Announcements

- Reading for this class is Chapter 8
- Reading for next Tuesday Chapter 9
- Project due: 10/3/96

Interconnection Networks

- Performance Metrics
  - latency: time for the first bits to arrive
  - bandwidth: sustained volume of communication
  - connectivity: how far is the furthest neighbor
  - hardware cost: can we afford to build this thing?
  - reliability: can links fail and the system still run?
  - functionality: “for free” features
    - combining messages
    - fault tolerance
- Options
  - topology
  - operation mode (synchronous or asynchronous)
  - switching strategy (circuit, store-and-forward, cut-through)
  - control strategy (central or distributed)

Networks

- Static
  - Processors only communicate with neighbors
    - non-neighbor communication requires help of intermediate processors
    - this is a simple structure to build
    - performance suffers due to using processors to forward
  - Usual topologies are possible
    - hypercube, tree, mesh
- Dynamic
  - "switches" take care of forwarding between nodes
    - requires extra hardware to forward messages
    - hardware has to be able to route data
  - Topologies
    - bus, multi-stage, crossbar networks
    - any static topology

Switching Options

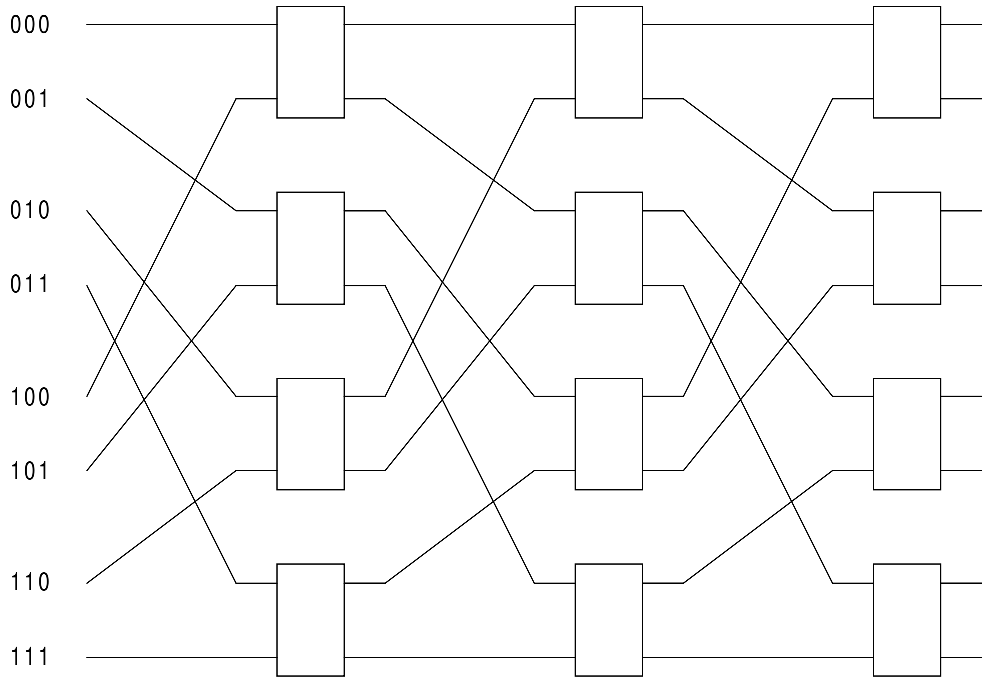
- Circuit switching
  - “connection” is established between end points
  - contention free connection is then used for data
  - latency is length + number of hops
- Store-and-forward
  - send hop by hop with the message being buffered
  - latency is message length * number of hops
- Cut-though (hybrid)
  - wormhole routing
    - first part of a message establishes a circuit
    - rest of message snakes its way long the path
  - possible to deadlock if not careful

Multistage Switching Networks

- several stages between source and destination
- provide different options in
  - cost
  - wires
  - blocking probability
- can be combined into many hybrid options

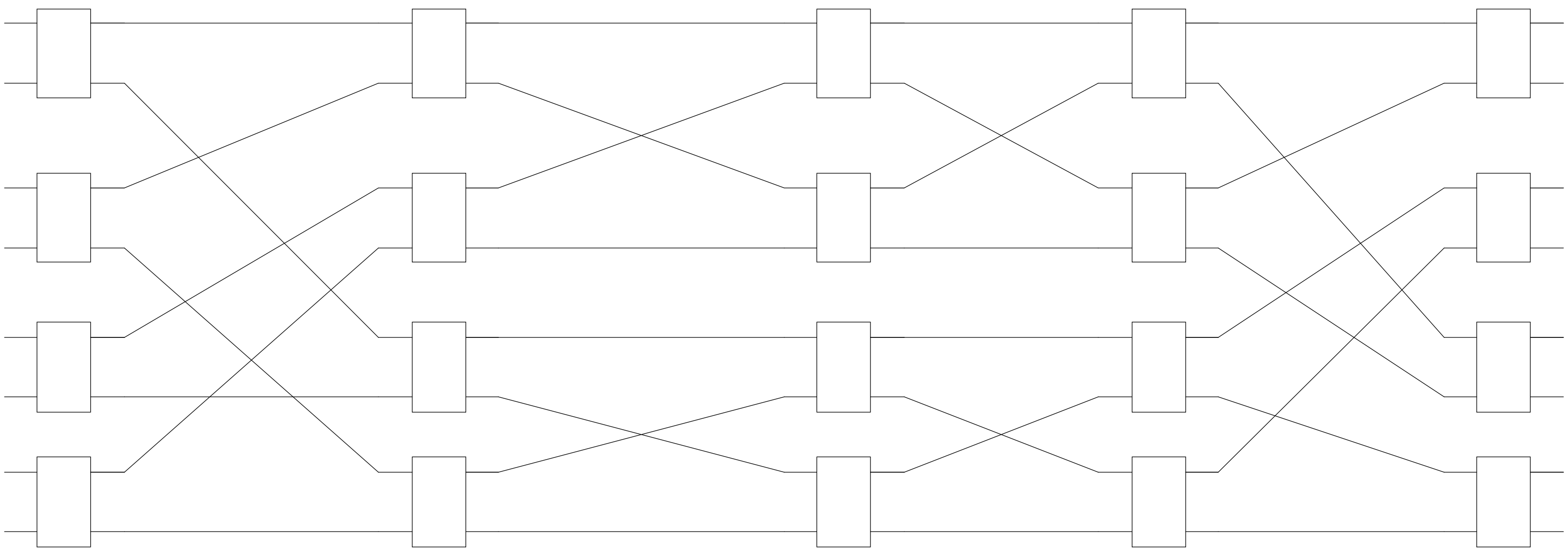
Omega Networks

- $\log_n(M)$ stages for M nodes and n by n cross bars
- message block if the required output link is not available



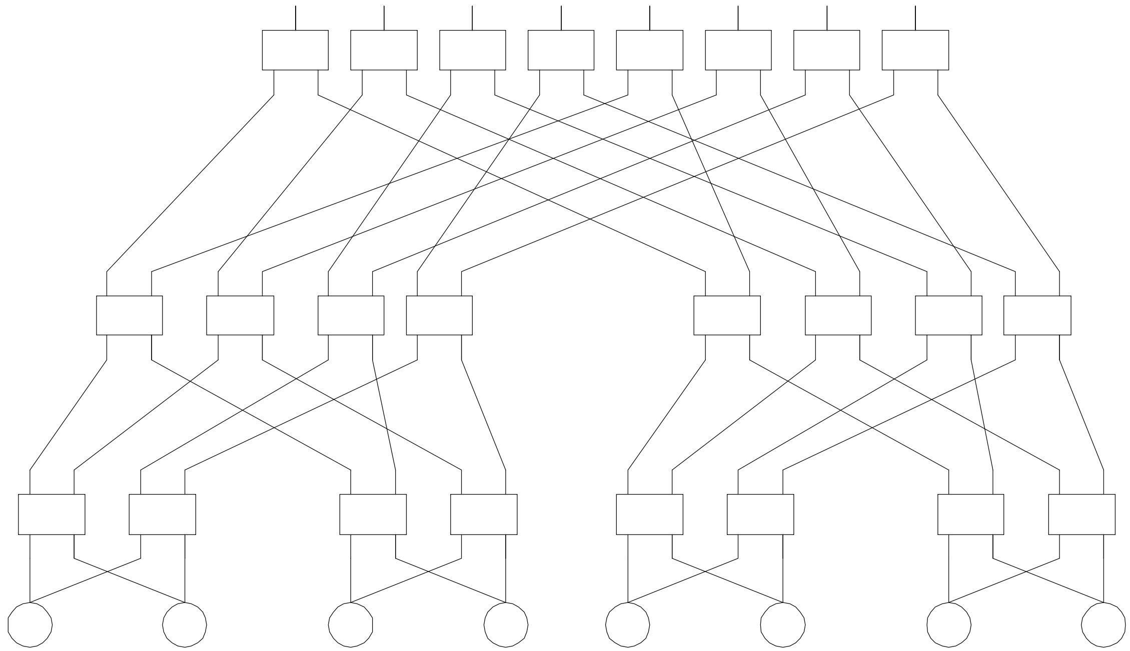
Benes networks

- additional stages to reduce blocking
- can route any disjoint src/dest pairs wo blocking
  – but must know requests in advance



Fat Trees

- adds extra bandwidth near the root
  - improves bi-section bandwidth
  - can use more hardware or faster clock rates
  - TMC CM-5 and Meiko CS-2 are examples of this design
  - can choose not to fully scale any any level (for cost savings)



Combining

- Try to reduce hot spots in a communication network
  - combine requests for the same location
    - really cache line
- Use topology of the network to match comm ops
  - broadcast
    - flood network - everyone sends to everyone else
    - form a broadcast tree
  - reduction
    - put arithmetic operations into switches
    - CM-5 fast hardware for and,or,min,max