PART VIII

Network Properties

(Ownership, Service Paradigm, Measures of Performance)

Network Ownership And Service Type

- *Private*
  - Owned by individual or corporation
  - Restricted to owner's use
  - Typically used by large corporations
- *Public*
  - Owned by a common carrier
  - Individuals or corporations can subscribe
  - ''Public'' refers to availability, not data

Advantages And Disadvantages

- Private
  - Complete control
  - Installation and operation costs
- Public
  - No need for staff to install / operate network
  - Dependency on carrier
  - Subscription fee

Public Network Connections

- One connection per subscriber
  - Typical for small corporation or individual
  - Communicate with another subscriber
- Multiple connections per subscriber
  - Typical for large, multi-site corporation
  - Communicate among multiple sites as well as with another subscriber

Virtual Private Network

- A service
- Provided over public network
- Interconnects sites of single corporation
- Acts like private network
  - No packets sent to other subscribers
  - No packets received from other subscribers
  - Data encrypted

Network Service Paradigm

- Fundamental characteristic of network
  - Understood by hardware
  - Visible to applications
- Two basic types of networks
  - Connectionless
  - Connection-oriented

Connectionless (CL)

- Sender
  - Forms packet to be sent
  - Places address of intended recipient in packet
  - Transfers packet to network for delivery
- Network
  - Uses destination address to forward packet
  - Delivers

Characteristics Of Connectionless Networks

- Packet contains identification of destination
- Each packet handled independently
- No setup required before transmitting data
- No cleanup required after sending data
- Think of postcards

Connection-Oriented (CO)

- Sender
  - Requests ‘‘connection’’ to receiver
  - Waits for network to form connection
  - Leaves connection in place while sending data
  - Terminates connection when no longer needed

Connection-Oriented (CO)
(continued)

- Network
  - Receives connection request
  - Forms path to specified destination and informs sender
  - Transfers data across connection
  - Removes connection when sender requests
- Think of telephone calls

Terminology

- In conventional telephone system
  - *Circuit*
- In CO data network
  - *Virtual Circuit*
  - *Virtual Channel*

Comparison Of CO and CL

- CO
  - More intelligence in network
  - Can reserve bandwidth
  - Connection setup overhead
  - State in packet switches
  - Well-suited to real-time applications
- CL
  - Less overhead
  - Permits asynchronous use
  - Allows broadcast/multicast

Two Connection Types

- *Permanent Virtual Circuit (PVC)*
  - Entered manually
  - Survives reboot
  - Usually persists for months
- *Switched Virtual Circuit (SVC)*
  - Requested dynamically
  - Initiated by application
  - Terminated when application exits

Examples Of Service Paradigm Various Technologies Use

Technology	CO	CL	used for LAN	used for WAN
Ethernet		•	•	
Token Ring		•	•	
FDDI		•	•	
Frame Relay	•			•
SMDS		•		•
ATM	•		•	•
LocalTalk		•	•	

Connection Multiplexing

- Typical computer has one physical connection to network
- All logical connections multiplexed over physical interconnection
- Data transferred must include *connection identifier*

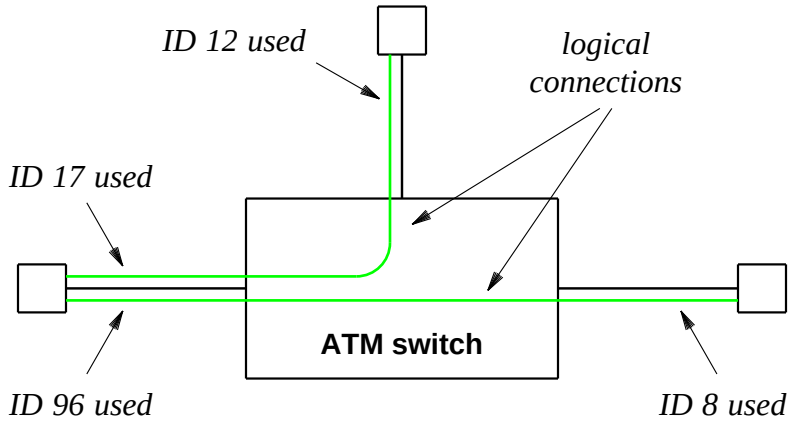
Connection Identifier

- Integer value
- One per active VC
- Not an address
- Allows multiplexing
  - Computer supplies when sending data
  - Network supplies when delivering data

Example Connection Identifier (ATM)

- 24 bits long
- Divided into two parts
  - *Virtual Path Identifier*
  - *Virtual Channel Identifier*
- Known as *(VPI/VCI)*
- Different at each end of connection
  - Mapped by switches

Illustration Of ATM VC



- Switch maps VPI/VCIs
  - *17* to *12*
  - *96* to *8*

Two Primary Performance Measures

- Delay
- Throughput

Delay

- Time required for one bit to travel through the network
- Three types (causes)
  - Propagation delay
  - Switching delay
  - Queuing delay
- Intuition: ‘‘length’’ of the pipe

Throughput

- Number of bits per second that can be transmitted
- Capacity
- Intuition: ‘‘width’’ of the pipe

Components Of Delay

- Fixed (nearly constant)
  - Propagation delay
  - Switching delays constant
- Variable
  - Queuing delay
  - Depends on throughput

Relationship Between Delay And Throughput

- When network idle
  - Queuing delay is zero
- As load on network increases
  - Queuing delay rises
- Load defined as ratio of throughput to capacity
  - Called *utilization*

Relationship Between Delay And Utilization

- Define
  - D_0 to be the propagation and switching delay
  - U to be the utilization $(0 \leq U \leq 1)$
  - D to be the total delay
- Then

$$D = \frac{D_0}{(1 - U)}$$

- High utilization known as *congestion*

Practical Consequence

Any network that operates with a utilization approaching 100% of capacity is doomed.

Delay-Throughput Product

- Delay
  - Time to cross network
  - Measured in seconds
- Throughput
  - Capacity
  - Measured in bits per second
- Delay $\times$ Throughput
  - Measured in bits
  - Gives quantity of data ‘‘in transit’’

Summary

- Network can be
  - Public
  - Private
- Virtual Private Network
  - Uses public network
  - Connects set of private sites
  - Addressing and routing guarantee isolation

Summary
(continued)

- Networks are
  - Connectionless
  - Connection-Oriented
- Connection types
  - Permanent Virtual Circuit
  - Switched Virtual Circuit
- Two performance measures
  - Delay
  - Throughput

Summary
(continued)

- Delay and throughput interact
- Queueing delay increases as utilization increases
- Delay $\times$ Throughput
  - Measured in bits
  - Gives total data ‘‘in transit’’