Computer Security: Principles and Practice

Chapter 9: Firewalls and Intrusion Prevention Systems

Firewalls and Intrusion Prevention Systems

- Effective means of protecting LANs
- Internet connectivity is essential
  - For organization and individuals
  - But creates a threat (enabling the outside world to reach and interact with local network assets)
- Could secure all workstations and servers (but this is not a practical approach)
- Also use firewall as perimeter defence
  - Single choke point to impose security

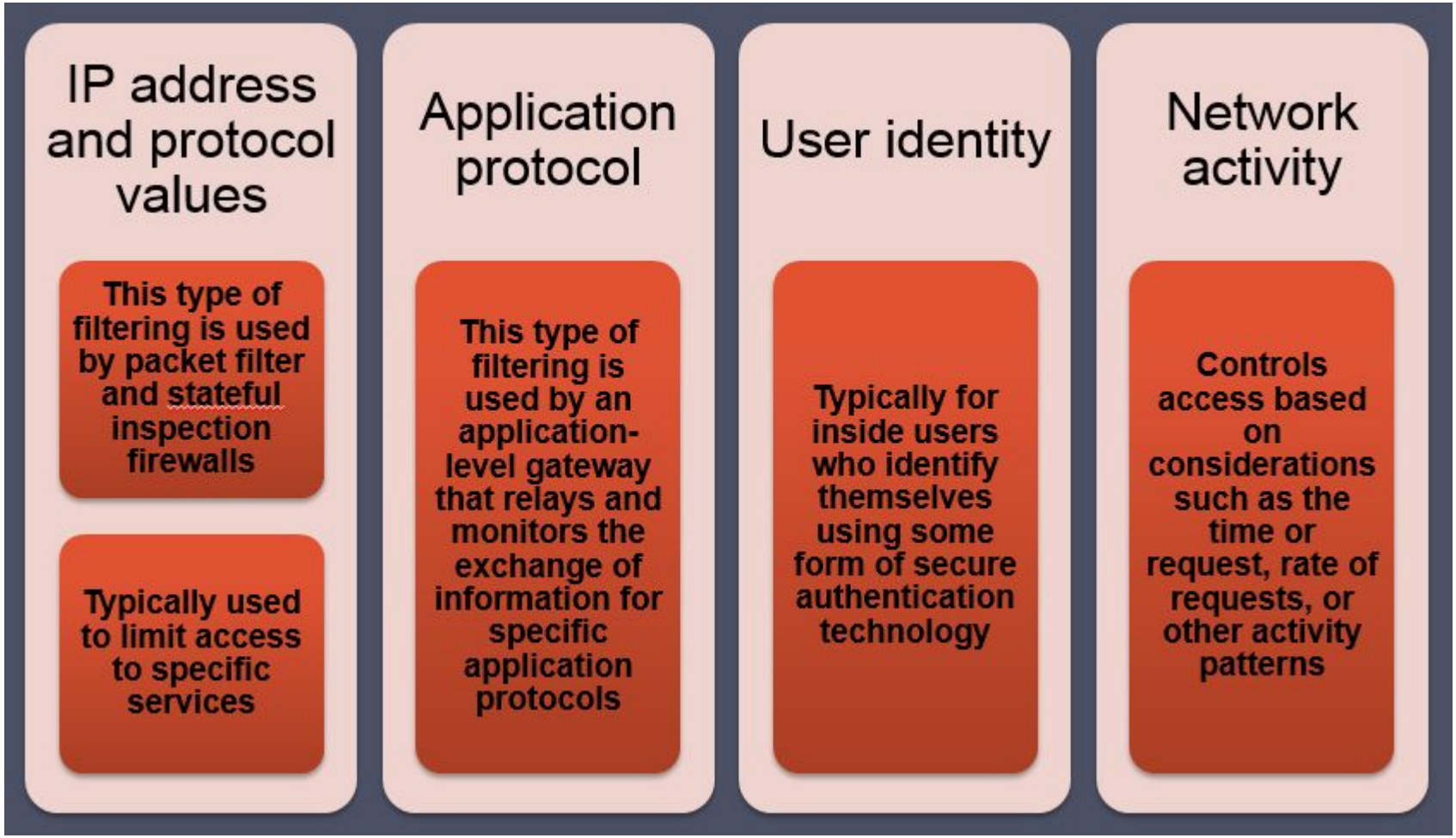
Firewall Access Policy

- A critical component in the planning and implementation of a firewall is specifying a suitable access policy
  - Types of traffic authorized to pass through the firewall
  - Includes address ranges, protocols, applications and content types
- The policy should be developed from the organization's 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 Capabilities & Limits

- Capabilities
  - Defines a single choke point
  - Provides a location for monitoring security events
  - Convenient platform for some Internet functions such as NAT, usage monitoring, IPSEC, VPNs
- Limitations
  - Cannot protect against attacks bypassing firewall (from dial-out, or a modem pool dial-in capability for traveling employees and telecommuters)
  - May not protect fully against internal threats
  - Improperly secure wireless LAN
  - Laptop, PDA, portable storage device infected outside then used inside

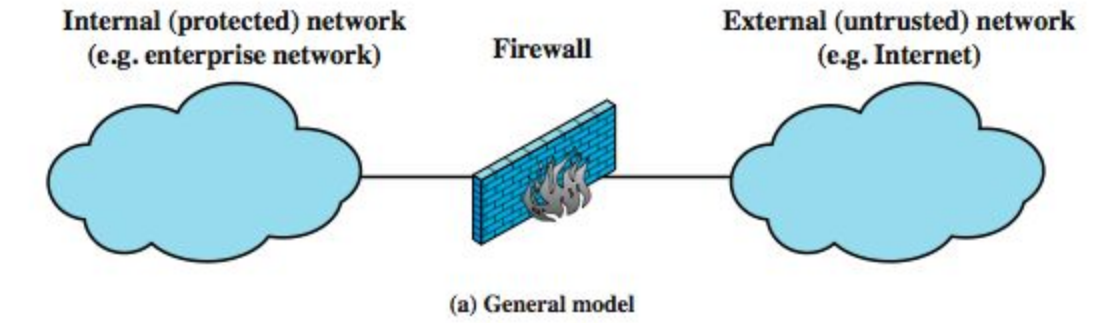
Firewall Filter Characteristics



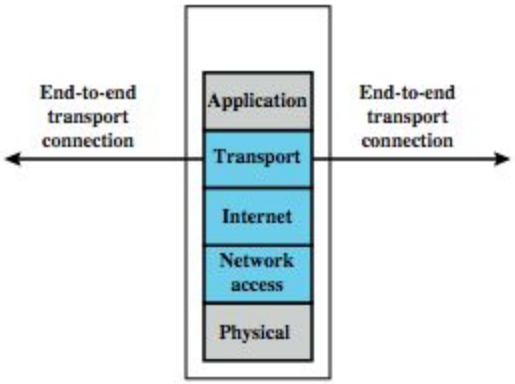
Types of Firewalls

Positive (negative) filter: Allow (reject) packets that meet a criteria

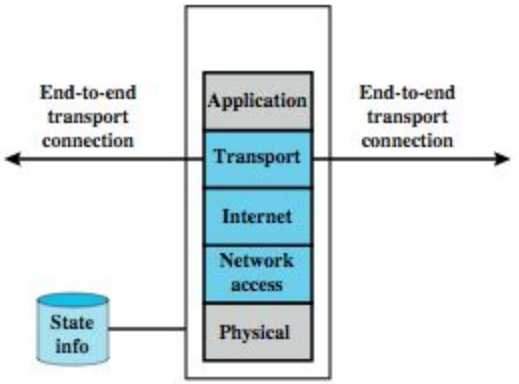
Stateful inspection: Keeps track of TCP connections



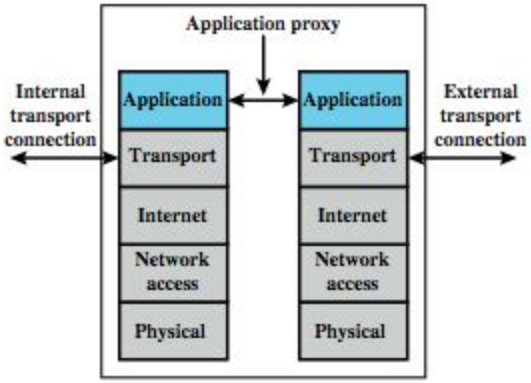
(a) General model



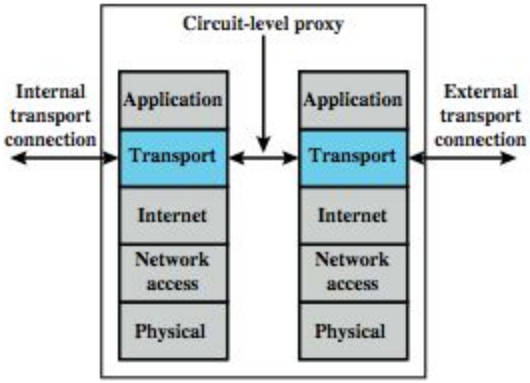
(b) Packet filtering firewall



(c) Stateful inspection firewall



(d) Application proxy firewall



(e) Circuit-level proxy firewall

Packet Filtering Firewall

- Applies rules to packets in/out of firewall
- based on information in packet header
  - src/dest IP addr & port, IP protocol, interface
- Typically a list of rules of matches on fields
  - If match rule says if forward or discard packet
- Two default policies:
  - Discard: prohibit unless expressly permitted
    - more conservative, controlled, visible to users
  - Forward: permit unless expressly prohibited
    - easier to manage/use but less secure

Packet Filter Rules

Default rule (usually the last rule)

Inside hosts can send email

A way of handling FTP

Rule Set A

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

Rule Set B

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

Rule Set C

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

Rule Set D

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

Rule Set 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

Packet Filter Rules

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

Packet Filter Weaknesses

- Weaknesses
  - Cannot prevent attack on application bugs
  - Limited logging functionality
  - Do no support advanced user authentication
  - Vulnerable to attacks on TCP/IP protocol bugs (e.g., IP address spoofing)
  - Improper configuration can lead to breaches
- Attacks
  - IP address spoofing
  - Source route attacks (srs dictates the pkt route)
  - Tiny fragment attacks (to circumvent filtering rules that depend on TCP header info)

Stateful Inspection Firewall

- Reviews packet header information but also keeps info on TCP connections
  - Typically have low, “known” port # for server and high, dynamically assigned (ephemeral) client port #
  - Stateful inspection packet firewall tightens rules for TCP traffic using a directory of TCP connections
  - only allow incoming traffic to high-numbered ports for packets matching an entry in this directory
  - may also track TCP seq numbers as well

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

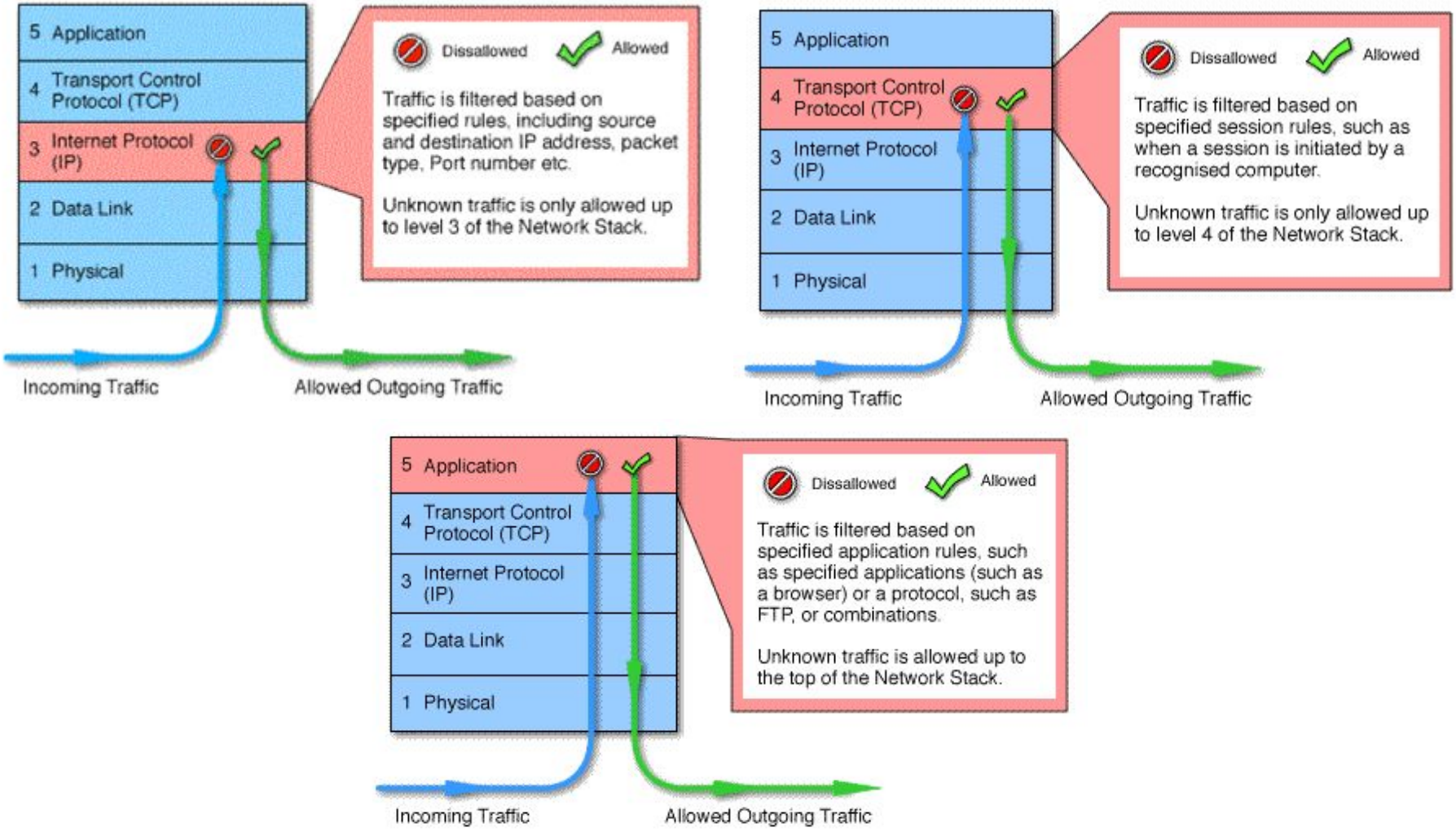
Application-Level (Proxy) Gateway

- Acts as a relay of application-level traffic
  - User contacts gateway with remote host name
  - Authenticates themselves
  - 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
  - Some services may not be available
- More secure than packet filters
- But have higher overheads

Circuit-Level Gateway

- Sets up two TCP connections, to an inside user and to an outside host
- Once connection is established, relays TCP segments from one connection to the other without examining contents
  - Hence independent of application logic
  - Just determines whether relay is permitted
- Typically used when inside users trusted
  - May use application-level gateway inbound and circuit-level gateway outbound
  - Hence lower overheads

Packet Filtering vs Gateway vs Application-Level Firewall



SOCKS Circuit-Level Gateway

- SOCKS v5 defined as RFC1928 to allow TCP/UDP applications to use firewall
- Components:
  - SOCKS server on firewall
  - SOCKS client library on all internal hosts
  - SOCKS-ified client applications
- Client app contacts SOCKS server, authenticates, sends relay request
- Server evaluates & establishes relay connection
- UDP handled with parallel TCP control channel

Firewall Basing

- Several options for locating firewall:
  - Bastion host
  - Individual host-based firewall
  - Personal firewall

Bastion Hosts

- Critical strongpoint in network
- Hosts application/circuit-level gateways
- Common characteristics:
  - Runs secure O/S, only essential services
  - May require user auth to access proxy or host
  - There may be many proxy services
  - Each proxy can restrict features, hosts accessed
  - Each proxy small, simple, checked for security
  - Each proxy is independent, can be uninstalled

Host-Based Firewalls

- Used to secure individual host
- Available in/add-on for many O/S
- Filter packet flows
- Often used on servers
- Advantages:
  - Tailored filter rules for specific host needs
  - Protection from both internal/external attacks
  - Additional layer of protection to org firewall when used with a standalone firewall

Personal Firewall

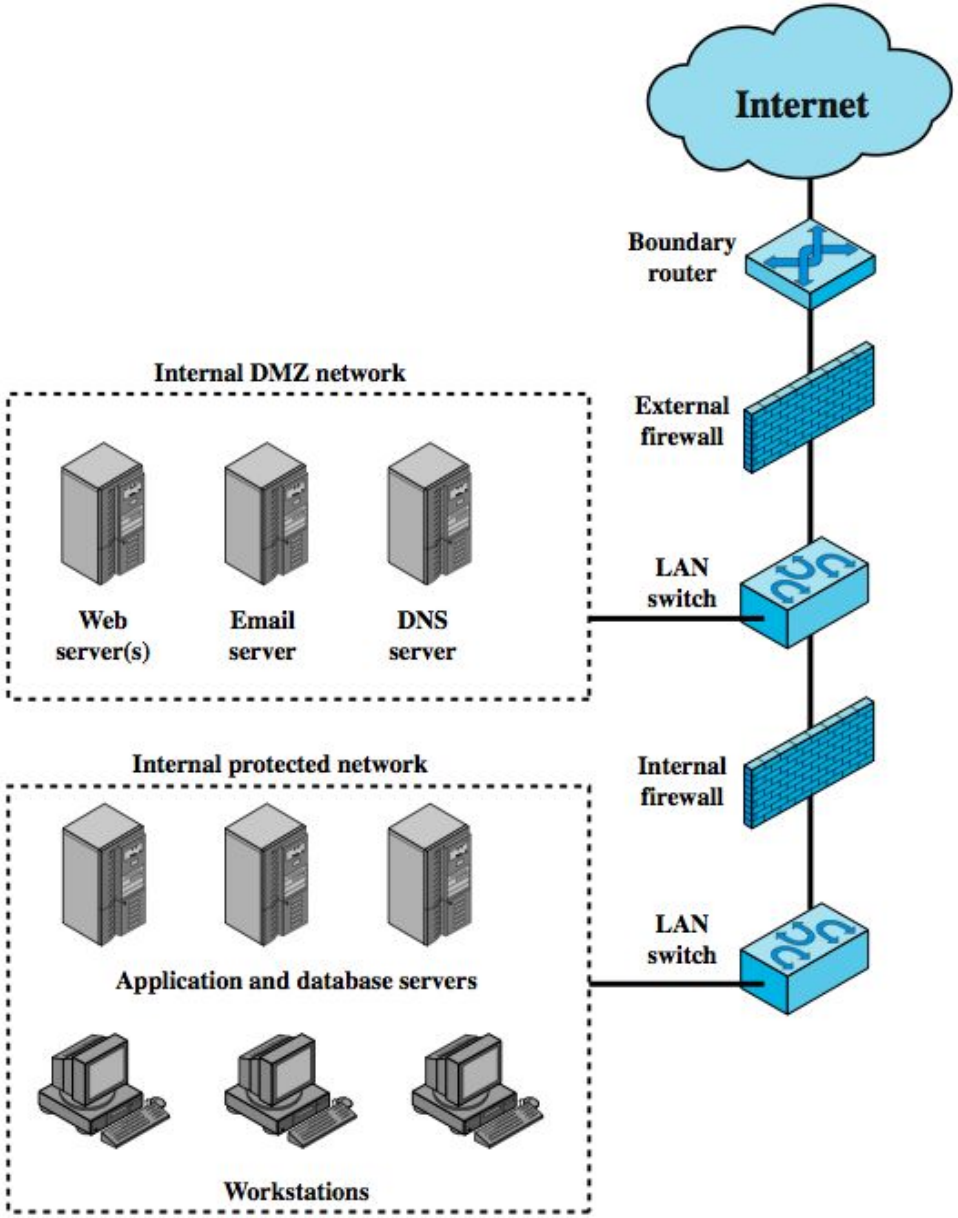
- Controls traffic flow to/from PC/workstation
- For both home or corporate use
- May be software module on PC
- Or in home cable/DSL router/gateway
- Typically much less complex
- Primary role to deny unauthorized access
- May also monitor outgoing traffic to detect/block worm/malware activity

Firewall Locations

External firewall: protection for the DMZ consistent with their need for external connectivity

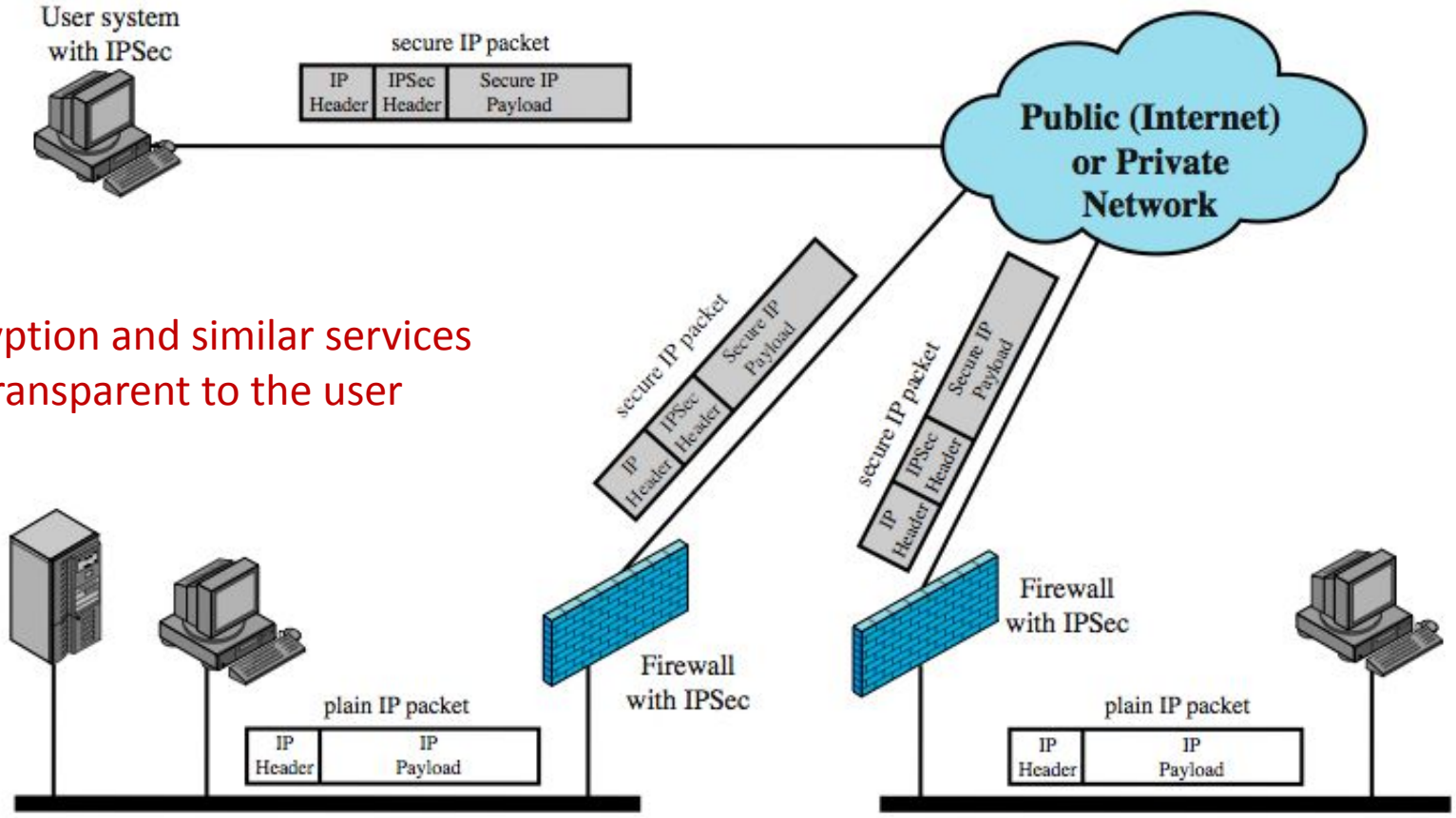
Internal firewall:

(a)more stringent filtering capability to provide protection from external attacks
(b) provides two way protection wrt the DMZ network



Virtual Private Networks

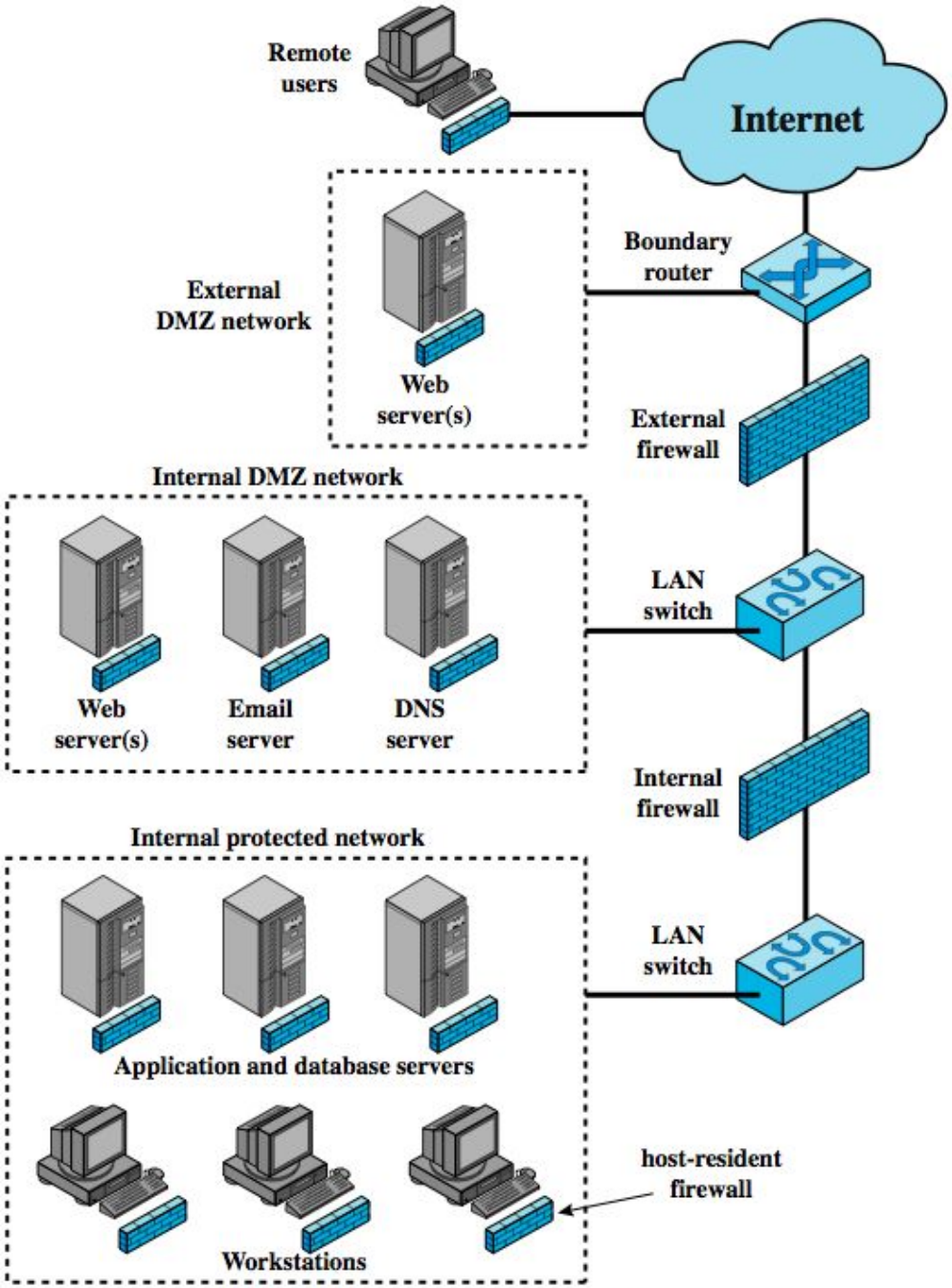
Encryption and similar services
but transparent to the user



Distributed Firewalls

A combination of earlier firewalls

Host-resident firewall on 100s of PCs plus standalone firewalls under a central administration



Firewall Topologies

- Host-resident firewall: personal firewall and firewall on servers (used alone or part of a defense in-depth)
- Screening router: a **single** router between internal and external networks, e.g., SOHO apps)
- Single bastion inline: **single** firewall **device** between an internal and external router (*stateful or app proxies*)
- Single bastion T: similar to above but has a **3rd NIC** on bastion to a DMZ (for medium to large organizations)
- Double bastion inline: DMZ is between (for large organizations)
- Distributed firewall configuration

Intrusion Prevention Systems (IPS)

- Recent addition to security products which
  - Inline network-/host-based IDS that can *block* traffic
  - Functional addition to firewall that adds IDS capabilities
- Using IDS algorithms but can *block* or *reject* packets like a firewall
- May be network or host based

Host-Based IPS

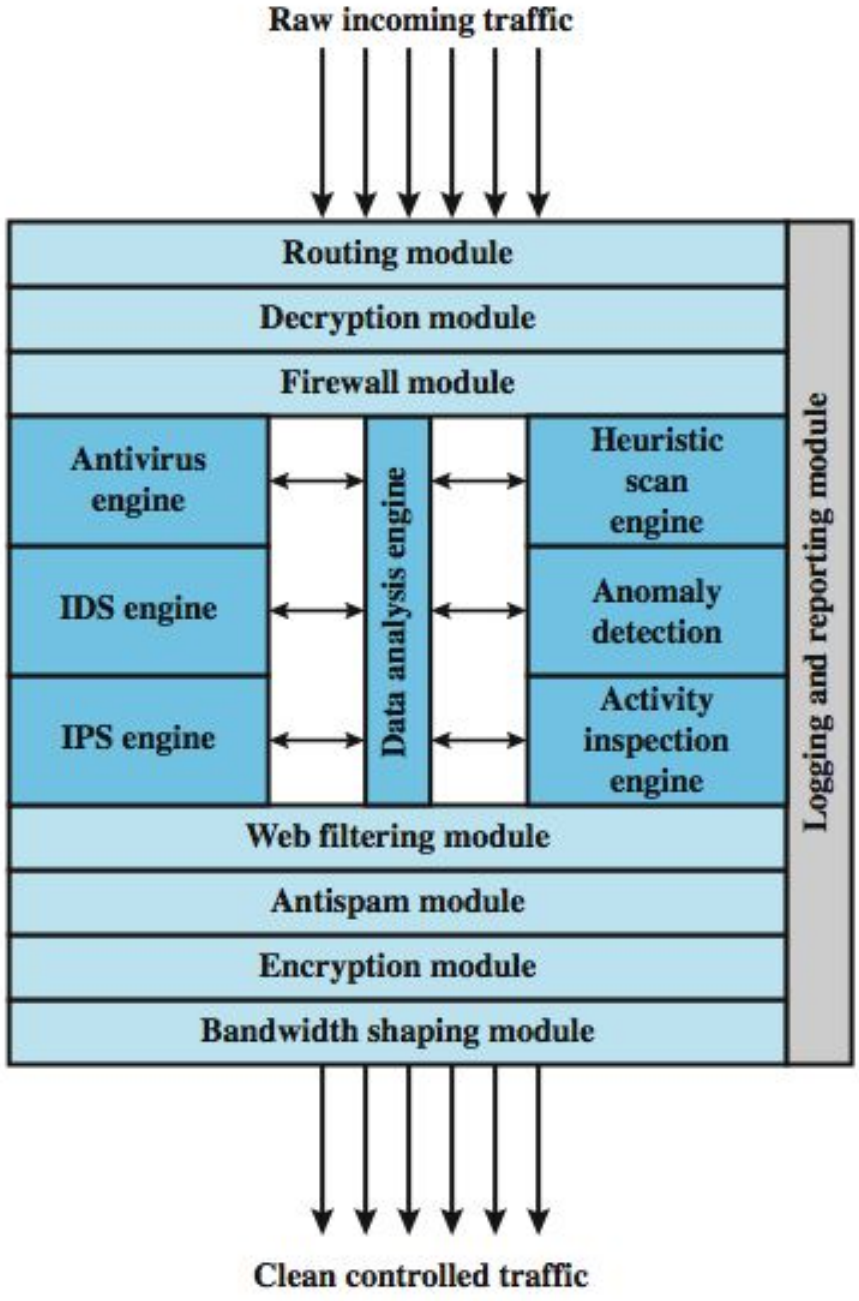
- Identifies attacks using both:
  - Signature techniques
    - malicious application packets
  - Anomaly detection techniques
    - behavior patterns that indicate malware
  - Example of malicious behavior: buffer overflow, access to email contacts, directory traversal
- Can be tailored to the specific platform
  - e.g. general purpose, web/database server specific
- Can also sandbox applets to monitor behavior
- May give desktop file, registry, I/O protection

Network-Based IPS

- inline NIDS that can discard packets or terminate TCP connections
- uses signature and anomaly detection
- may provide flow data protection
  - monitoring full application flow content
- can identify malicious packets using:
  - pattern matching (for specific byte seq)
  - stateful matching (to stop attack streams rather than a single pkts)
  - protocol anomaly (deviations from stds)
  - traffic anomaly (unusual traffic like a UDP floods)

Unified Threat Management Products

Reduce admin burden by replacing network products (firewall, IDS, IPS, …)
With a single device



Summary

- Introduced need for & purpose of firewalls
- Types of firewalls
  - packet filter, stateful inspection, application and circuit gateways
- Firewall hosting, locations, topologies
- Intrusion prevention systems