

## Communication Services

- Applications often need more services from the network than simple packet delivery
- Not all networks offer all services
- Which services do applications need?
- Which services should a network implement?

The rest of this chapter describes useful services. The next chapter describes techniques for implementing these services.

## Connection-Oriented Communication

- Communication between exactly two machines
- Similar to telephone system; endpoints establish and maintain a connection as long as they have data to exchange
- One endpoint tries to start the connection
- The other endpoint agrees to the connection
- All further data exchange occurs over the pre-established connection
- Typically accessed via a **stream interface**
- Data transmission doesn't need to be continuous; like telephones, the connection remains in place even when no data is being transmitted
- So how do you stop a connection?

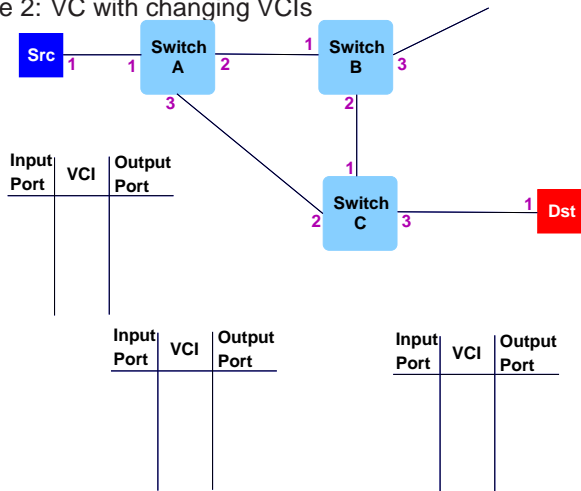
## Chapter 15 Network Services and Performance

### Defining the Services

- So far we have focused on the problem of getting data from one machine on a LAN to another machine on the same LAN
- Although this is an important service, networks typically provide lots of additional services
- In this chapter we will investigate what types of services network users would like from the network

## Virtual Circuits: (continued)

- Example 2: VC with changing VCIs



## Virtual Circuits: (continued)

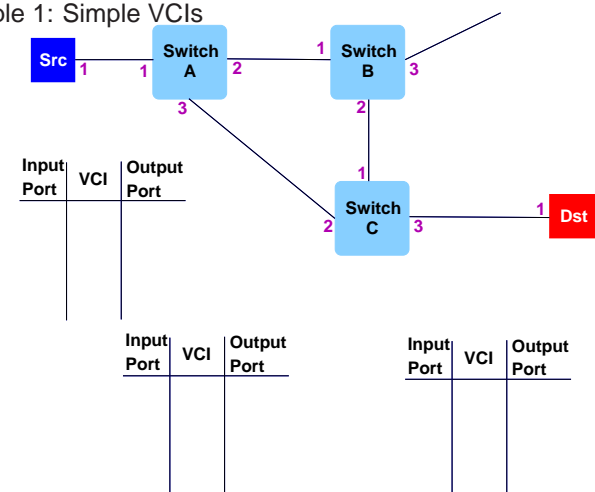
- Example 3: Hierarchical VCIs
  - Each VC identifier broken into two parts:
    1. VPI (Virtual Path Identifier)
    2. VCI (Virtual Circuit Identifier)
  - VPI used for similar destination traffic
  - VCI used with VPI to uniquely identify a VC

## What exactly is a “Connection”?

- ATM provides connection-oriented service (we will use it as an example)
- recall that an ATM cell is \_\_\_ octets long with \_\_\_ octets of header and \_\_\_ octets of payload
- recall that an NSAP address is \_\_\_ octets long
- Question: How are ATM cells addressed? The header is not large enough to hold the destination NSAP address.
- Answer:

## Virtual Circuits

- Example 1: Simple VCIs



## Connectionless Communication

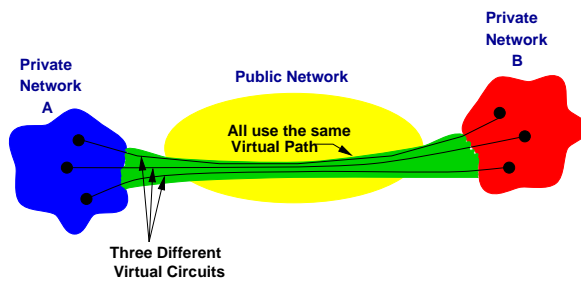
- No connection necessary
- Source of data adds destination information to data and gives it to the network to deliver
- Network delivers each packet individually

- Packets can be delivered to multiple recipients

## Communication Direction

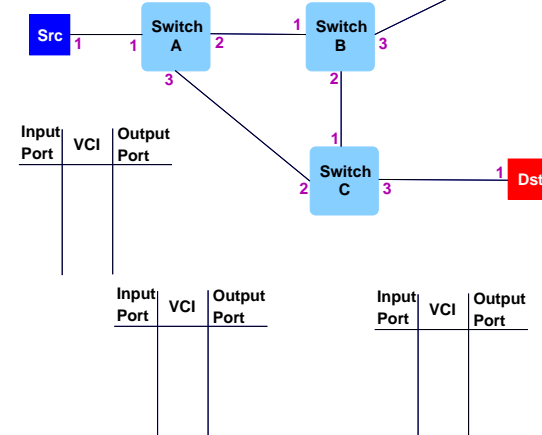
- communication may be **uni-directional**
- communication may be **bi-directional**

## Virtual Circuits: (continued)



## Virtual Circuits: (continued)

- Example 3 (continued): ATM Hierarchical VCs
  - Switch-Switch use VPI, Host-Switch use VPI/VCI



## Performance

- users will want the network to delivery certain performance
- how do we define performance?
- what are the factors influencing performance?

## Bandwidth/Throughput

- **Bandwidth** describes the number of bits that can be transmitted over the network in some period of time. Usually measured in Millions of bits/sec (Mbps).
- Really a measure of how fast we can send data out of a machine
- Thus you could think of it as the amount of time it takes to send out one bit
- In the analog world it is typically measured in Hertz (Hz)
- “b” vs. “B”

## Reliable Communication

- some apps may require **reliable delivery**
  - other apps may be happy with **best-effort delivery**
  - some apps may require that packets be delivered in the order they were sent (**ordered delivery**)
  - other apps may not care about the ordering (**out-of-order delivery**)
  - How reliable should reliable delivery be?
- 
- We will revisit the issue of reliable delivery in the next chapter

## Miscellaneous Services

- Request/Reply style communication
  - Secure packet delivery
  - Compressed/Encoded packet delivery
  - Guaranteed bandwidth (what does this mean?)
- 
- Guaranteed max delay
  - Jitter bounded delivery
  - ... etc ...

### Types of Latency: (continued)

- **Transmission Latency:** The time it takes to send a packet out of the machine.
- This depends on
  - the bandwidth of the network, and
  - the amount of data you want to send (i.e., packet size).
- may depend on operating system efficiency too

### Types of Latency: (continued)

- Store-n-forward packet switches store packets for a (hopefully) brief amount of time before forwarding the packet.
- Usually the packet is stored in a *queue of packets* all waiting to be forwarded.
- Thus each bridge/switch/router between the source and destination adds a **Queuing Delay** to the overall latency.
- some people define a related term, **Access Latency**, as the time required to get access to the media. Others lump access latency in with the queuing delays.

### Latency/Delay

- **Latency** describes how long it takes a single bit to propagate from one machine to another machine.
- Measured in terms of time
- We can also use computer instructions to measure it (which is important since it tells how much work the computer can get done during the latency).
- Sometimes we are really more interested in **Round-Trip-Time (RTT)** as an alternate way to measure latency.
  
- Why are we interested in RTT?

### Types of Latency

- **Propagation Latency:** The time it takes for 1 bit to travel across the wire.
  - cannot go faster than the speed of light
  - the speed of light depends on the media; The speed of light is:
  
    - the speed of light can even vary for the same basic type of media

## Delay x Bandwidth Product

How much data can be in transit at any given time? The Delay × Bandwidth Product gives the volume of the network “pipe”.

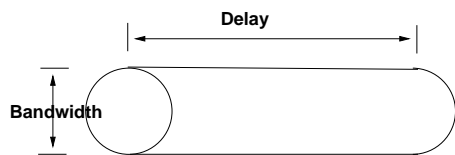


Figure 2: DelayxBandwidth Product

## Delay x Bandwidth Examples: (continued)

**Ethernet:** Delay = 0.5 ms  
 Bandwidth = 10 Mbps  
 Holds =  $(0.5 \times 10^{-3} \text{ sec}) \times (10 \times 10^6 \text{ bits/sec}) = 5 \times 10^3 = 5 \text{ Kbps} = 0.625 \text{ KBps}$

**Modem Line:** Delay = 85 ms  
 Bandwidth = 28.8 Kbps  
 Holds =  $(85 \times 10^{-3} \text{ sec}) \times (28.8 \times 10^3 \text{ bits/sec}) = 2.448 \times 10^3 = 2.5 \text{ Kbps} = 0.31 \text{ KBps}$

**Cross Country DS3 Line:** Delay = 50 ms  
 Bandwidth = 45 Mbps  
 Holds =  $(50 \times 10^{-3} \text{ sec}) \times (45 \times 10^6 \text{ bits/sec}) = 2.25 \times 10^6 = 2.25 \text{ Mbps} = 0.28 \text{ MBps}$

## Types of Latency: (continued)

### Summary

- **Latency** = Propagation Delay + Transmission Delay + Queuing Delay
- **Propagation Delay** = Wire Distance / Speed-of-Light-on-wire
- **Transmission Delay** = Packet Size / Link Bandwidth
- **Queuing Delay** = (depends but) Avg Switch/Router Delay × Number of Routers on Path
- **USA Latency** (min over 3000 miles) = 24 ms

## Types of Latency: (continued)

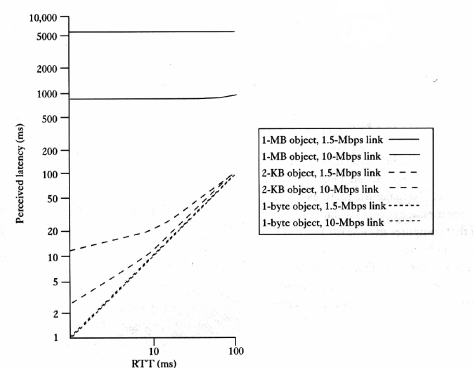


Figure 1: Perceived Latency (response time) versus Round Trip Time for various object sizes and link speeds.

Delay x Bandwidth: (continued)

- The **Delay x Bandwidth** product is important because it is the amount of data the source will transmit before the first bit arrives at the destination!
- If we consider the **RTT** , a sender will transmit **2 x Delay x Bandwidth** amount of data before hearing anything back from the destination.
- Thus, **A sender might transmit a lot of data before it finds out if an error occurred .**