CSE and EE 461
Lecture 22

Summer Quarter 1998

Internetworking

- At some level there must be a uniform single space over all parties in an internet. This enables potential communication between parties.
- The number of hosts is so large that hierarchical addressing is essential to keep the routing tables small.
- Individual subnets may have their own address and routing schemes. Address translation might be needed.
- Individual subnets may use different size or forms of packets. There may fragmentation or "tunneling".
- Individual subnets may be under different authorities. There must be a way to control the traffic through an individual subnet. There may be a need for security, or so-called "firewalls".
- One subnet might provide a connectionless datagram service while another provides a connection oriented virtual circuit service.

Repeaters, Bridges, Routers

- Repeater - physical layer

  - can connect several LANs of the same type
  - little or no buffering or at most a bit for regeneration
- Bridge - data link layer or mac layer

  - can connect several LANs of different or the same types
  - buffers frames
  - there can be loss if LANs are incompatible in some way: different frame sizes or different speeds
- Multiprotocol router (gateway) - network layer

  - may divide packets up into smaller packets
  - typically used to connect WANs with LANs and other WANs
  - routers provide good "firewalls" between networks.

IP

- Designed originally in 1980 to handle internetworking. It now dominates and is a de facto international standard.
- IP packets are of variable length but usually about 1500 bytes, can be up to 65,535 bytes.
- An IP packet may be fragmented into smaller IP packets and reassembled multiple times during its time in the Internet.
- IP addresses are essentially universal but only 32 bits long.
- IP addresses have a two level hierarchy

Fields of an IP Packet

- Version (4)
- Header Length (4)
- Type of Service (8)
- Total Length (16)
- Identification - all fragments of a datagram have the same id (16)
- Don't fragment field (1)
- More fragments field (1)
- Fragment offset - which fragment is this (13)
- Time to live (8)
- Protocol - what is the transport protocol (8)
- Header Checksum - does not use CRC (16)
- Source Address (32)
- Destination Address (32)

IP Addresses

- 0.0.0.0 to 255.255.255.255 = 2^{32} = 4 billion addresses
- Classes A, B, C have addresses partitioned into (network, host)

  A - 126 networks with 16 million hosts each
  B - 16,382 networks with 65,536 hosts each
  C - 2 million networks with 254 hosts each

  Example: 128.95.1.4 = June is a Class B IP address
- Class D address is a multicast address used for broadcast - 250 million multicast addresses are available
- Class E reserved for future use

Hierarchical Routing

- IP addresses support a 2 level routing hierarchy
- A router in a network only needs to have in its routing table an entry for:

  - each nodes in its network

  - each other network
- Example:
- UW Class B address is 128.95.*.*

Destination	Next Hop	
128.95.1.4	128.95.25.2	local destination
130.14.*.*	128.95.17.1	remote destination

possibly a multiprotocol router

CIDR = Classless InterDomain Routing

- We are running out of IP addresses
  - There are only 16,000 class B network addresses with 65,000 nodes
  - There are plenty, 2,000,000 class C network address with 250 nodes
- CIDR - is a way of combining class C network addresses into a single network address. It complicates the routing tables.
- Example: Create a network with addresses between

  200.200.004.000 and 200.200.007.255 (4 class C network addresses)

  In binary the address range is:

  11001000 11001000 00000100 00000000
  11001000 11001000 00000111 11111111

  The network address is:

  11001000 11001000 000001xx xxxxxxxx

  CIDR uses a "mask" to look up these new network addresses in routing tables.

Address Resolution Protocol for LANs

- ARP is a simple way to locate a local host using an IP address.
- Recall that an ethernet has its own addressing scheme. Given an IP address the sending host first determines if the IP address is local or remote.

  - if remote then send to the external router on the LAN

  - if local then broadcast the IP address on the LAN. Each station on the LAN looks up it own IP address to see if it matches the broadcasted IP address. If it is then it sends its LAN address to the sending host. The sending host can now send the IP packet enclosed in a LAN packet to the correct receiver.
- Typically, each host caches often used LAN addresses so that the broadcast does not have to be used all the time.

Internet Routing

- Internet is made up of many autonomous networks each under separate authority

  - interior gateway protocol within an autonomous network (OSPF)
  - exterior gateway protocol for routing between networks (BGP)
- Interior gateway protocol

  - Originally - RIP (distance vector routing)
  - OSPF - (Open Shortest Path First) emerging standard
- OSPF

  - Link state routing protocol among routers in the autonomous network
  - Published in open literature - not proprietary
  - Support for type of service field in IP (QoS)
  - Load balancing capable, splitting loads over multiple routes
  - Hierarchical routing support to keep routing tables smaller
  - Security enhancements

OSPF

- A large autonomous network can divide itself into areas.

  - Each area behaves like an isolated network
  - One of the areas is called the backbone and all the other areas are directly connected to the backbone.
  - Effectively the internet is a three level hierarchy
- Classes of Routers

  - intra-area router - solely in one area, not the backbone
  - area border router - overlaps two or more areas
  - backbone router - solely in the backbone
  - autonomous system border router - overlaps two or more autonomous networks
- OSPF used within an area and within an autonomous networks

  - An area border router needs multiple routing tables, one for each area it belongs to.

Border Gateway Protocol (BGP)

- Exterior gateway protocol used between autonomous networks
- Reason for BGP - different autonomous networks are under different organizations. BGP has to deal with "politics." For example, one autonomous network might not want traffic in its network to or from some certain other autonomous networks.
- Network categories

  - Stub network - only one connection to BGP network, no pass-through traffic possible.
  - Multiconnected network - more than one connection to BGP network, but may refuse pass-through traffic.
  - Transit network - willing to handle third party traffic, MCI or ATT backbones.
- BGP uses a form of distance vector routing, but calculates entire paths, not just next hops.
- Peers vs. Customers

The Future - IPv6

- Address space is 128 bits = 3.4×10^{38} addresses.
- Much simplified protocol so that the routers can work faster

  - no checksum
  - no encouragement for longer packets which could be fragmented
- More attention to quality of service

  - packets have information embedded to indicate quality of service requirements.