Announcements

- Reading: Chapter 16
- Project #6 Due on next Tuesday 5:00 pm

Secure Socket Layer

- Goal:
  - Provide secure access to remote services
  - Authenticate remote servers to local users
  - Allow remote systems to authenticate users
  - Permit encrypted communication
- Approach
  - Public Key Cryptography
    - Certificates (signed by certificate authorities)
  - Sever sends:
    - Certificate (signed use CA's private key)
    - Certificate contains server's public key
    - Client responds by encrypting reply using servers pub key
    - Server checks response with private key

Sending Data

- Data is split into *packets*
  - limited size units of sending information
  - can be
    - fixed sized (ATM)
    - variable size (Ethernet)
- Need to provide a destination for the packet
  - need to identify two levels of information
    - machine to send data to
    - comm abstraction (e.g. process) to get data
  - address may be:
    - a globally unique destination
      - for example every host has a unique id
    - may unique between hops
      - unique id between two switches

TCP/IP Protocol

- Name for a family of Network and Transport layers
  - can run over many link layers:
    - Arpanet, Ethernet, Token Ring, SLIP/PPP, T1/T3, etc.
- IP - Internet Protocol
  - network level packet oriented protocol
  - 32 bit host addresses (dotted quad 128.8.128.84)
  - 8 bit protocol field (e.g. TCP, UDP, ICMP)
- TCP - Transmission Control Protocol
  - transport protocol
  - end-to-end reliable byte streams
  - provides ports for application specific end-points
- UDP- user datagram protocol
  - transport protocol
  - unreliable packet service
  - provides ports for application specific end-points

TCP/IP History

- Arpanet was the origin of today's Internet
  - started in 1969 to connect universities and DoD sites
  - early example of packet switched network
  - original links were 64kbps and 9.6kpbs
- TCP/IP v4
  - started in use Jan 1, 1983
  - This was a *flag day*
    - all systems had to change to the new protocol at once
    - with the modern Internet this would be **hard** to do
- TCP/IP v6
  - Moves to 128 bit addresses
  - Simplified packet header

Subnet Addressing

- Single site which has many physical networks
  - Only local routers know about all the physical nets
  - Site chooses part of address that distinguishes between physical networks
- subnet mask: splits the IP address into two parts
  - /xx notation defines boundary where xx is the number of bits in part 1
  - First part is network mask
  - Second part is address within that network
- Common /24 site mask 255.255.255.0
  - use 24 bits represent physical net
  - Final 8 bits represent host

Routing

- How does a packet find its destination?
  – problem is called routing
- Several options:
  – source routing
    - end points know how to get everywhere
    - each packet is given a list of hops before it is sent
  – hop-by-hop
    - each host knows for each destination how to get one more hop in the right direction
- Can route packets:
  – per session
    - each packet in a connection takes same path
  – per packet
    - packets may take different routes
    - possible to have out of order delivery

Routing IP Datagrams

- Direct Delivery:
  - a machine on a physical network can send a physical frame directly to another
  - transmission of an IP datagram between two machines on a single physical network does not involve routers.
    - Sender encapsulates datagram into a physical frame, maps destination IP address to a physical address and sends frame directly to destination
  - Sender knows that a machine is on a directly connected network
    - compare network portion of destination ID with own ID - if these match, the datagram can be sent directly
  - Direct delivery can be viewed as the final step in any datagram transmission

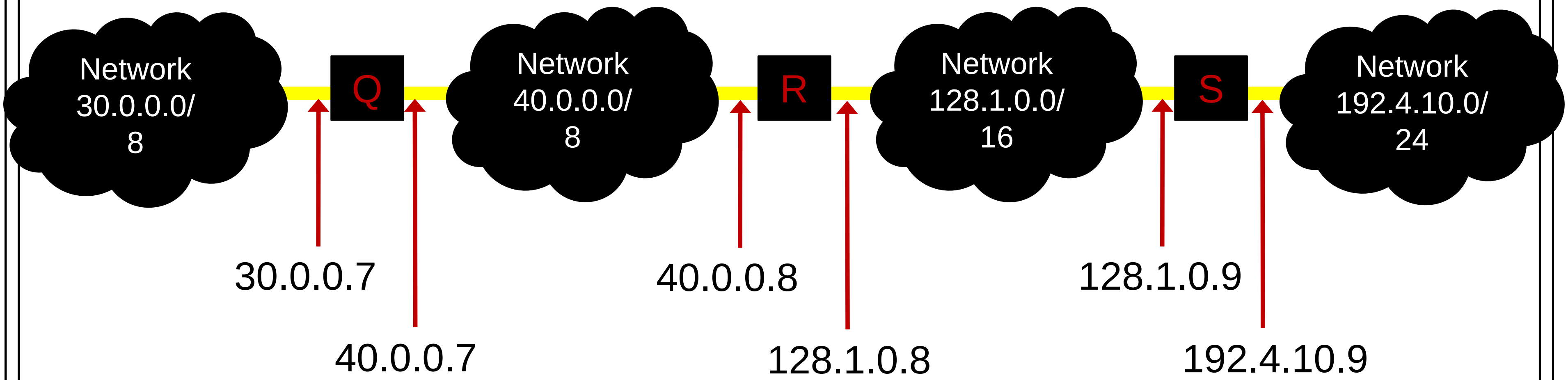
Routing Datagrams (cont.)

- Indirect Delivery
  - sender must identify a router to which a datagram can be sent
  - sending processor can reach a router on the sending processor's physical network (otherwise the network is isolated!)
  - when frame reaches router, router extracts encapsulated datagram and IP software selects the next router
    - datagram is placed in a frame and sent off to the next router

Table Driven Routing

- Routing tables on each machine store information about possible destinations and how to reach them
- Routing tables only need to contain network prefixes, not full IP addresses
  - No need to include information about specific hosts
- Each entry in a routing table points to a router that can be reached across a single network
- Hosts and routers decide
  - can packet be directly sent?
  - which router should be responsible for a packet (if there is more than one on physical net)

Routing (w/ subnets)



To reach hosts on network	Mask*	Next Hop
30.0.0.0	255.0.0.0	40.0.0.7
40.0.0.0	255.0.0.0	<DIRECT>
128.1.0.0	255.255.0.0	<DIRECT>
192.4.10.0	255.255.255.0	128.1.0.9

Mask field is used to extract the network part of an address during lookup.

If((Mask[i] & D) == Destination[i]) forward to nextHop[i]

Consider a datagram destined for address 192.4.10.3 and the datagram arrives at router R

Extract destination IP address, D from datagram and compute network prefix N

255.0.0.0&192.4.10.3 is not equal to 30.0.0.0

<same for entry 2 and 3>

255.255.255.0&192.4.10.3=192.4.10.0
→ send to 128.1.0.9

Example from Comer book: Internetworking with TCP/IP: volume 1 [Third Edition]

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Algorithm: RouteDatagram (Datagram, RoutingTable)

Extract destination IP address, D, from datagram and compute network prefix N

If N matches any directly connected network address
[Direct delivery]

Else if the table contains a host-specific route for D
[send datagram to next-hop specified in table]

Else if the table contains a route for network N
[send datagram to next-hop specified in table]

Else if the table contains a default route
[send the datagram to the default route]

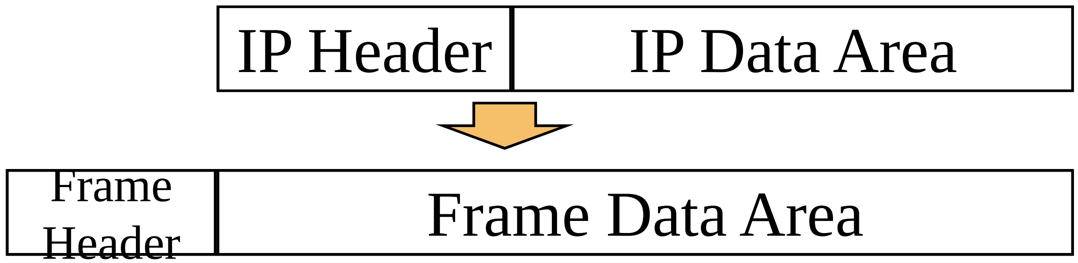
Else *declare a routing error*

Algorithm from Comer book: Internetworking with TCP/IP: volume 1 [Third Edition]

Encapsulation

How do we send higher layer packets over lower layers?

- Higher level info is opaque to lower layers
  – it's just data to be moved from one point to another



- Higher levels may support larger sizes than lower
  – could need to *fragment* a higher level packet
    - split into several lower level packets
    - need to re-assemble at the end
  – examples:
    - ATM cells are 48 bytes, but IP packets can be 64K
    - IP packets are 64K, but files are megabytes