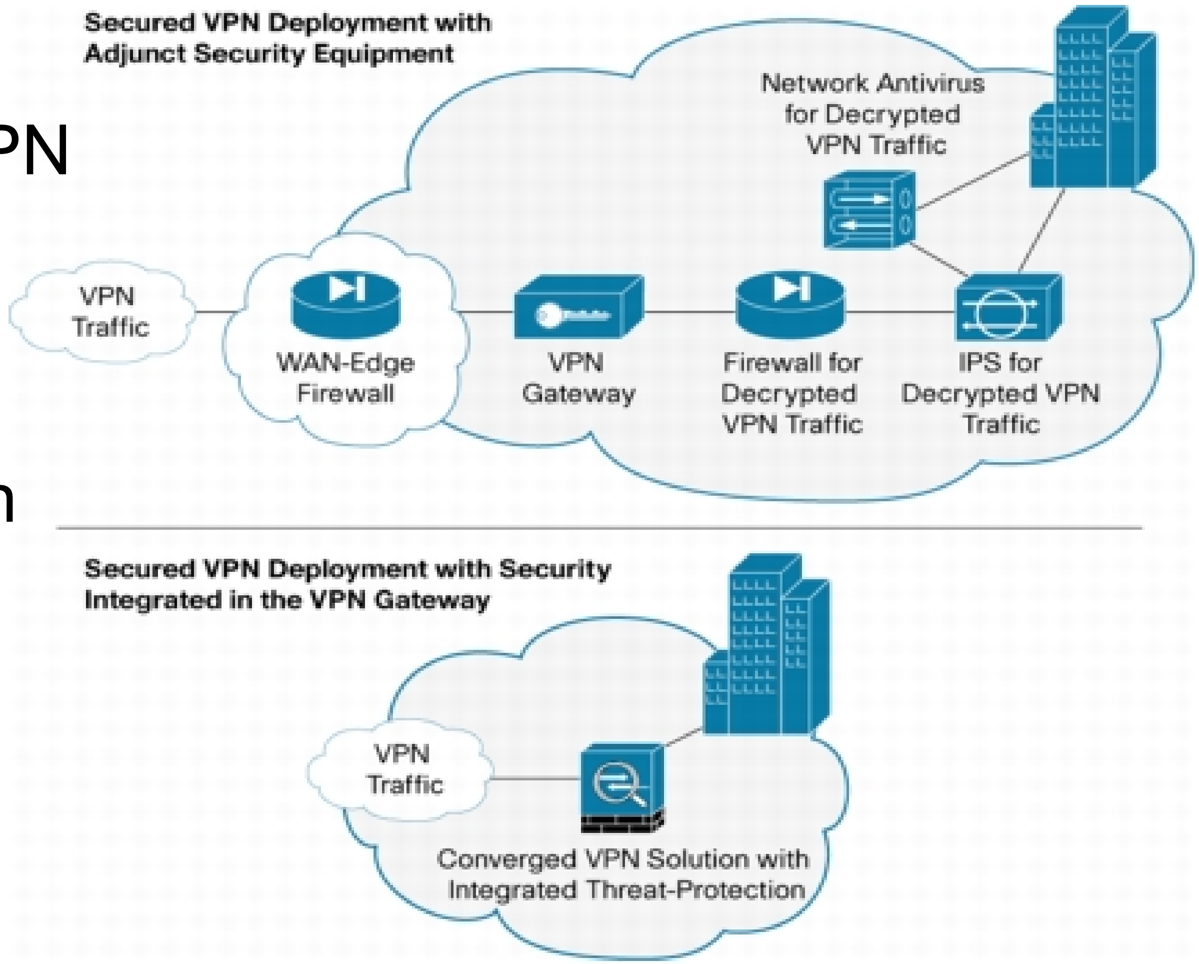
DDoS Mitigation at Source

- CAR - Committed Access Rate
  - Limits (a class of traffic) traffic to a specific rate
  - Token bucket model
  - Avoids that a single source may generate/transmit traffic above a per-defined threshold



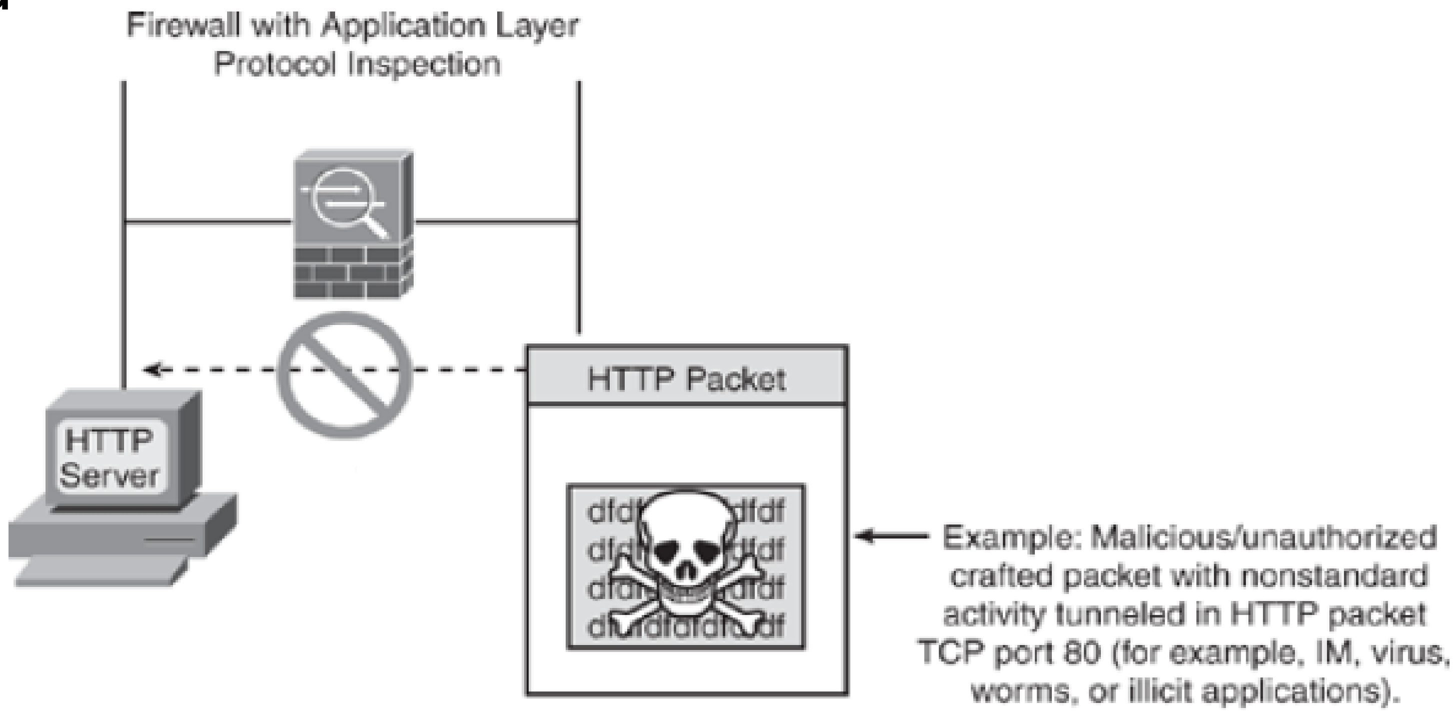
Firewalls and Remote-Access VPN

- Firewalls need work with VPN gateways
  - To filter all traffic
  - To filter decrypt VPN traffic
- Most firewalls integrate both Security and VPN gateway services



Application Layer Intelligence

- Application layer Intelligence provides advanced protocol inspection
- Any non-compliance operation in the payload is blocked
- Only packets with standard operation (RFC compliant) are allowed



Firewall Performance Evaluation

- Basic Firewall
  - IP Throughput
    - Raw capability of the firewall to pass traffic from interface to interface
  - Latency
    - Time traffic delay in the firewall
    - Should be measured and reported when the firewall is at its operating load
- Traditional Enterprise Firewall
  - Connection Establishment Rate
    - Speed at which firewalls can set up connections
  - Concurrent Connection Capability
    - Total number of open connections through the firewall at any given moment
  - Connection Teardown Rate
    - Speed at which firewalls can teardown connections and free resources
- Next Generation Firewall
  - Application Transaction Rate
    - Capability of the firewall to secure discrete application-layer transactions contained in an open connection
    - May include application-layer gateways, intrusion prevention, or deep-inspection technology
    - Application transaction rate are highly data dependent

Cisco's Access Control Lists (ACL)

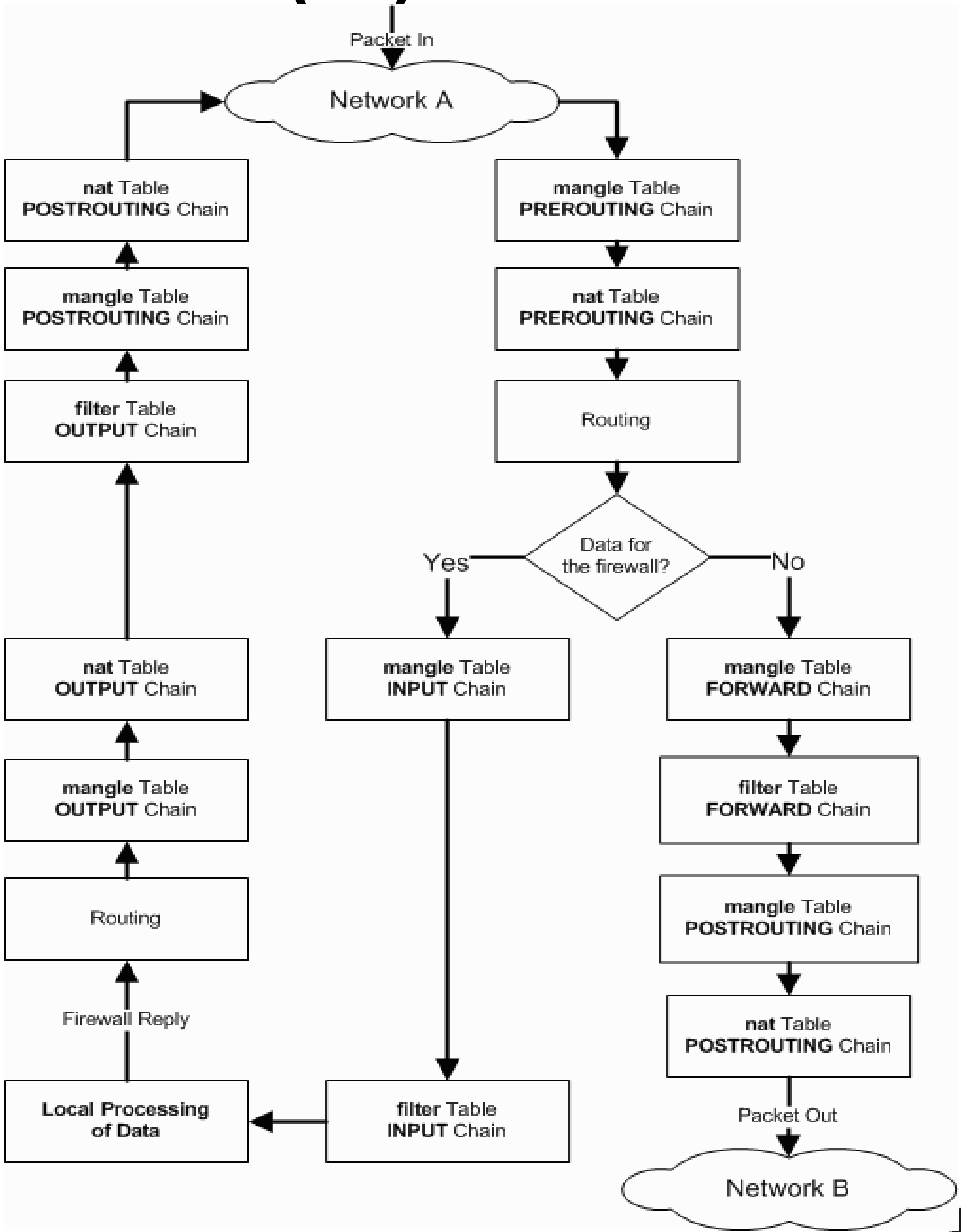
- An access list is a sequential collection of **permit** and **deny** conditions.
- Software tests packets against the conditions in an access list one by one.
- The first match determines whether the software accepts or rejects the packet.
  - Because the software stops testing conditions after the first match, the order of the conditions is critical.
- If no conditions match, the software rejects the packet.
- Can be applied to inbound or outbound traffic.

ACL Types

- Standard
  - Control traffic by the analysis of the source address of the IP packets.
  - Numbered from 1 to 99
    - Example: access-list 1 permit 10.1.1.0 0.0.0.255
- Extended
  - Control traffic by the analysis of the source and destination addresses and protocol of the IP packets.
  - Numbered from 100 to 199
    - Example: access-list 101 permit ip any 10.1.1.0 0.0.0.255
- Named
  - Allow standard and extended ACLs to be given names instead of numbers Intuitively identify an ACL using an alphanumeric name.
  - Eliminate the number limits that exist on standard and extended ACLs.
  - Named ACLs provide the ability to modify ACLs without deleting and then reconfiguring them.
    - Example: ip access-list {extended | standard} name
- Reflexive
  - Allow IP packets to be filtered based on upper-layer session information.
  - Communication in one direction opens doors in the opposite direction.
  - Generally used to allow outbound traffic and to limit inbound traffic in response to sessions that originate inside the network.
- Context-Based Access Control (CBAC)
  - Inspects traffic to discover and manage state information for TCP and UDP sessions
  - This state information is used to create temporary openings in the firewall access lists

Linux IPTables (1)

- Name of the user space tool by which administrators create rules for the packet filtering and NAT modules.
- Used to set up, maintain, and inspect the tables of IP packet filtering rules within the Linux kernel.
- Has 5 default chains:
  - INPUT, OUTPUT, FORWARD
  - PREROUTING
  - POSTROUTING
- Has 3 default tables,
  - Filter, nat and mangle
- Basic decisions
  - ACCEPT, DROP, QUEUE and RETURN
- Extended decisions
  - LOG, MARK, REJECT, TOS, SNAT, DNAT, MASQUERADE, REDIRECT, etc...
- Multiple state machines
  - For example: Conntrack (connection tracker).



Linux IPTables (2)

- In addition to the built-in chains, the user can create any number of user-defined chains within each table, which allows them to group rules logically.
- Each chain contains a list of rules,
  - When a packet is sent to a chain, it is compared against each rule in the chain in order.
- The rule specifies what properties the packet must have for the rule to match (such as the port number or IP address).
- If the rule does not match, then processing continues with the next rule.
- If, however, the rule does match the packet, then the rule's target instructions are followed (and further processing of the chain is usually aborted).
- Some packet properties can only be examined in certain chains,
  - For example, the outgoing network interface is not valid in the INPUT chain.
- Some targets can only be used in certain chains, and/or certain tables,
  - For example, the SNAT target can only be used in the POSTROUTING chain of the NAT table.
- The target of a rule can be the name of a user-defined chain or one of the built-in targets (ACCEPT, DROP, RETURN, DNAT, SNAT and MASQUERADE).
- You can think of a target in the same way as a subroutine.