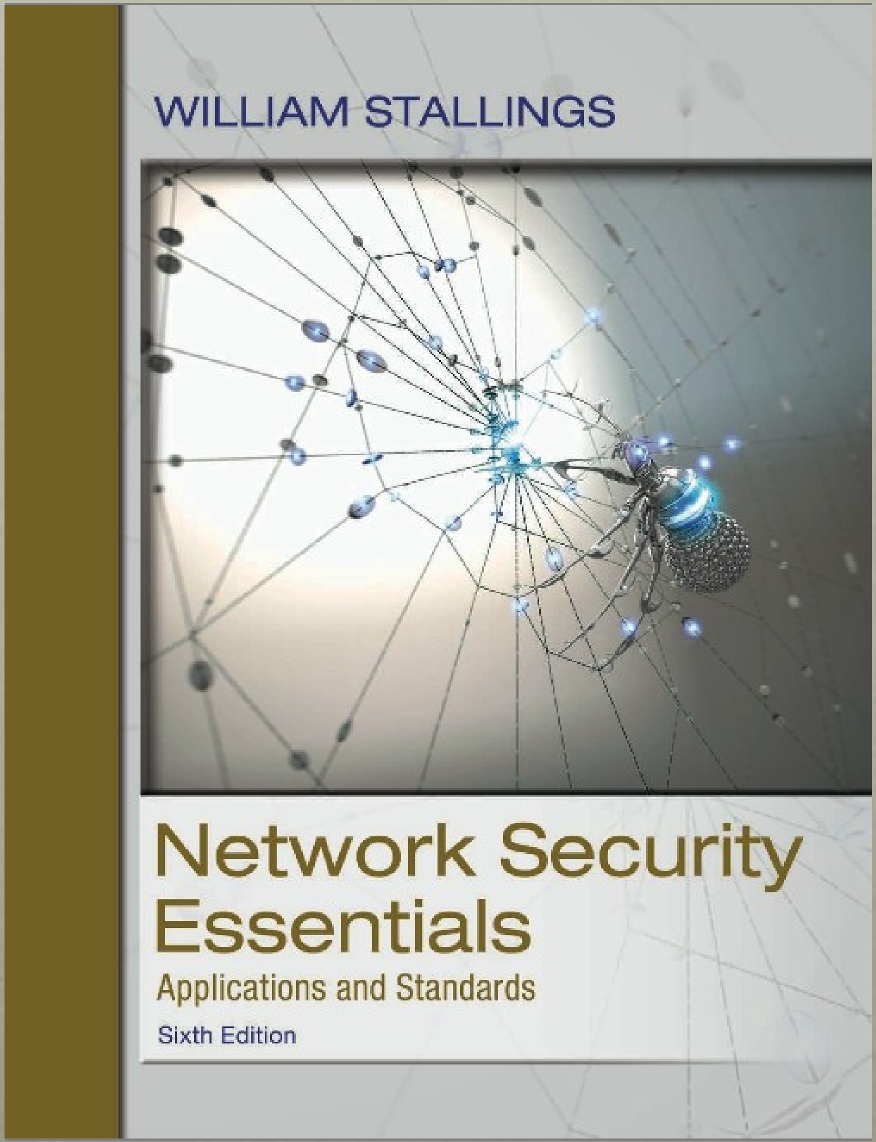
Network Security Essentials

Sixth Edition

by William Stallings


WILLIAM STALLINGS

Network Security Essentials

Applications and Standards

Sixth Edition

Chapter 12

Firewalls

The Need for firewalls

- Internet connectivity is not optional
  - Individual users within the organization want and need Internet access
- While Internet access provides benefits to any organization, it enables the outside world to reach in and interact with local network assets
  - This creates a threat to the organization
  - While it is possible to equip each workstation and server on the premises network with strong security features, this may not be sufficient and in some cases is not cost-effective.
- Firewall
  - An alternative, or at least complement, to host-based security services
  - Is inserted between the premises network and the Internet to establish a controlled link and to erect an outer security wall or perimeter
  - The aim of this perimeter is to protect the premises network from Internet-based attacks and to provide a single choke point where security and auditing can be imposed
  - May be a single computer system or a set of two or more systems that cooperate to perform the firewall function

Firewall characteristics

Design goals for a firewall:

- 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.

FiLTer characteristics

Range of characteristics that a firewall access policy could use to filter traffic:

- IP Address and Protocol Values: Controls access based on the source or destination addresses and port numbers, direction of flow being inbound or outbound, and other network and transport layer characteristics. This type of filtering is used by packet filter and stateful inspection firewalls. It is typically used to limit access to specific services.

- Application Protocol: Controls access on the basis of authorized application protocol data. This type of filtering is used by an application-level gateway that relays and monitors the exchange of information for specific application protocols, for example, checking SMTP e-mail for spam, or HTPP Web requests to authorized sites only.

- User Identity: Controls access based on the users identity, typically for inside

Firewall expectations

The following capabilities are within the scope of a firewall:

1. A firewall defines a single choke point that keeps unauthorized users out of the protected network, prohibits potentially vulnerable services from entering or leaving the network, and provides protection from various kinds of IP spoofing and routing attacks. The use of a single choke point simplifies security management because security capabilities are consolidated on a single system or set of systems.

2. A firewall provides a location for monitoring security-related events. Audits and alarms can be implemented on the firewall system.

3. A firewall is a convenient platform for several Internet functions that are not security related. These include a network address translator, which maps local addresses to Internet addresses, and a network management function that audits or logs Internet usage.

4. A firewall can serve as the platform for IPsec. Using the tunnel mode capability described in Chapter 9, the firewall can be used to implement virtual private networks.

Firewall limitations

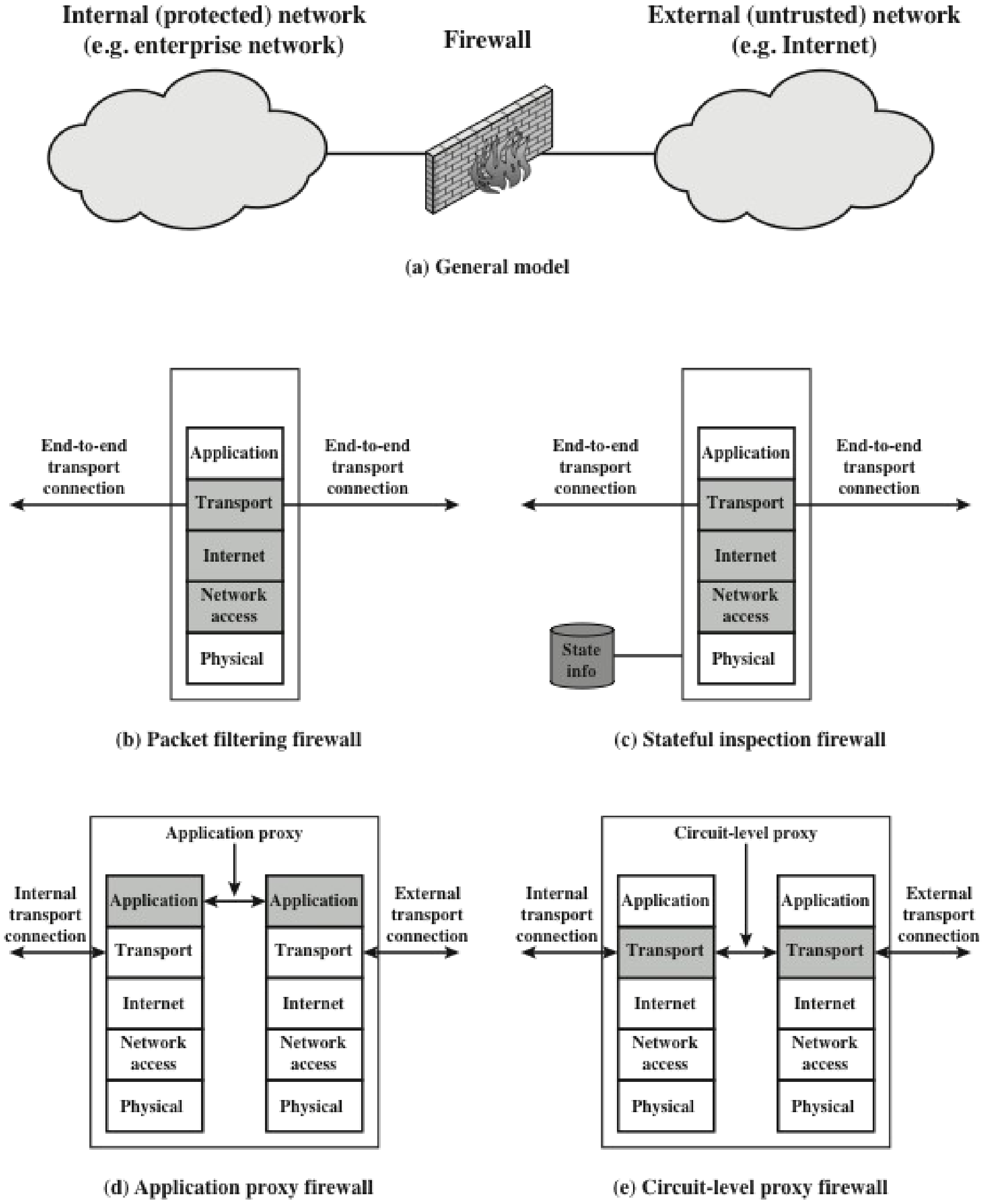
Firewalls have their limitations, including the following:

1. The firewall cannot protect against attacks that bypass the firewall. Internal systems may have dial-out capability to connect to an ISP. An internal LAN may support a modem pool that provides dial-in capability for traveling employees and telecommuters.

2. The firewall may not protect fully against internal threats, such as a disgruntled employee or an employee who unwittingly cooperates with an external attacker.

3. An improperly secured wireless LAN may be accessed from outside the organization. An internal firewall that separates portions of an enterprise network cannot guard against wireless communications between local systems on different sides of the internal firewall.

4. A laptop, tablet, PDA, printer, scanner, or portable storage device may be used and infected outside the corporate network, and then attached and used internally.


Internal (protected) network (e.g. enterprise network)
Firewall
External (untrusted) network (e.g. Internet)
End-to-end transport connection
Application
Transport
Internet
Network access
Physical
End-to-end transport connection
State info
Application proxy
Internal transport connection
External transport connection
Circuit-level proxy

(a) General model

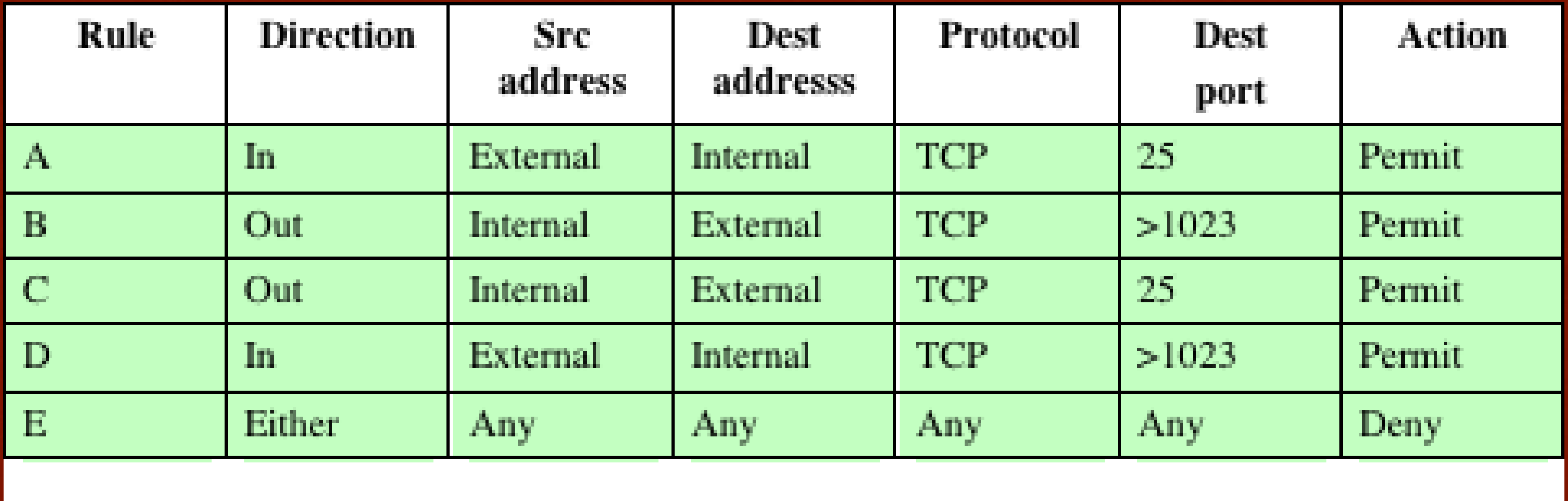
(b) Packet filtering firewall

(c) Stateful inspection firewall

(d) Application proxy firewall

(e) Circuit-level proxy firewall

Figure 12.1 Types of Firewalls



Rule	Direction	Src address	Dest addresss	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

Table 12.1
Packet-Filtering Example

Packet Filtering firewalls

One advantage of a packet filtering firewall is its simplicity. Also, packet filters typically are transparent to users and are very fast. Weaknesses of packet filter firewalls:

- Because packet filter firewalls do not examine upper-layer data, they cannot prevent attacks that employ application-specific vulnerabilities or functions. For example, a packet filter firewall cannot block specific application commands; if a packet filter firewall allows a given application, all functions available within that application will be permitted.

- Because of the limited information available to the firewall, the logging functionality present in packet filter firewalls is limited. Packet filter logs normally contain the same information used to make access control decisions (source address, destination address, and traffic type).

- Most packet filter firewalls do not support advanced user authentication schemes. Once again, this limitation is mostly due to the lack of upper-layer functionality by the firewall.

- Packet filter firewalls are generally vulnerable to attacks and exploits that take advantage of problems within the TCP/IP specification and protocol stack, such as network layer address spoofing . Many packet filter firewalls cannot detect a network packet in which the OSI Layer 3 addressing information has been altered. Spoofing attacks are generally employed by intruders to bypass the security controls implemented in a firewall platform.

- Finally, due to the small number of variables used in access control decisions, packet filter firewalls are susceptible to security breaches caused by improper configurations. In other words, it is easy to accidentally configure a packet filter firewall to allow traffic types, sources, and destinations that should be denied based on an organization’s information security policy.

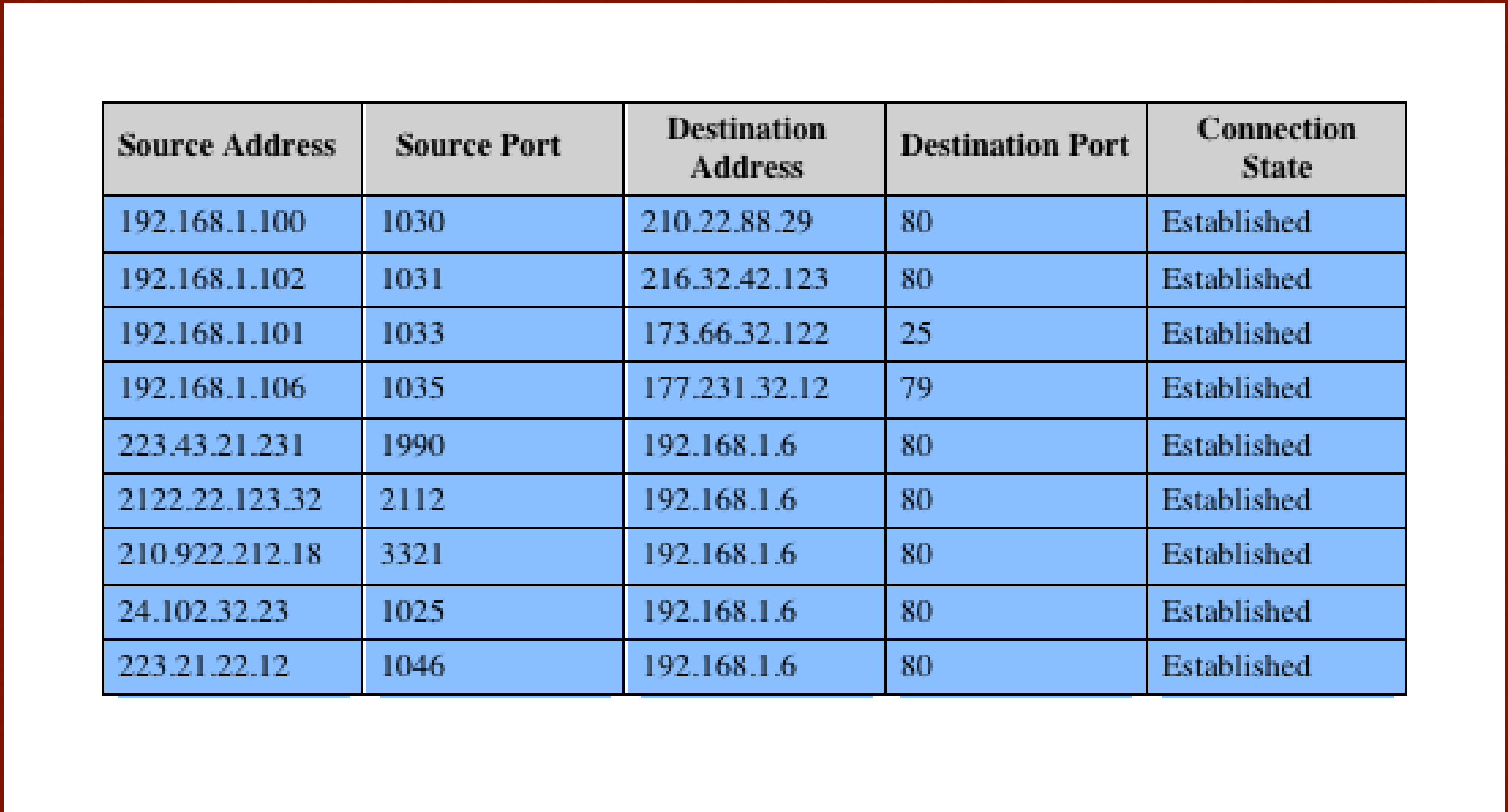
Attacks and countermeasures

Some of the attacks that can be made on packet filtering firewalls and the appropriate countermeasures are the following:

- IP address spoofing: The intruder transmits packets from the outside with a source IP address field containing an address of an internal host. The attacker hopes that the use of a spoofed address will allow penetration of systems that employ simple source address security, in which packets from specific trusted internal hosts are accepted. The countermeasure is to discard packets with an inside source address if the packet arrives on an external interface. In fact, this countermeasure is often implemented at the router external to the firewall.

- Source routing attacks: The source station specifies the route that a packet should take as it crosses the Internet, in the hopes that this will bypass security measures that do not analyze the source routing information. The countermeasure is to discard all packets that use this option.

- Tiny fragment attacks: The intruder uses the IP fragmentation option to create extremely small fragments and force the TCP header information into a separate packet fragment. This attack is designed to circumvent filtering rules that depend on TCP header information. Typically, a packet filter will make a filtering decision on the first fragment of a packet. All subsequent fragments of that packet are filtered out solely on the basis that they are part of the packet whose first fragment was rejected. The attacker hopes that the filtering firewall examines only the first fragment and that the remaining fragments are passed through. A tiny fragment attack can be defeated by enforcing a rule that the first fragment of a packet must contain a predefined minimum amount of the transport header. If the first fragment is rejected, the filter can remember the packet and discard all subsequent fragments.



Source Address	Source Port	Destination Address	Destination Port	Connection State
192.168.1.100	1030	210.22.88.29	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
2122.22.123.32	2112	192.168.1.6	80	Established
210.922.212.18	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

Table 12.2

Example Stateful Firewall Connection State Table [SCAR09b]

Application Level Gateway

- Also called an *application proxy*
- Acts as a relay of application-level traffic
- If the gateway does not implement the proxy code for a specific application, the service is not supported and cannot be forwarded across the firewall
- The gateway can be configured to support only specific features of an application that the network administrator considers acceptable while denying all other features
- Tend to be more secure than packet filters
- Disadvantage:
  - The additional processing overhead on each connection

Bastion Host

- A system identified by the firewall administrator as a critical strong point in the network's security
- Typically serves as a platform for an application-level or circuit-level gateway
- Common characteristics:
  - Executes a secure version of its operating system, making it a hardened system
  - Only the services that the network administrator considers essential are installed
  - May require additional authentication before a user is allowed access to the proxy services
  - Each proxy is configured to support only a subset of the standard application's command set
  - Each proxy is configured to allow access only to specific host systems
  - Each proxy maintains detailed audit information by logging all traffic, each connection, and the duration of each connection
  - Each proxy module is a very small software package specifically designed for network security
  - Each proxy is independent of other proxies on the bastion host
  - A proxy generally performs no disk access other than to read its initial configuration file
  - Each proxy runs as a nonprivileged user in a private and secured directory on the bastion host

Host-Based Firewall

- A software module used to secure an individual host
- Is available in many operating systems or can be provided as an add-on package
- Filters and restricts the flow of packets
- Common location is a server
- Advantages:
  - Filtering rules can be tailored to the host environment
  - Protection is provided independent of topology
  - Used in conjunction with stand-alone firewalls, provides an additional layer of protection

Personal Firewall

- Controls the traffic between a personal computer or workstation on one side and the Internet or enterprise network on the other side
- Can be used in the home environment and on corporate intranets
- Typically is a software module on the personal computer
- Can also be housed in a router that connects all of the home computers to a DSL, cable modem, or other Internet interface
- Primary role is to deny unauthorized remote access to the computer
- Can also monitor outgoing activity in an attempt to detect and block worms and other malware

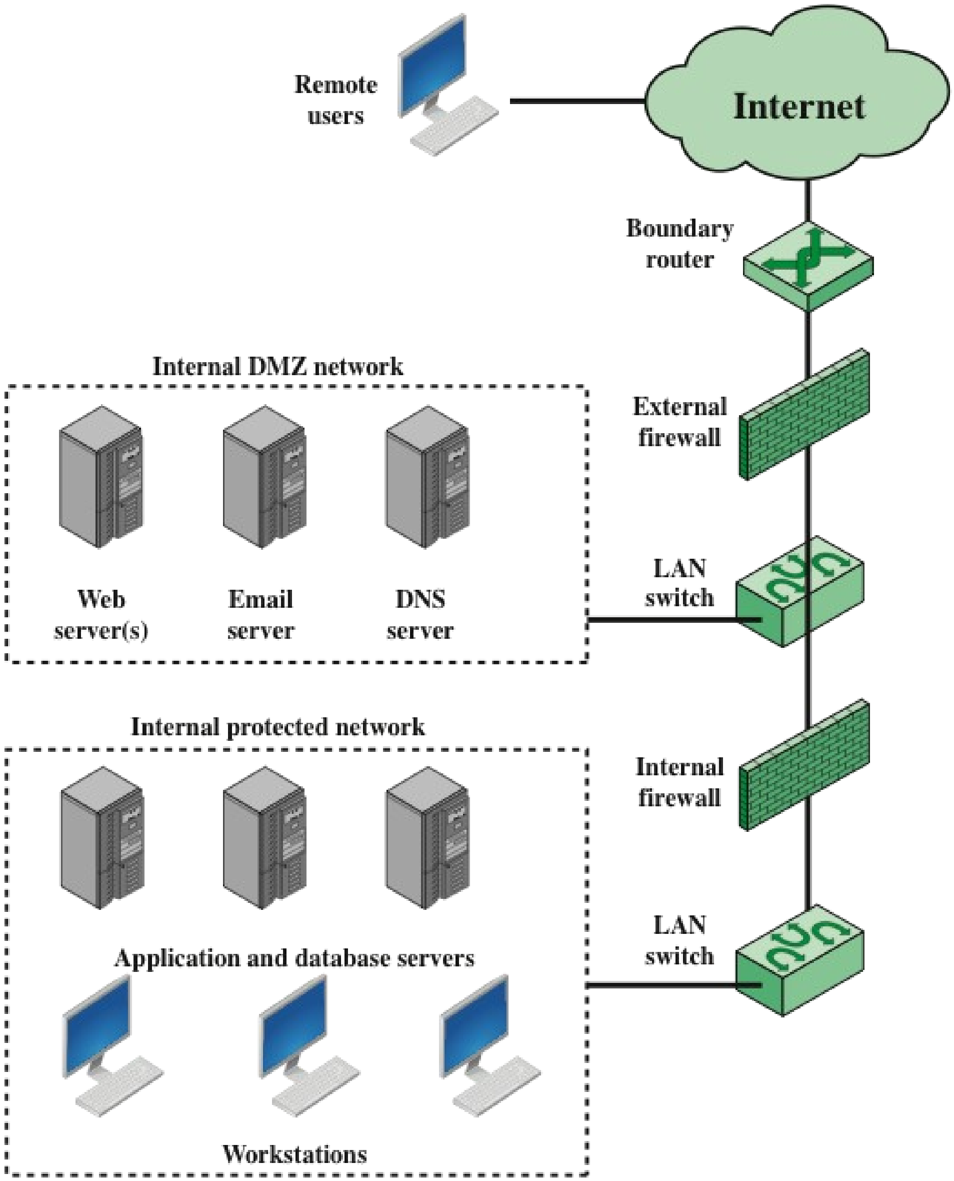


Figure 12.2 Example Firewall Configuration

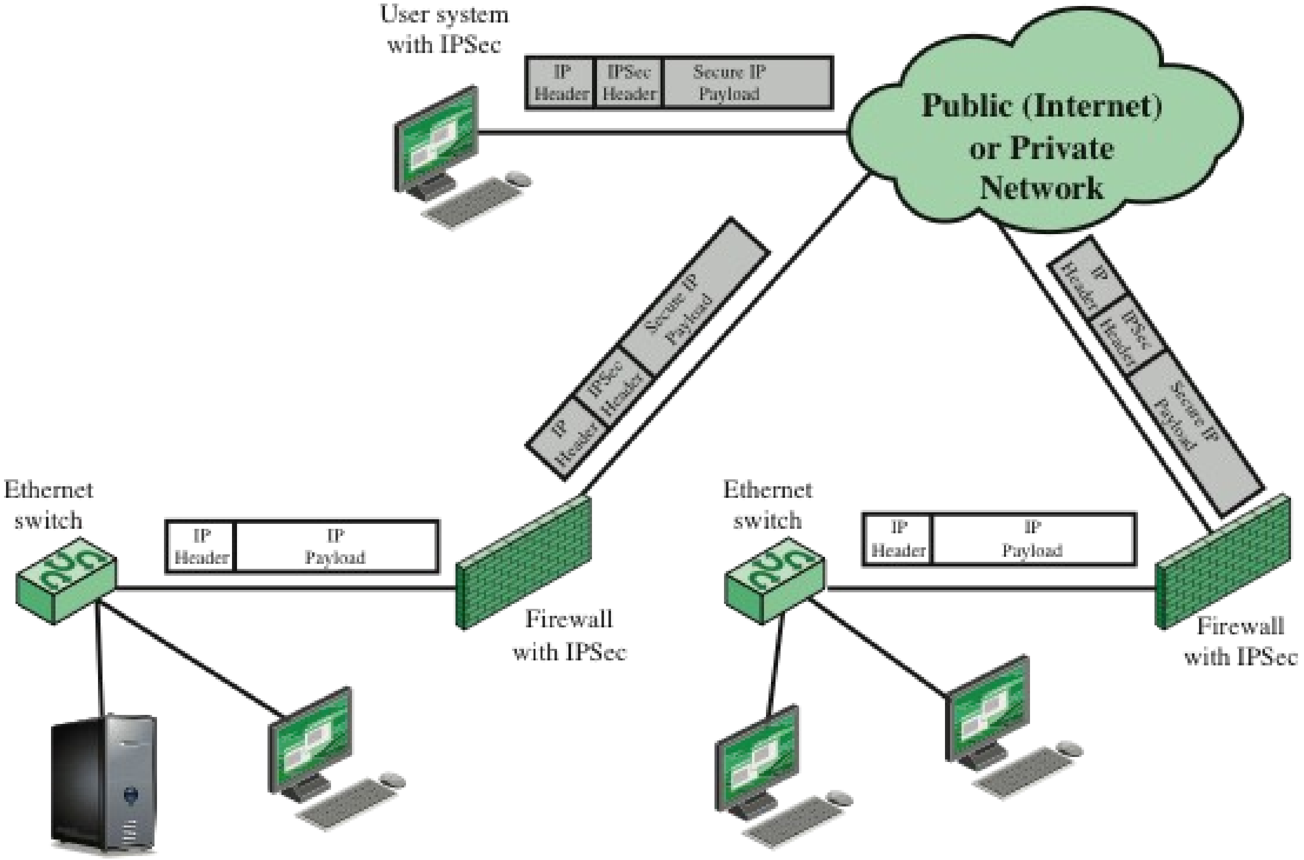


Figure 12.3 A VPN Security Scenario

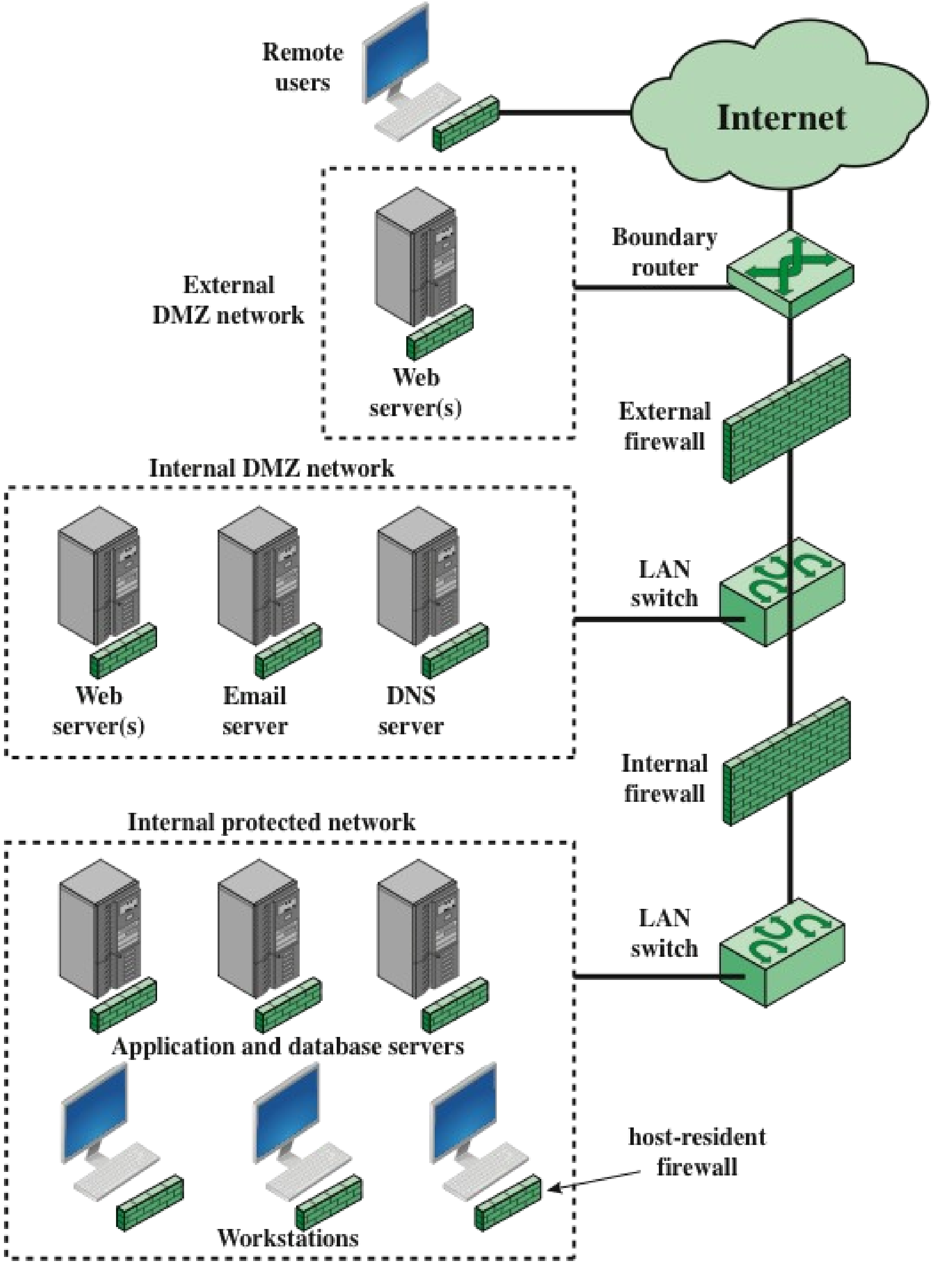


Figure 12.4 Example Distributed Firewall Configuration

Summary of Firewall Locations and Topologies

- **Host-resident firewall**
  - This category includes personal firewall software and firewall software on servers
  - Can be used alone or as part of an in-depth firewall deployment
- **Screening router**
  - A single router between internal and external networks with stateless or full packet filtering
  - This arrangement is typical for small office/home office (SOHO) applications
- **Single bastion inline**
  - A single firewall device between an internal and external router
  - This is the typical firewall appliance configuration for small-to-medium sized organizations
- **Single bastion T**
  - Similar to single bastion inline but has a third network interface on bastion to a DMZ where externally visible servers are placed
- **Double bastion inline**
  - DMZ is sandwiched between bastion firewalls
- **Double bastion T**
  - DMZ is on a separate network interface on the bastion firewall
- **Distributed firewall configuration**
  - Used by some large businesses and government organizations

Summary

- The need for firewalls
- Firewall characteristics and access policy
- Types of firewalls
  - Packet filtering firewall
  - Stateful inspection firewalls
  - Application level gateway
  - Circuit level gateway
- Firewall basing
  - Bastion host
  - Host based firewalls
  - Personal firewall
- Firewall locations and configurations
  - DMZ networks
  - Virtual private networks
  - Distributed firewalls
  - Firewall location and topologies summary

Circuit-Level Gateway

- Also called *circuit-level proxy*
- Can be a stand-alone system or it can be a specialized function performed by an application-level gateway for certain applications
- Does not permit an end-to-end TCP connection
- The security function consists of determining which connections will be allowed
- Typical use is a situation in which the system administrator trusts the internal users
- Can be configured to support application-level or proxy service on inbound connections and circuit-level functions for outbound connections
- Example of implementation is the SOCKS package