Review of Machines Seen So Far

- Machines
  - Illiac IV
  - Staran
  - MPP
  - CM-2
  - Butterfly
- Issues:
  - SIMD, MIMD, associative SIMD
  - Number of PE's, width of PE, memory per PE
  - PE interconnection
  - Software
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  -
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Interconnection Networks (Terminology)

- Diameter of network = largest distance between two nodes
  - Low is good, why?
- Bisection width of network = minimum number of edges that must be removed in order to divide the network into two halves (within one)
  - High is better, why?
- Number of edges per node, Maximum edge length
  - Best if these are a constant independent of network size, why?

Mesh Network

- 2-D mesh
  - Interior nodes communicate with 4 nodes
  - Variations allow wrap-around to same or adjacent rows / columns
    - If all ends wrap to opposite side the mesh is called a torus
- q-D mesh
  - Diameter is $q(k–1)$ for k^q nodes
  - Bisection width is $k^{q–1}$ for k^q nodes
- Used in:
  - Illiac IV
  - MPP
  - CM-2 (NEWS grid)
  - DAP, MP-1 (covered later in course)

Tree Networks

- Binary Tree
  - $2^k–1$ nodes arranged into complete binary tree of depth k–1
  - Diameter is 2(k–1)
  - Bisection width is 1
- Hypertree
  - Low diameter of a binary tree plus improved bisection width
  - Hypertree of degree k and dept d
    - From "front", looks like k-ary tree of height d
    - From "side", looks like upside-down binary tree of height d
    - Join both views to get complete network
  - 4-ary hypertree of depth d
    - 4^d leaves and $2^d(2^{d+1}–1)$ nodes
    - Diameter is 2d
    - Bisection width is 2^{d+1}
    - Used in CM-5 (covered later in course)

Butterfly

- Butterfly network
  - $(k+1)2^k$ nodes divided into k+1 rows (ranks, labeled 0 through k), each containing $n=2^k$ nodes
  - Diameter of a network with $(k+1)2^k$ nodes is 2k
  - Bisection width for that size is 2^{k-1}
  - Used in BBN Butterfly
- Hypercube
  - Butterfly with columns collapsed into single nodes
    - 2^k nodes forms a k-dimensional hypercube
    - Nodes are labeled 0 through 2^k-1, two nodes are adjacent if labels differ by 1 bit
  - Diameter of a network with 2^k nodes is k
  - Bisection width for that size is 2^{k-1}
  - Used in CM-2, nCUBE (covered later)