# Information Security

CS3002

Lecture 23

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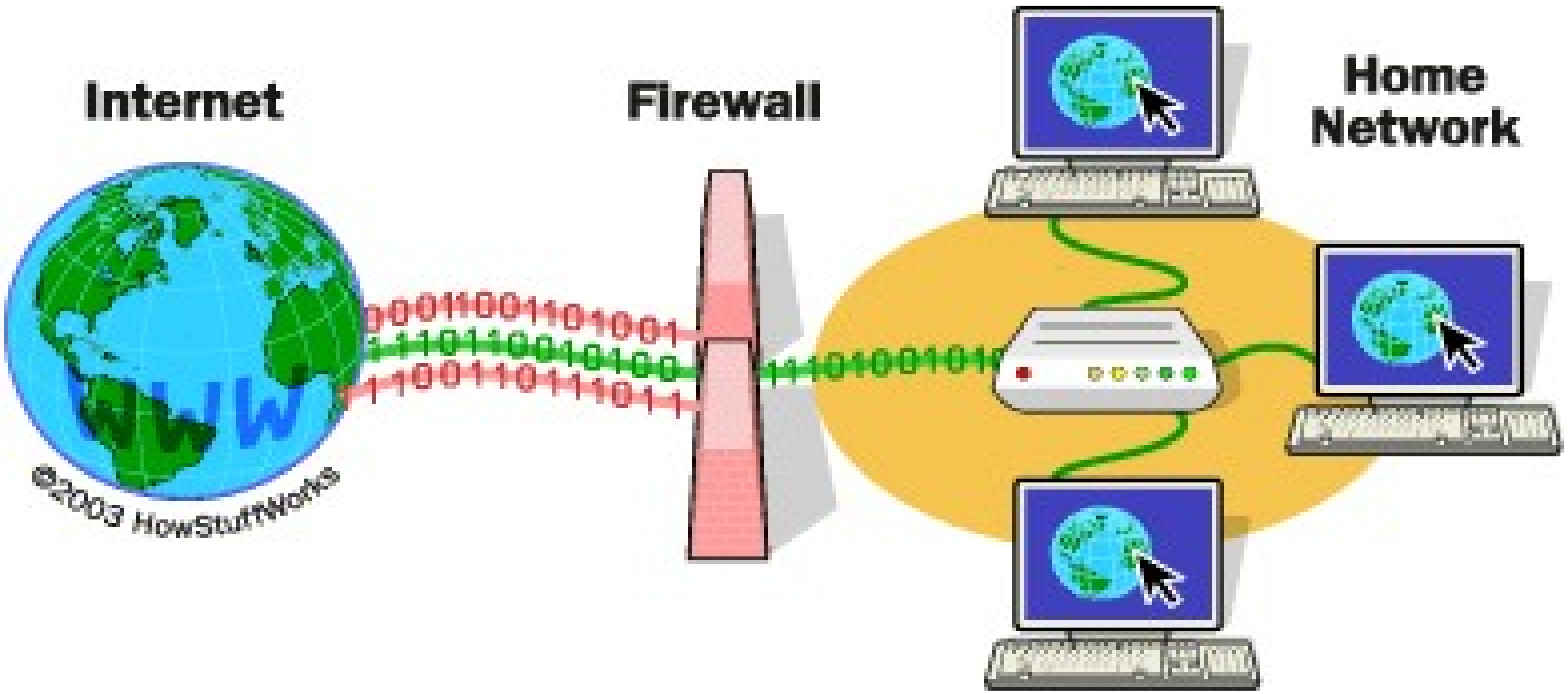
# Firewalls

# Firewalls

A **firewall** is a **device** or **application** that filters all traffic between a protected or "inside" network and a less trustworthy or "outside" network.

- Usually **runs** on a **dedicated device** for better performance.
- The **purpose** of a firewall is to keep "bad" things outside a protected environment.
- Firewall implements a **Security Policy (Rules)**
- **Security policy** might permit accesses only from certain places, from certain users, or for certain activities.

# Firewalls


Internet
Firewall
Home Network
WWW
©2003 HowStuffWorks
00011001101001
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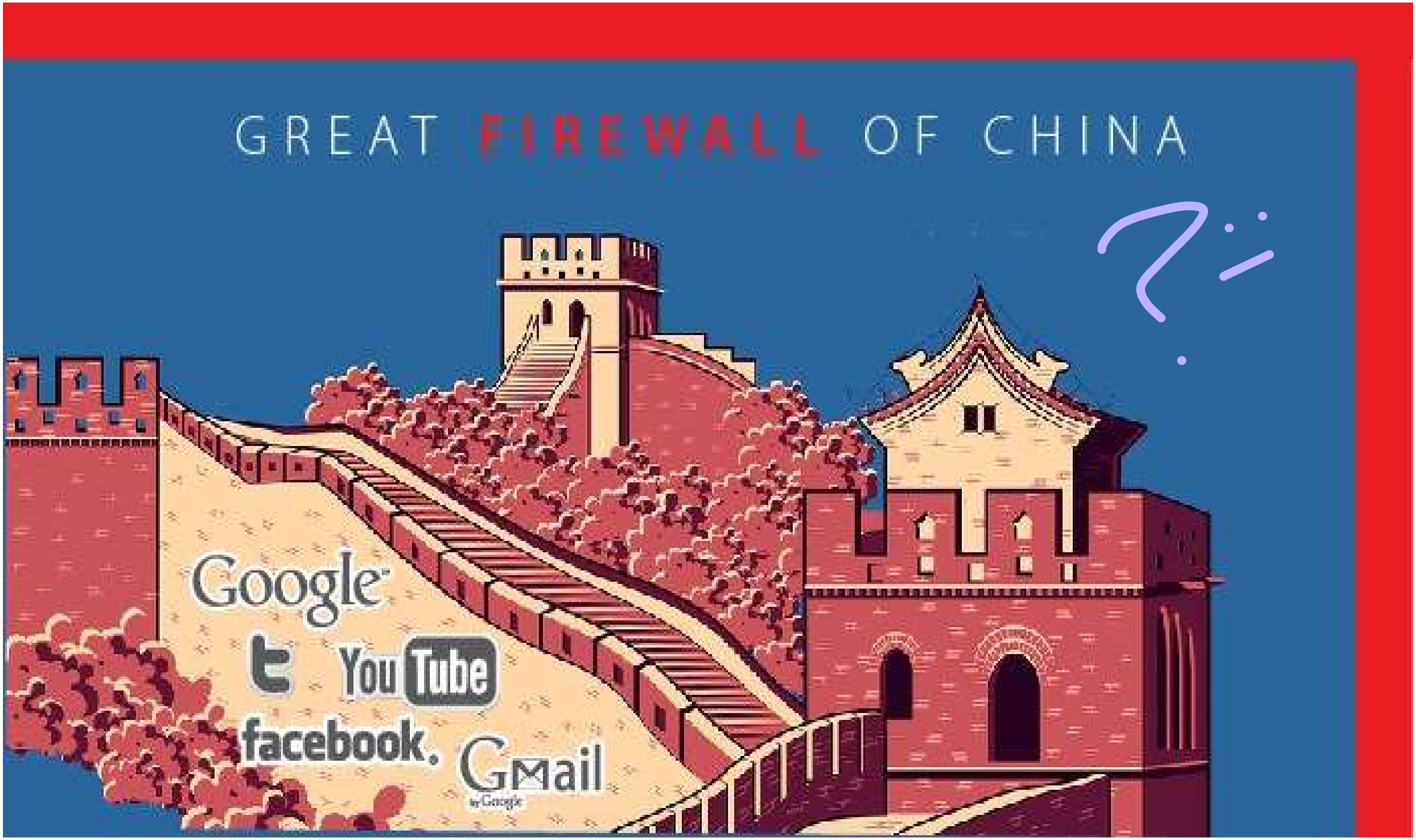
# Firewalls

Cisco Firewall Device

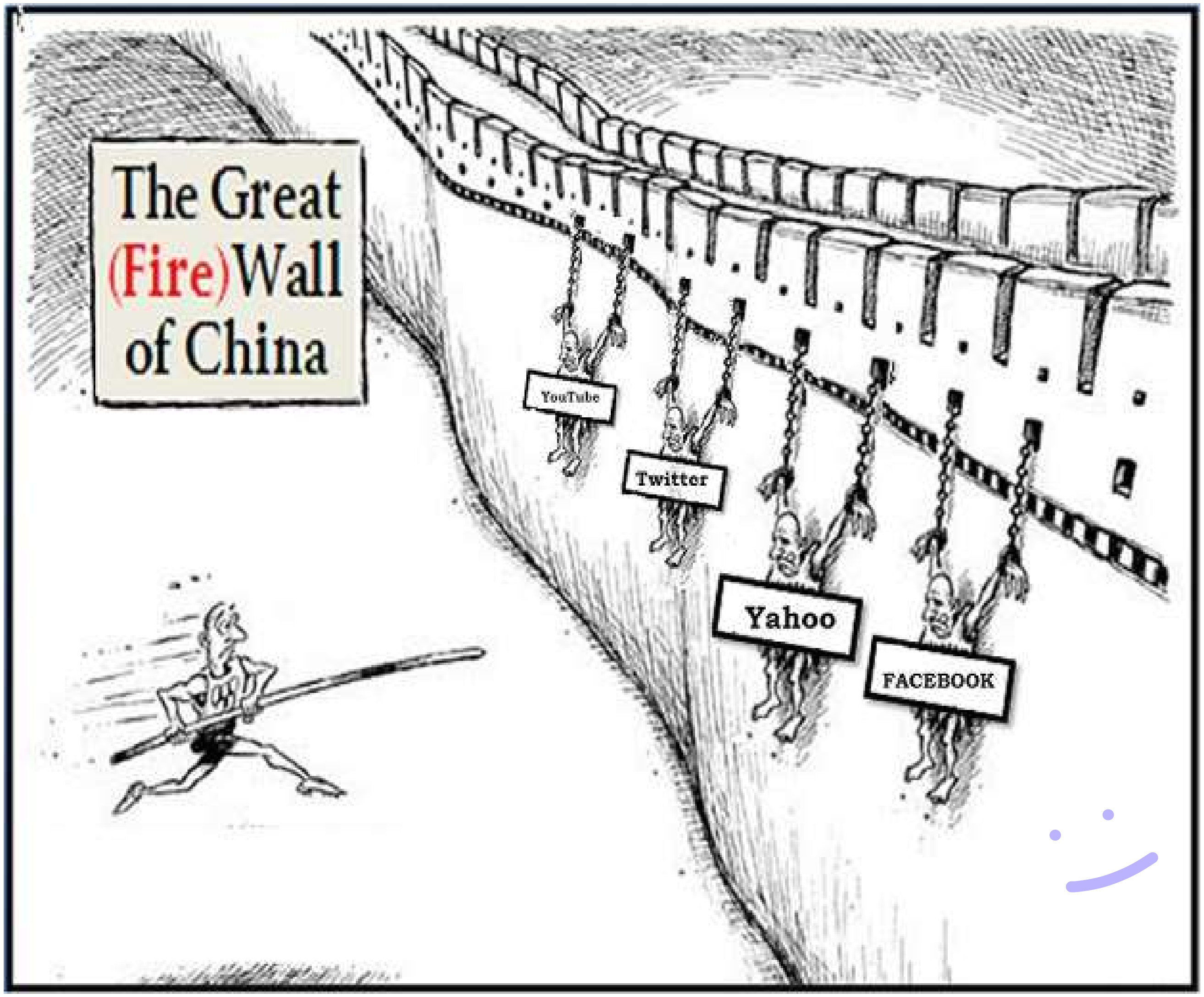
Juniper Firewall Device

# Great Firewall of China



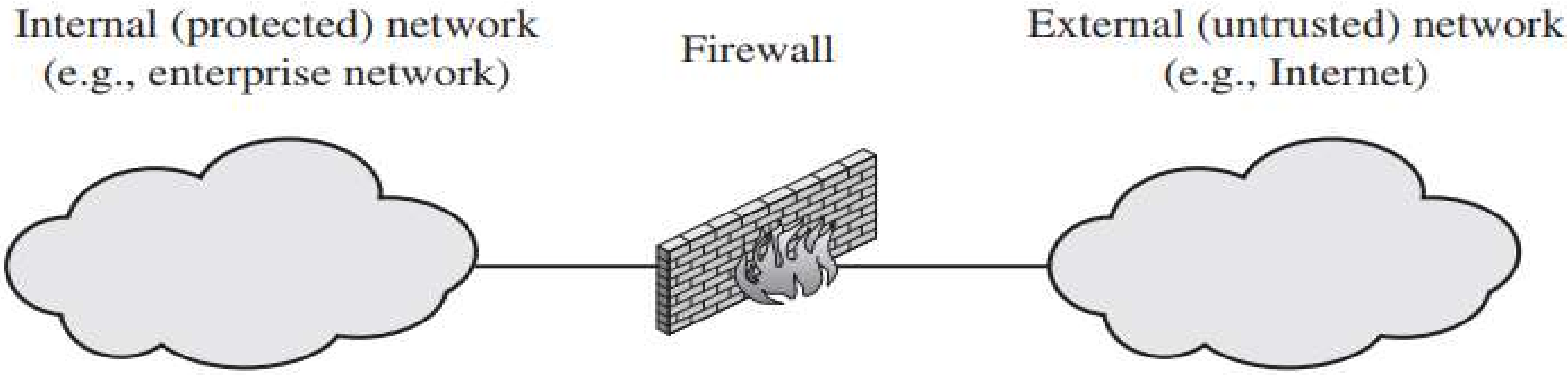
# Home Task

- ❑ Search and Read **How** **Great Firewall** *of* **China** **Works**?



# The Need for Firewalls

- Internet connectivity is essential for organizations
  - However it creates a threat
- Firewalls are effective means of protecting LANs
  - Protection at single point, rather on every computer within LAN
- Inserted between the premises network and the Internet to establish a controlled link
- Used as a perimeter defense
  - Single choke point to impose security and auditing
  - Insulates the internal systems from external networks


Internal (protected) network
(e.g., enterprise network)
Firewall
External (untrusted) network
(e.g., Internet)

(a) General model

# Firewall Characteristics

**Design Goals**

- All traffic from inside to outside 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

**General Techniques**

1 - Service control, e.g. filter based on IP address, port number
2 - Direction control, e.g. to internal LAN, to external Internet
3 - User control, e.g. student vs faculty
4 - Behaviour control, e.g. filter email with spam

# Capabilities & Limitations

## 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 platform for VPN end point

## 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, phone, or USB drive may be infected outside the corporate network then used internally

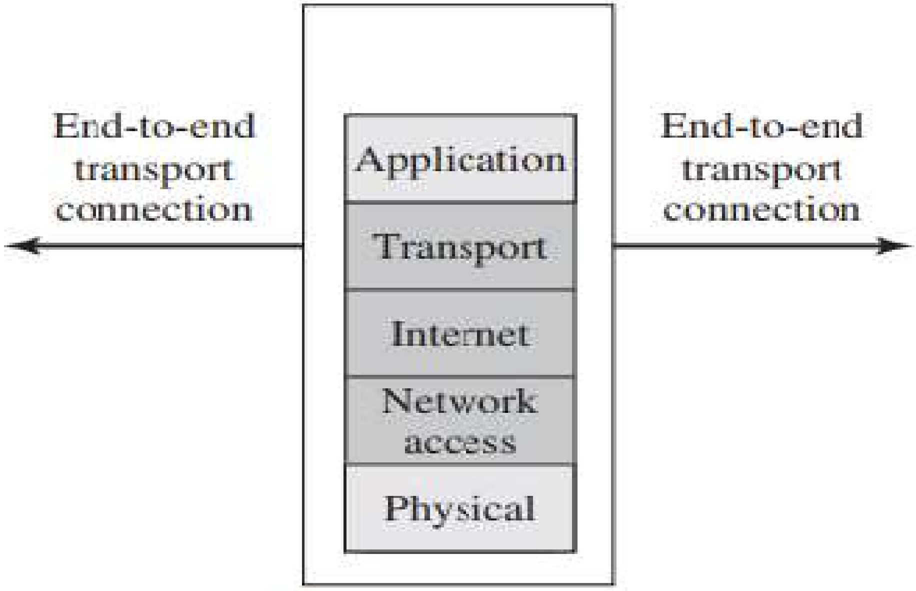
# Types of Firewalls

- Packet Filtering accepts/rejects packets based on protocol headers
- Stateful Packet Inspection adds state information on what happened previously to packet filtering firewall
- Application Proxy relay for application traffic
- Circuit-level Proxy relay for transport connections

- Normally a firewall is implemented on a router
- That router may perform other (non-)security functions, e.g. VPN end-point, accounting, address and port translation (NAT)

# 1. Packet Filtering Firewall

- Security policy implemented by set of rules
- Rules define which packets can pass through the firewall
- Firewalls inspects each arriving packet (in all directions), compares against rule set, and takes action based on matching rule
- Default policies: action for packets for which no rule matches
- Accept (allow, forward)
- Drop (reject, discard)


End-to-end transport connection
Application
Transport
Internet
Network access
Physical
End-to-end transport connection

(b) Packet filtering firewall

# Packet Filtering Rules

## Packet Information

- IP address: identifies host or network
- Port number: identifies server, e.g. web (80), email (25)
- Protocol number: identifies transport protocol, e.g. TCP or UDP
- Firewall interface: identifies immediate source/destination
- Other transport, network, data link packet header fields

## Rules

- Conditions defined using packet information, direction
- Wildcards (*) support to match multiple values
- Actions typically accept or drop
- List of rules processed in order

# Packet Filtering Firewalls

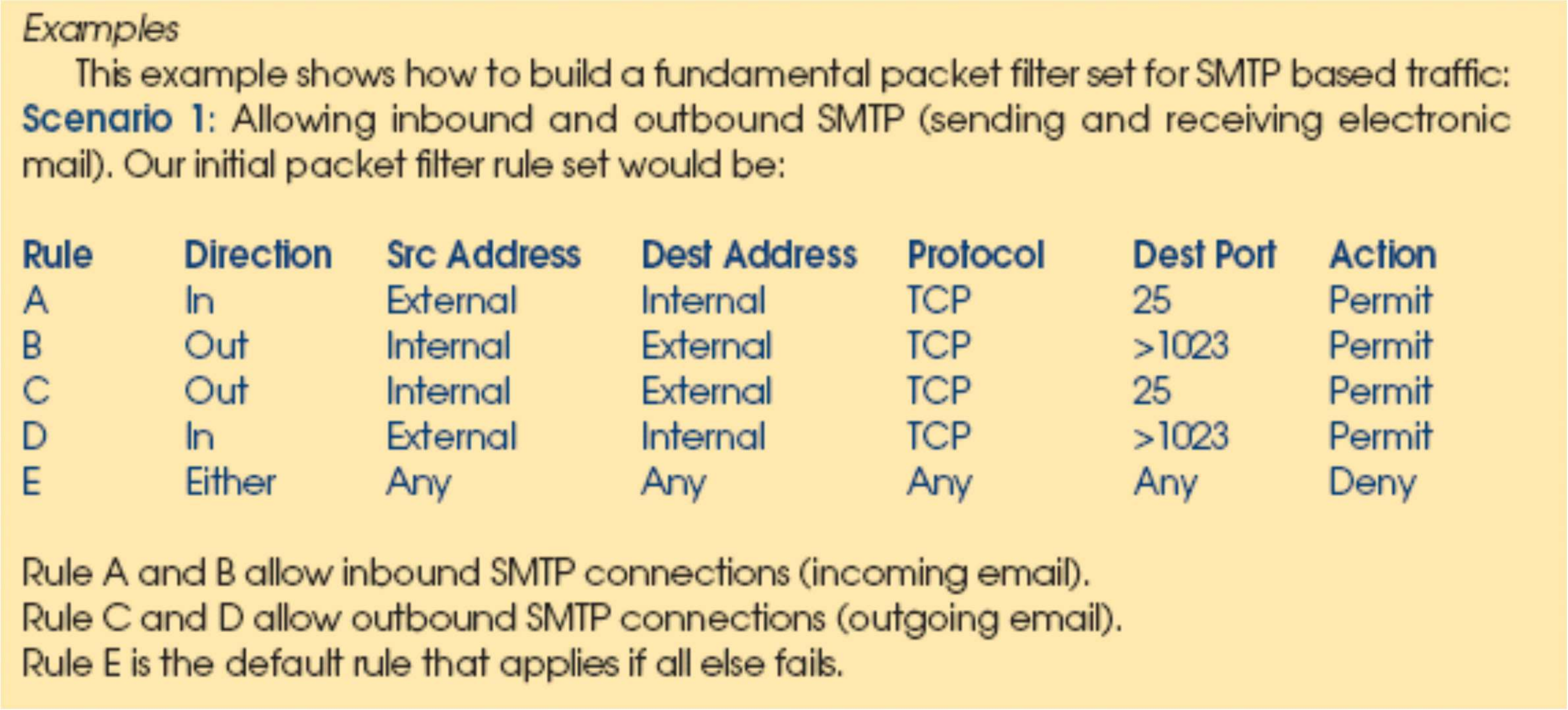
**Advantages**

- Simplicity
- Transparent to users
- Very fast

**Disadvantages**

- Cannot prevent attacks that employ application specific vulnerabilities or functions
- Limited logging functionality
- Do not support advanced user authentication
- Improper configuration can lead to breaches

# Example



*Examples*

This example shows how to build a fundamental packet filter set for SMTP based traffic:

**Scenario 1:** Allowing inbound and outbound SMTP (sending and receiving electronic mail). Our initial packet filter rule set would be:

| Rule | Direction | Src Address | Dest Address | Protocol | Dest Port | Action |
|---|---|---|---|---|---|---|
| A | In | External | Internal | TCP | 25 | Permit |
| B | Out | Internal | External | TCP | >1023 | Permit |
| C | Out | Internal | External | TCP | 25 | Permit |
| D | In | External | Internal | TCP | >1023 | Permit |
| E | Either | Any | Any | Any | Any | Deny |

Rule A and B allow inbound SMTP connections (incoming email).
Rule C and D allow outbound SMTP connections (outgoing email).
Rule E is the default rule that applies if all else fails.

# Packet Filtering Firewalls

- Uses transport-layer information only
  - IP Source Address, Destination Address
  - Protocol/Next Header (TCP, UDP, ICMP, etc)
  - TCP or UDP source & destination ports
  - TCP Flags (SYN, ACK, FIN, RST, PSH, etc)
  - ICMP message type

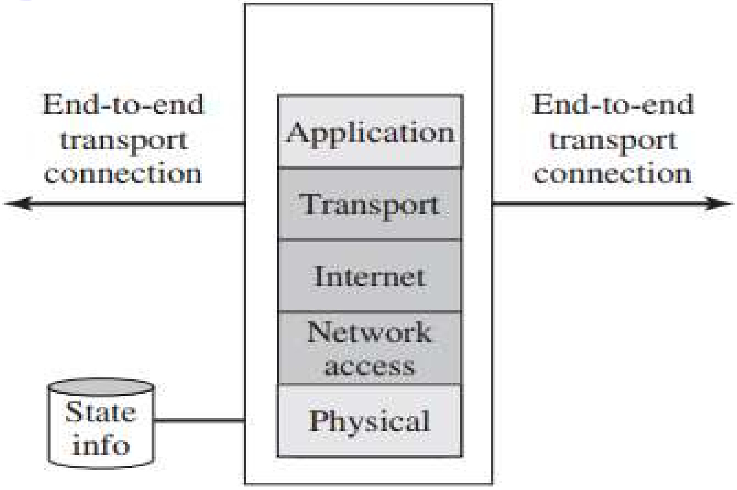
- Examples
  - DNS uses port 53
    - No incoming port 53 packets except known trusted servers

# 2. Stateful Packet Inspection

- Traditional packet filtering firewall makes decisions based on individual packets; don’t consider past packets (stateless)
- Many applications establish a connection between client/server; group of packets belong to a connection
- Often easier to define rules for connections, rather than individual packets
- Need to store information about past behavior (stateful)
- Stateful Packet Inspection (SPI) is extension of traditional packet filtering firewalls
- Issues: extra overhead required for maintaining state information

# Stateful Packet Inspection

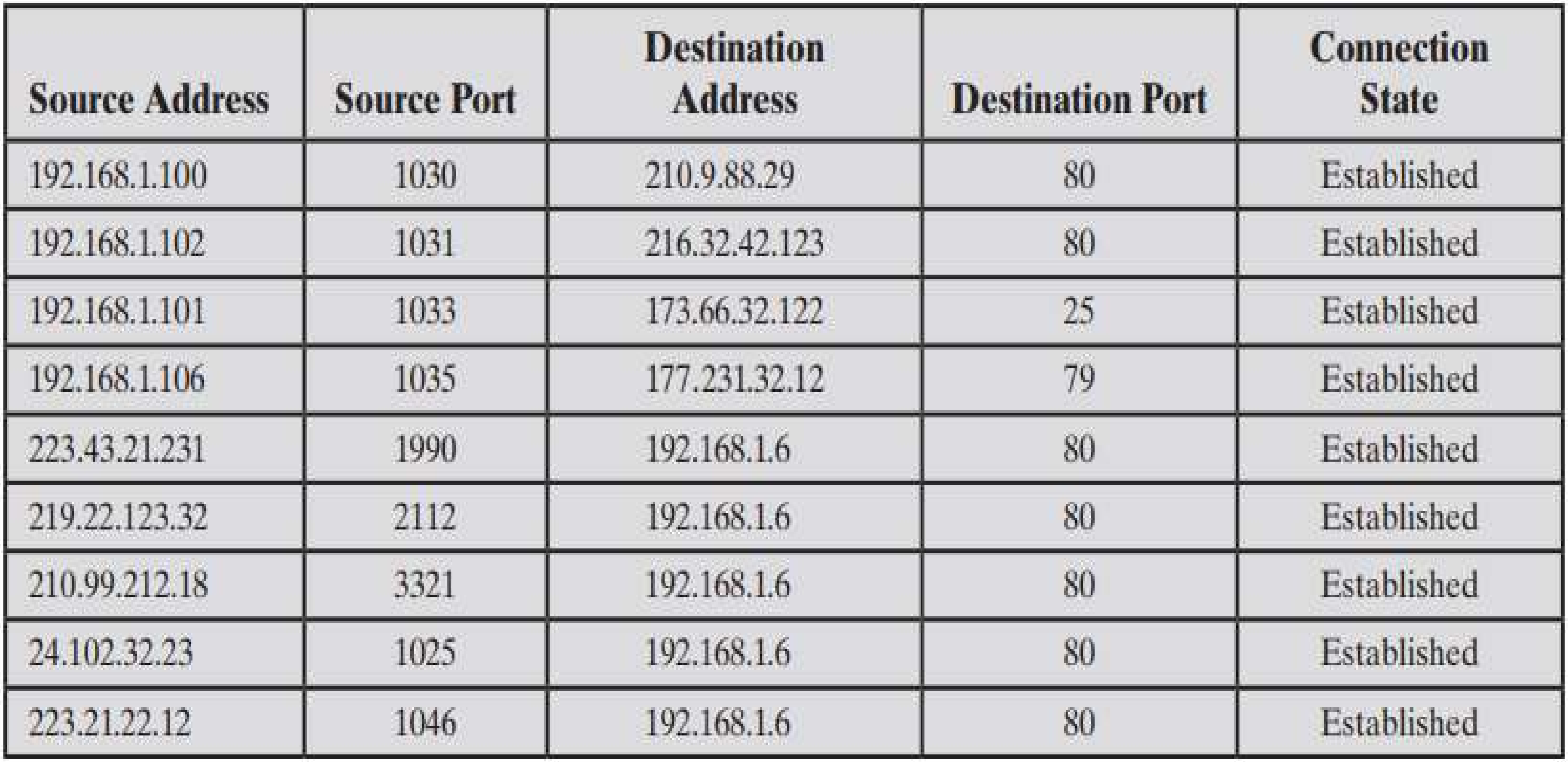
- For connections accepted by packet filtering firewall, record connection information
  - src/dest IP address, src/dest port, sequence numbers, connection state (e.g. Established, Closing)
- Packets arriving that belong to existing connections can be accepted without processing by firewall rules


End-to-end transport connection
Application
Transport
Internet
Network access
Physical
End-to-end transport connection
State info

(c) Stateful inspection firewall

# Stateful Packet Inspection

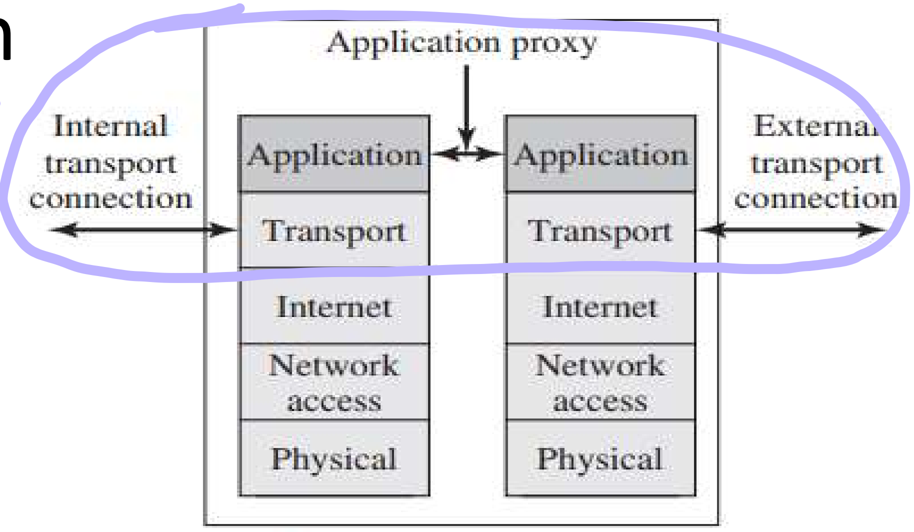
Table 9.2 **Example Stateful Firewall Connection State Table**



| 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 |

# 3. Application Proxy

- Also called Application-level Gateway
  - Allows data into/out of a process based on that process' type
  - Can act on a single computer or at the network layer
    - e.g. allowing only HTTP traffic to a website
  - Log access – attempted access and allowed access
- Tend to be more secure than packet filters
- Disadvantage is the additional processing overhead on each connection



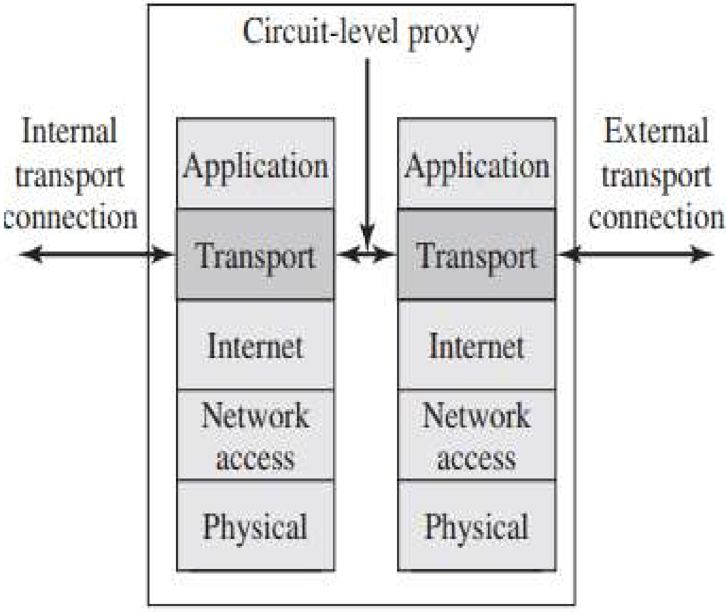
(d) Application proxy firewall

# 4. Circuit-level Proxy Firewall

- Also called Circuit-level Gateway
- Sets up two TCP connections, one between itself and a TCP user on an inner host and one on an outside host
  - For incoming data
    - Proxy is server to internal network clients
  - For outgoing data
    - Proxy is client sending out data to the internet

2

- 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



(e) Circuit-level proxy firewall

# Content Blocking Techniques in Pakistan?

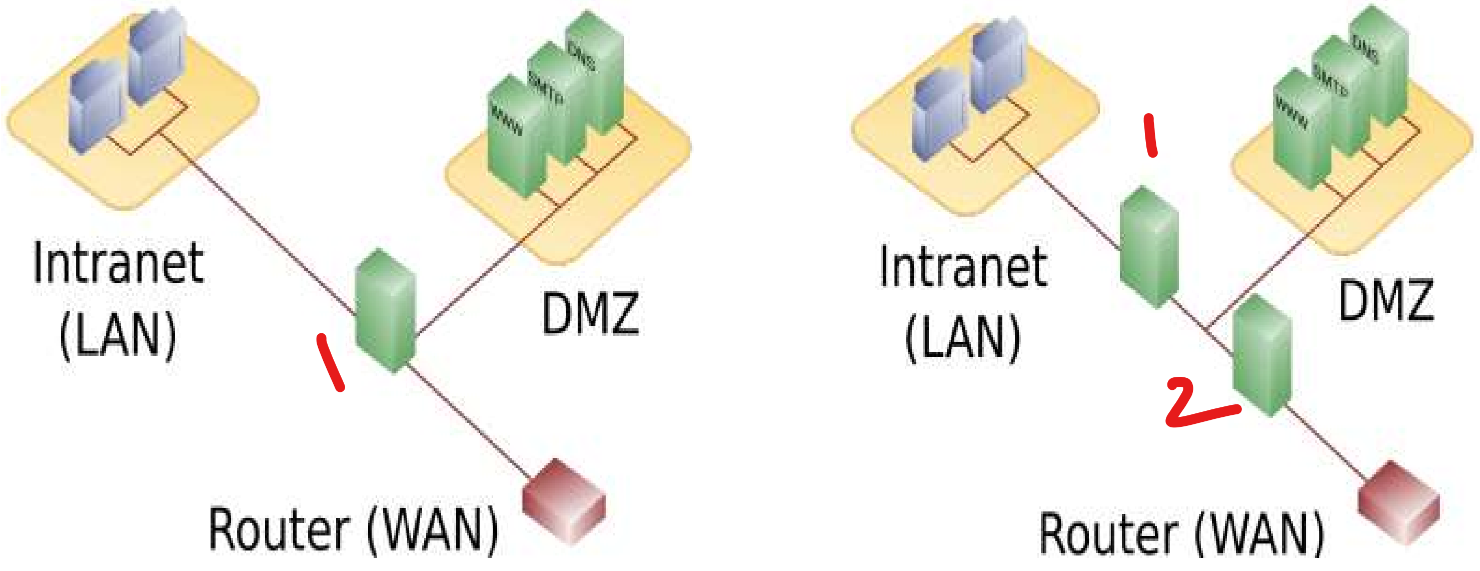
- Application Filtering
- URL Filtering
- DNS Filtering
- Keyword Filtering
- DPI-based Filtering
- IP Filtering
- Throttling

# Firewall Locations

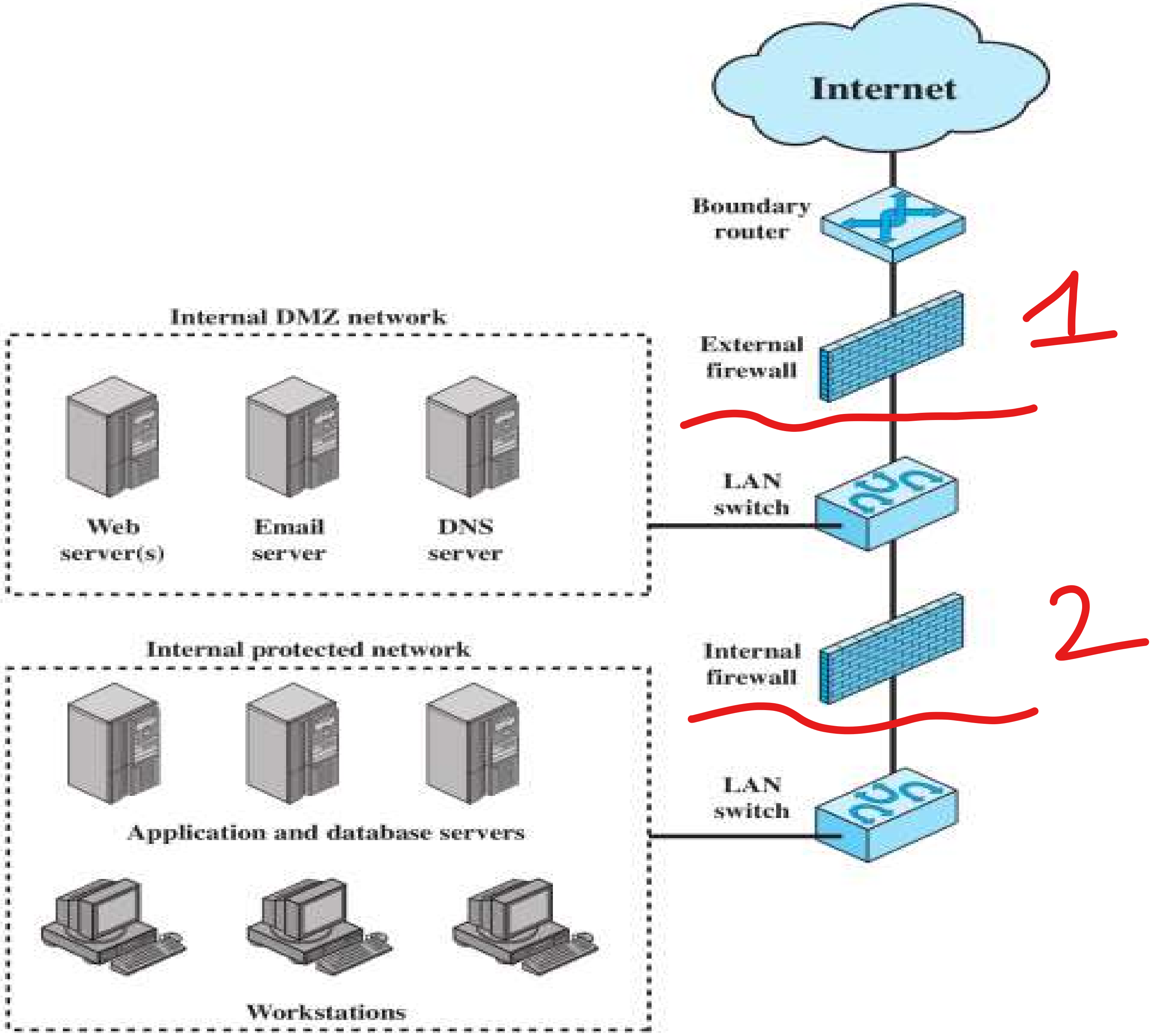
- Firewalls can be located on hosts: end-users computers and servers
- With large number of users, firewalls located on network devices that interconnect internal and external networks

- Common to separate internal network into two zones:
  1. Public-facing servers, e.g. web, email, DNS
  2. End-user computers and internal servers, e.g. databases, development web servers
- Public-facing servers put in De-Militarized Zone (DMZ)

# DMZ with 1 or 2 Firewalls



# Example DMZ with 2 Firewalls



# Security Issues

- Complexity and human error: writing firewall rules that implement the security policy is difficult for large networks

- Bypassing security policies using tunnels

- Bypassing firewalls using other networks (WiFi, mobile) or devices (laptop, USB)