Network Security

Firewalls

Why Firewalls?

- The Internet allows you access to worldwide resources, but…
  …the Internet also allows the *world* to try and access your resources

Why Firewalls?

- A firewall is inserted between the private network and the Internet
- Provides a choke point where security and audits can be imposed
- Single computer system or a set of systems can perform the firewall function

Design Goals

- All traffic, from inside to outside and vice versa, must pass through the firewall
- Only authorized traffic (defined by the security policy) is allowed to flow

Scope of Firewalls

- Single choke point - to protect vulnerable services from various kinds of attack (spoofing, DOS)
- Platform for non-security functions – can be used for network address translation and network management
- Platform for IPSec – implements VPN via tunnel mode

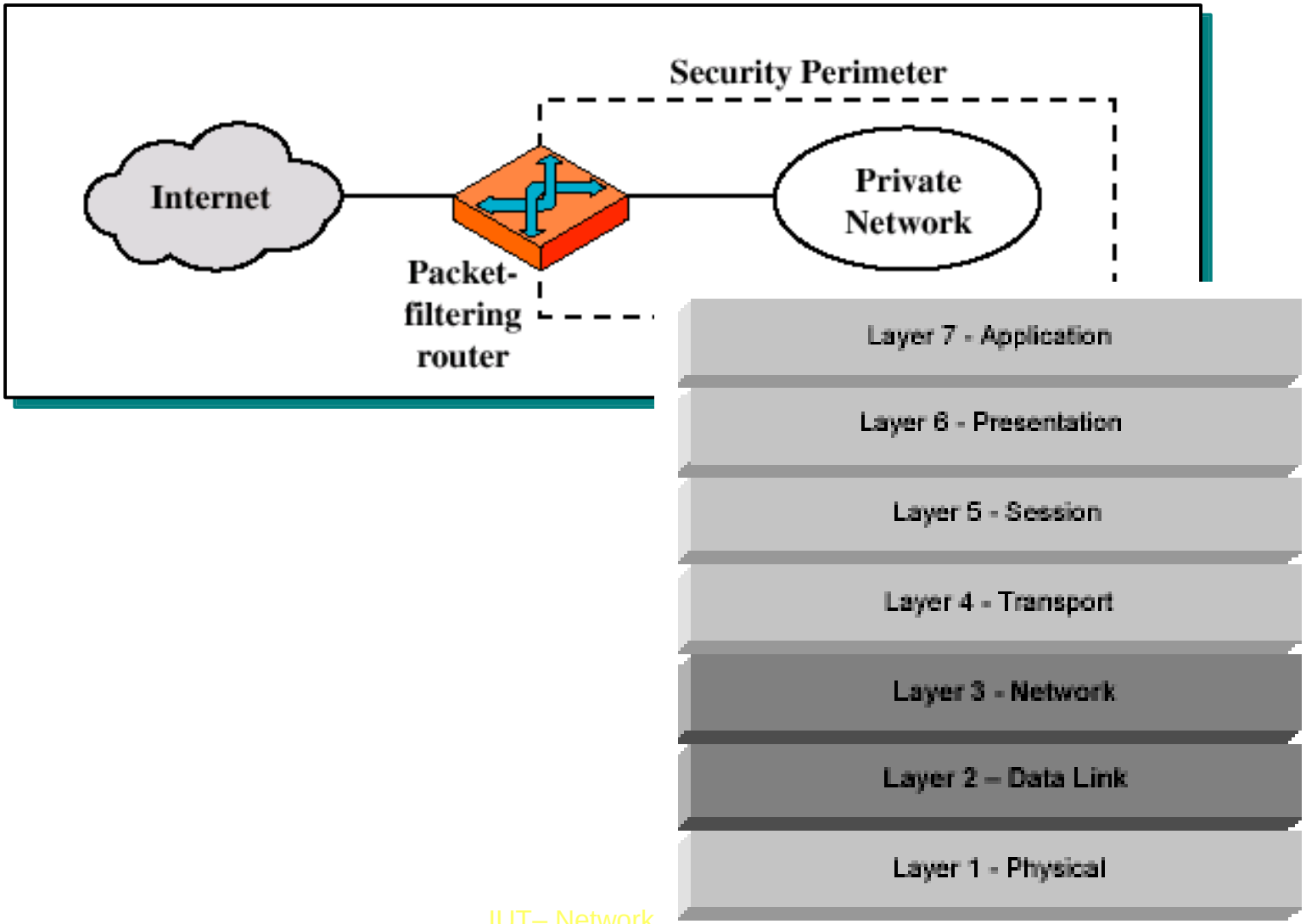
Limitations of Firewalls

- Cannot protect against attack that bypasses the firewall – bypass attack
- Does not protect against internal threats
- Cannot protect against the transfer of virus-infected programs

Types of Firewalls

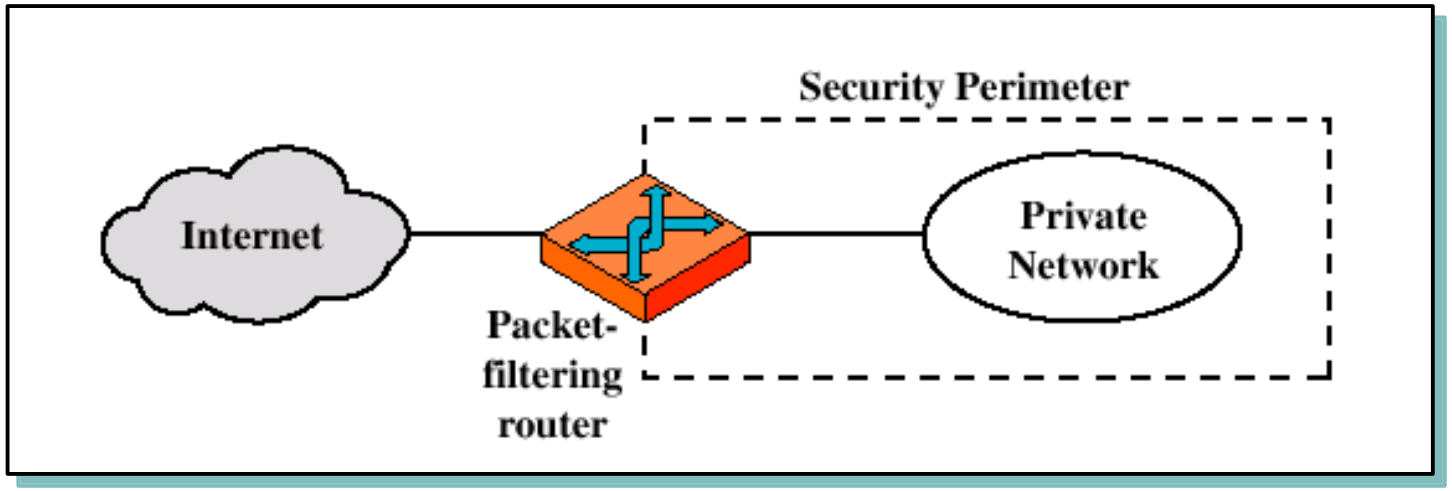
- Packet Filtering Router
- Application Level Gateway
- Circuit Level Gateway

Packet Filtering



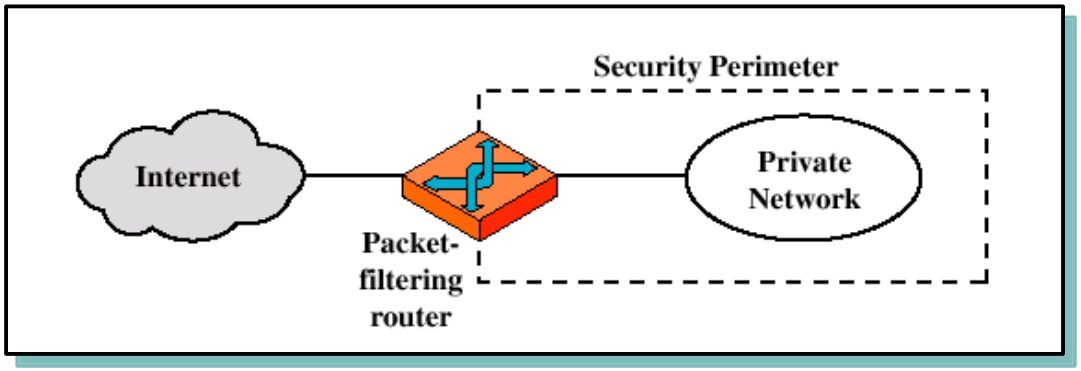
Packet Filtering Router

- Applies a set of rules to each incoming IP packet and *forwards* or *discards* the packet
- Filters packets in *both directions*



Packet Filtering Router

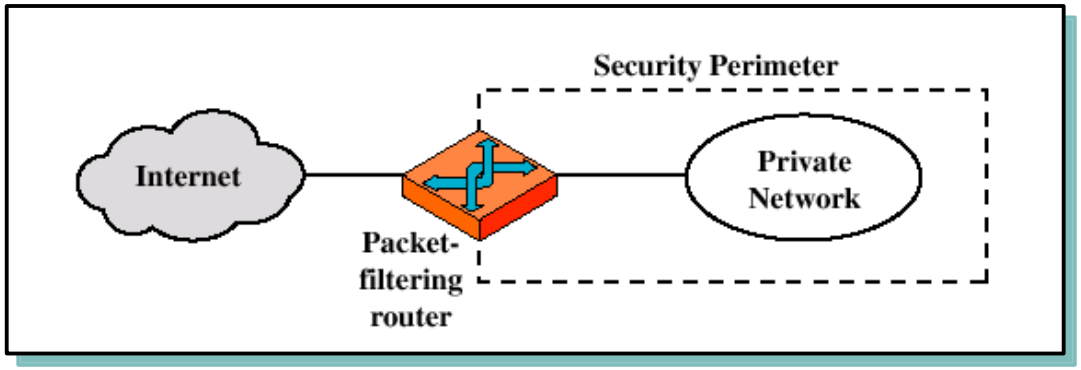
- Rules based on *source* and *destination* address and *port* number and IP protocol and interface
- *List of rules* looking for a match
- If no match, *default* action is taken



Packet Filtering Router

Two default policies:

- **default = discard:**
  That which is not expressly permitted is prohibited
- **default = forward:**
  That which is not expressly prohibited is permitted



Packet Filtering Rules

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

- Inbound mail is allowed (port 25), but only to a mentioned host
- Everything from SPIGOT is blocked

Packet Filtering Rules

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

- This is the *default policy*
- It is usually the *last* rule
- This rule *drops everything*

Packet Filtering Rules

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

- Inside host can send mail to the outside
- Some other application could be linked to port 25
- Attacker could gain access through port 25

Packet Filtering Rules

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

- This improves on the last situation
- Internal hosts can access SMTP anywhere
- ACKs from any SMTP server are permitted

Packet Filtering

- *Advantage:* simple, transparent and very fast
- *Disadvantage:*
  - Difficulty in setting up rules correctly and completely
  - Vulnerable again Application layer attacks

Real Life Example

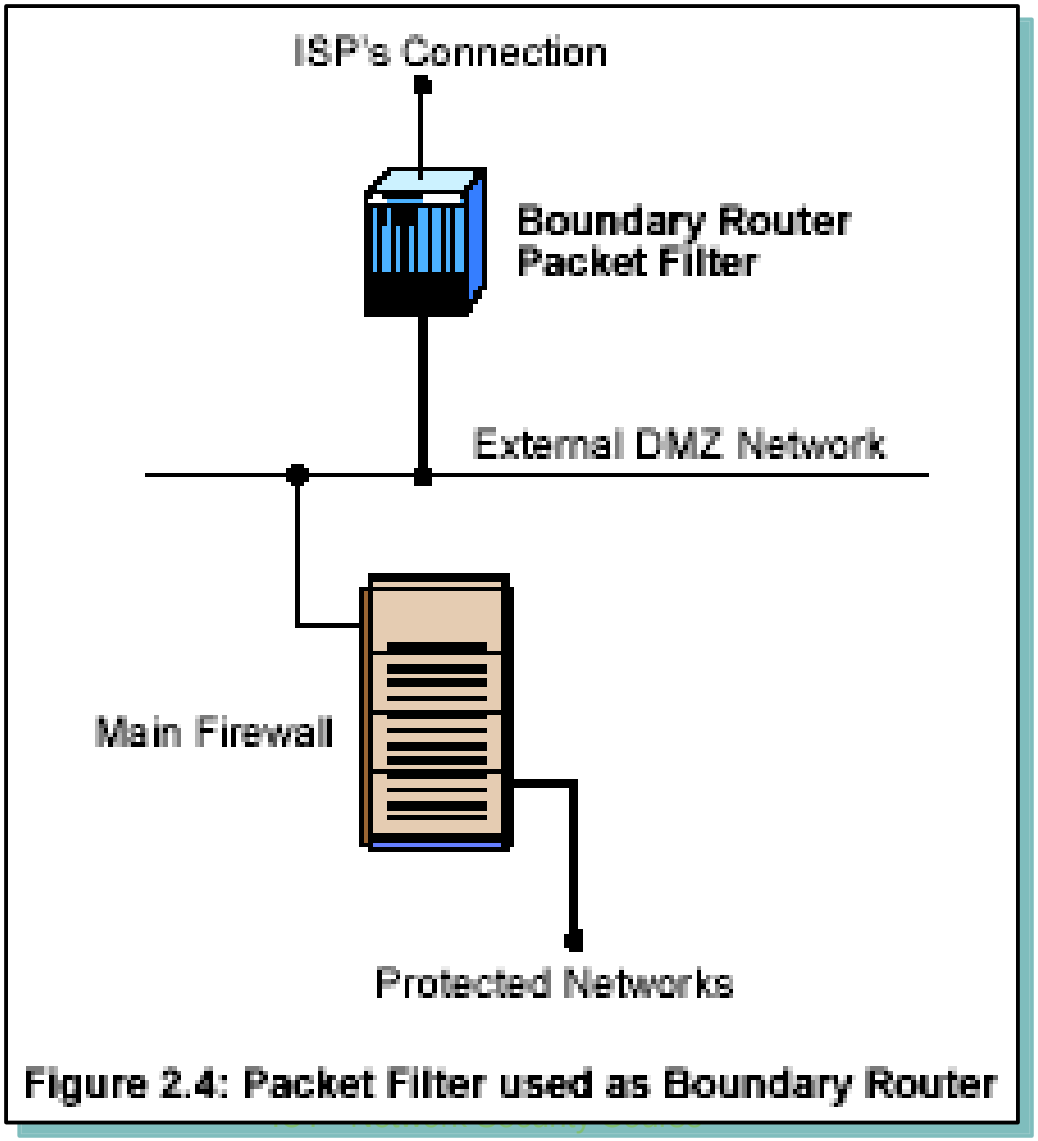
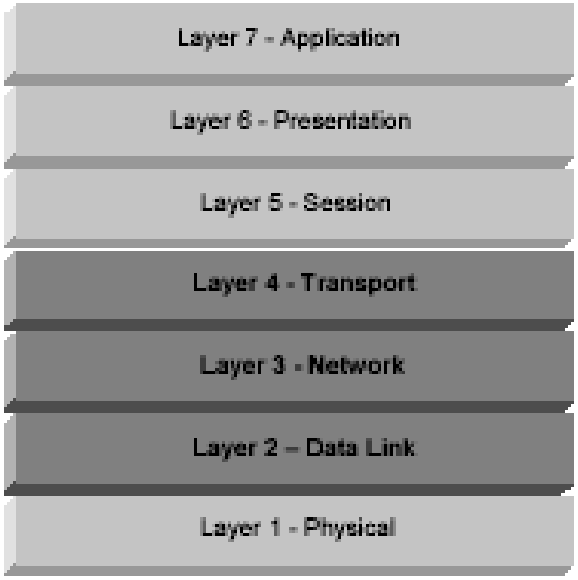


Figure 2.4: Packet Filter used as Boundary Router

Stateful Inspection

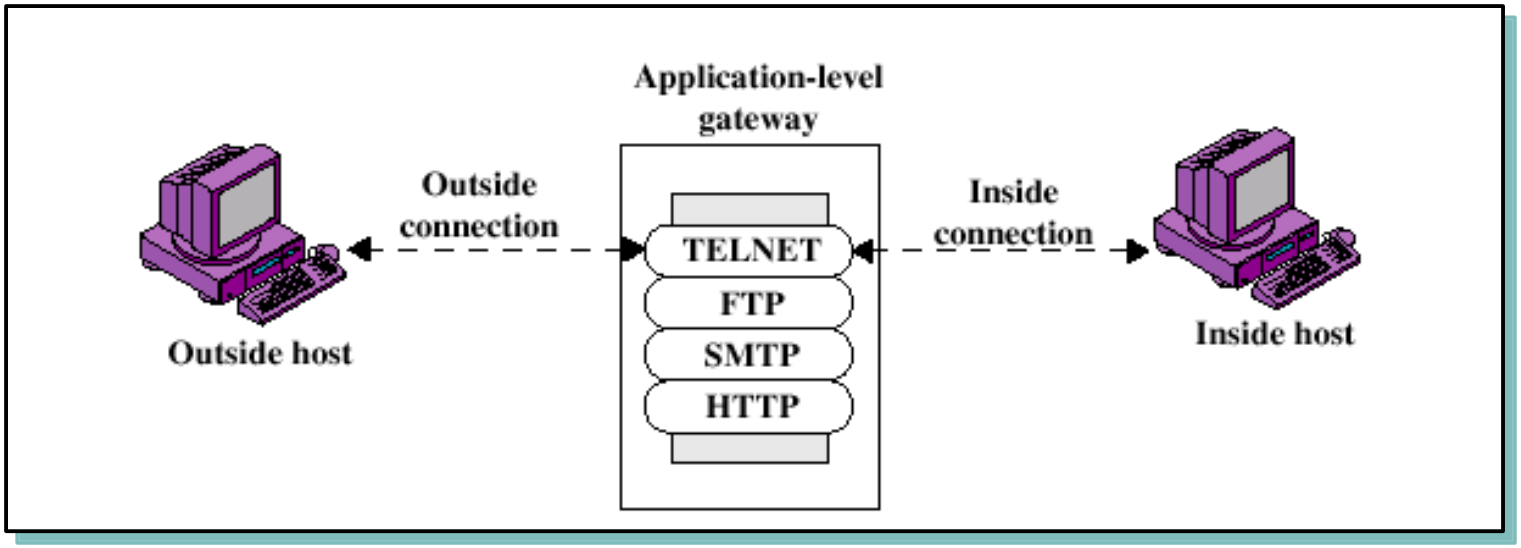


Layers Addressed By Stateful Inspection

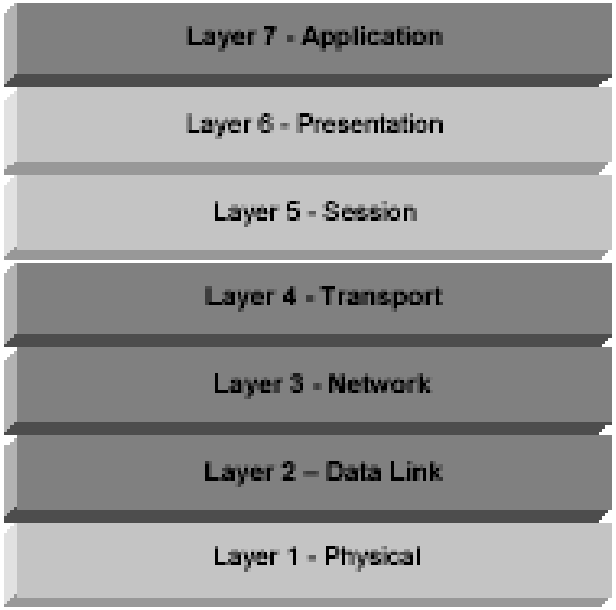
Stateful Inspection

- More secure because the firewall tracks client ports individually rather than opening all high-numbered ports for external access.
- Adds Layer 4 awareness to the standard packet filter architecture.

Application Level Gateway



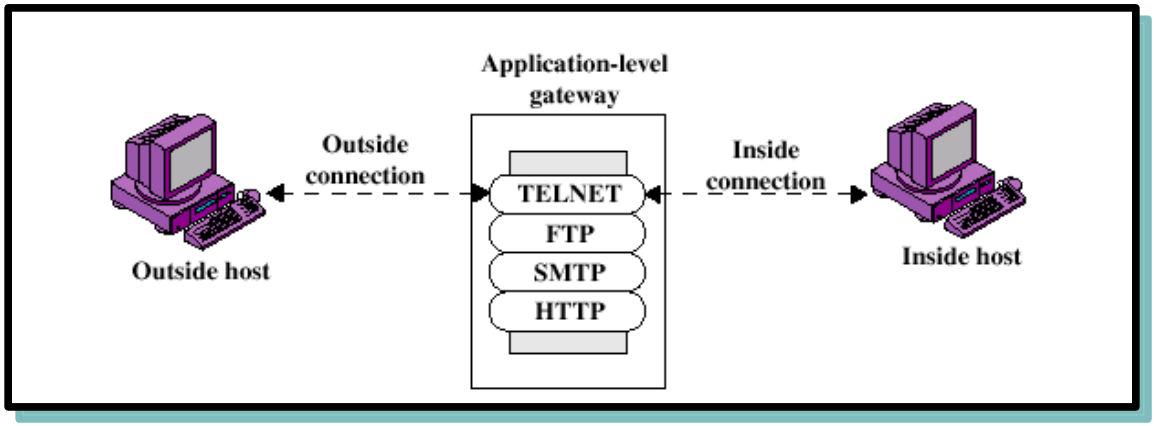
Application Gateway Firewalls



Layers Addressed by
Application-Proxy Gateway Firewalls

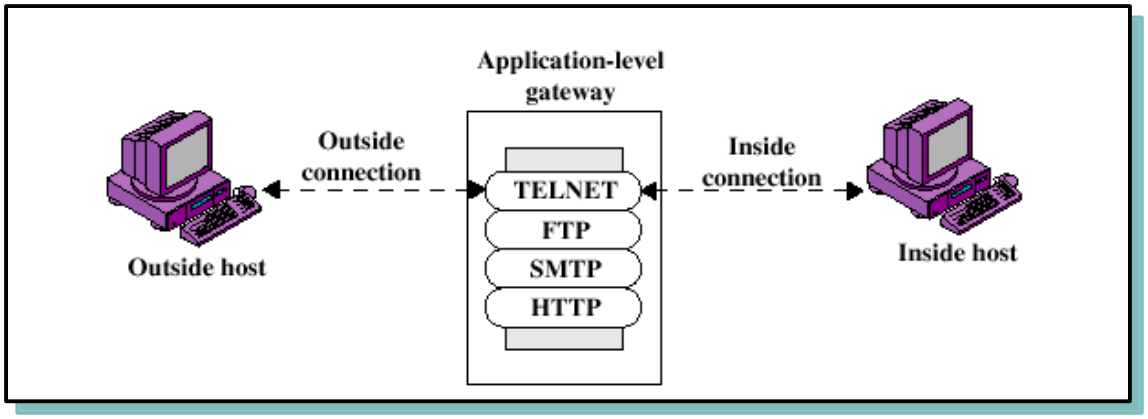
Application Level Gateway

- Acts as a relay of application level traffic
- Also called a proxy
- User contacts gateway for TELNET to remote host, user is authenticated, then gateway contacts remote host and relays info between two end points

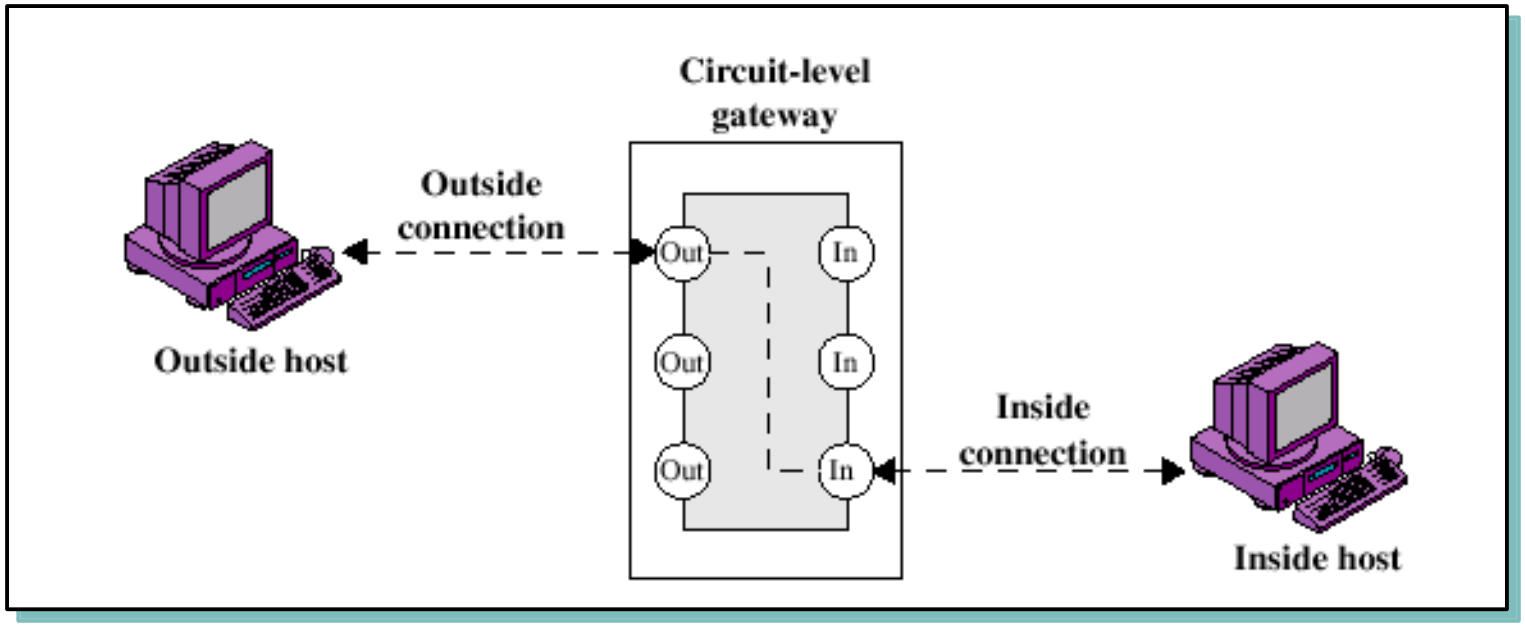


Application Level Gateway

- Can examine the packets to ensure the security of the application – full packet awareness
- Very easy to log since entire packet seen
- *Disadvantage:* additional processing overhead for each connection – increase load

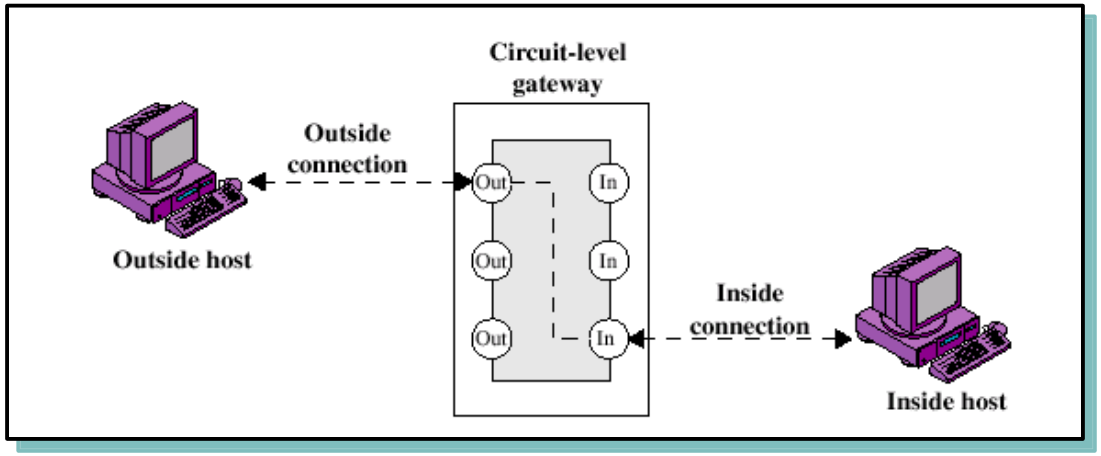


Circuit-Level Gateway



Circuit Level Gateway

- *Does not* permit an end-to-end TCP connection
- Sets up *two TCP connections* one between itself and a TCP user on the inside and one between itself and a TCP user on the outside
- *Relays TCP segments* from one connection to the other without examining the contents



Firewall Basing

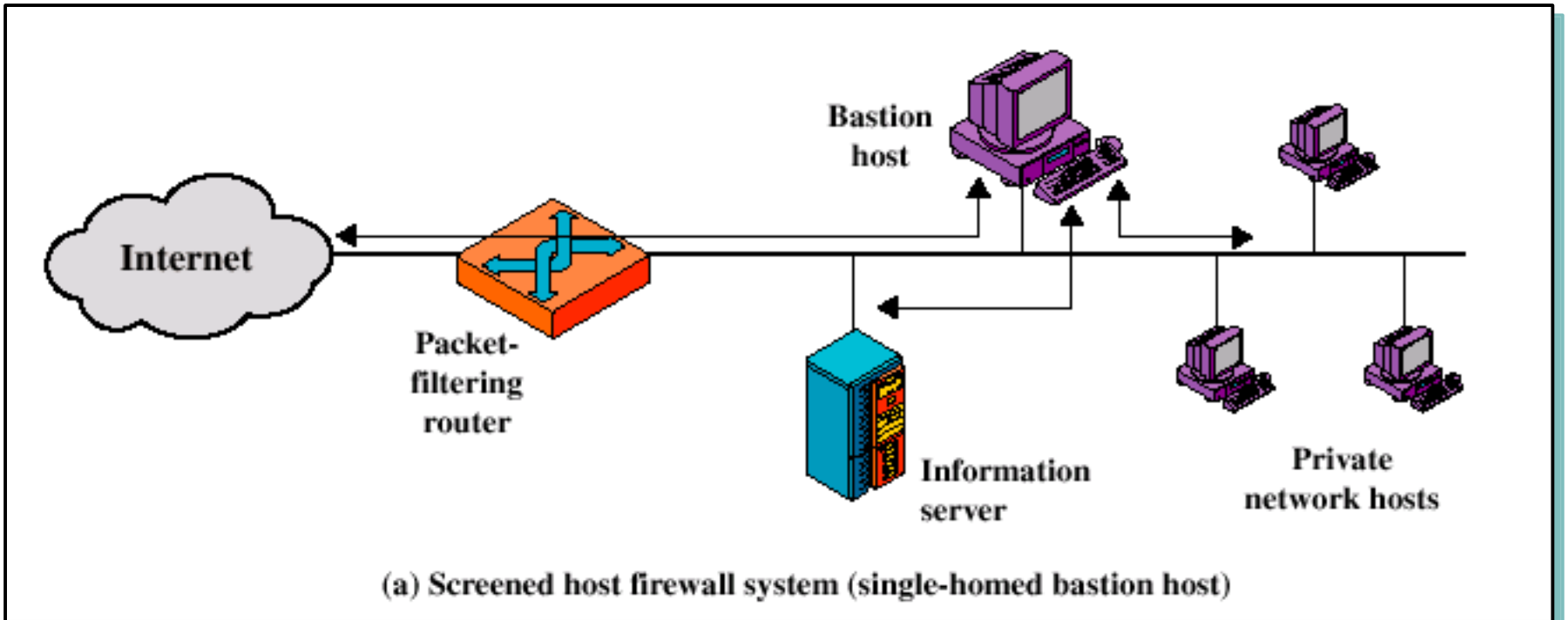
- It is common to base a firewall on a stand-alone machine running a common operating system, such as UNIX or Linux.
- Firewall functionality can also be implemented as a software module in a router or LAN switch

Bastion Host

- Usually a platform for an application or circuit level gateway
- Only essential services
- Allows *access* only to *specific hosts*
- Maintains detailed *audit information* by logging all traffic
- *Choke point* for discovering and terminating intruder attacks

Bastion Host, Single-Homed

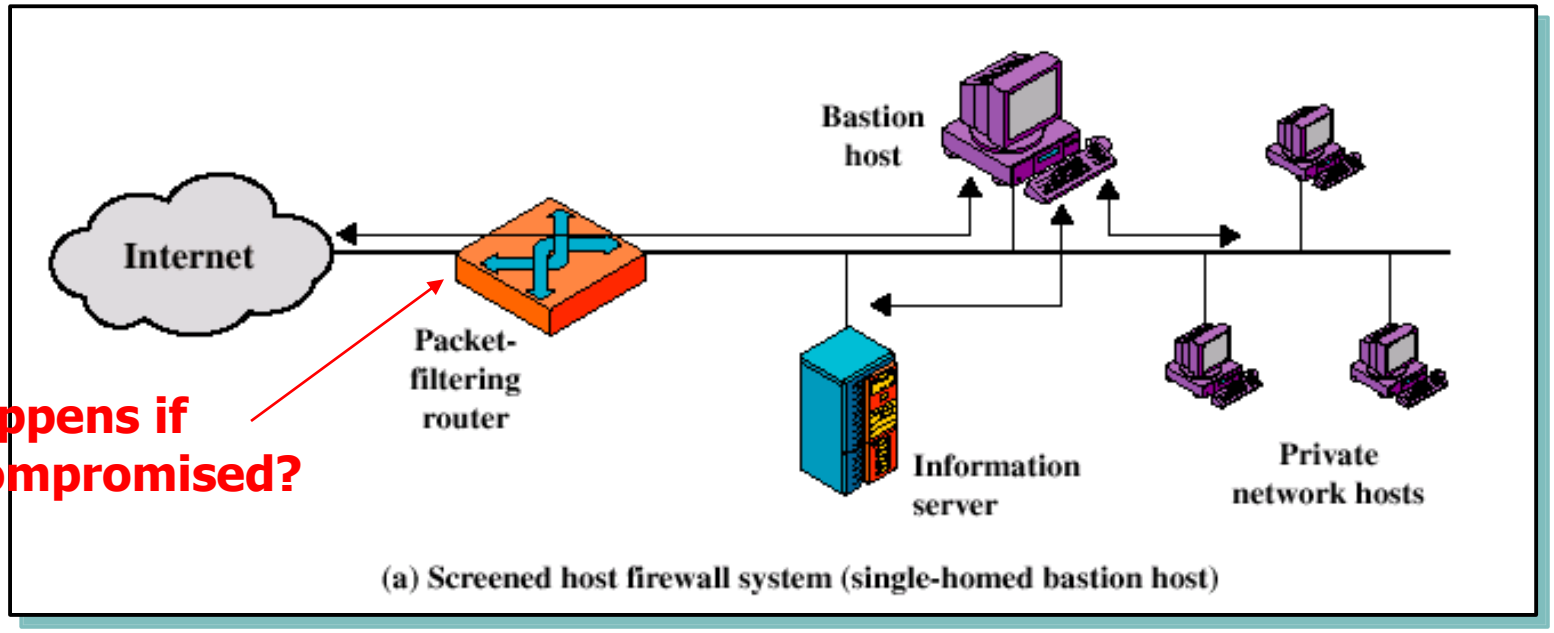
- *Two systems:* packet filtering router and bastion host
- For traffic from the *Internet*, only IP packets *destined* for the *bastion* host are allowed
- For traffic from the *internal network*, only relayed packets *from* the *bastion* host are allowed out



(a) Screened host firewall system (single-homed bastion host)

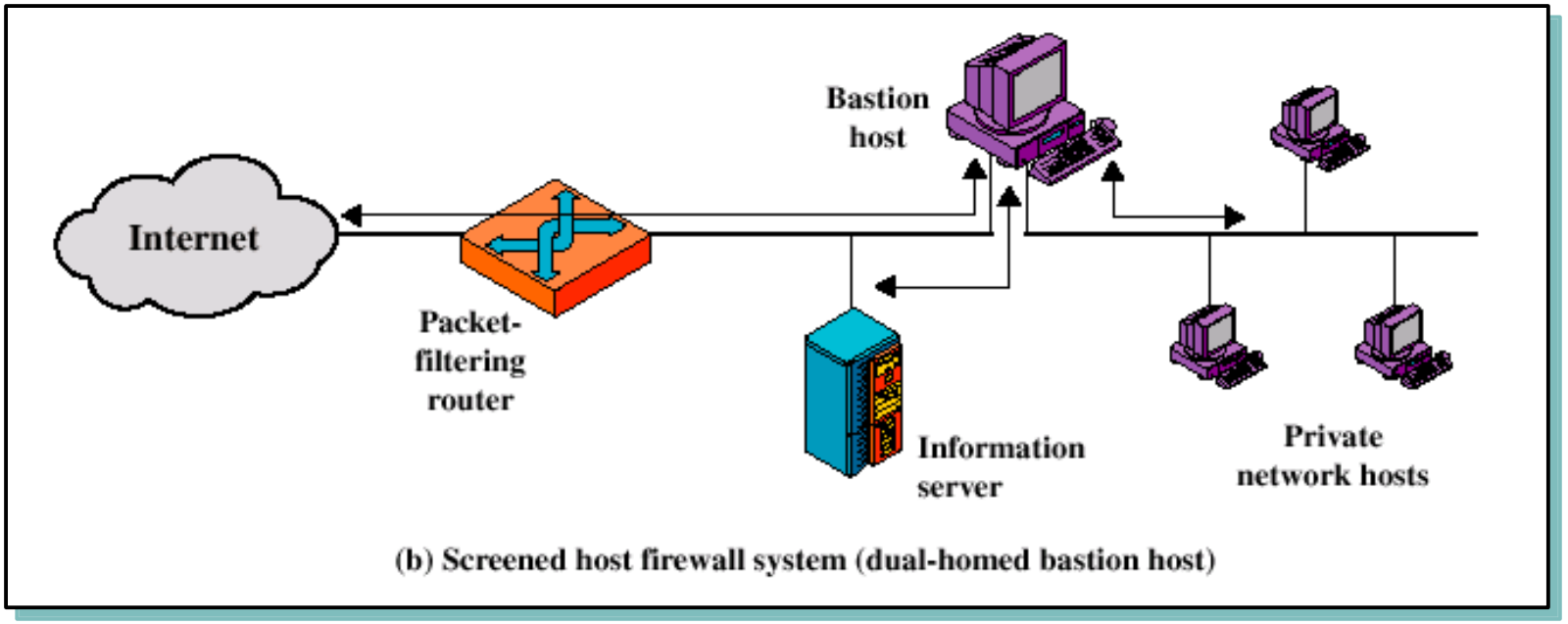
Bastion Host, Single-Homed

A Big Problem!!!



What happens if this is compromised?

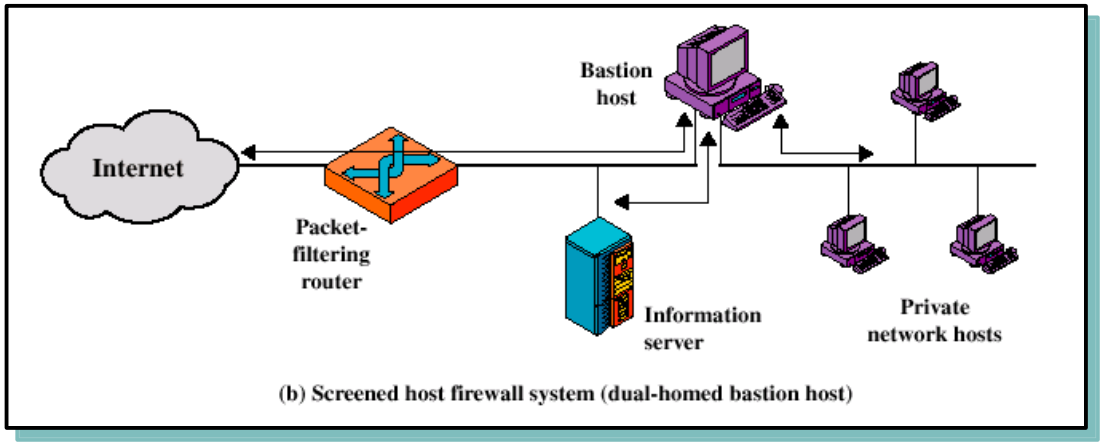
Bastion Host, Dual-Homed



(b) Screened host firewall system (dual-homed bastion host)

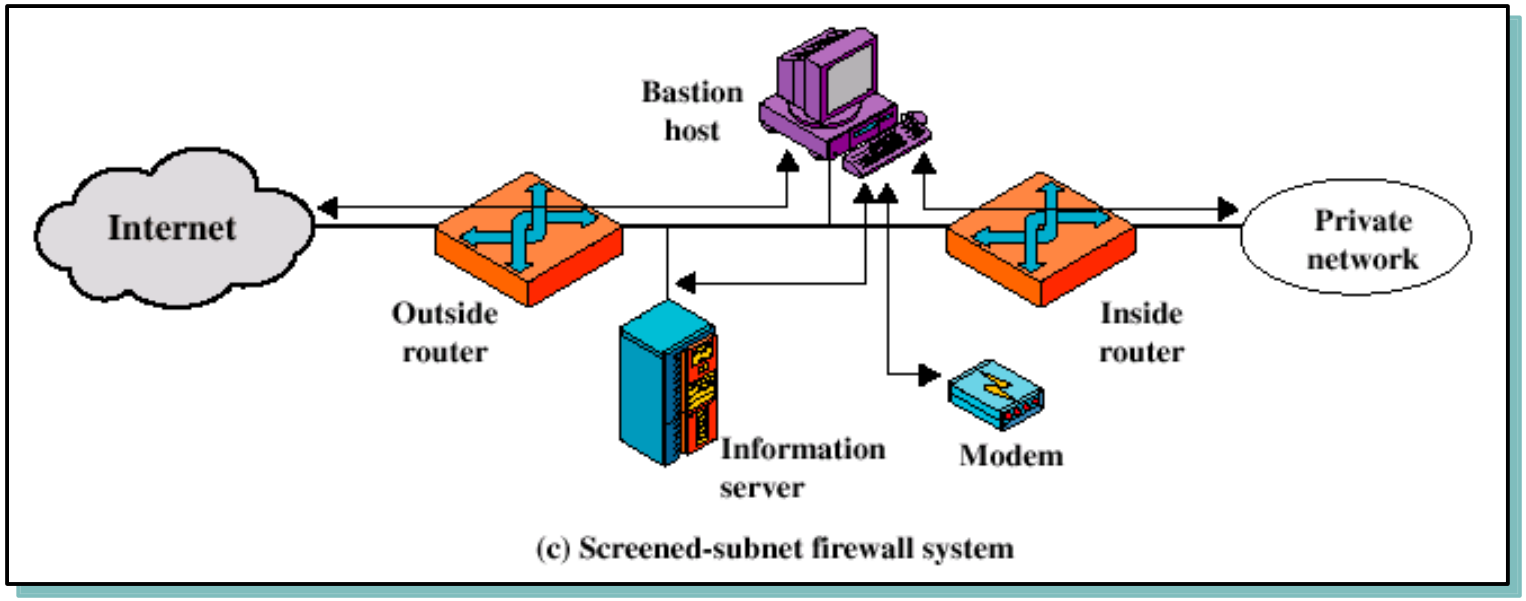
Bastion Host, Dual-homed

- Bastion host *second defense layer*
- Internal network is completely isolated
- Packet forwarding is turned off
- More secure



(b) Screened host firewall system (dual-homed bastion host)

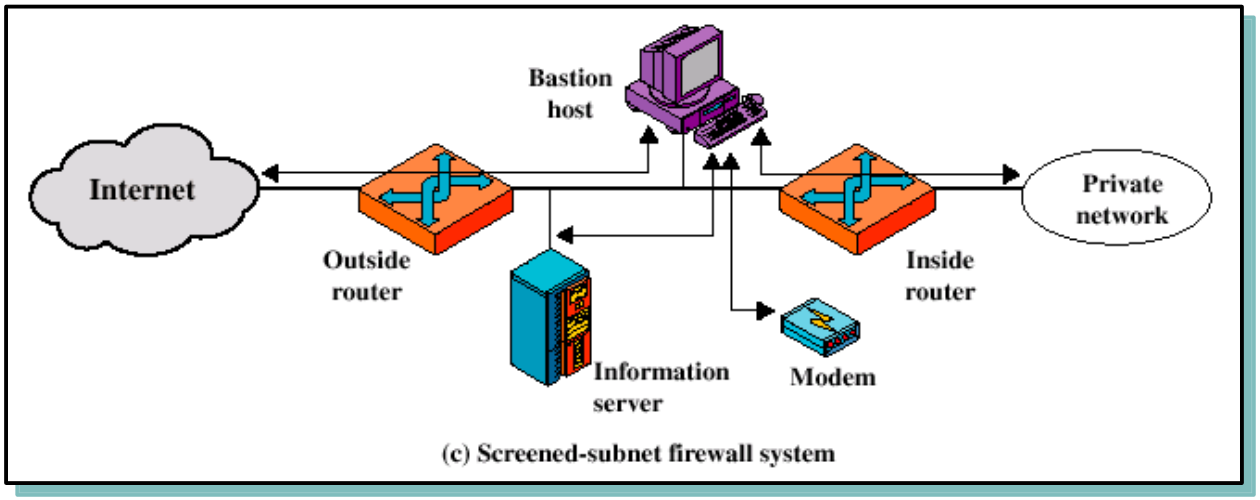
Screened Subnet



(c) Screened-subnet firewall system

Screened Subnet

- Most secure
- Isolated subnet with bastion host between two packet filtering routers
- Traffic across screened subnet is blocked
- Three layers of defense
- Internal network is invisible to the Internet

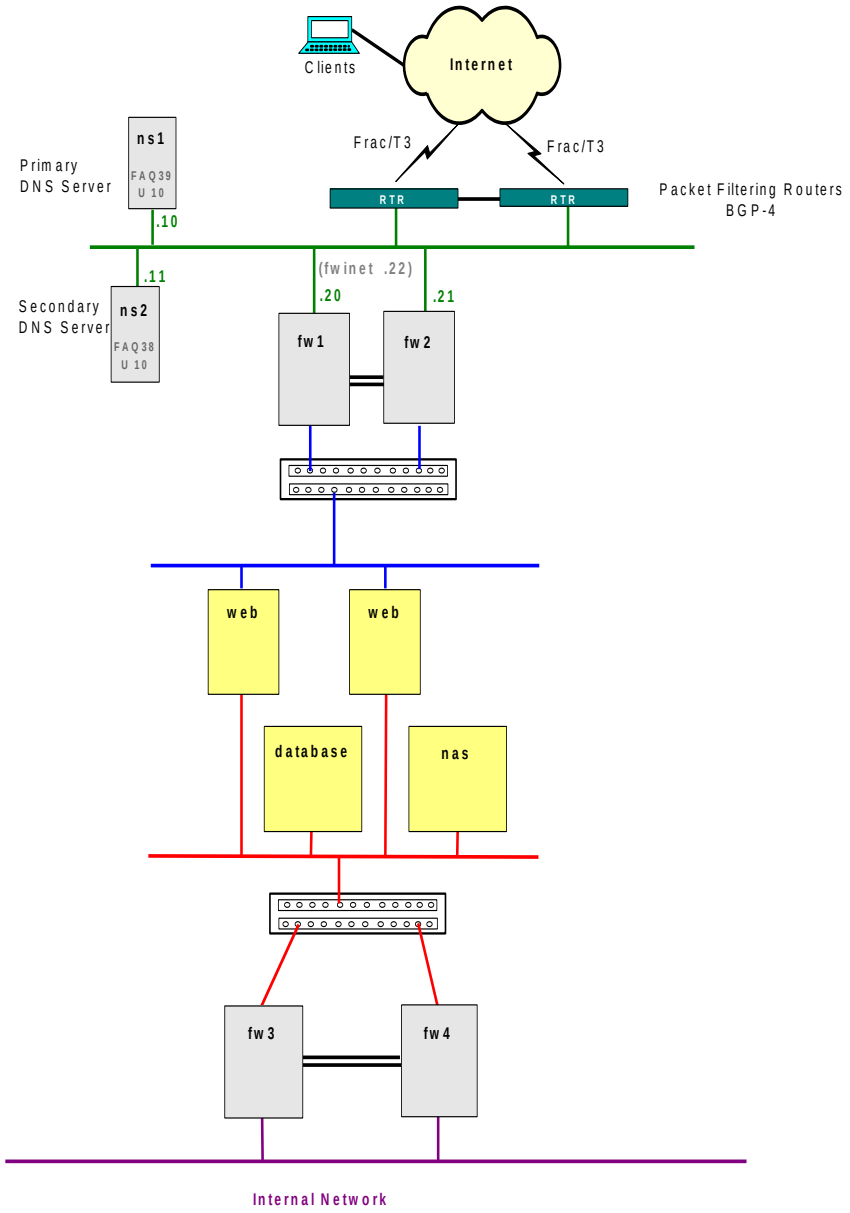


Typical DMZ

external network

DMZ

internal network



What Is iptables?

- Stateful packet inspection.

  The firewall keeps track of each connection passing through it, This is an important feature in the support of active FTP and VoIP.

- Filtering packets based on MAC address, IPv4 and IPv6
- Filtering packets based the values of the flags in the TCP header

  Helpful in preventing attacks using malformed packets and in restricting access.

- Network address translation and Port translating NAT/NAPT

  Building DMZ and more flexible NAT enviroments to increase security.

- System logging of network activities

  Provides the option of adjusting the level of detail of the reporting

- A rate limiting feature

  Helps to block some types of denial of service (DoS) attacks.

Packet Processing In iptables

- Three builtin tables (queues) for processing:

1. MANGLE: is used in QOS to handle marking of packet or in data load distribution to distribute packets to different routes

2. FILTER: packet filtering, has three builtin chains (your firewall policy rules)

   Forward chain: filters packets to servers protected by firewall

   Input chain: filters packets destinated for the firewall

   Output chain: filters packets orginating from the firewall

3. NAT: network adress translation, has two builtin chains

   Pre-routing: NAT packets when destination address need changes

   Post-routing: NAT packets when source address need changes

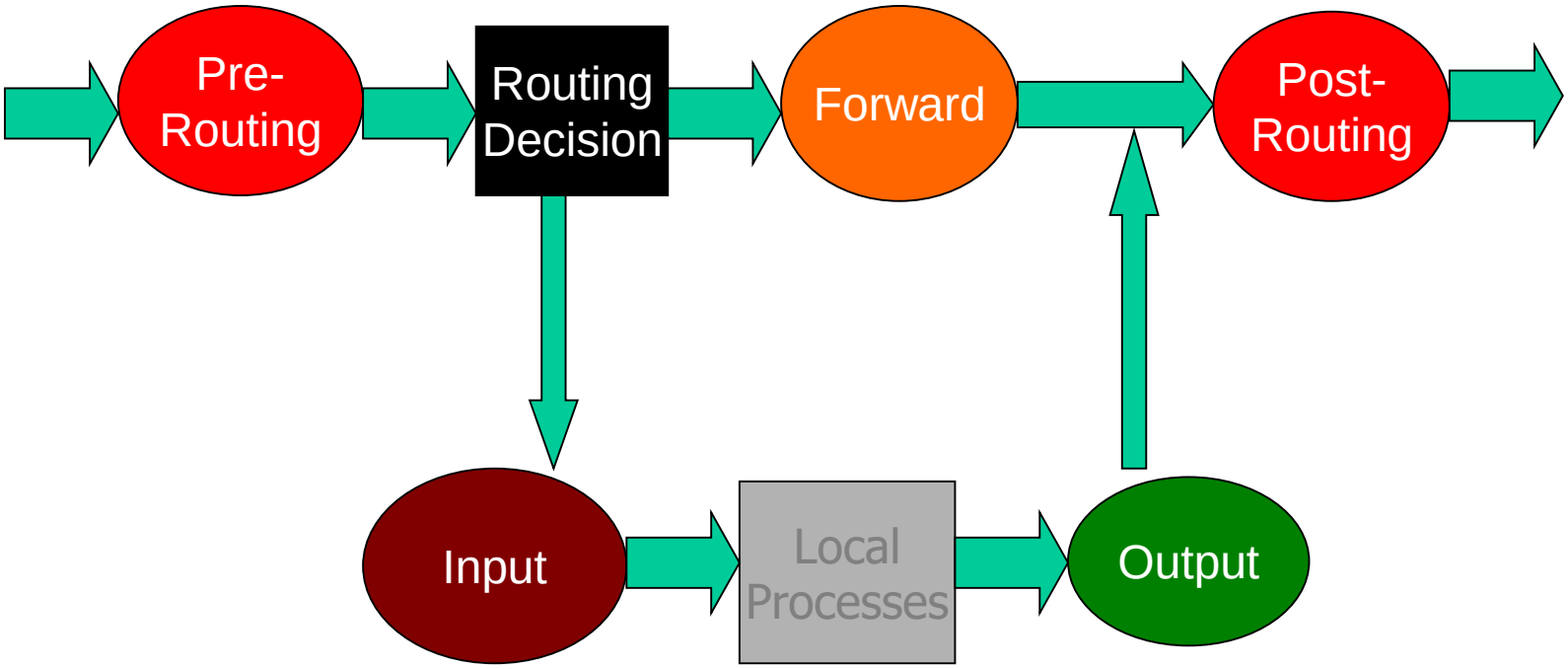
Processing For Packets Routed By The Firewall 1/2

Queue Type	Queue Function	Packet transformation chain in Queue	Chain Function
Filter	Packet filtering	FORWARD	Filters packets to servers accessible by another NIC on the firewall.
		INPUT	Filters packets destined to the firewall.
		OUTPUT	Filters packets originating from the firewall
Nat	Network Address Translation	PREROUTING	Address translation occurs before routing. Facilitates the transformation of the destination IP address to be compatible with the firewall's routing table. Used with NAT of the destination IP address, also known as **destination NAT** or **DNAT**.

Processing For Packets Routed By The Firewall 2/2

		POSTROUTING	Address translation occurs after routing. This implies that there was no need to modify the destination IP address of the packet as in pre-routing. Used with NAT of the source IP address using either one-to-one or many-to-one NAT. This is known as **source NAT**, or **SNAT**.
		OUTPUT	Network address translation for packets generated by the firewall. (Rarely used in SOHO environments)
Mangle	TCP header modification	PREROUTING POSTROUTING OUTPUT INPUT FORWARD	Modification of the TCP packet quality of service bits before routing occurs (Rarely used in SOHO environments)

Packet Traversal in Linux



IPtables “chains”

- A *chain* is a sequence of filtering rules.
- Rules are checked in order. First match wins. Every chain has a default rule.
- If no rules match the packet, default policy is applied.
- Chains are dynamically inserted/ deleted.

iptables command Switch	Description
`-t <table>`	If you don't specify a table, then the `filter` table is assumed. As discussed before, the possible built-in tables include: filter, nat, mangle
`-j <target>`	Jump to the specified target chain when the packet matches the current rule.
`-A`	Append rule to end of a chain
`-F`	Flush. Deletes all the rules in the selected table
`-p <protocol-type>`	Match protocol. Types include, `icmp`, `tcp`, `udp`, and `all`
`-s <ip-address>`	Match source IP address
`-d <ip-address>`	Match destination IP address
`-i <interface-name>`	Match "input" interface on which the packet enters.
`-o <interface-name>`	Match "output" interface on which the packet exits

Switch	Description
`-p tcp --sport <port>`	TCP source port Can be a single value or a range in the format: *start-port-number:end-port-number*
`-p tcp --dport <port>`	TCP destination port Can be a single value or a range in the format: *starting-port:ending-port*
`-p tcp --syn`	Used to identify a new TCP connection request ! --syn means, not a new connection request
`-p udp --sport <port>`	UDP source port Can be a single value or a range in the format: *starting-port:ending-port*

- Example:

- **iptables -A FORWARD -s 0/0 -i eth0 -d 192.168.1.58 -o eth1 -p TCP **

  --sport 1024:65535 --dport 80 -j ACCEPT

- `iptables` is being configured to allow the firewall to accept TCP packets for routing when they enter on interface eth0 from any IP address and are destined for an IP address of 192.168.1.58 that is reachable via interface eth1. The source port is in the range 1024 to 65535 and the destination port is port 80 (www/http).

- **You can expand on the limit feature of iptables to reduce your vulnerability to certain types of denial of service attack. Here a defense for SYN flood attacks was created by limiting the acceptance of TCP segments with the SYN bit set to no more than five per second.**

- –m limit sets maximum number of SYN packets
  - **`iptables` is being configured to allow the firewall to accept maxim 5 TCP/SYN packeds per second on interface eth0.**

iptables -A INPUT -p tcp --syn -m limit --limit 5/s -i eth0 -j ACCEPT

  - **If more than 5 SYN packets per second, the packets are dropped.**
  - **If source/destination sence dropped packets, it will resend three times**
  - **If drops continue after 3 reset packets, source will reduce packet speed.**