# Interconnection Networks

# Introduction

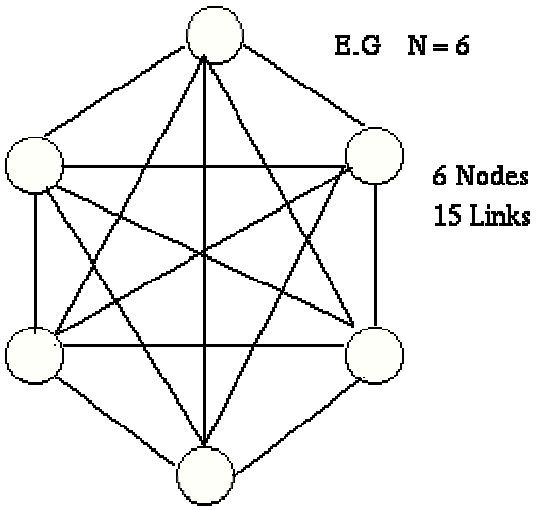
- One way for processors to communicate data is to use a shared memory and shared variables. However this is unrealistic for large numbers of processors. A more realistic assumption is that each processor has its own private memory and data communication takes place using message passing via an Interconnection Network.

Interconnection Networks

- The interconnection network plays a central role in determining the overall performance of a multicomputer system. If the network cannot provide adequate performance, for a particular application, nodes will frequently be forced to wait for data to arrive. Some of the more important networks include:
  - Fully connected or all-to-all
  - Mesh
  - Rings
  - Hypercube
  - X - Tree
  - Shuffle Exchange
  - Butterfly
  - Cube Connected Cycles
  - Metrics for Interconnection Networks

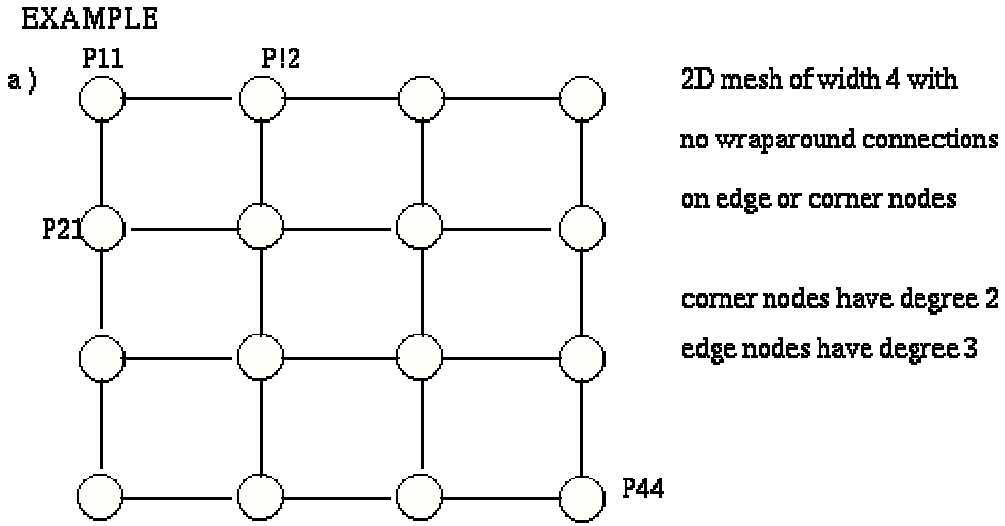
# Fully connected or all-to-all

- This is the most powerful interconnection network ( topology ): each node is directly connected to ALL other nodes.
- Each node has N-1 connections (N-1 nearest neighbours) giving a total of N(N-1) / 2 connections for the network.
  Even though this is the best network to have the high number of connections per node mean this network can only be implemented for small values of N. Therefore some form of limited interconnection network must be used.

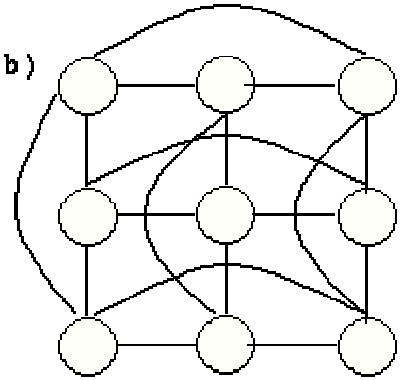


# Mesh (Torus)

- In a mesh network, the nodes are arranged in a k dimensional lattice of width w, giving a total of w^k nodes.
  [ usually k=1 (linear array) or k=2 (2D array) e.g. ICL DAP ]
  Communication is allowed only between neighbouring nodes. All interior nodes are connected to 2k other nodes.



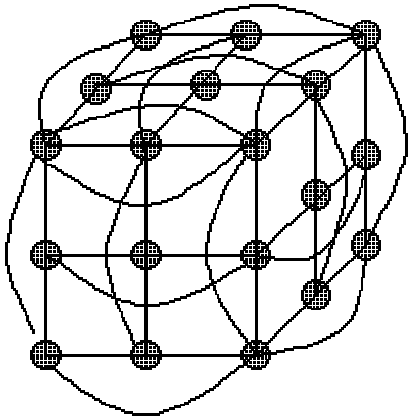
b )



2D mesh of width 3 with wraparound connections between nodes on same row or column

Edge and corner nodes have degree 4

C )



k = 3 w = 3

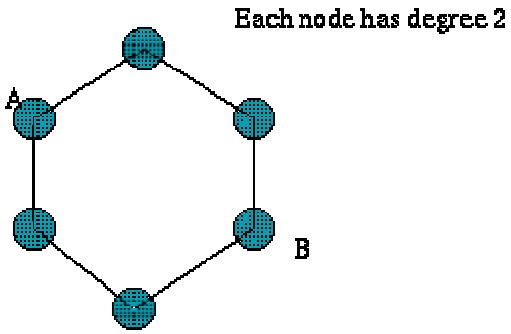
i.e. 3 ^ 3 = 27 nodes

with wraparound connections

all nodes have degree 6 (2k)

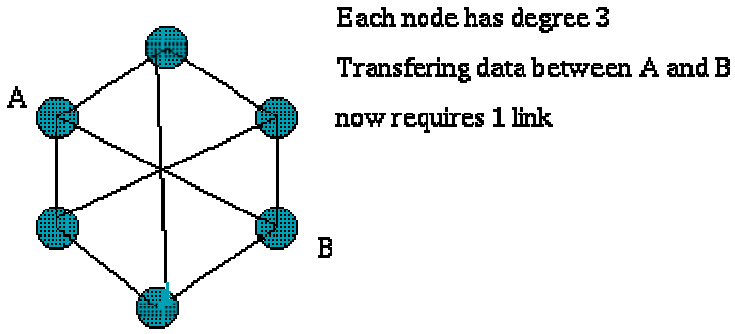
# Rings

- A simple ring is just a linear array with the end nodes linked.



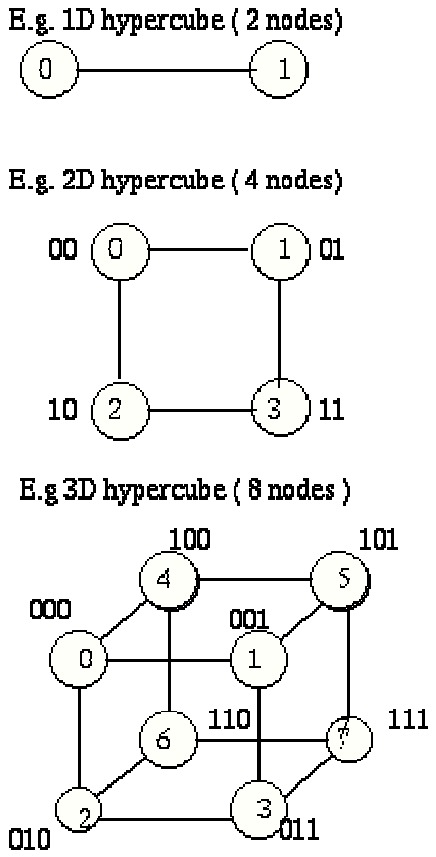

- It is equivalent to a 1D mesh with wraparound connections. One drawback to this network is that some data transfers may require N/2 links to be traversed e.g. A and B above ( 3 ).

- This can be reduced by using a chordal ring. This is a simple ring with cross or chordal links between nodes on opposite sides.

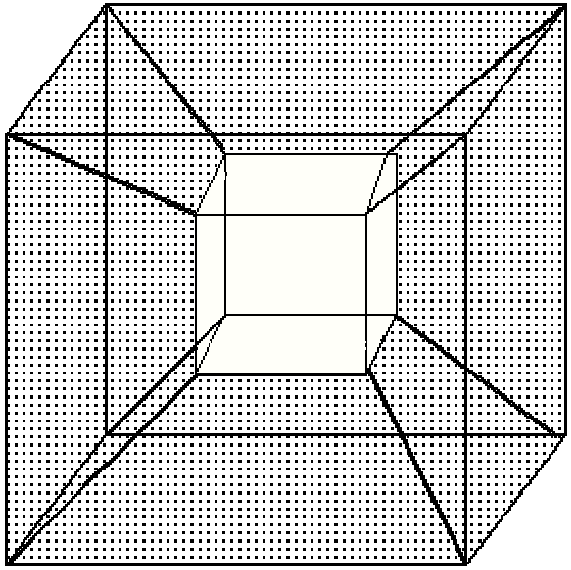


# Hypercube Connection (Binary n-Cube)

- Hypercube networks consist of N = 2^k nodes arranged in a k dimensional hypercube. The nodes are numbered 0 , 1, ....2^k - 1 and two nodes are connected if their binary labels differ by exactly one bit.



4D Hypercube or Binary 4-Cube



- K dimensional hypercube is formed by combining two k-1 dimensional hypercubes and connecting corresponding nodes i.e. hypercubes are recursive, each node is connected to k other nodes i.e. each is of degree k.

# Metrics for Interconnection Networks

- Metrics provide a framework to compare and evaluate interconnection networks. The metrics we will use are:
  - Network connectivity
  - Network diameter
  - Narrowness
  - Network expansion increments