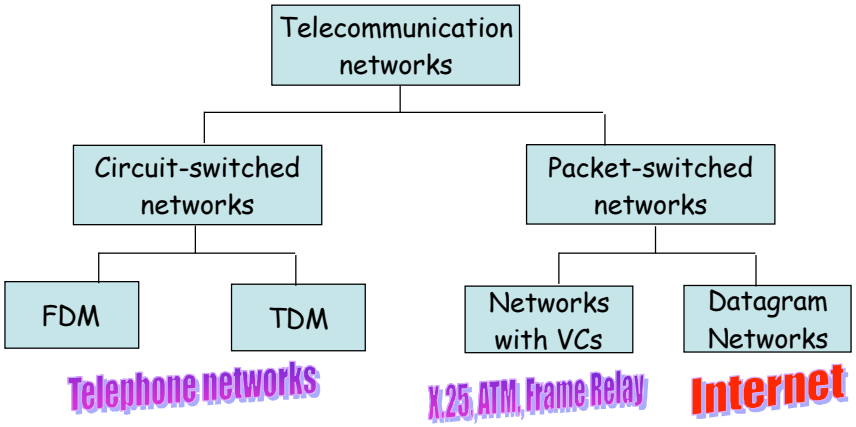
An Overview of Network Security

Coverage

- Lower Layers
- Upper Layers
- The Web

- From Security Point of View

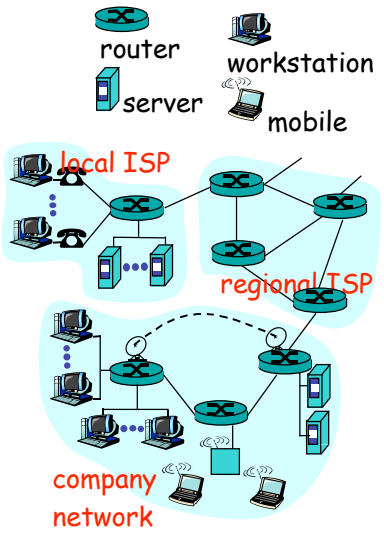
Network taxonomy



What's the Internet: "nuts and bolts" view

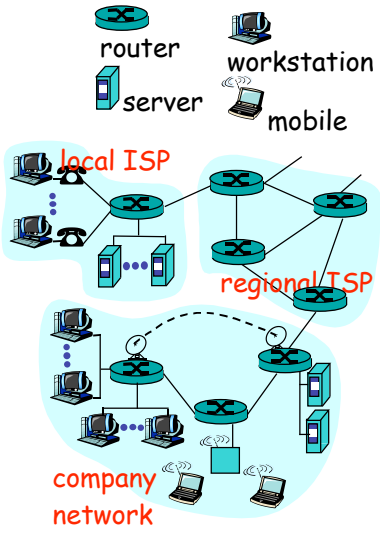
- millions of connected computing devices: *hosts, end-systems*
  - PCs workstations, servers
  - PDAs phones, toasters

  running *network apps*
- *communication links*
  - fiber, copper, radio, satellite
  - transmission rate = ***bandwidth***
- *routers:* forward packets (chunks of data)



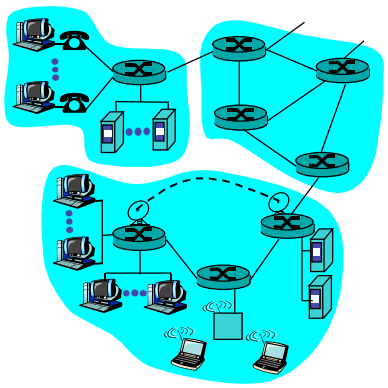
What's the Internet: "nuts and bolts" view

- *protocols* control sending, receiving of msgs
  - e.g., TCP, IP, HTTP, FTP, PPP
- *Internet:* "network of networks"
  - loosely hierarchical
  - public Internet versus private intranet
- Internet standards
  - RFC: Request for comments
  - IETF: Internet Engineering Task Force



What's the Internet: a service view

- communication *infrastructure* enables distributed applications:
  - Web, email, games, e-commerce, database., voting, file (MP3) sharing
- communication services provided to apps:
  - connectionless
  - connection-oriented

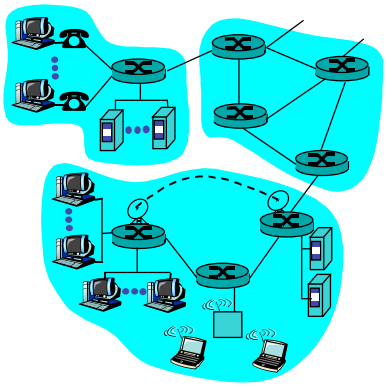


- cyberspace [Gibson]:

"a consensual hallucination experienced daily by billions of operators, in every nation, ..."

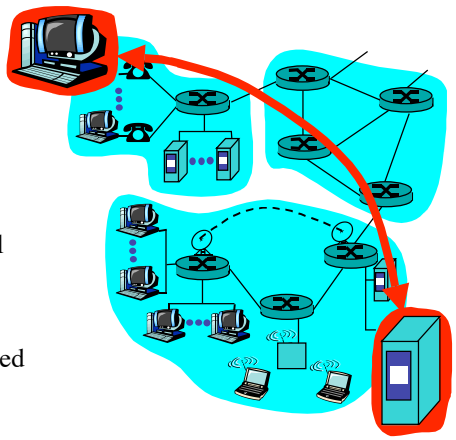
A closer look at network structure:

- network edge: applications and hosts
- network core:
  - routers
  - network of networks
- access networks, physical media: communication links



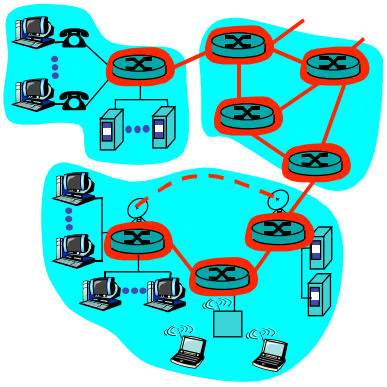
The network edge:

- end systems (hosts):
  - run application programs
  - e.g. Web, email
  - at "edge of network"
- client/server model
  - client host requests, receives service from always-on server
  - e.g. Web browser/server; email client/server
- peer-peer model:
  - minimal (or no) use of dedicated servers
  - e.g. Gnutella, KaZaA



The network core

- mesh of interconnected routers
- *the* fundamental question: how is data transferred through net?
  - circuit switching: dedicated circuit per call: telephone net
  - packet-switching: data sent thru net in discrete "chunks"

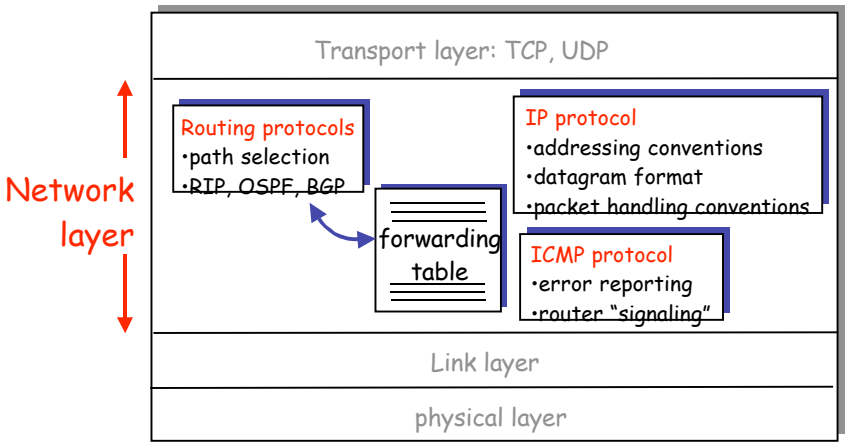


Lower Layers

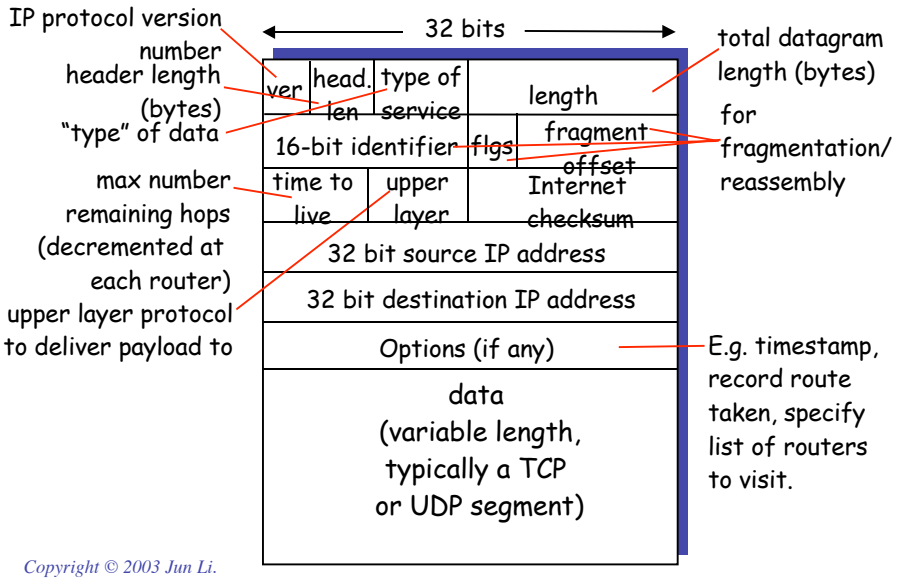
- IP
- ARP
- ICMP
- TCP
- UDP
- SCTP
- Routing Protocols
  - RIP, OSPF, BGP
- DNS
- BOOTP & DHCP
- IPv6
- NAT
- Wireless Security

IP

A network layer protocol:

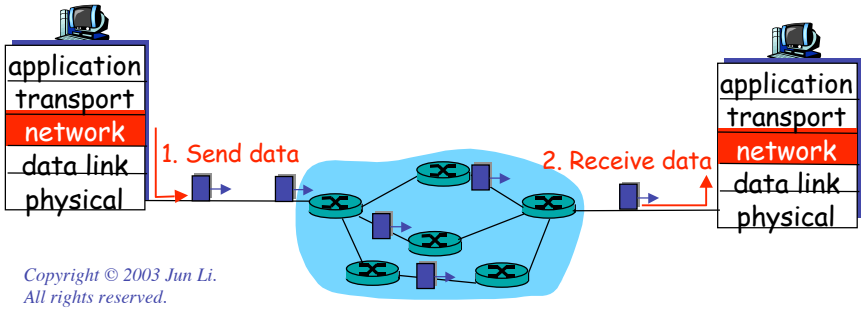


IP datagram format



IP Packet Forwarding

- no call setup at network layer
- routers: no state about end-to-end connections
  - no network-level concept of "connection"
- packets forwarded using destination host address
  - packets between same source-dest pair may take different paths

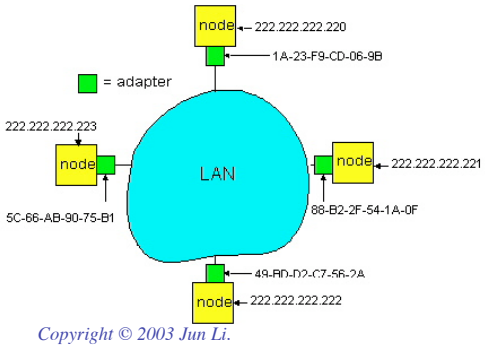


IP Security Issues

- IP Spoofing
  - Forged source address
    - Any host can transmit a packet with any source address
- Packet inception
  - Man-in-the-middle attack
- What else?

ARP: Address Resolution Protocol

Question: how to determine MAC address of B knowing B's IP address?



- Each IP node (Host, Router) on LAN has ARP table
- ARP Table: IP/MAC address mappings for some LAN nodes

  < IP address; MAC address; TTL>
  - TTL (Time To Live): time after which address mapping will be forgotten (typically 20 min)

ARP Security Issues

- Problematic if an untrusted node has write access to the local net
- ARP spoofing
  - Use phony queries or replies
  - Such that all/some traffic misdirected
- What else?

ICMP: Internet Control Message Protocol

- used by hosts, routers, gateways to communication network-level information
  - error reporting: unreachable host, network, port, protocol
  - echo request/reply (used by ping)
- network-layer "above" IP:
  - ICMP msgs carried in IP datagrams
- ICMP message: type, code plus first 8 bytes of IP datagram causing error

Type	Code	description
0	0	echo reply (ping)
3	0	dest. network unreachable
3	1	dest host unreachable
3	2	dest protocol unreachable
3	3	dest port unreachable
3	6	dest network unknown
3	7	dest host unknown
4	0	source quench (congestion control - not used)
8	0	echo request (ping)
9	0	route advertisement
10	0	router discovery
11	0	TTL expired
12	0	bad IP header

ICMP Security Issues

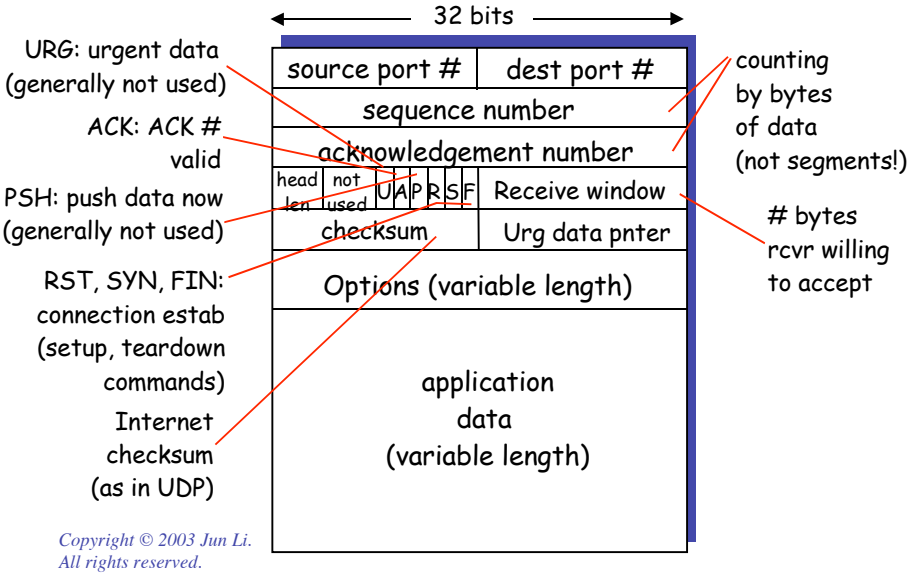
- ICMP can be abused to tear down connections
- Can also be abused to create new paths to a destination
  - Using the REDIRECT ICMP message
- Block ICMP messages at firewalls?

TCP

- point-to-point:
  - one sender, one receiver
- reliable, in-order *byte steam:*
  - no "message boundaries"
- pipelined:
  - TCP congestion and flow control set window size
- *send & receive buffers*

- full duplex data:
  - bi-directional data flow in same connection
  - MSS: maximum segment size
- connection-oriented:
  - handshaking (exchange of control msgs) init's sender, receiver state before data exchange
- flow controlled:
  - sender will not overwhelm receiver

TCP Segment

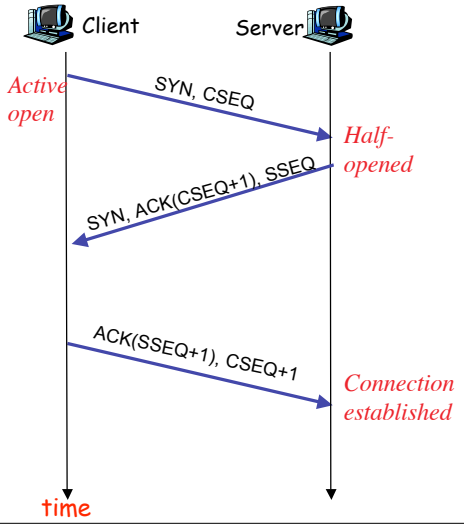


TCP Security Issues

- TCP open
- TCP privileged ports
- TCP stream vs. firewall

TCP Security Issues - TCP Open

- SYN Attacks
  - Flood a TCP server with SYN packets
  - Make the server in half-opened status with many connections
  - Can cause DDoS
- Detect what services a server provides
- Sequence number attack
  - If an attacker can predict the sequence number expected by an victim



TCP Security Issues - Privileged ports

- What are privileged ports
  - A unix convention that only can be created by the *root*
  - Less than 1024
  - Goal: remote systems can trust the authenticity of into written to such ports
- This goal really is just a hope
  - Not required by TCP specification
  - Meaningless on non-Unix systems
  - One may not necessarily trust the sanctity of a privileged port

TCP Security Issues - TCP Stream vs. Firewall

- With TCP, data flows like a stream
  - There is no boundary
  - Thus hard for a firewall to filter individual packets

TCP Security Issues

- What else?

UDP

- Extends to applications the same level of service used by IP
  - Best-effort delivery
- Security Issues
  - UDP has no flow control, etc.
    - Large UDP transmissions may swamp the network
  - Certainly still has the IP spoofing problem
  - What else?

SCTP

- A new transport protocol (stream control transmission protocol)
- Read the brief description from course reserve materials

Routing Protocols

- Routing is the process of discovering, selecting, and employing paths from sources to destinations
- Often asymmetric
- RIP, OSPF, IS-IS, BGP, etc.

Security Issues

- Some routing options can be abused
  - Source routing
- A routing protocol itself can be subverted
  - Inject bogus routing updates, for example
    - A good router may be cheated to spread deceptive routing updates
  - A router could be compromised

BGP Security Issues

- BGP is a routing protocol for the core of the Internet at AS level
  - Routing announcements are exchanged via TCP
- Corrupt announcements can be used to perform a variety of attacks
  - An attacker can play BGP games
    - Can eavesdrop on, hijack or suppress BGP sessions
  - And other attacks

DNS

- A distributed database that maps hostnames to IP addresses, or vice versa
- Two logically distinct tree-structured namespaces
  - One for name to IP address (forward mapping), the other for IP address to name (backward mapping)
- Transport protocols for DNS
  - DNS query is UDP-based
  - But zone transfer is TCP-based
    - For backup servers to get a full copy of their portion in the name space

DNS Security Issues

- An attacker in control of the inverse mapping tree
  - A non-trusted IP address may thus map to a trusted name
  - Well, easy to deal if the forward mapping tree is authentic (cross-checking)
  - The attacker can further try to poison the victim's DNS cache
- Omission of a trailing period
  - "foo.com" will be tried as "foo.com.cs.uoregon.edu" then "foo.com.uoregon.edu" then "foo.com.edu" then "foo.com"
  - What if an attacker builds a name server for "com.edu" domain?

BOOTP & DHCP

- DHCP is an extension of the simpler BOOTP
- Through a DHCP server, a client can obtain a lot of info
  - IP address
  - DNS server
  - Default route address
  - Default domain name, or even
  - NTS server
  - etc.

DHCP Security Issues

- DHCP runs on a LAN
  - Thus less security concerns
- But still subject to man-in-the-middle and DOS attacks
  - Essentially same security issues as ARP
- A rogue DHCP server?
- Applying for DHCP service endlessly?
  - To deplete available IP addresses for a local domain
- What else?

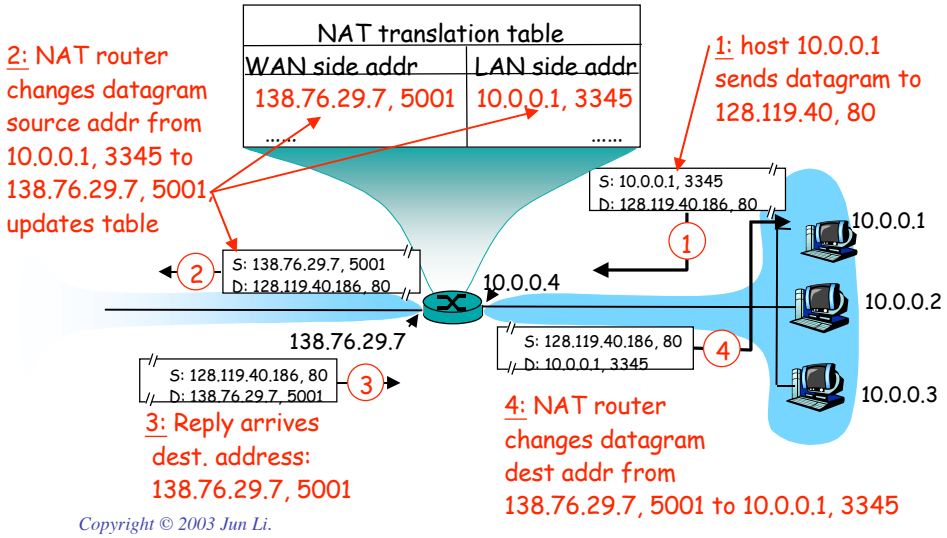
IPv6

- Same philosophy as IPv4 as an unreliable best-effort delivery protocol
- Allows interesting address types
  - *Anycast* adrdresses
    - Multiple machines map to the same address
  - *Site-local* addresses
    - Some addresses are purely local to a "site"
  - *Link-local* addresses
    - Limited to a single link
- New protocols
  - Neighbor Discovery protocol (similar to ARP)
  - DHCPv6

IPv6 Security Issues

- Renumbering
  - How to enfoce a secure incremental v4->v6 transition?
- Hosts can generate its own temporary IP address
  - Making the traceback harder
- *Anycast* addresses
  - How to decide exactly which machine is the attacker
- *Site-local* and *link-local* addresses
  - Uncertain whether this is a good access control mechanism
- IPv6-capable firewall?
- What else?

NAT: Network Address Translation



NAT Security Issues

- Does not get along well with encryption
  - The port number is often encrypted as part of IP payload
  - IPsec is not compatible with NAT
    - IPsec protects checksum, which includes the IP address

Wireless Security

- Limited energy
  - Battery attack
- Easier eavesdropping
  - Cannot just lock your office door
- Harder border control
  - Can a wireless firewall be set up?
- Fragile routing infrastructure
  - Normal wireless nodes used as forwarding nodes
- Harder to trace back an attacker
  - Nodes are often mobile
- Security service is often not available
  - Hardly any on authentication, key management, etc.