Basic Switch Model

A “switch” moves a packet from an input port to an output port
- Forwarding -- output port selection
- Switching -- actually transferring the packet
- Routing -- deciding how to forward

Scalable, largely without limits to ...
- Number of hosts
- Geographic areas
Routing Alternatives

■ Selection of output port determines routing and is based on information in packet header
  ● Destination address
  ● Path or circuit identifier
  ● Port specification

■ Routing ... Where? When?
  ● Source routing
  ● Virtual circuit switching or routing
  ● Datagram routing
Datagram Routing

Routing decisions are made at each switch as each packet is processed
- Connectionless
- Requires full address information be carried in packet header

Switch must make routing decisions, so it must know something about the network topology
Datagram Routing Example

Routing Table

dest | out
---|---
A | 3
B | 2

Routing Table

dest | out
---|---
A | 1
B | 0

... ...
Datagram Routing Features

- No setup is required, so source can transmit packets immediately
- Packet is transmitted “into the night”
  - Is a path available?
  - Is the destination available?
- Each packet is routed independently
  - Network can route around failed or congested links
  - Out of order delivery is possible
- Header must contain full address
- Used in Internet Protocol (IP)
Source Routing

- Routing decisions are made at the source node when the packet is transmitted

- Source selects route
  - Must have information about the network topology
  - This capability does not scale -- limits the use of source routing

- Source indicates route in the packet header contains route information
  - Information can be used by the destination to route return packets along the reverse path
Source Routing Example
Virtual Circuit Routing

- Routing decisions are made at each switch (or, possibly, at a source) when a connection is established
  - Explicit connection
  - Explicit disconnect (“tear down”)
- All packets that are part of the connection follow the same path
  - Connection-oriented
- Each switch maintains a VC (virtual circuit) table
  - Maps (input port, VC identifier) to (output port, VC identifier)
Virtual Circuit Routing Example

VC Table

<table>
<thead>
<tr>
<th>in</th>
<th>vci</th>
<th>out</th>
<th>vci</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

VC Table

<table>
<thead>
<tr>
<th>in</th>
<th>vci</th>
<th>out</th>
<th>vci</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>
Virtual Circuit Routing Features

- Setup must occur before data is sent (for reliability, at least)
  - RTT delay occurs before first packet can be sent
  - Overhead for connection setup

- Virtual circuit identifier (VCI)
  - Changed on a link-by-link basis
  - Must be unique to a particular input port on a particular switch
  - Placed in header, but can be quite small

- Resources can be allocated during setup
  - Supports quality of service (QoS)

- Virtual circuit routing is used in ATM
Two Distinctions

- **Contention versus congestion**
  - Contention occurs when two or more packets need to be transmitted on the same outgoing link
  - Congestion occurs when the switch is so busy that its buffers fill (or overflow)

- **Forwarding versus routing**
  - Forwarding is the process of looking at a packet, consulting a table, and sending the packet on the appropriate output port -- easy to do
  - Routing is the process of building the forwarding tables -- much harder to do, especially well