CS165 – Computer Security

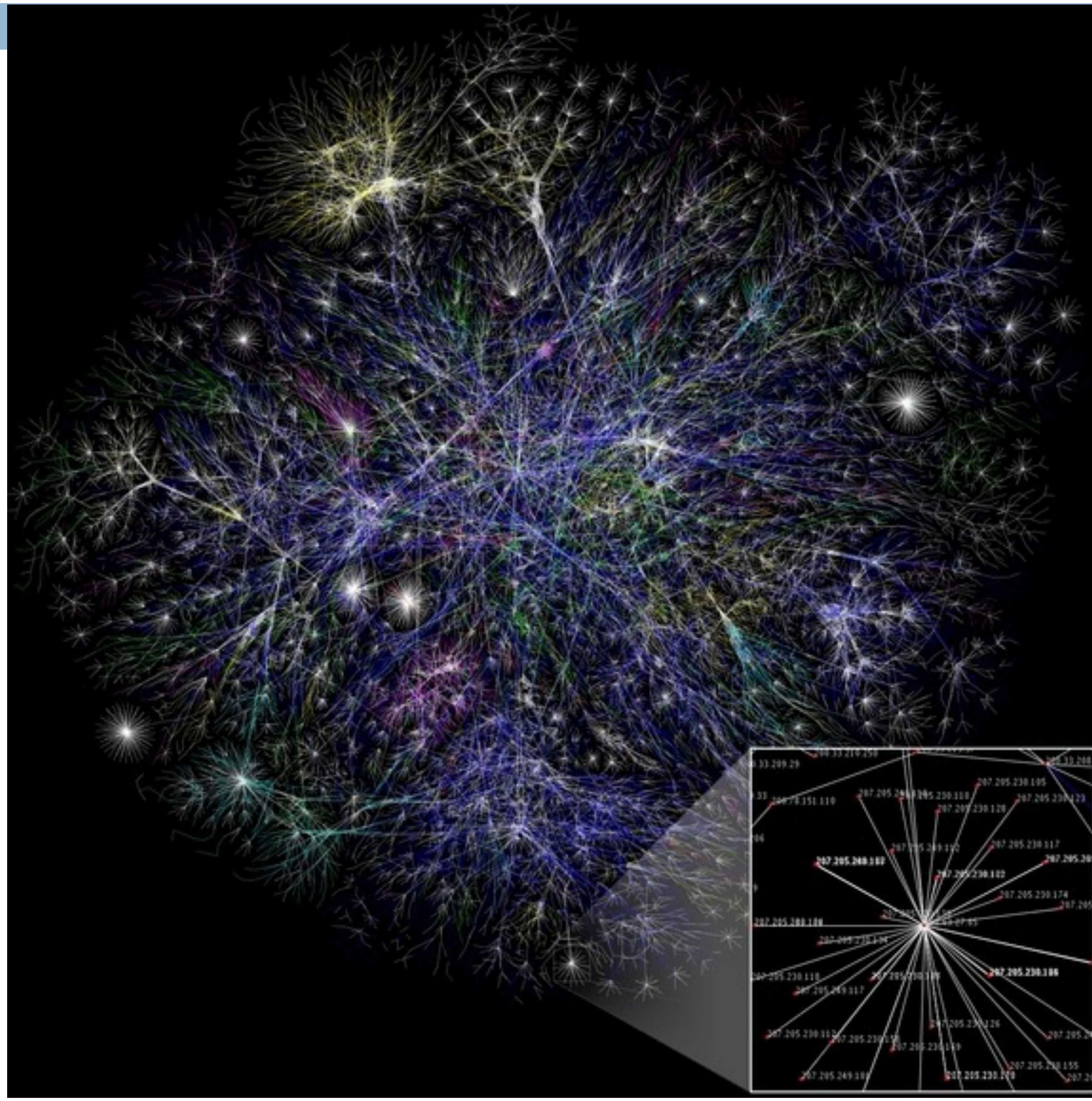
Network Security

December 2, 2024

History of Network Security

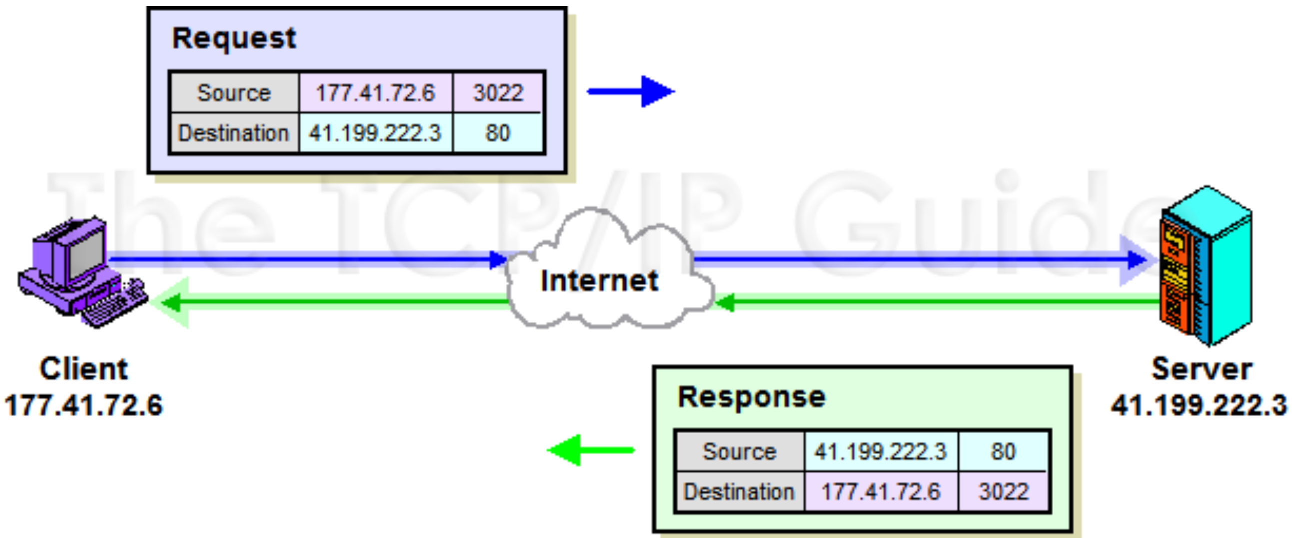
- Initially built for communication between research institutions
  - ARPANET (TCP/IP)
  - First packet sent from UCLA to SRI
- Internet designed without security in mind
  - Including key protocols such as TCP/IP
  - Getting it to work is already an amazing job
- Hard to retrofit security into existing protocols
  - Have to remain backward-compatible
    - E.g., TCP/IP used by every machine now
  - Solutions often are patches or require an additional layer of indirection

How the Internet looks



Quick Overview of TCP/IP

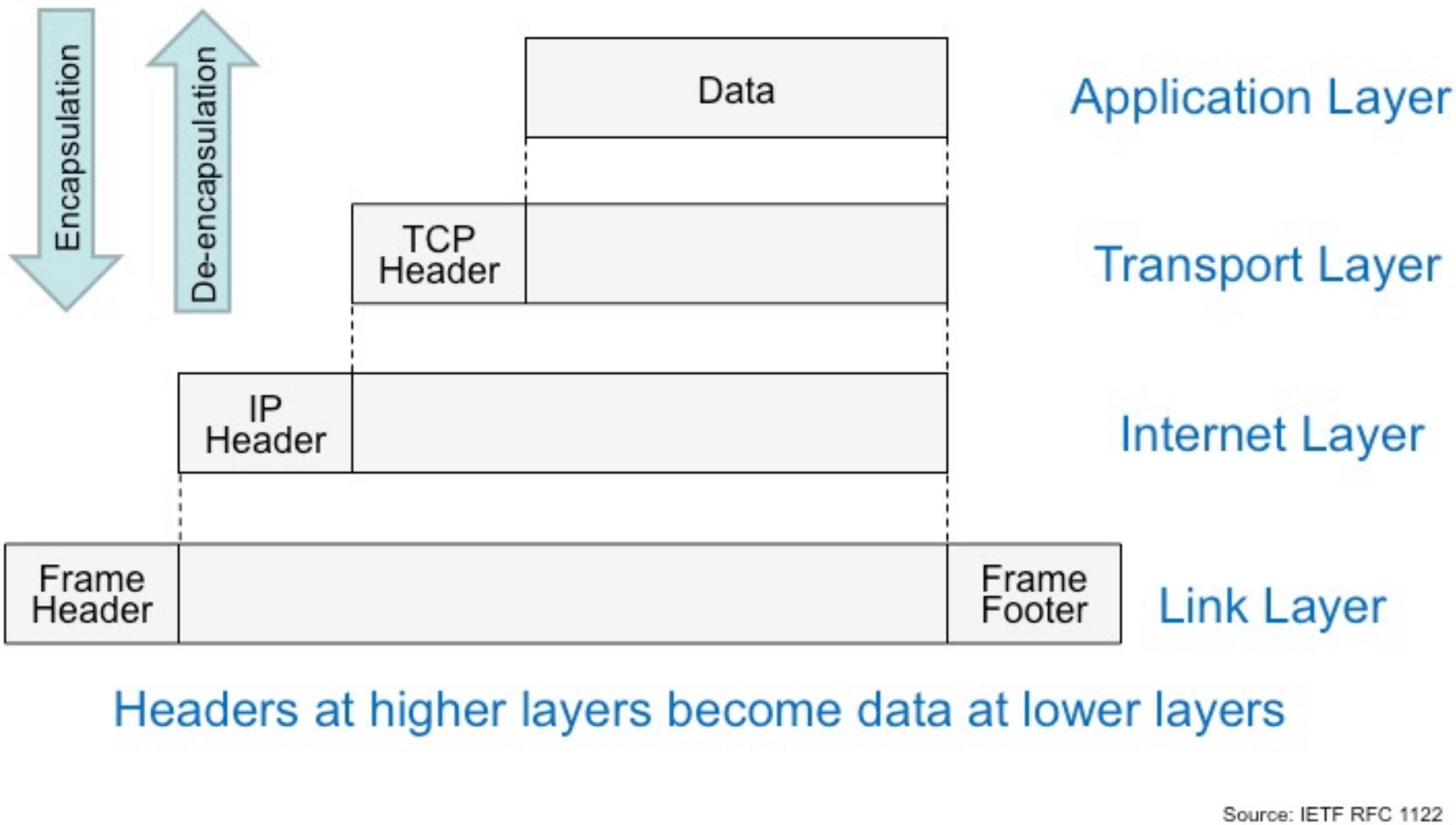
- Example:



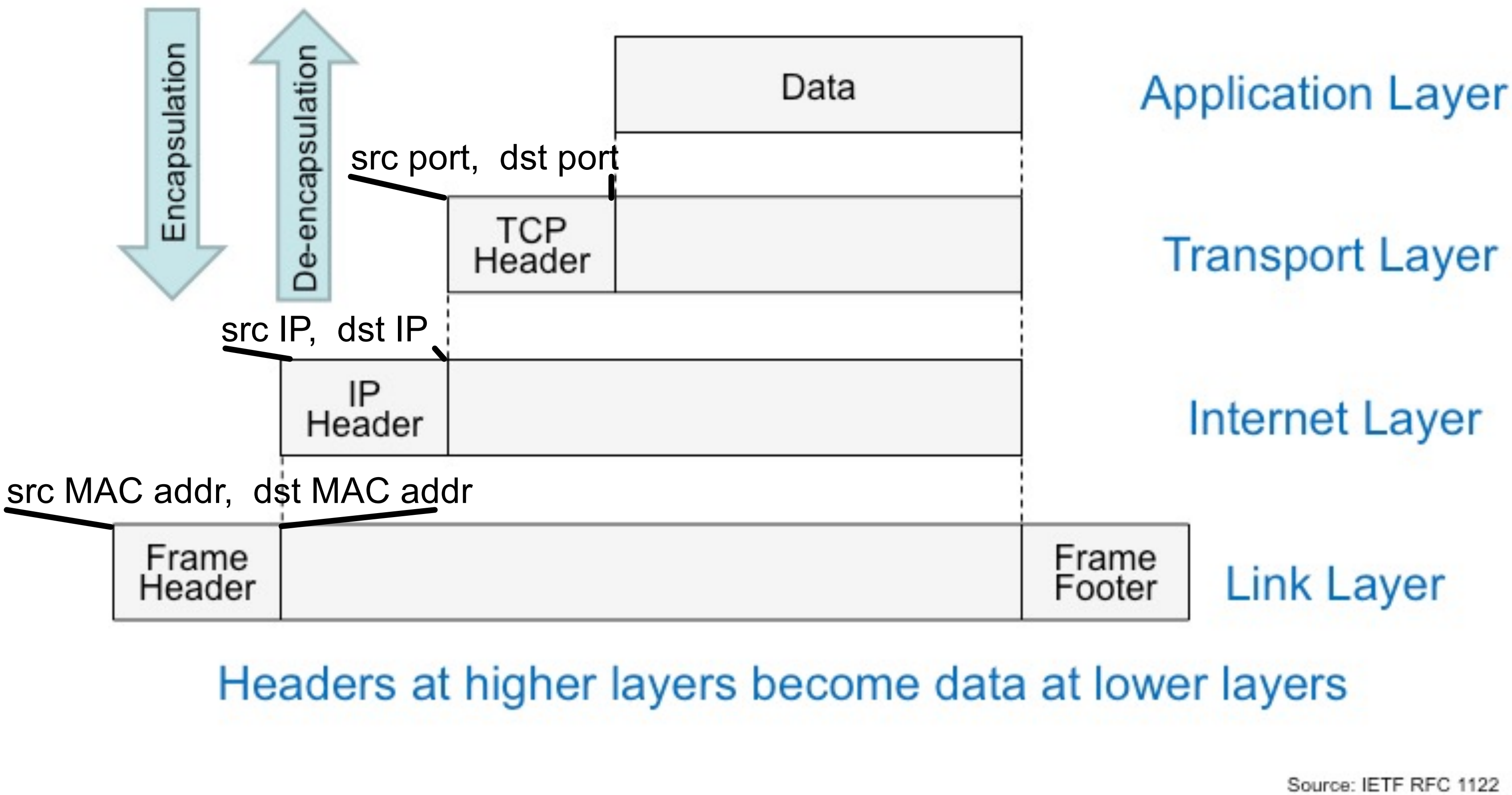
Hosting a web server at TCP port 80

- Network traffic is broken down into "packets" containing information at 4 main layers

TCP/IP Network Layers



TCP/IP Network Layers



Applications of TCP

- Most things!
  - HTTP, FTP, SMTP…
- Saves applications a lot of work, so used unless there’s a good reason not to
  - QUIC and HTTP 3.0 build on UDP for max performance

Current state of affairs

- **Traffic almost never encrypted**
  - IP, TCP/UDP, DNS, telnet
- **Traffic encrypted often**
  - Web traffic (HTTPS, QUIC) > 50% encrypted
  - Mileage varies
- **Traffic always encrypted**
  - SSH, Email traffic (SMTP)
- **Encryption sometimes can be broken too!**

Finding a way into the network -- Scanning

Host 192.168.2.1 appears to be up.
MAC Address: 00:04:E2:34:B6:CE (SMC Networks)
Host 192.168.2.79 appears to be up.
MAC Address: 00:11:11:5B:7A:CD (Intel)
Host 192.168.2.82 appears to be up.
MAC Address: 00:10:5A:0D:F6:D7 (3com)
Host 192.168.2.198 appears to be up.
MAC Address: 00:10:DC:55:89:27 (Micro-star International)
Host 192.168.2.199 appears to be up.
MAC Address: 00:C0:4F:36:33:91 (Dell Computer)
Host 192.168.2.200 appears to be up.
MAC Address: 00:0C:41:22:CC:01 (The Linksys Group)
Host 192.168.2.251 appears to be up.
MAC Address: 00:0F:66:75:3D:75 (Cisco-Linksys)

Does That Matter?

- If they identify a service that has a known vulnerability (e.g., buffer overflow), they can launch the corresponding exploit

```
$ nmap -Pn www.cs.ucr.edu

Starting Nmap 6.40 ( http://nmap.org ) at 2015-
11-17 20:03 UTC
Nmap scan report for www.cs.ucr.edu
(169.235.30.15)
Host is up (0.00033s latency).
rDNS record for 169.235.30.15: thoth.cs.ucr.edu
Not shown: 996 closed ports
PORT     STATE SERVICE
22/tcp    open  ssh
80/tcp    open  http
111/tcp   open  rpcbind
5666/tcp open  nrpe
```

Firewalls

- Basic problem – many network applications and protocols have security problems that are fixed over time (i.e., may not be fixed yet)
  - Difficult for users to keep up with patches to keep hosts secure
  - Solution
    - Administrators limit access to end hosts by using a firewall
    - Firewall is kept up-to-date by administrators
- Access control over network communications with hosts and their services

Firewalls

- A firewall is like a castle with a drawbridge
  - Only one point of access into the network
    - Need to ensure complete mediation
  - This can be good or bad
- Can be hardware or software
  - E.g., Some routers come with firewall functionality
  - ipfw, iptables, pf on Unix systems, Windows XP and Mac OS X have built in firewalls

Firewalls

- Used to filter packets based on a combination of features
  - These are called packet filtering firewalls
    - There are other types too, but they will not be discussed
  - E.g., Drop packets with destination port of 23 (Telnet)
  - Can use any combination of IP/UDP/TCP header information
- But why don't we just turn Telnet off?

Firewalls

- Used to filter packets based on a combination of features
  - These are called packet filtering firewalls
    - There are other types too, but they will not be discussed
- Consist of a rule base
  - Rules are checked in sequence
  - First one to match is determines the response
  - One rule may match many packets due to wildcards
    - E.g., Block all telnet (by port number 23) to your network (1.1.1.*) – all hosts

Firewall Rules

- Specifies what traffic is (not) allowed
  - Maps attributes to address and ports
  - Example: HTTP should be allowed to any external host, but inbound only to web-server

Source		Destination		Protocol	Flags	Actions
Address	Port	Address	Port			
*	*	1.1.1.1	80	TCP	SYN	Accept
1.1.1.*	*	*	80	TCP	SYN	Accept
*	*	*	80	TCP		Accept
*	*	*	*	TCP		Deny

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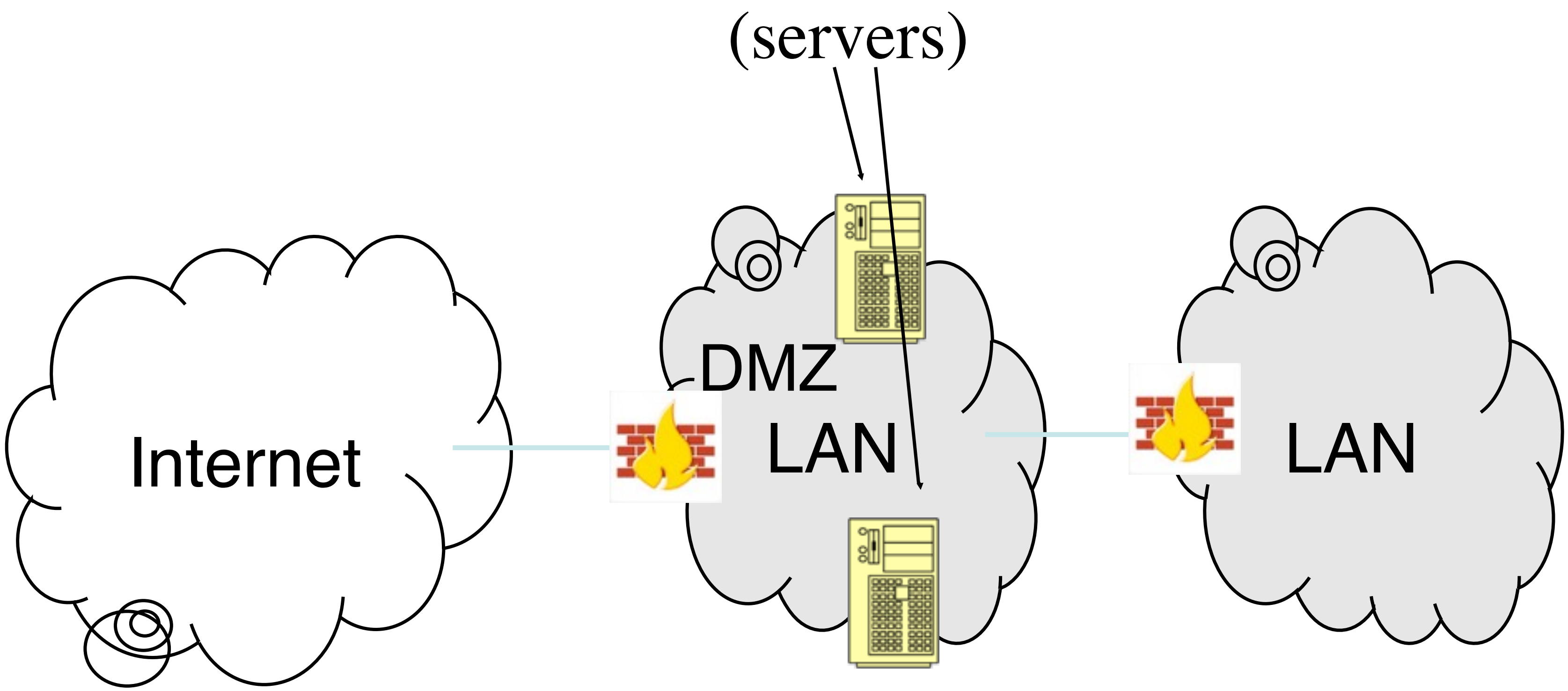
De-Militarized Zone (DMZ)



- Zone between LAN and Internet (*public facing*)

Stateful, Proxy, and Transparent

- Single packet may not contain sufficient data to make an access control decision
- Stateful: allows historical context consideration
  - Firewall collects data over time
  - e.g.,TCP packet is part of established session
- Firewalls may affect network traffic
  - Proxy: Application firewall
    - Receives, interprets, and reinitiates communication
  - Transparent: Network firewall
    - Invisible to communication, like a router
- Transparent good for speed, and proxies good for complex state

Real Firewall: Linux iptables

- The iptables firewall looks in the firewall table to seek if a rule in the current chain matches a packet – executes the rule’s target if it does.

- Table: all the firewall rules, grouped in chains
- Chain: one list of rules
  - A rule can initiate a new chain (like a function call)
- Rule: description of packets with a target
- Match: when all a rule’s fields match the packet
- Target: operation to execute on a packet given a match

iptables Simple Test

- Use loopback to test the rules locally on your machine using ICMP
  - IP address 127.0.0.1
- ICMP protocol
  - Submit "ping" requests to 127.0.0.1 (next slide)
- TCP protocol (use "netcat" – nc)
  - submit requests to 127.0.0.1 at specific port
  - nc –l –p 3750 (server)
    - Listen at port 3750
  - nc –p 3000 localhost 3750
    - Send from port 3000 to localhost at port 3750

iptables Simple Test

- Run "ping" on a Linux machine – sending to "loopback"
  - `ping -c 1 127.0.0.1`
- Add iptables rule to block this ping (must be "root")
  - `iptables -A INPUT -s 127.0.0.1 -p icmp -j DROP`
    - `-A INPUT` – Add to the INPUT chain
    - `-s 127.0.0.1` – Source address (loopback)
    - `-p icmp` – for the ICMP protocol (used by "ping")
    - `-j DROP` – target is to drop the packet
- Run ping again
  - Should be blocked

iptables Simple Test

- Run "ping" on a Linux machine – sending to "localhost"
  - `ping -c 1 127.0.0.1`
- Add iptables rule to block this ping
  - `iptables -A INPUT -s 127.0.0.1 -p icmp -j DROP`
- Run ping again
- Delete the rule (one of)
  - `iptables -D INPUT 1`
  - `iptables -D INPUT -s 127.0.0.1 -p icmp -j DROP`
  - `iptables -F INPUT`

iptables Targets

- Define what to do with the packet on match
- ACCEPT/DROP
- QUEUE for user-space application
- LOG any packet that matches
- REJECT drops and returns error packet
- RETURN enables packet to return to previous chain
- <user-specified> passes packet to that chain

iptables Examples


```
iptables -A INPUT -s 200.200.200.2 -j ACCEPT
```

- Accept packets from source `200.200.200.2`

```
iptables -A INPUT -s 200.200.200.1 -j DROP
```

- Drop packets from source `200.200.200.1`

```
iptables -A INPUT -s 200.200.200.1 -p tcp -j DROP
```

- Drop TCP packets (only) from source `200.200.200.1`

```
iptables -A INPUT -s 200.200.200.1 -p tcp --dport telnet -j DROP
```

- Drop packet from that source destined for the telnet port

```
iptables -A INPUT -p tcp --destination-port telnet -i ppp0 -j DROP
```

- Drop TCP packet destined for the telnet port using network interface ppp0

Conclusions

- Network communication is fundamentally useful
  - TCP is the common communication protocol
- Networks of hosts have many network services
  - Early worms exploited the easy access to services
- Modern networks employ firewalls to access control over packet send/rcv to hosts, services (ports), protocols, etc.
  - Linux iptables is one example

Questions