Lecture 23 – Firewalls

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Chapter 9
Firewalls

The Need For Firewalls

- Internet connectivity is essential
  - However it creates a threat
- Effective means of protecting LANs
- Inserted between the premises network and the Internet to establish a controlled link
  - Can be a single computer system or a set of two or more systems working together
- Used as a perimeter defense
  - Single choke point to impose security and auditing
  - Insulates the internal systems from external networks

Firewall Characteristics

Design goals

All traffic from inside to outside, and vice versa, must pass through the firewall

Only authorized traffic as defined by the local security policy will be allowed to pass

The firewall itself is immune to penetration

Firewall Access Policy

- A critical component in the planning and implementation of a firewall is specifying a suitable access policy
  - This lists the types of traffic authorized to pass through the firewall
  - Includes address ranges, protocols, applications and content types
- This policy should be developed from the organization's information security risk assessment and policy
- Should be developed from a broad specification of which traffic types the organization needs to support
  - Then refined to detail the filter elements which can then be implemented within an appropriate firewall topology

Firewall Filter Characteristics

- Characteristics that a firewall access policy could use to filter traffic include:

IP address and protocol values

This type of filtering is used by packet filter and stateful inspection firewalls

Typically used to limit access to specific services

Application protocol

This type of filtering is used by an application-level gateway that relays and monitors the exchange of information for specific application protocols

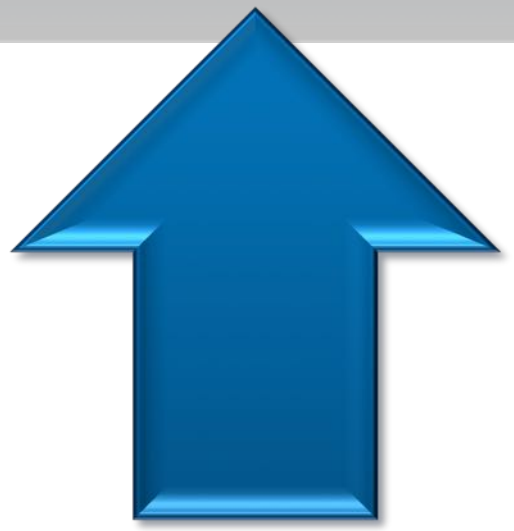
User identity

Typically for inside users who identify themselves using some form of secure authentication technology

Network activity

Controls access based on considerations such as the time or request, rate of requests, or other activity patterns

Firewall Capabilities And Limits



Capabilities:

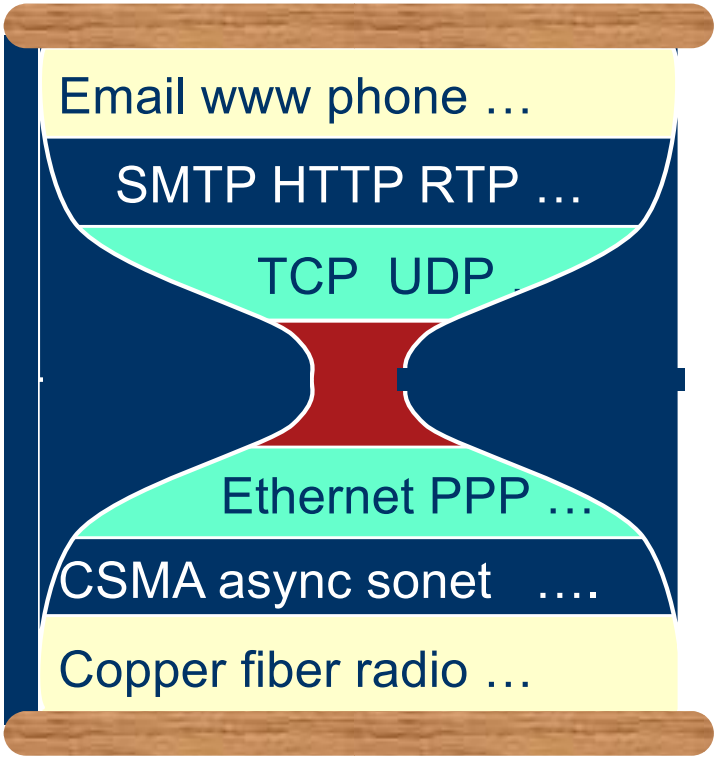
- Defines a single choke point
- Provides a location for monitoring security events
- Convenient platform for several Internet functions that are not security related
- Can serve as the platform for IPSec

Limitations:

- Cannot protect against attacks bypassing firewall
- May not protect fully against internal threats
- Improperly secured wireless LAN can be accessed from outside the organization
- Laptop, PDA, or portable storage device may be infected outside the corporate network then used internally

Internet is a Layered Architecture

- Application layer
  - Communication between networked applications
  - Protocols: HTTP, FTP, NTP, and many others
- Transport layer
  - Communication between processes
  - Protocols: TCP and UDP
- Network layer
  - Communication between nodes
  - Protocols: IP
- Link and Physical Layers
  - Communication between devices
  - Ethernet, Wifl, Bluetooth, and many others



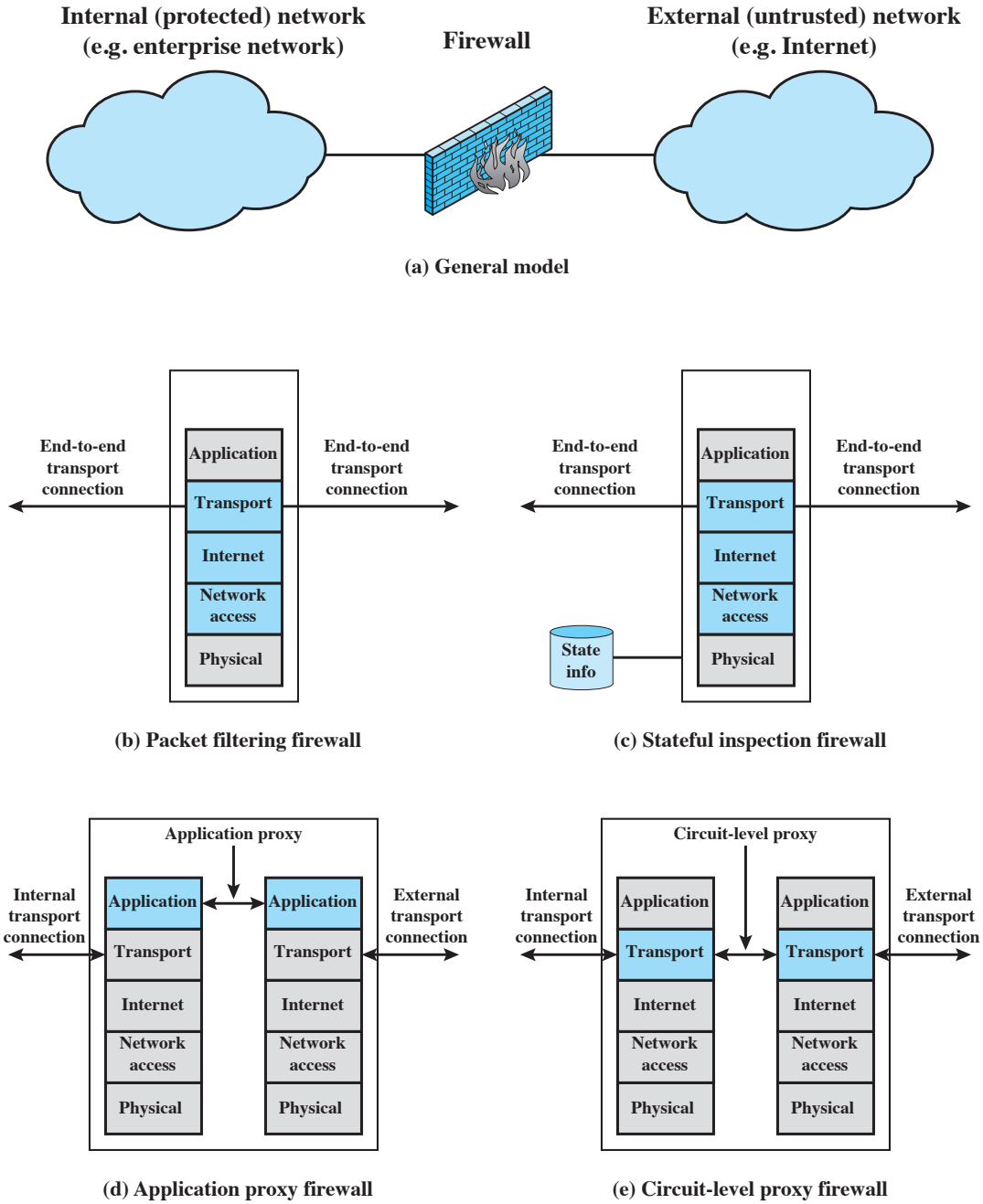


Figure 9.1 Types of Firewalls

Packet Filtering Firewall

- Applies rules to each incoming and outgoing IP packet
  - Typically a list of rules based on matches in the IP or TCP header
  - Forwards or discards the packet based on rules match

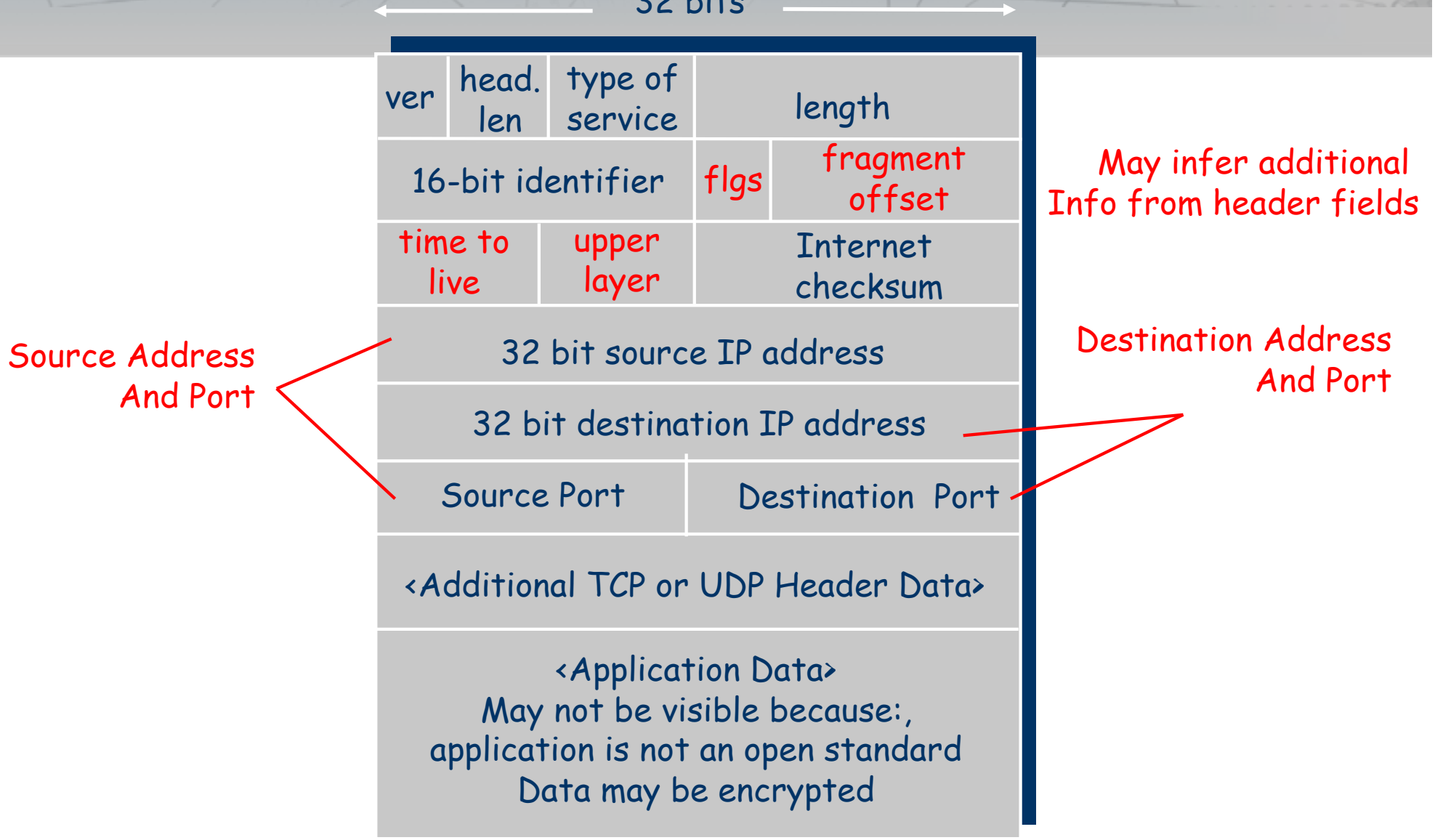
Filtering rules are based on information contained in a network packet
• Source IP address • Destination IP address • Source and destination transport-level address • IP protocol field • Interface

- Two default policies:
  - Discard - prohibit unless expressly permitted
    - More conservative, controlled, visible to users
  - Forward - permit unless expressly prohibited
    - Easier to manage and use but less secure

Packet Filtering Firewall's View of a Packet

<Frame Header - Ethernet or Wifi or Etc information>

Know what interface it arrived on - may or may not be visible to the firewall

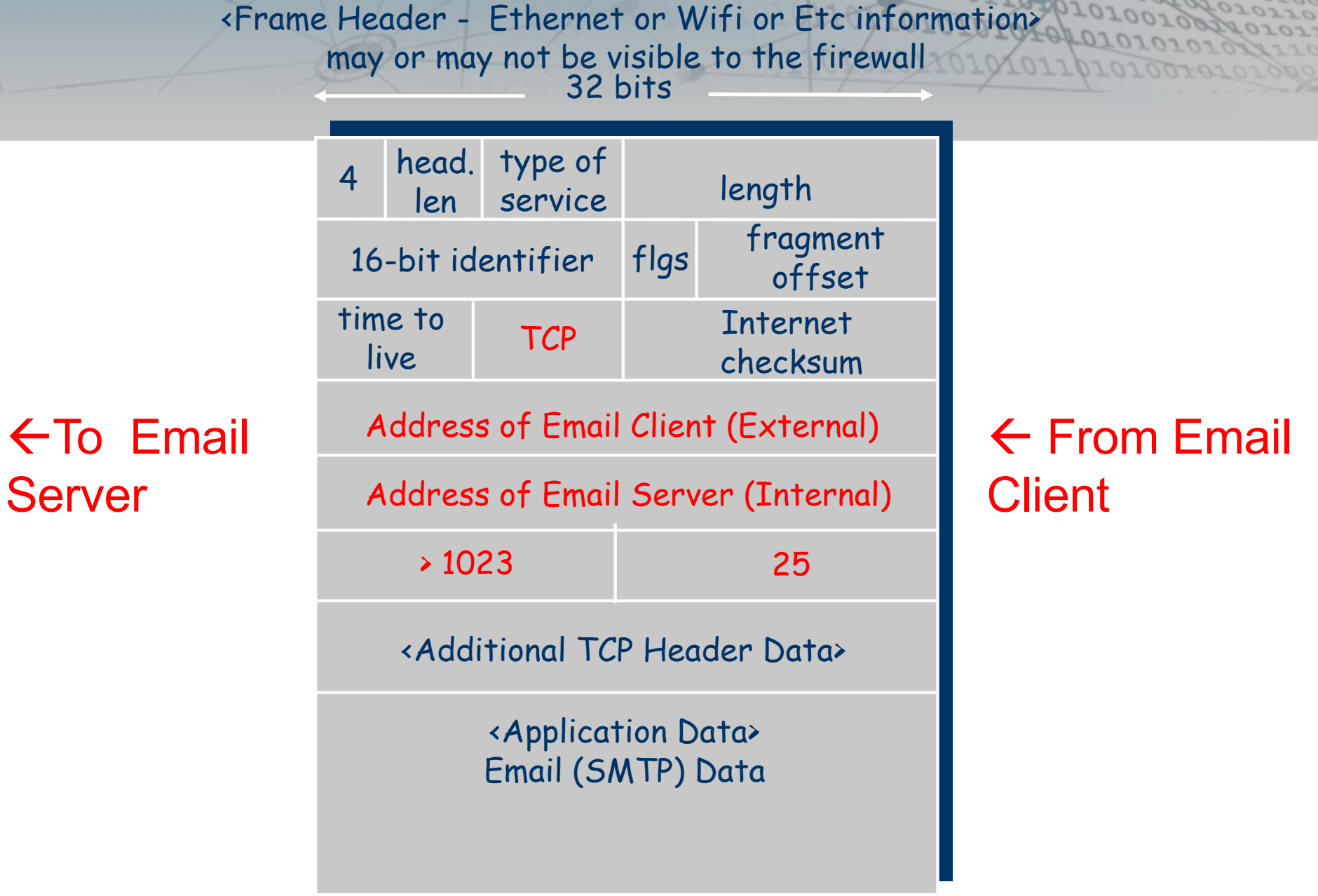


Packet-Filtering Examples

Rule	Direction	Src address	Dest addresss	Protocol	Dest port	Action
1	In	External	Internal	TCP	25	Permit
2	Out	Internal	External	TCP	>1023	Permit
3	Out	Internal	External	TCP	25	Permit
4	In	External	Internal	TCP	>1023	Permit
5	Either	Any	Any	Any	Any	Deny

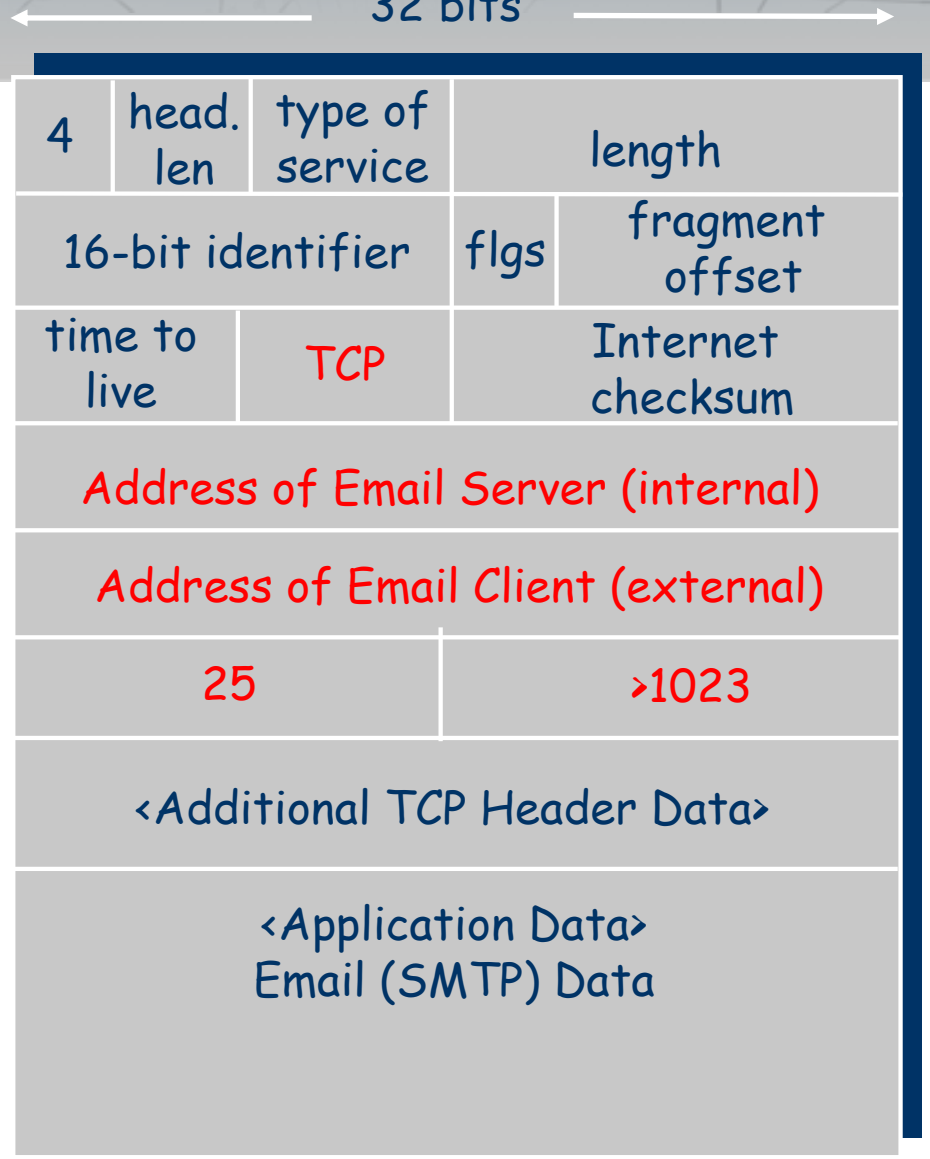
Rule 1: allow external user to contact our mail server (port 25)
Rule 2: allow our mail server to reply (client port > 1023)

Packet From External Email Client to Our Server



Reply From Our Server to External Email Client

<Frame Header - Ethernet or Wifi or Etc information>
may or may not be visible to the firewall



From Email Server →

To Email Client →

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5	Either	Any	Any	Any	Any	Deny

Rule 1: allow external user to contact our mail server (port 25)

Rule 2: allow our mail server to reply (client port > 1023)

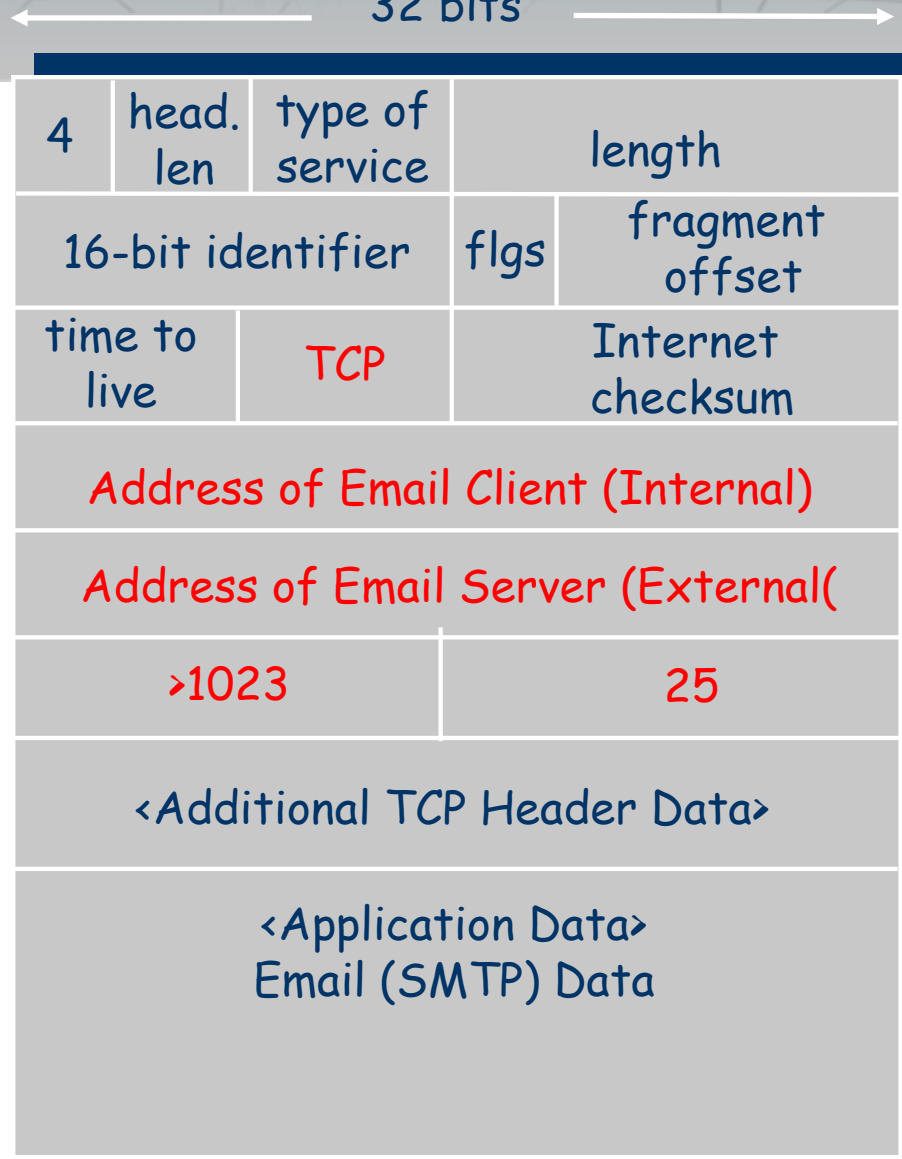
Rule 3: allow our client to contact external mailserver

Rule 4: allow the external reply back to our client

Rule 5: nothing else allowed

Packet From Our Email Client to External Server

<Frame Header - Ethernet or Wifi or Etc information>
may or may not be visible to the firewall

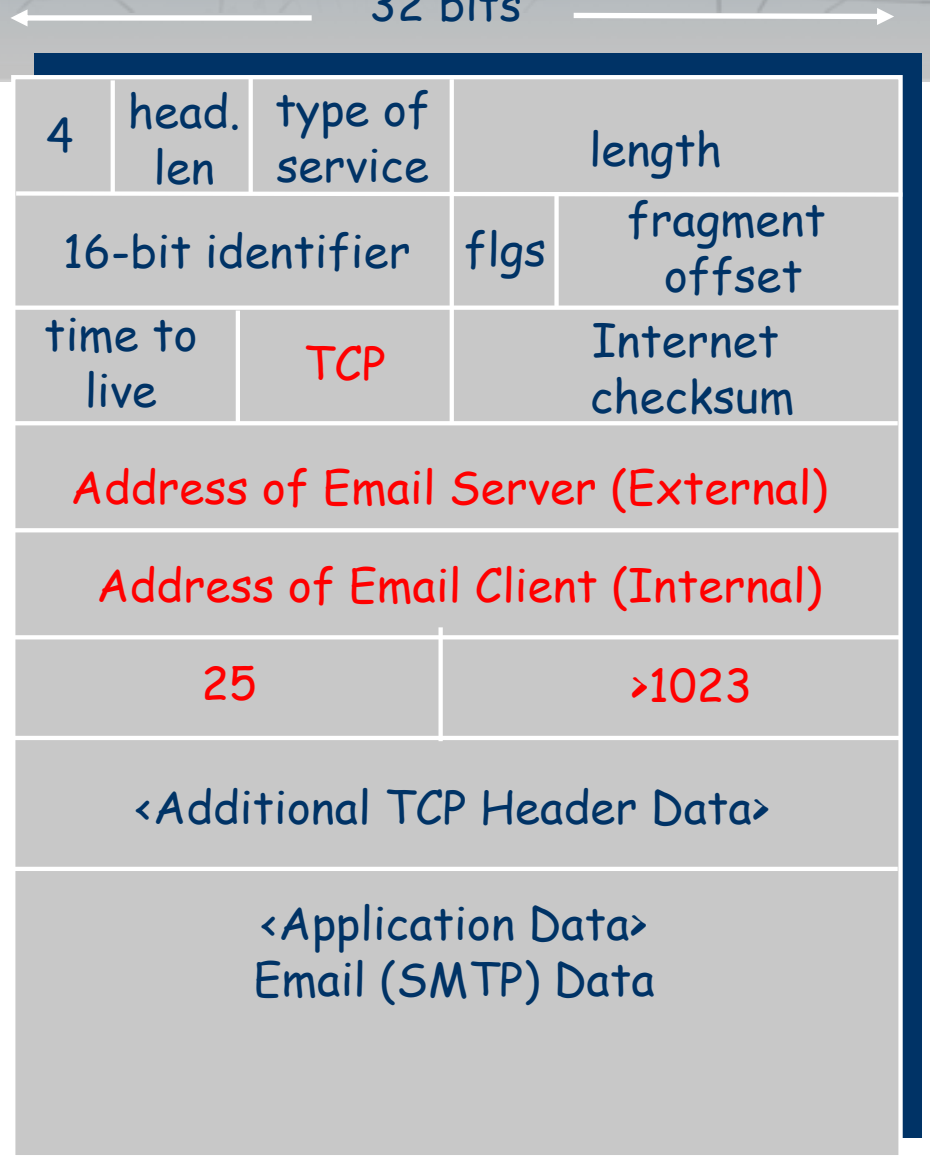


From Email Client →

To Email Server →

Packet From Email Server to Client

<Frame Header - Ethernet or Wifi or Etc information>
may or may not be visible to the firewall



←To Email Client

←From Email Server

Packet-Filtering Examples

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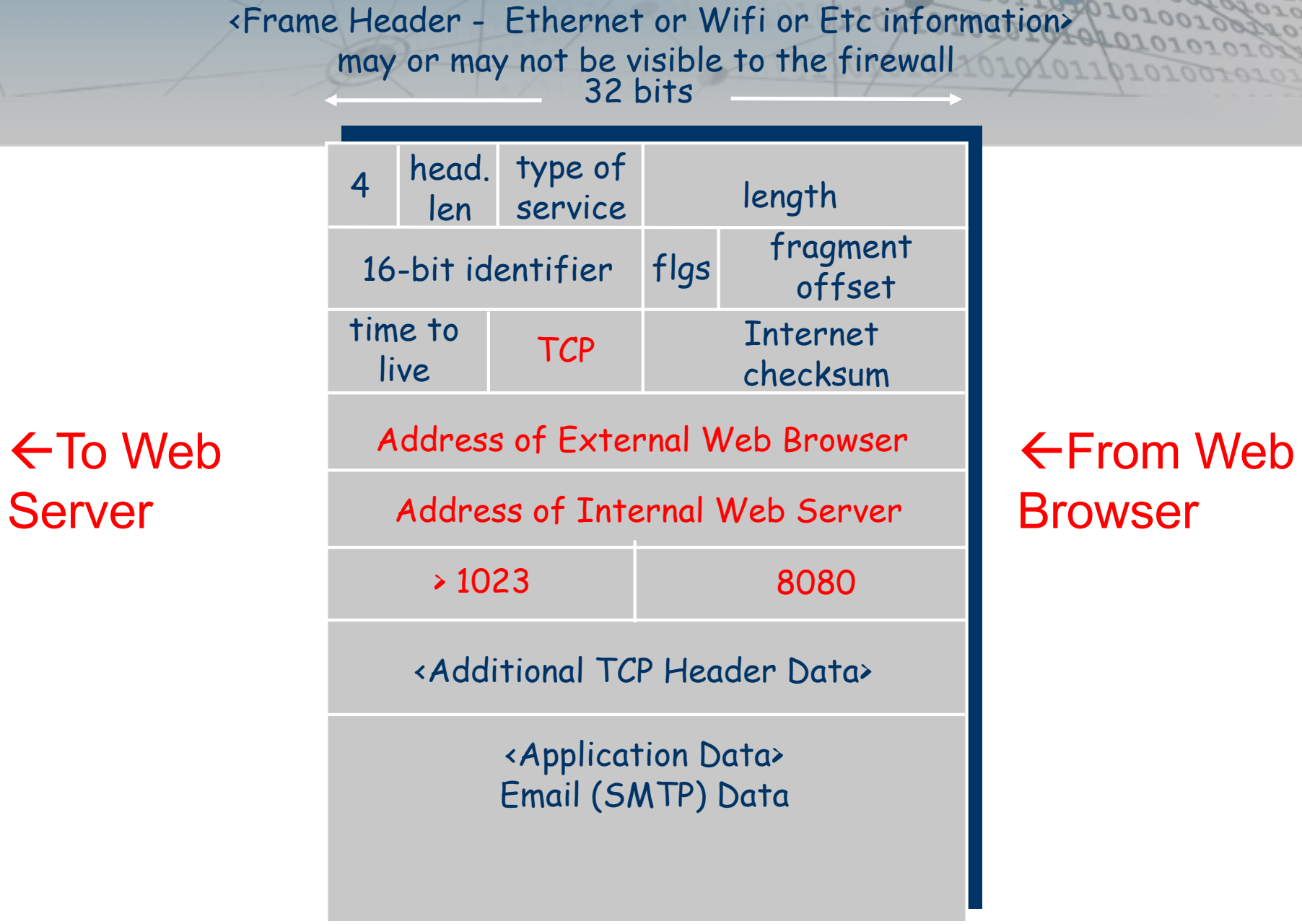
5	Either	Any	Any	Any	Any	Deny

Do the above rules prevent an insider from running an unauthorized web server on port 8080?

Packet To Unauthorized Internal Web Server



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3	Out	Internal	External	TCP	25	Permit
4	In	External	Internal	TCP	>1023	Permit
5	Either	Any	Any	Any	Any	Deny

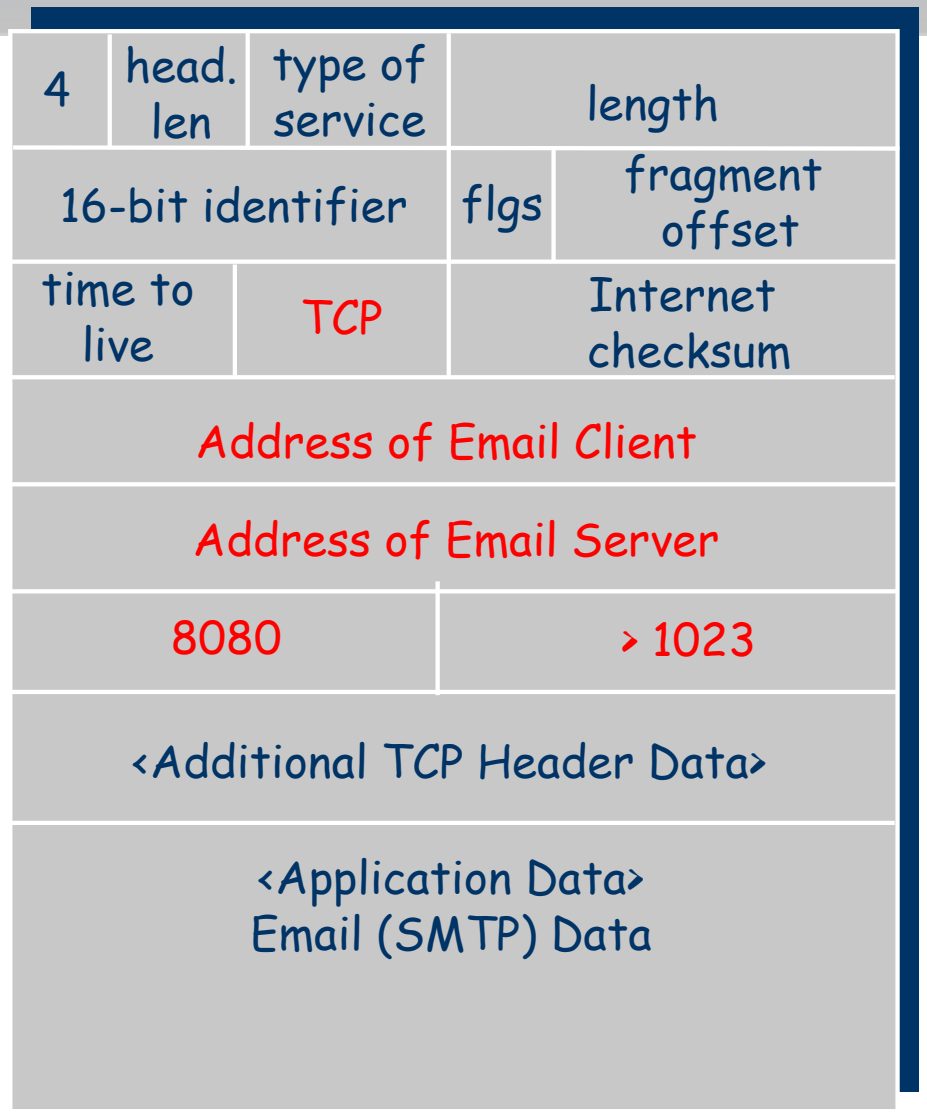
Do the above rules prevent an insider from running an unauthorized web server on port 8080?

External client contacts unauthorized web server:
SRC=External, port >1023, DST=Internal, port 8080. (Rule 4)

Reply From Internal Web Server

<Frame Header - Ethernet or Wifi or Etc information>
may or may not be visible to the firewall

32 bits



From Web Server →

To Web Browser →

Packet-Filtering Examples

Rule	Direction	Src address	Dest addresss	Protocol	Dest port	Action
1	In	External	Internal	TCP	25	Permit
2	Out	Internal	External	TCP	>1023	Permit
3	Out	Internal	External	TCP	25	Permit
4	In	External	Internal	TCP	>1023	Permit
5	Either	Any	Any	Any	Any	Deny

Do the above rules prevent an insider from running an unauthorized web server on port 8080?

Reply from unauthorized web server
SRC=Internal, port 8080, DST=external, port >1023 (Rule 2)

Packet Filter Advantages And Weaknesses

- Advantages
  - Simplicity
  - Typically transparent to users and are very fast
- Weaknesses
  - Cannot prevent attacks that employ application specific vulnerabilities or functions
  - Limited logging functionality
  - Do not support advanced user authentication
  - Vulnerable to attacks on TCP/IP protocol bugs
  - Improper configuration can lead to breaches

Stateful Inspection Firewall

Tightens rules for TCP traffic by creating a directory of outbound TCP connections

- There is an entry for each currently established connection
- Packet filter allows incoming traffic to high numbered ports only for those packets that fit the profile of one of the entries in this directory

Reviews packet information but also records information about TCP connections

- Keeps track of TCP sequence numbers to prevent attacks that depend on the sequence number
- Inspects data for protocols like FTP, IM and SIPS commands

Example Stateful Firewall Connection State Table

Source Address	Source Port	Destination Address	Destination Port	Connection State
192.168.1.100	1030	210.9.88.29	80	Established
192.168.1.102	1031	216.32.42.123	80	Established
192.168.1.101	1033	173.66.32.122	25	Established
192.168.1.106	1035	177.231.32.12	79	Established
223.43.21.231	1990	192.168.1.6	80	Established
219.22.123.32	2112	192.168.1.6	80	Established
210.99.212.18	3321	192.168.1.6	80	Established
24.102.32.23	1025	192.168.1.6	80	Established
223.21.22.12	1046	192.168.1.6	80	Established

Application-Level Gateway

- Also called an application proxy
- Acts as a relay of application-level traffic
  - User contacts gateway using a TCP/IP application
  - User is authenticated
  - Gateway contacts application on remote host and relays TCP segments between server and user
- Must have proxy code for each application
  - May restrict application features supported
- Tend to be more secure than packet filters
- Disadvantage is the additional processing overhead on each connection

Circuit-Level Gateway

Circuit level proxy

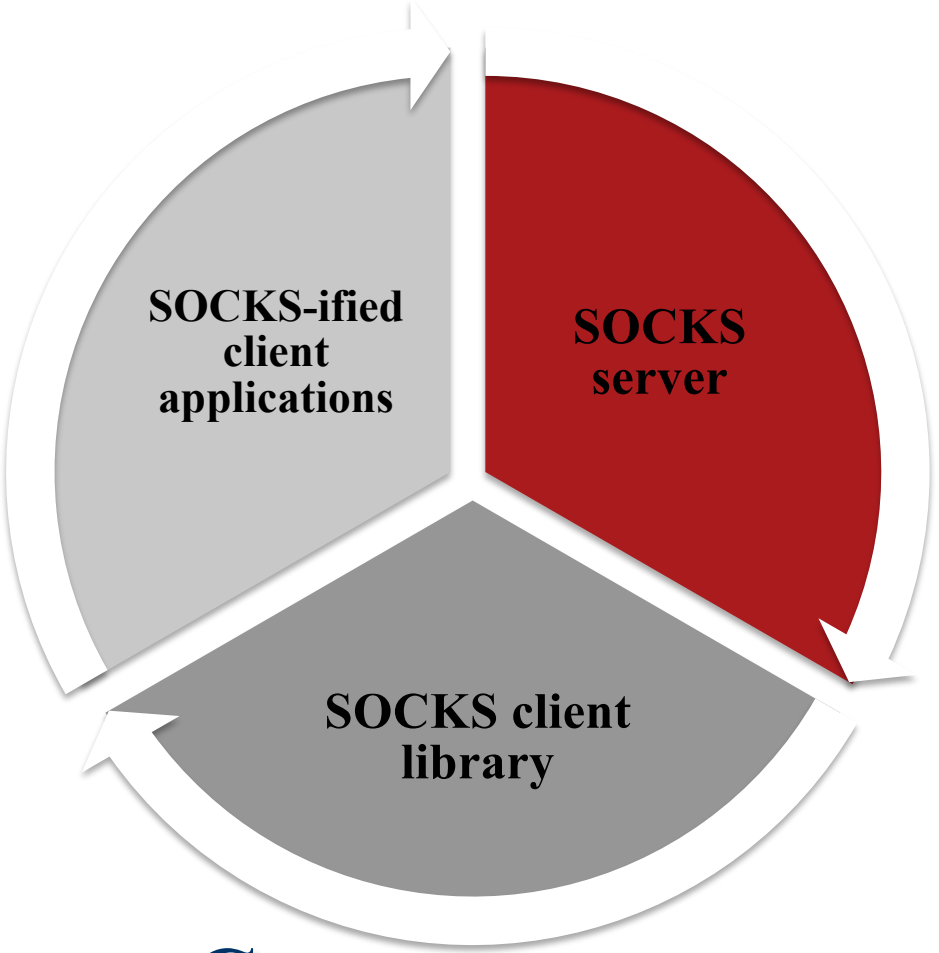
- Sets up two TCP connections, one between itself and a TCP user on an inner host and one on an outside host
- Relays TCP segments from one connection to the other without examining contents
- Security function consists of determining which connections will be allowed

Typically used when inside users are trusted

- May use application-level gateway inbound and circuit-level gateway outbound
- Lower overheads

SOCKS Circuit-Level Gateway

- SOCKS v5 defined in RFC1928
- Designed to provide a framework for client-server applications in TCP/UDP domains to conveniently and securely use the services of a network firewall
- Client application contacts SOCKS server, authenticates, sends relay request
  - Server evaluates and either establishes or denies the connection



Components

Bastion Hosts

- System identified as a critical strong point in the network's security
- Serves as a platform for an application-level or circuit-level gateway
- Common characteristics:
  - Runs secure O/S, only essential services
  - May require user authentication to access proxy or host
  - Each proxy can restrict features, hosts accessed
  - Each proxy is small, simple, checked for security
  - Each proxy is independent, non-privileged
  - Limited disk use, hence read-only code

Host-Based Firewalls

- Used to secure an individual host
- Available in operating systems or can be provided as an add-on package
- Filter and restrict packet flows
- Common location is a server

Advantages:
• Filtering rules can be tailored to the host environment • Protection is provided independent of topology • Provides an additional layer of protection

Personal Firewall

- Controls traffic between a personal computer or workstation and the Internet or enterprise network
- For both home or corporate use
- Typically is a software module on a personal computer
- Can be housed in a router that connects all of the home computers to a DSL, cable modem, or other Internet interface
- Typically much less complex than server-based or stand-alone firewalls
- Primary role is to deny unauthorized remote access
- May also monitor outgoing traffic to detect and block worms and malware activity

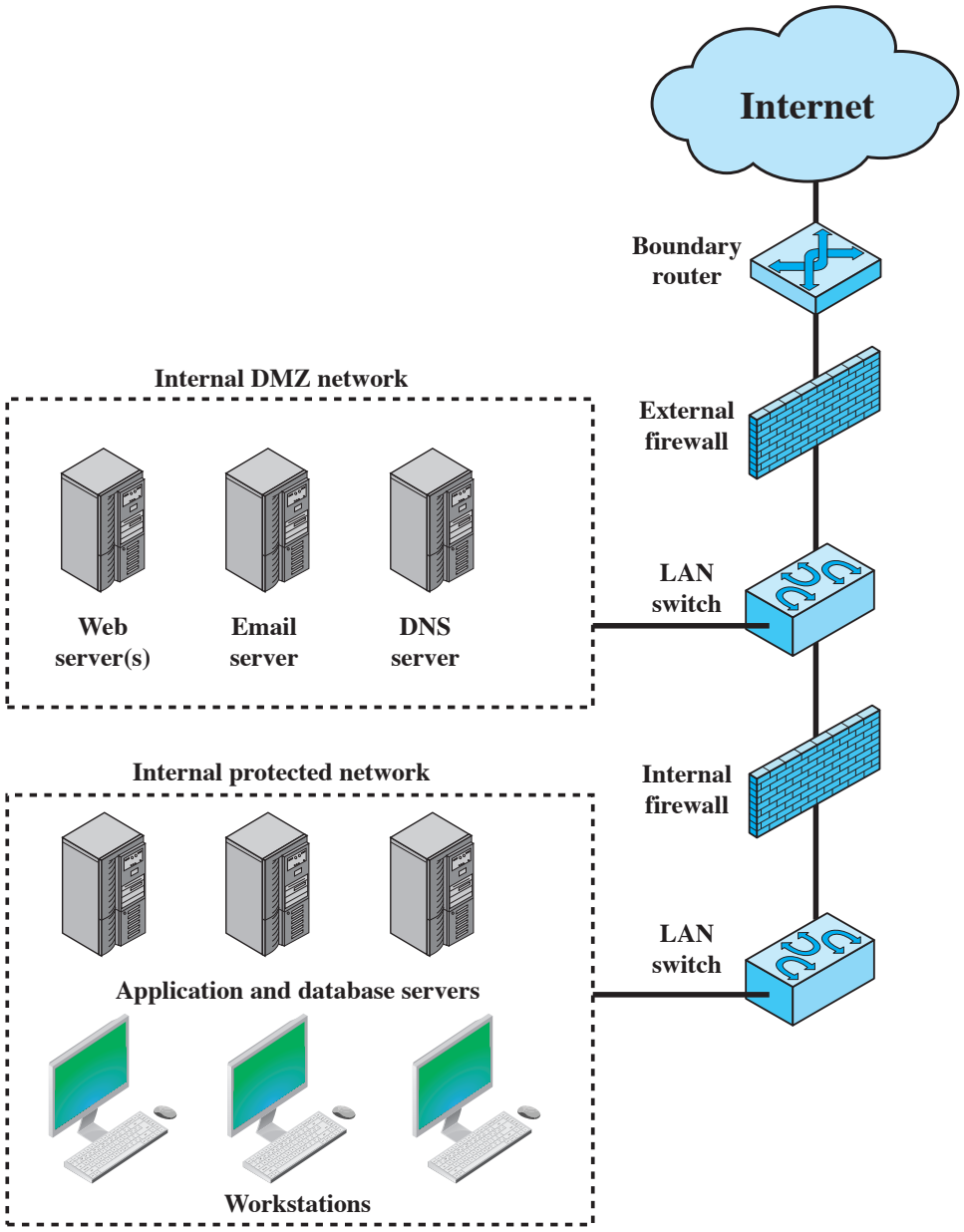


Figure 9.2 Example Firewall Configuration

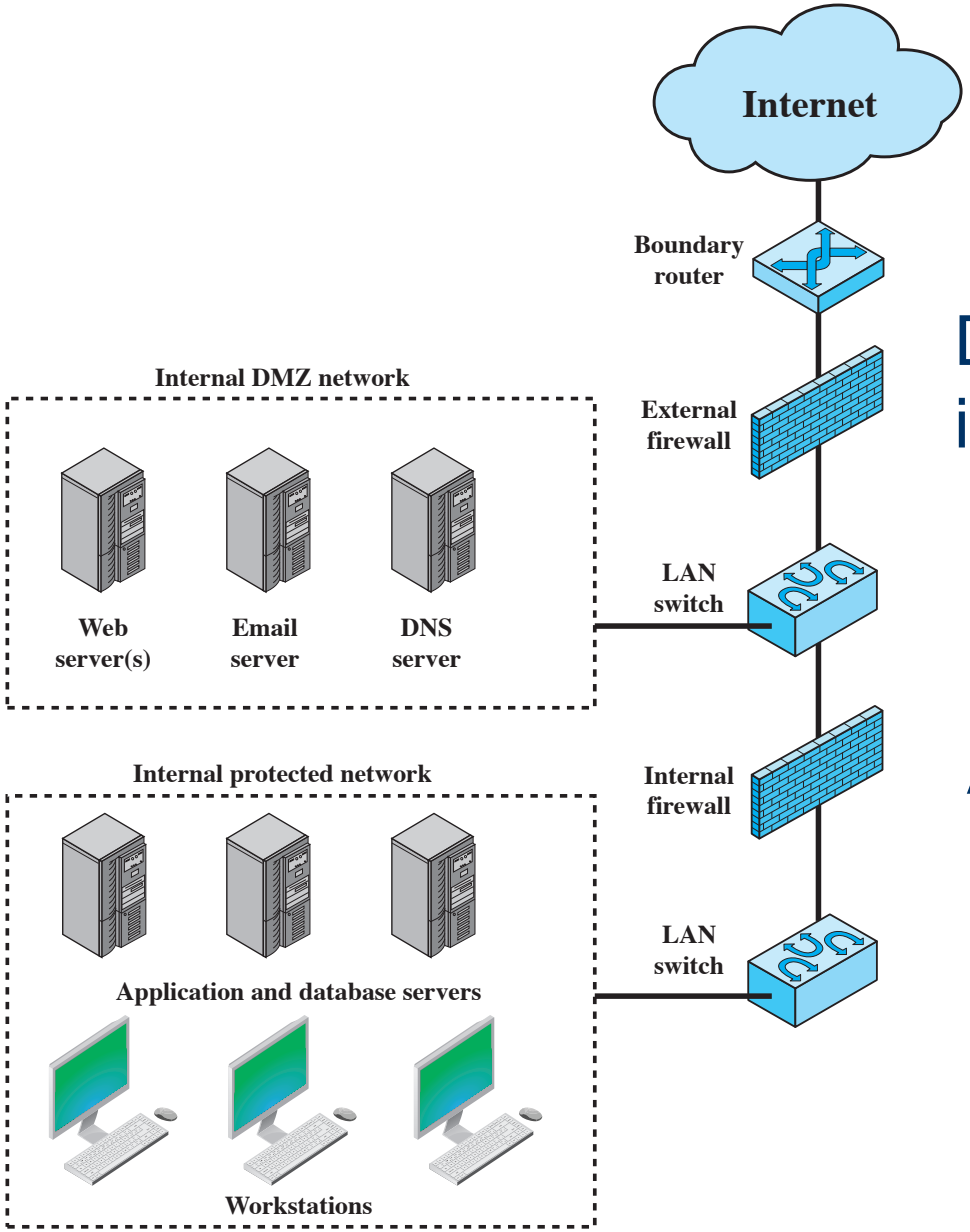


Figure 9.2 Example Firewall Configuration

Don't block off internal net!

Apply application limits all email to/from the DMZ proxy web service ?

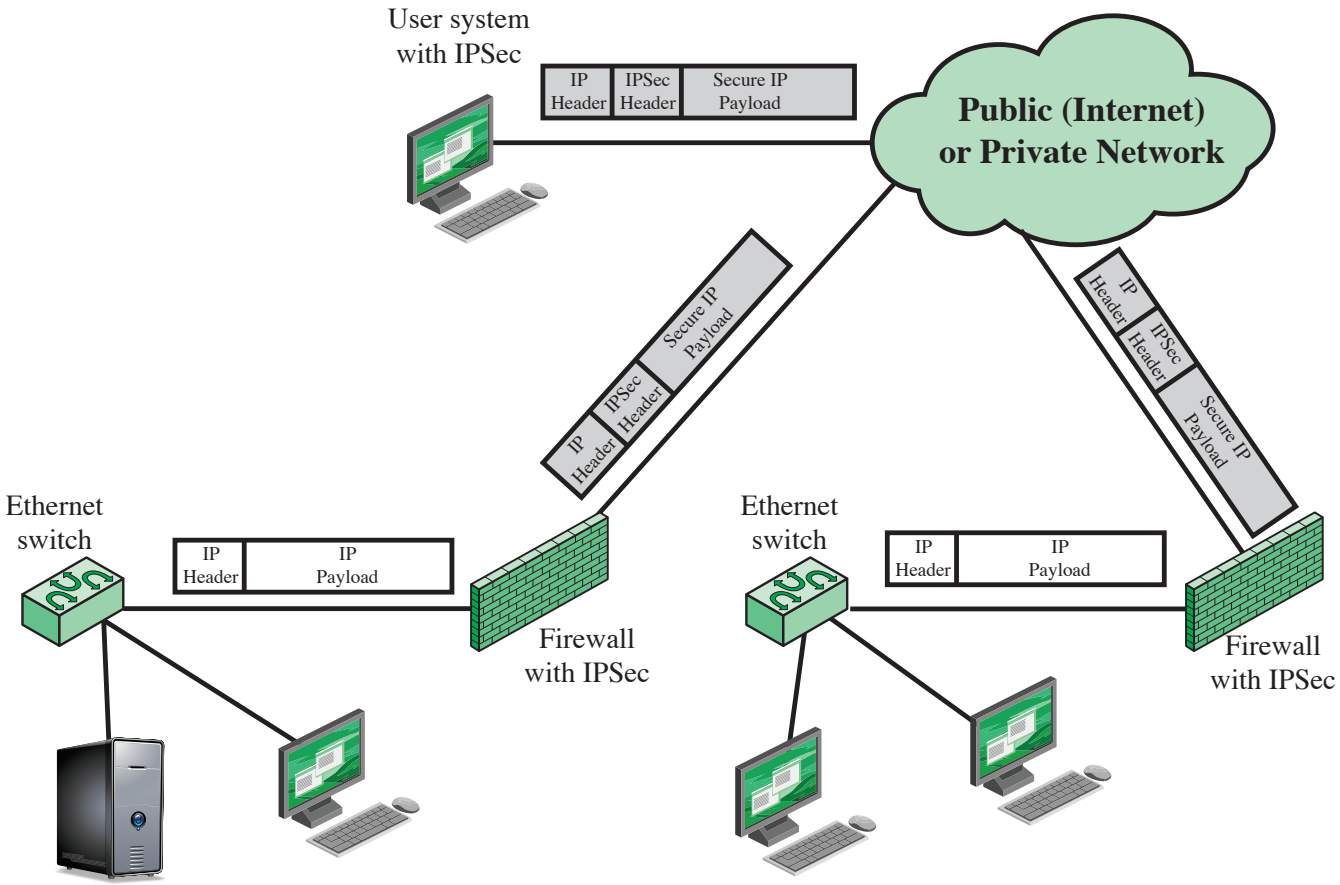


Figure 9.3 A VPN Security Scenario

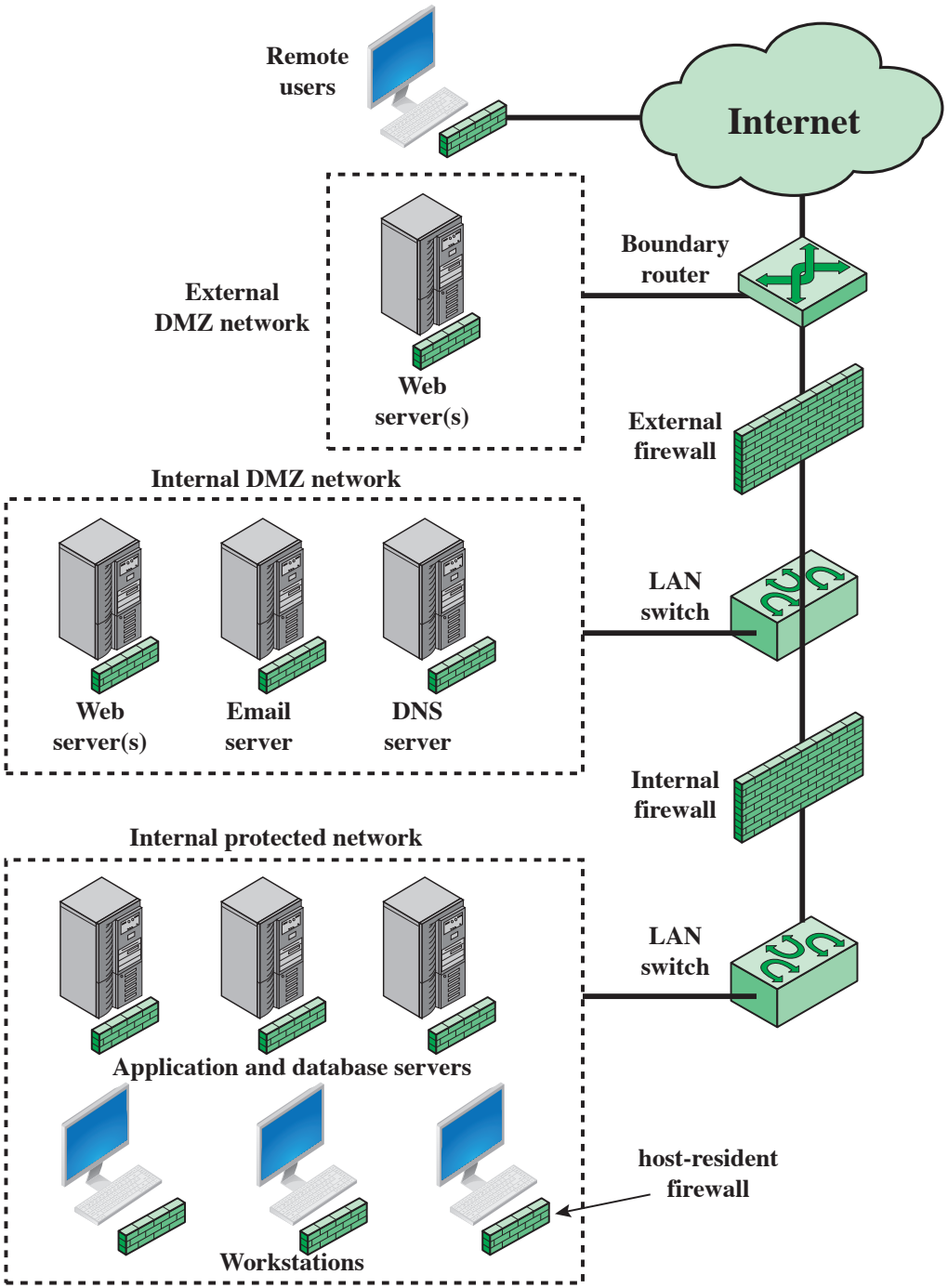


Figure 9.4 Example Distributed Firewall Configuration

Heilmeier Questions

- What are you trying to do? Articulate your objectives using absolutely no jargon.
- How is it done today, and what are the limits of current practice?
- What is new in your approach and why do you think it will be successful?
- Who cares? If you succeed, what difference will it make?
- What are the risks?
- How much will it cost?
- How long will it take?
- What are the mid-term and final “exams” to check for success?