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

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)