

Firewalls

ITS335: IT Security

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Firewall Characteristics

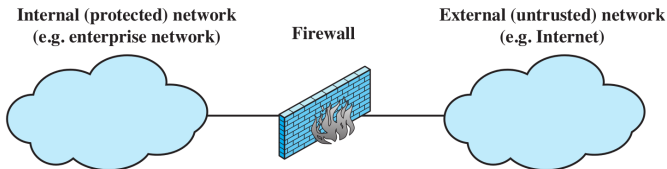
Types of Firewalls

Firewall Locations

Summary

The Need for Firewalls

- ▶ Internet connectivity is essential for organisations
 - ▶ 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



Firewall Characteristics

Design Goals

- ▶ All traffic from inside to outside must pass through the firewall
- ▶ Only authorised traffic as defined by the local security policy will be allowed to pass
- ▶ The firewall itself is immune to penetration

General Techniques

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

Capabilities and 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 organisation
- ▶ Laptop, phone, or USB drive may be infected outside the corporate network then used internally

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Packet Filtering accepts/rejects packets based on protocol headers

Stateful Packet Inspection adds state information on what happened previously to packet filtering firewall

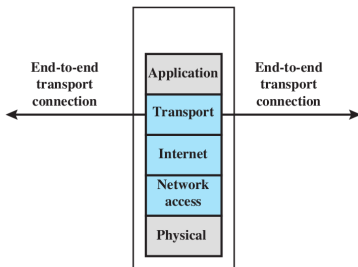
Application Proxy relay for application traffic

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)

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) - **recommended**



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

Example Packet Filtering Firewalls

Software

- ▶ In operating systems: iptables (Linux), ipfw (Mac OSX), pf (BSD), Windows Firewall
- ▶ Standalone software: Comodo, Kaspersky, Norton, ZoneAlarm, Check Point, . . .

Appliances

- ▶ Firewall included in most consumer and enterprise routers
- ▶ Dedicated hardware: Cisco ASA/PIX, Dell SonicWALL, HP, Barracuda, Juniper, . . .
- ▶ Dedicated software distributions: pfSense, Monowall, Smoothwall, ClearOS, Untangle, IPCop, . . .

Issues with Packet Filtering Firewalls

Advantages

- ▶ Simplicity
- ▶ Transparent to users
- ▶ Very fast

Disadvantages

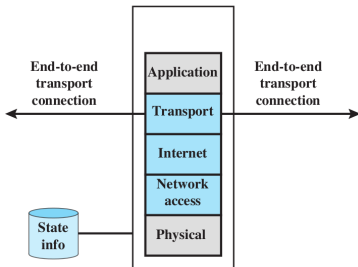
- ▶ Cannot prevent attacks that employ application specific vulnerabilities or functions
- ▶ Limited logging functionality
- ▶ Do not support advanced user authentication
- ▶ Vulnerable to attacks on TCP/IP protocol bugs
- ▶ Improper configuration can lead to breaches

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 behaviour (stateful)
- ▶ Stateful Packet Inspection (SPI) is extension of traditional packet filtering firewalls
- ▶ Issues: extra overhead required for maintaining state information

Stateful Packet Inspection

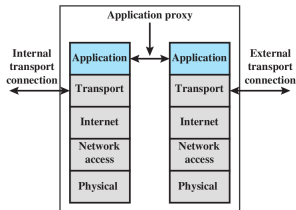
- ▶ For connections accepted by packet filtering firewall, record connection information
 - ▶ src/dest IP address, src/dest port, sequence numbers, connection state (e.g. Established, Closing)
- ▶ Packets arriving that belong to existing connections can be accepted without processing by firewall rules



Credit: Figure 9.1(c) in Stallings and Brown, *Computer Security*, 2nd Ed., Pearson 2012

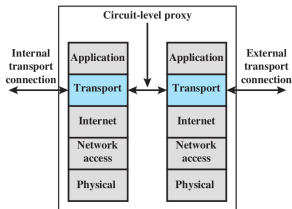
Application Proxy

- ▶ Also called Application-level Gateway
- ▶ Acts as a relay of application-level traffic
 - ▶ User contacts gateway using a TCP/IP application
 - ▶ 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 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
- ▶ 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



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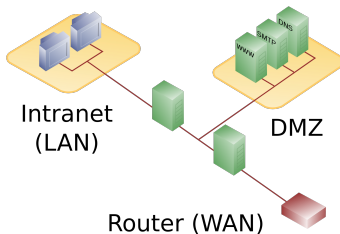
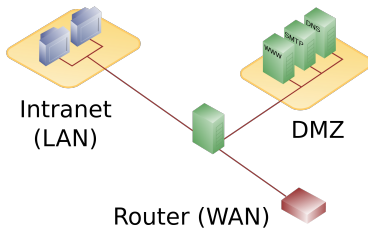
Firewall Locations

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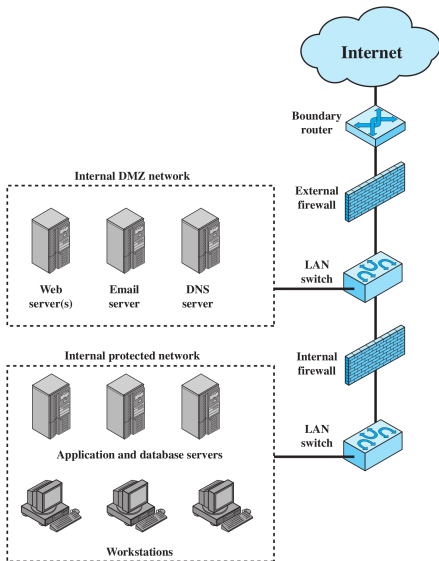
- ▶ Firewalls can be located on hosts: end-users computers and servers
- ▶ With large number of users, firewalls located on network devices that interconnect internal and external networks
- ▶ Common to separate internal network into two zones:
 1. Public-facing servers, e.g. web, email, DNS
 2. End-user computers and internal servers, e.g. databases, development web servers
- ▶ Public-facing servers put in De-Militarised Zone (DMZ)

DMZ with 1 or 2 Firewalls



Credit: Pbroks13/Sangre Viento, Wikimedia Commons, Public Domain

Example DMZ with 2 Firewalls



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Key Points

- ▶ Firewall controls traffic into and out of a network (or computer)
- ▶ Control based on services, direction, user and behaviour
- ▶ Packet filtering: accept/reject packets based on headers
- ▶ Stateful packet inspection: keep track of past connections
- ▶ Proxy firewalls: relay application or connection traffic

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)

Areas To Explore

- ▶ Deep Packet Inspection