# TSN: Lecture 6
# Circuit & Packet Switching

# Topics Covered

- Circuit switching
- Packet switching
  - Switch generations
  - Switch fabrics
  - Buffer placement
  - Multicast switches

# Switch fabrics

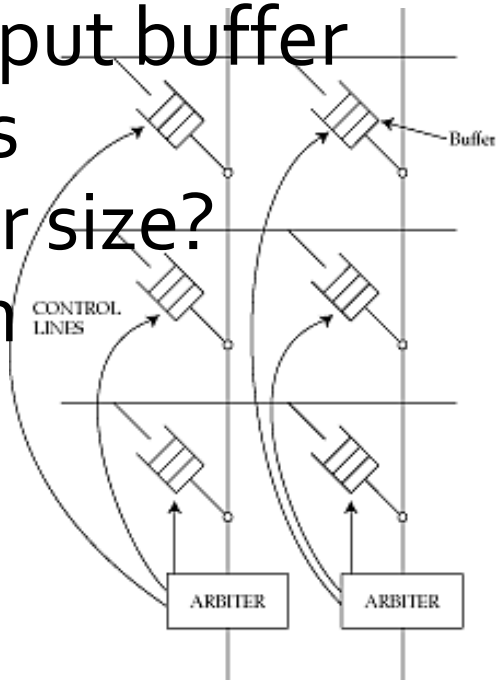
- Transfer data from input to output, ignoring scheduling and buffering
- Usually consist of links and *switching elements*

# Crossbar

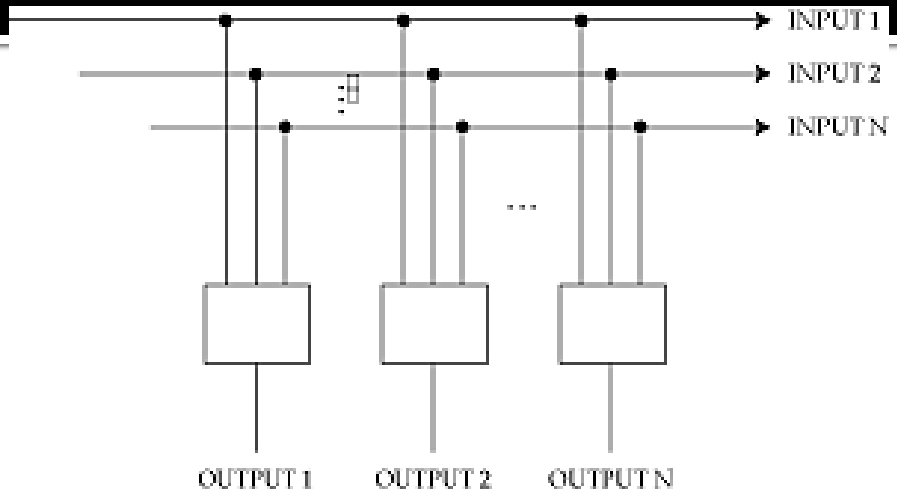
- Simplest switch fabric
  - think of it as 2N buses in parallel
- Used here for *packet* routing: cross-point is left open long enough to transfer a packet from an input to an output
- For fixed-size packets and known arrival pattern, can compute schedule in advance (e.g., circuit switching)
- Otherwise, need to compute a schedule on-the-fly (what does the schedule depend on?)

# Buffered crossbar

- What happens if packets at two inputs both want to go to same output?
  - Output blocking
- Can defer one at an input buffer
- Or, buffer cross-points
- How large is the buffer size?
- Overflow in the switch
  - Can we afford?
  - Solutions?
    - Backpressure



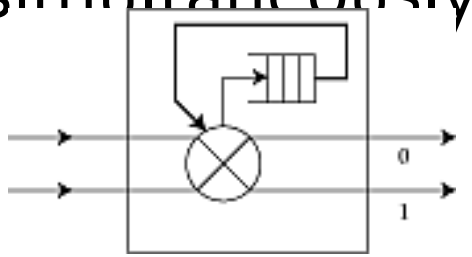
# Broadcast




- Packets are tagged with output port #
- Each output matches tags
- Need to match N addresses in parallel at each output
- Useful only for small switches, or as a stage in a large switch

# Switch fabric element

- Can build complicated fabrics from a simple element consisting of two inputs, two outputs and an optional buffer
- Packets arrive simultaneously; Look at the header;



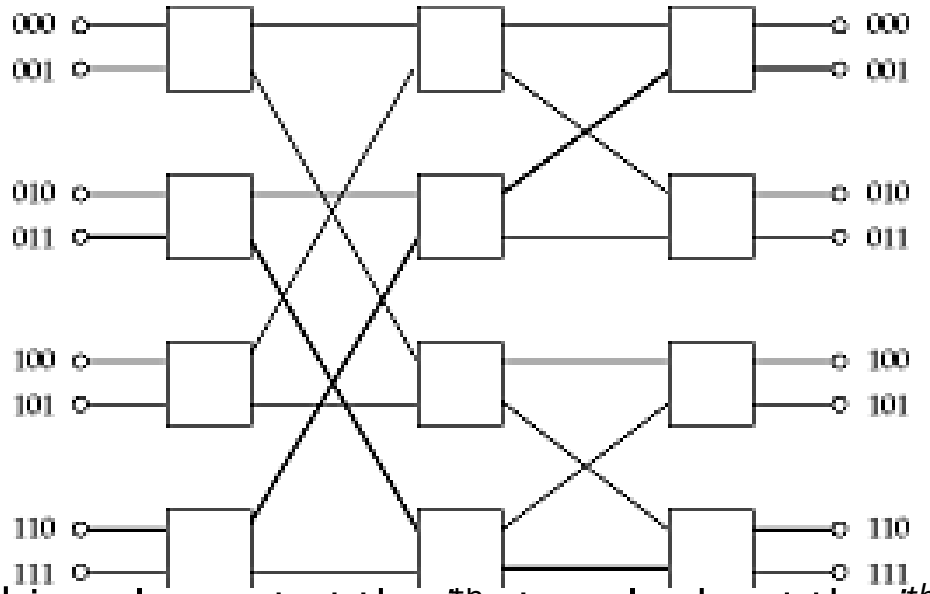

- Routing rule: if 0, send packet to upper output, else to lower output
- If both packets to same output, buffer or drop

# Features of fabrics built with switching elements

- NxN switch with bxb elements has $\lceil N/b \rceil$ elements per stage and $\lceil \log_b N \rceil$ stages with
  - e.g., 8x8 switch with 2x2 elements has 3 stages of 4 elements per stage
  - e.g., 4096x4096 switch built with 8x8 blocks has four stages with 512 elements in each stage
- Fabric is *self routing*
  - Once a packet is labeled to a correct output, it will automatically makes its way
- Recursive
  - composed of smaller components that resemble larger network
- Can be synchronous or asynchronous (permits variable length packets)
- Regular and suitable for VLSI implementation

# Banyan

- Simplest self-routing recursive port in binary
- Made of 2x2 switches
- Fabric needs *n* stages for $2^n$ outputs with $2^{n-1}$ elements in each stage




- (why does it work?) Each switching element at the $i^{th}$ stage looks at the $i^{th}$ bit to make a forwarding decision
- What if two packets both want to go to the same output?
  - output blocking

# Banyan (Example)