**Computer Networks**

**Principles of Routing and Switching**

Based on Computer Networking, 4th Edition by Kurose and Ross

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**Router Architecture Overview**

Two key router functions:
- run routing algorithms/protocol (RIP, OSPF, BGP)
- *forwarding* datagrams from incoming to outgoing link

![Diagram of router architecture](image-url)
### Input Port Functions

- **line termination**
- **data link processing (protocol, decapsulation)**
- **lookup, forwarding**
- **switch fabric**

**Decentralized switching:**
- Given datagram dest., lookup output port using forwarding table in input port memory
- Goal: complete input port processing at 'line speed'
- Queuing: if datagrams arrive faster than forwarding rate into switch fabric

**Physical layer:**
- Bit-level reception

**Data link layer:**
- E.g., Ethernet

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### Three types of switching fabrics

- **Memory**
- **Bus**
- **Crossbar**
**Switching Via Memory**

First generation routers:
- traditional computers with switching under direct control of CPU
- packet copied to system’s memory
- speed limited by memory bandwidth (2 bus crossings per datagram)

![Diagram of memory switching](image)

**Switching Via a Bus**

- datagram from input port memory to output port memory via a shared bus
- bus contention: switching speed limited by bus bandwidth
- 1 Gbps bus, Cisco 1900: sufficient speed for access and enterprise routers (not regional or backbone)

![Diagram of bus switching](image)
Switching via an Interconnection Network

- overcome bus bandwidth limitations
- Banyan networks, other interconnection nets initially developed to connect processors in multiprocessor
- Advanced design: fragmenting datagram into fixed length cells, switch cells through the fabric.
- Cisco 12000: switches 60 Gbps through the interconnection network

Output Ports

- **Buffering** required when datagrams arrive from fabric faster than the transmission rate
- **Scheduling discipline** chooses among queued datagrams for transmission
Output port queueing

- buffering when arrival rate via switch exceeds output line speed
- queueing (delay) and loss due to output port buffer overflow!

Input Port Queuing

- Fabric slower than input ports combined -> queueing may occur at input queues
- Head-of-the-Line (HOL) blocking: queued datagram at front of queue prevents others in queue from moving forward
- queueing delay and loss due to input buffer overflow!