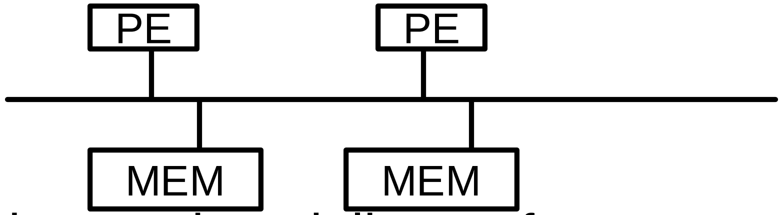
Introduction

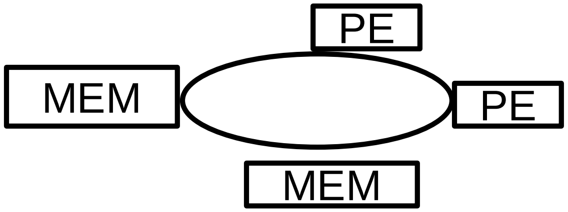
- Photos are now on the class Web Page
  – See Dr. Hollingsworth for the username/password
- Reading
  – Today 2.1-2.2
  – Thursday 4.1
- Midterm will be **3/16 not 3/18**

Communication Networks

- Connect
  - PE's, memory, I/O
- Key Performance Issues
  - latency: time for first byte
  - throughput: average bytes/second
- Possible Topologies
  - bus - simple, but doesn't scale

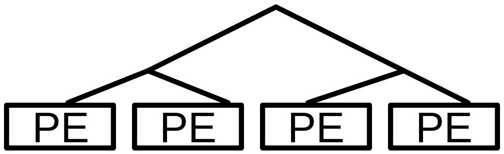


  - ring - orders delivery of messages

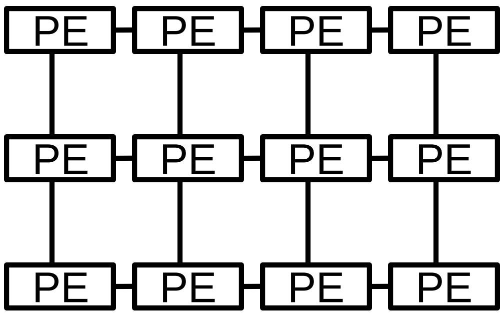


Topologies (cont)

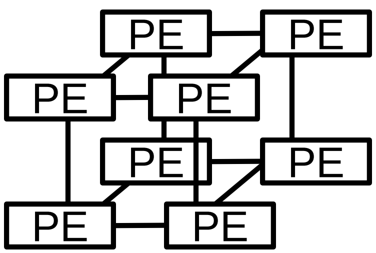
- tree - needs to increase bandwidth near the top



- mesh - two or three dimensions



- hypercube - needs a power of number of nodes



Memory Systems

- Key Performance Issues
  - latency: time for first byte
  - throughput: average bytes/second
- Design Issues
  - Where is the memory
    - divided among each node
    - centrally located (on communication network)
  - Access by processors
    - can all processors get to all memory?
    - is the access time uniform?

Coordination

- Synchronization
  - protection of a single object (locks)
  - coordination of processors (barriers)
- Size of a unit of work by a processor
  - need to manage two issues
    - load balance - processors have equal work
    - coordination overhead - communication and sync.
  - often called “grain” size - large grain vs. fine grain

Sources of Parallelism

- Statements
  - called “control parallel”
  - can perform a series of steps in parallel
  - basis of dataflow computers
- Loops
  - called “data parallel”
  - most common source of parallelism
  - each processor gets one (or more) iterations to perform

Applications

- Easy (embarrassingly parallel)
  - multiple independent jobs (i.e..., different simulations)
- Scientific
  - linear algebra
  - particle simulations
- Databases
  - biggest success of parallel computing
  - exploits semantics of relational calculus
- AI
  - search problems
  - pattern recognition and image processing (main SIMD use)

Issues in Application Performance

- Speedup
  - ratio of time on n nodes to time on a single node
  - hold problem size fixed
  - should really compare to best serial time
  - goal is linear speedup
  - super-linear speedup is possible due to:
    - adding more memory
    - search problems
- Iso-Speedup
  - scale data size up with number of nodes
  - goal is a flat horizontal curve
- Amdahl's Law
  - max speedup is 1/(serial fraction of time)
- Computation to Communication Ratio
  - goal is to maximize this ratio