# Firewall

Dr. Asem Kitana

# What is a Firewall?

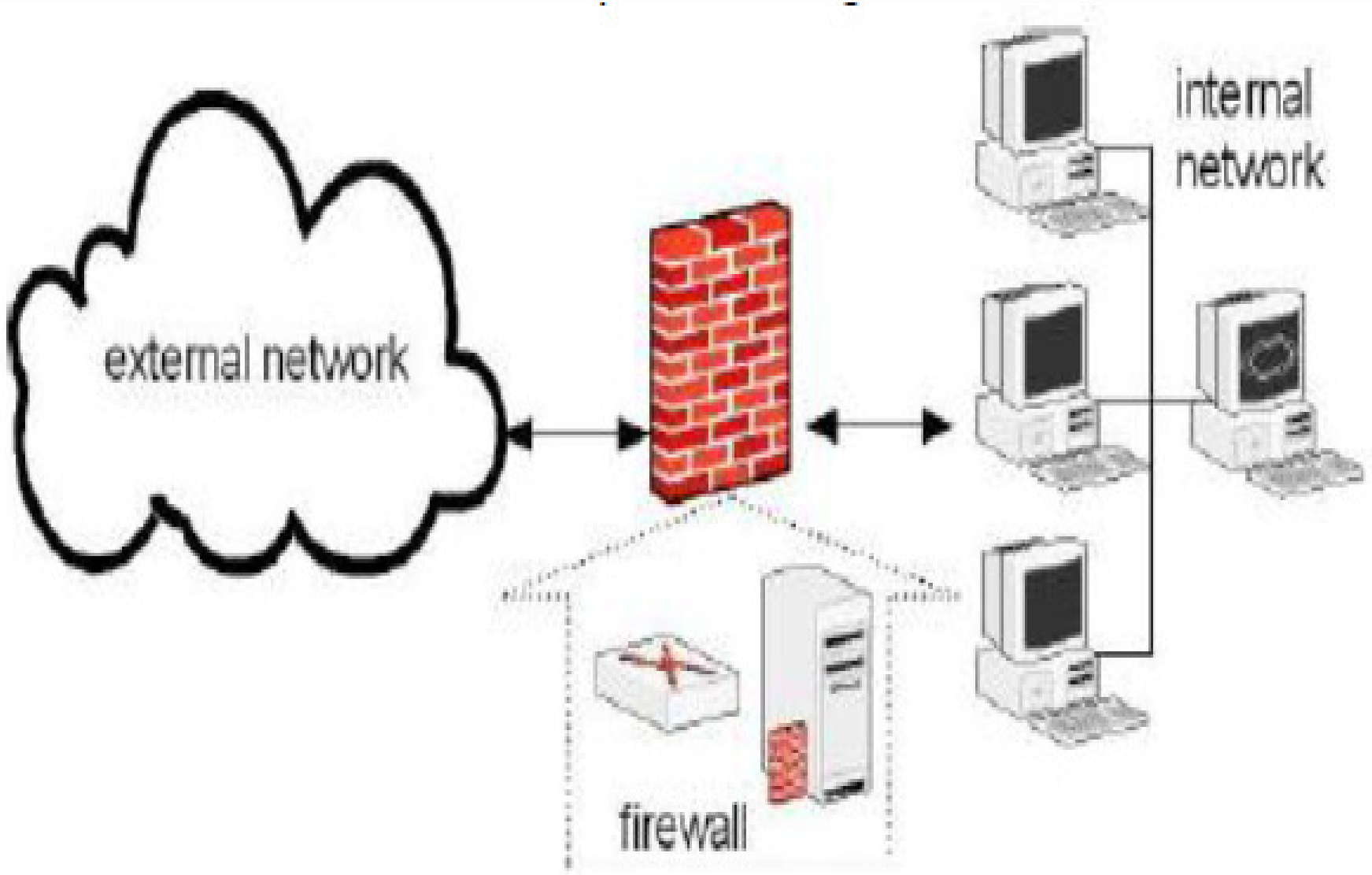
- A firewall is a system that enforces access policy between two (or more) networks.
- A firewall makes the decision on what to do with connection packets based on rules/policies.
- The actions a firewall can take are:
  - Forward/accept the packet (Allows authorized traffic).
  - Drop the packet silently (Blocks prohibited traffic).
  - Drop the packet and send back ICMP messages to the source to notify why it was dropped (Blocks prohibited traffic with notification). but is this action wise?

# Firewall Mechanism

- Two main approaches to setup a firewall:
  - Block all that is not explicitly authorized.
  - Allow all that is not specifically blocked.

- Firewall Mechanism:
  - Firewall examines all traffic packets between the networks.
  - Packets are evaluated against a list of “rules/policies” and conditions.
  - When the packet matches a rule: the action is triggered (reject or allow). The rest of the rules are not evaluated.
  - Rules are checked from top to bottom and the first rule found is applied. If no rules match, the packet is blocked by default.

# Firewall Architecture



# Firewall Architecture

- The previous example shows a firewall architecture made of two blocks. The external network (left side) and the internal network composed of four computers (right side) are two entities separated physically by a firewall, whose goal is filter the inbound traffic and outbound traffic.
- Inbound traffic: the traffic that comes from the external network and destined to the internal network.
- Outbound traffic: the traffic that goes from the internal network towards the external network.

# Default Firewall Policies

- Default to block all
  - If we don't explicitly enable it, then it is blocked
  - May block unintended items
  - Most secure implementation
  - Often implemented by a refinement process…
- Default to allow all
  - If we aren't explicitly blocking it, then it is allowed
  - May miss things you want to block
  - Least secure implementation
  - Hard to refine, hard to audit.  Can you really trust it???

# Types of Firewalls

- Stateless Packet Filtering – Network Layer
- Stateful Packet Filtering – Network Layer
- Circuit Proxy – Transport Layer
- Application Proxy – Application Layer

# Stateless Packet Filtering Firewalls

- Stateless packet filtering firewall acts at layer 3 (Network Layer)
- Control the forwarding or dropping of the data based on the IP header information, not the payloads.
- The information and fields that may be taken into consideration are:
  - IP destination address, IP source address, Protocol type (e.g. TCP, UDP, ICMP), Source protocol port number (e.g. TCP/80, UDP/53), Destination protocol port number, Flags (e.g. SYN, ACK, FIN)
- It does not keep track of the connection or session state.

# Stateless Packet Filtering Example

A

| action | ourhost | port | theirhost | port | comment |
|---|---|---|---|---|---|
| block | * | * | SPIGOT | * | we don't trust these people |
| allow | OUR-GW | 25 | * | * | connection to our SMTP port |

B

| action | ourhost | port | theirhost | port | comment |
|---|---|---|---|---|---|
| block | * | * | * | * | default |

C

| action | ourhost | port | theirhost | port | comment |
|---|---|---|---|---|---|
| allow | * | * | * | 25 | connection to their SMTP port |

D

| action | src | port | dest | port | flags | comment |
|---|---|---|---|---|---|---|
| allow | {our hosts} | * | * | 25 | | our packets to their SMTP port |
| allow | * | 25 | * | * | ACK | their replies |

E

| action | src | port | dest | port | flags | comment |
|---|---|---|---|---|---|---|
| allow | {our hosts} | * | * | * | | our outgoing calls |
| allow | * | * | * | * | ACK | replies to our calls |
| allow | * | * | * | >1024 | | traffic to nonservers |

# Stateful Packet Filtering

- Stateful packet filtering firewall acts at layer 3 (Network Layer)
- Perform all the functions of a stateless packet filtering firewall but also keep track of the state of the connection and past packets in the communication.
- Stateful packet filtering firewall allows inspecting both complex combinations of payload (message content) and context established by prior packets to influence filtering decisions.

# Stateful Packet Filtering

- The firewall will attempt to track all the information in the communication. For instance:
  - If it evaluate a TCP packet from B to A that has a SYN-ACK flag, it will verify that it has seen a corresponding SYN packet from A to B before (is the TCP connection behaving correctly?).
- In other words: the stateful packet filter will keep track of all conversations and ensure that all packets transiting comply with proper protocol rules and operations.

# Stateful Packet Filtering Example

-The connection tracking states used in building rules include the following:

| State | Meaning |
|---|---|
| NEW | This packet belongs to a session that is not an already known connection. Thus, it is considered to be a NEW connection. |
| ESTABLISHED | Packets belong to a session that has seen traffic flowing in both directions. |
| RELATED | This connection is related to another connection (in NEW or ESTABLISHED state). |
| INVALID | A state that denotes an error. |

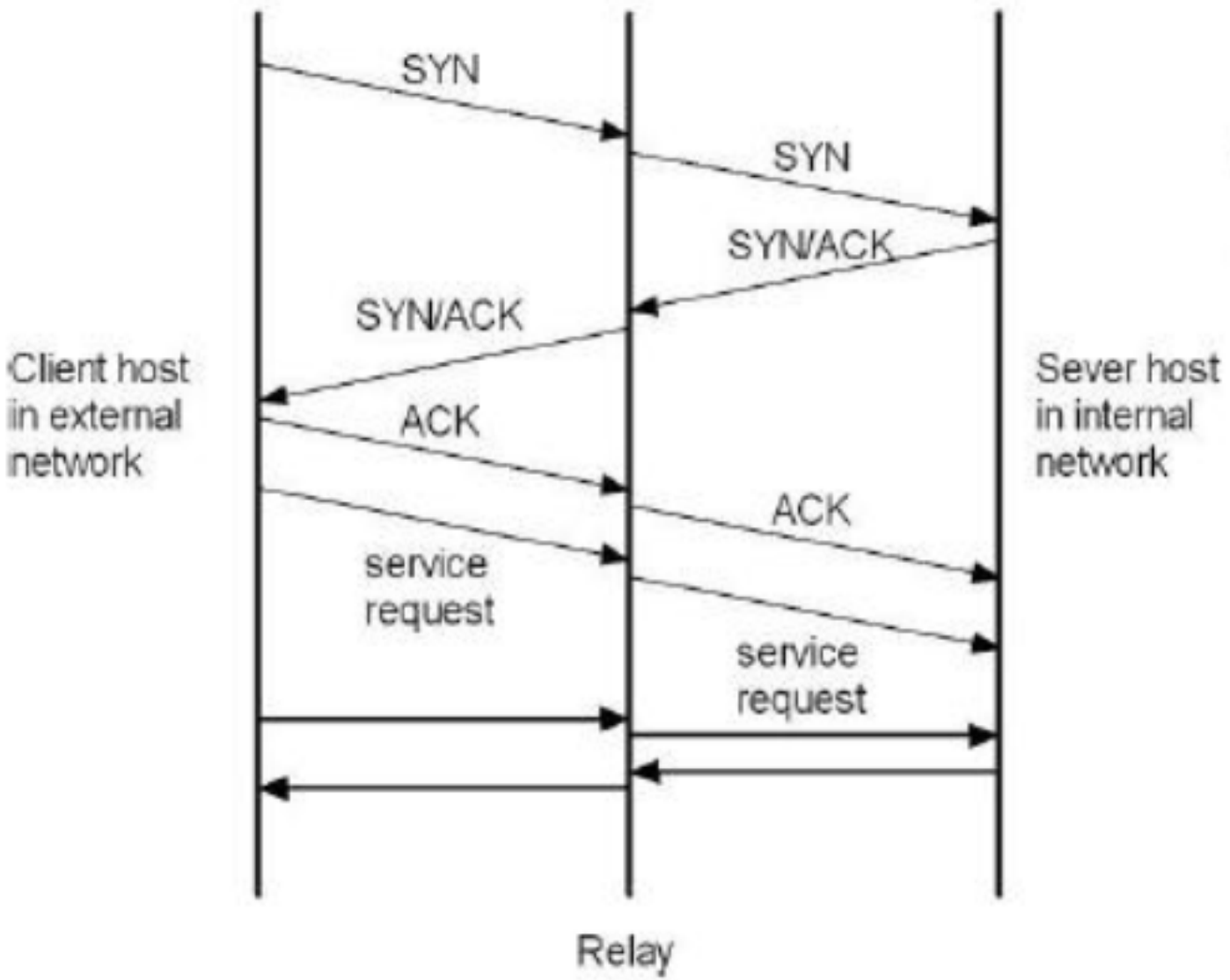
*Connection state table example*

| client addr | client port | server addr | server port | connection state | protocol |
|---|---|---|---|---|---|
| 219.22.101.32 | 1030 | 129.63.24.84 | 25 | established | TCP |
| 219.22.101.54 | 1034 | 129.63.24.84 | 161 | established | UDP |
| 210.99.201.14 | 2001 | 129.63.24.87 | 80 | established | TCP |
| 24.102.129.21 | 3389 | 129.63.24.87 | 110 | established | TCP |

# Circuit Proxy

- Circuit proxy firewall acts at layer 4 (Transport Layer).
- Their purpose is to examine information of IP addresses and port numbers in TCP/UDP headers to determine if a connection is allowed.
- They act as intermediate that relay a TCP connection between an internal and external host.
- They disallow the direct connection between the external and the internal networks.

# Circuit Proxy



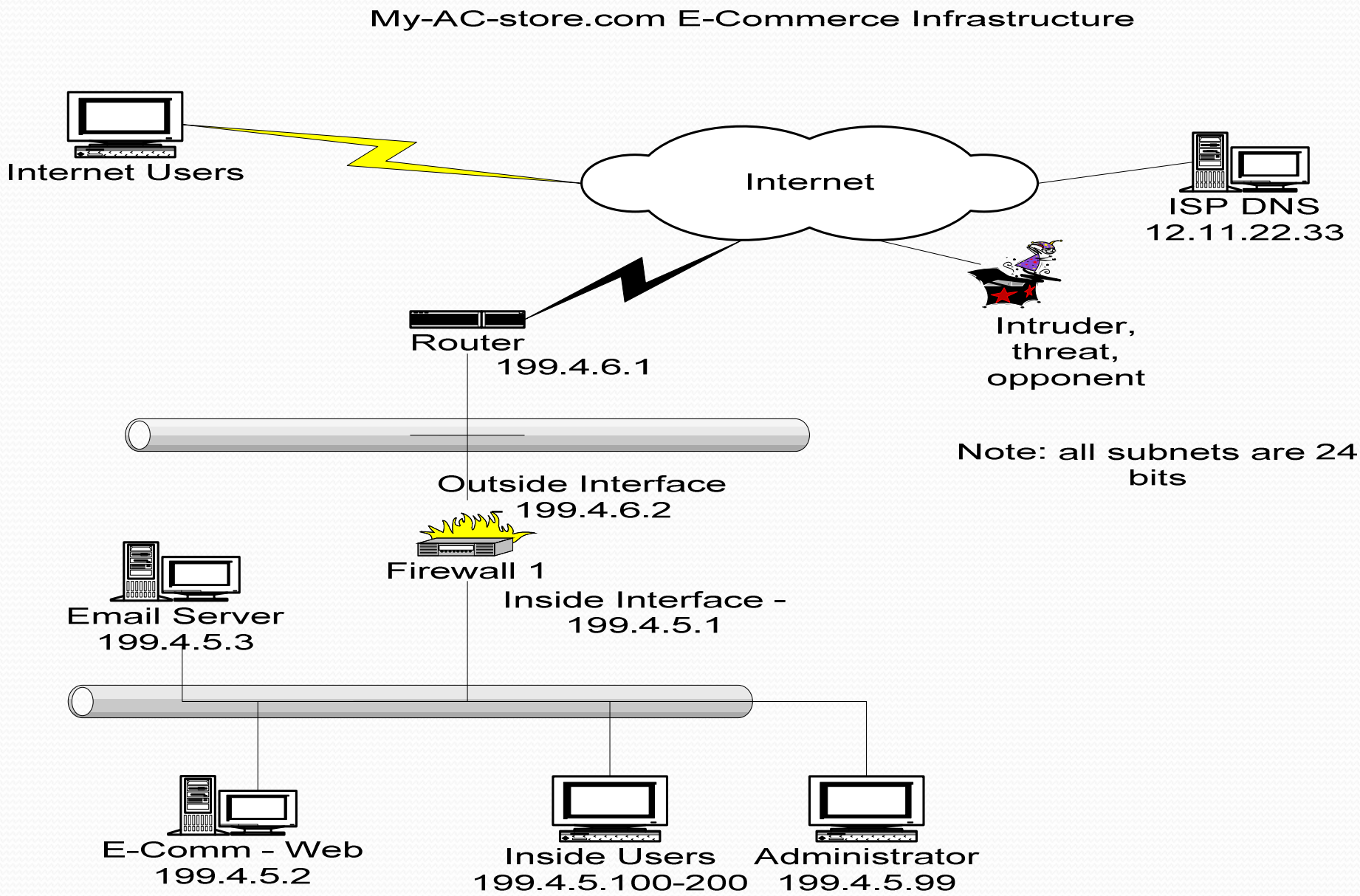
# Application Proxy

- Application proxy firewall acts as an intermediate communication point between 2 parties:
  - Each party "think" they directly communicate to the other.
  - Actually they communicate to the Application Proxy Firewall.
  - A – Proxy – B: A communicates to the proxy, the proxy then "acts" as A when communicating to B and vice-versa.
- These application proxy firewalls act at layer 7 (Application Layer).

# Application Proxy

- Basic functionalities of application proxy include:
  - Accepting the client sessions and appearing to them as a server.
  - Receiving from the client software the name of the actual server.
  - Contacting the actual server and appearing to it as a client.
  - Relaying all the data from the client to a server.
  - Performing access control and enforcement functions by checking, and accepting or rejecting the incoming and outgoing connections.

# Firewall Policy



# Firewall Policy

| Set Name | Rule # | Protocol | A/R | Source IP | Src Port | Dest IP | Dest Port | Flag | Comments |
|---|---|---|---|---|---|---|---|---|---|
| set1 | 1 | tcp | R | any | any | any | any | SYN+FIN | |
| set1 | 2 | tcp | A | any | any | 199.4.5.2 | 80/443 | | |
| set1 | 3 | tcp | A | any | any | 199.4.5.3 | smtp + pop3 | | |
| set1 | 4 | tcp | A | any | 80/443 | 199.4.5.99 | any | ack | |
| set1 | 5 | udp | A | any | 53 | 199.4.5.0 | any | | |
| set1 | 6 | IP | R | any | any | any | any | any | |
| | | | | | | | | | |
| set2 | 1 | tcp | A | 199.4.5.99 | any | any | 80/443 | | |
| set2 | 2 | udp | A | 199.4.5.0 | any | any | 53 | | |
| set2 | 3 | tcp | A | 199.4.5.99 | any | 199.4.5.1 | 23 | | |
| set2 | 4 | tcp | A | 199.4.5.2 | 80/443 | any | any | ack | |
| set2 | 5 | tcp | A | 199.4.5.3 | smtp + pop3 | any | any | ack | |
| set2 | 6 | IP | R | any | any | any | any | any | |

Set1 applied to outside interface of firewall
Set2 applied to inside interface of firewall

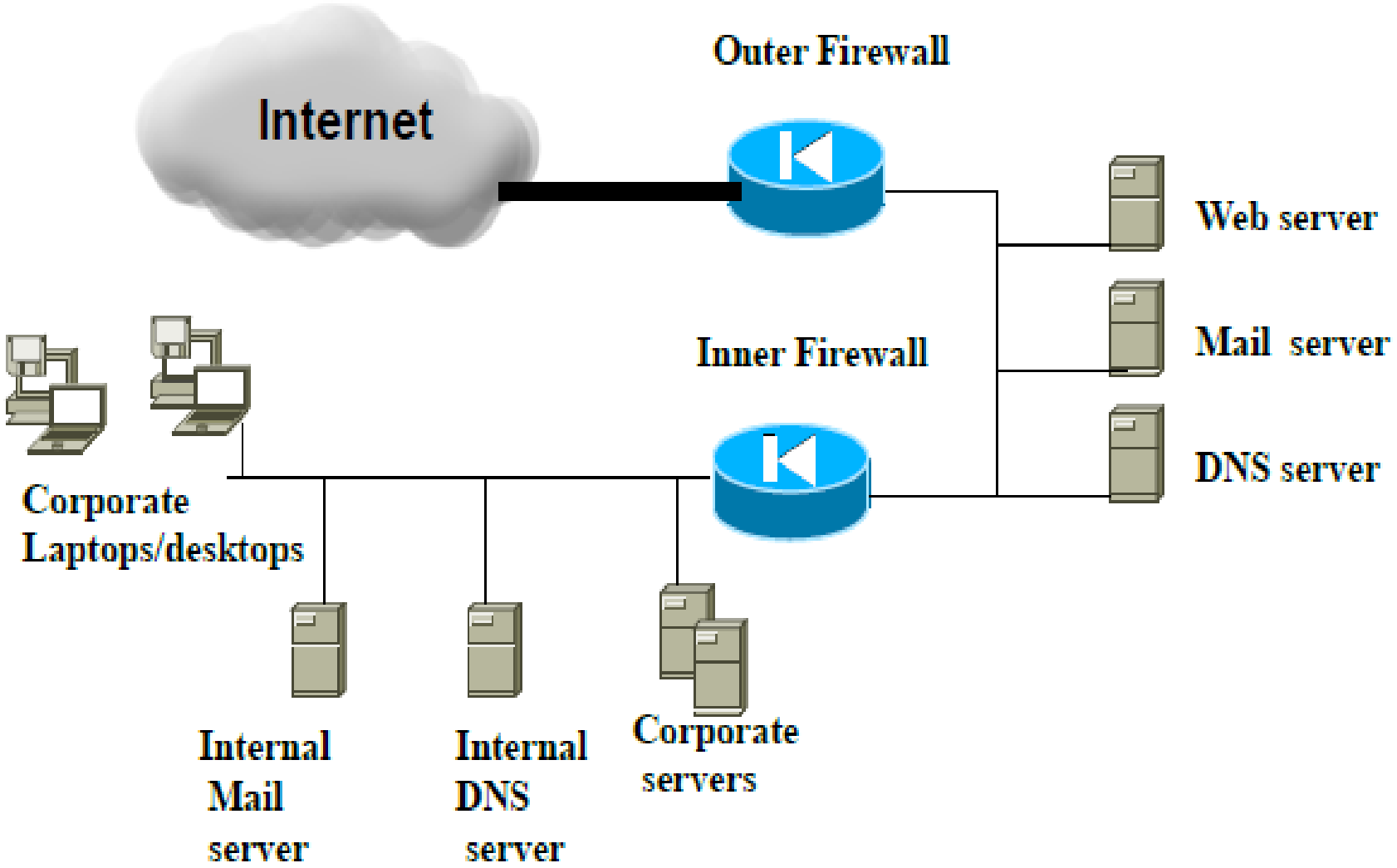
# Demilitarized Zones (DMZ)

DMZ is a subnet between two firewalls in an internal network

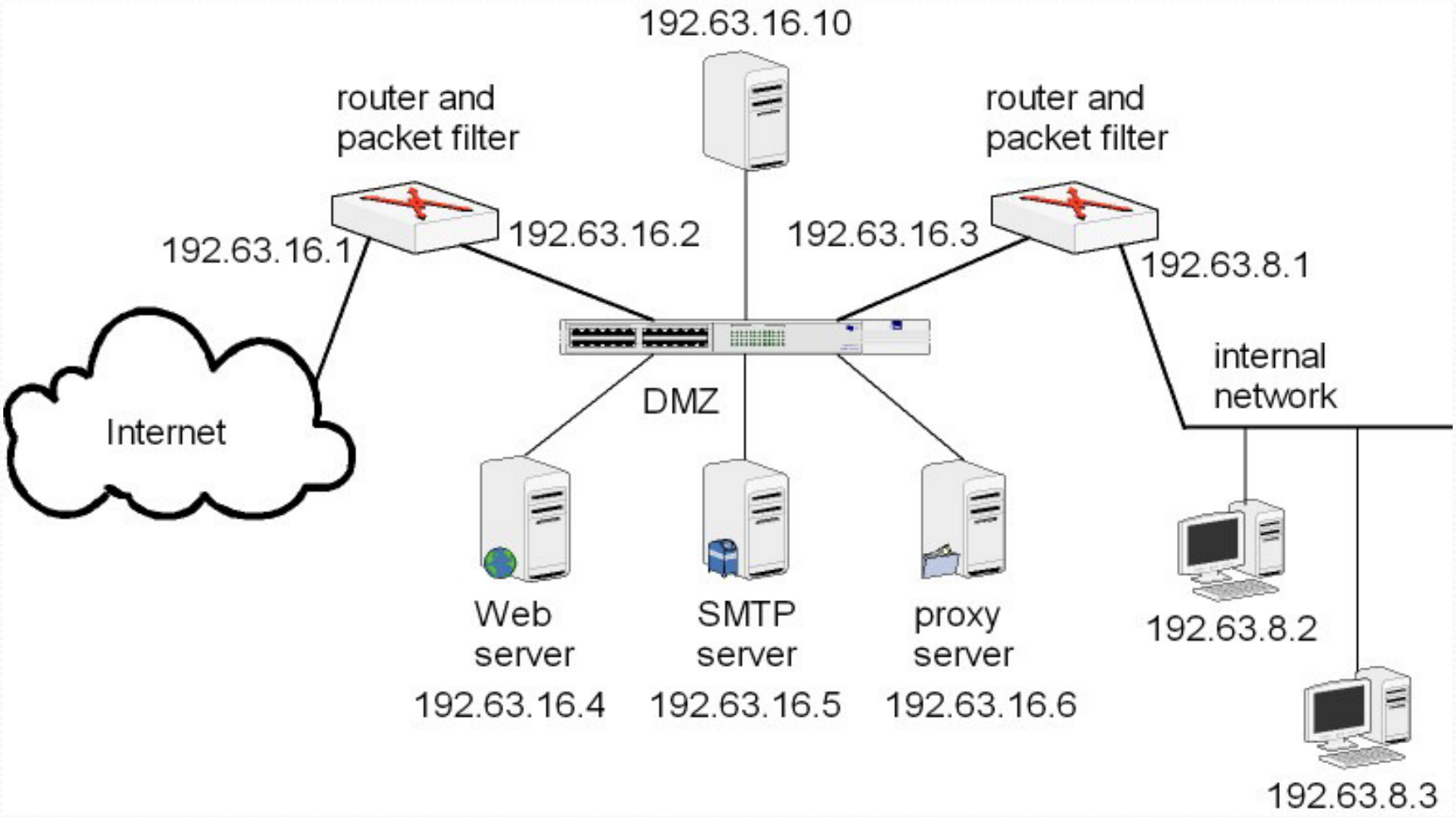
- External firewall protects DMZ from external threats
- Internal firewall protects internal network from DMZ

- The role of the DMZ is to provide strong separation between the external and internal networks.

# DMZ Example1



# DMZ Example2



# Benefits of Firewall

- Control access based on sender or receiver addresses.
- Control access based on the service requested.
- Hiding the internal network (e.g., topology, addresses, traffic, etc.)
- Authentication based on the source of traffic.
- Choke point for security audit (Logging activities).
- Reduce attacks by hackers.