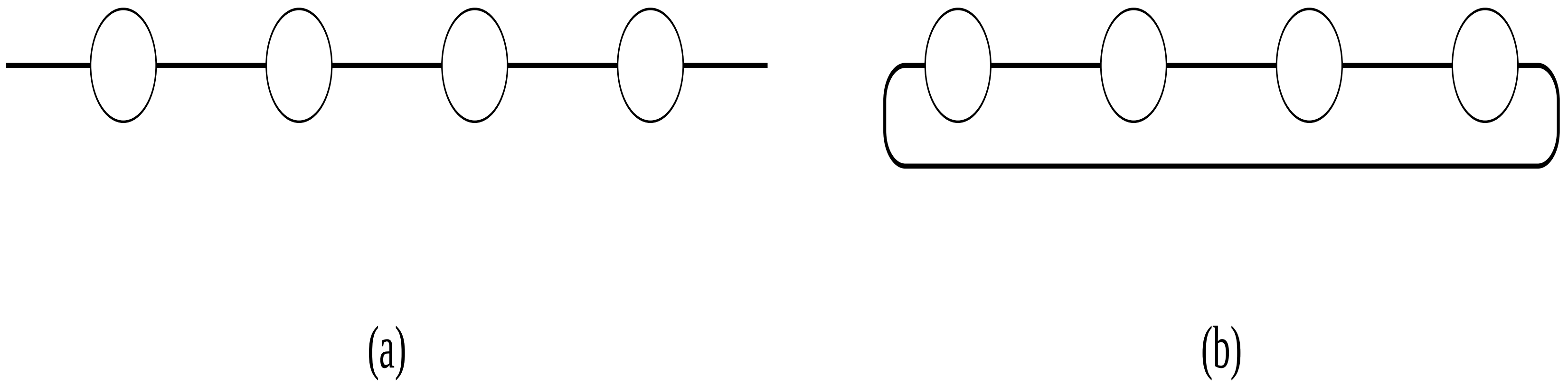
Interconnection Network Topologies

- Linear Arrays, Rings
- Meshes
- Trees, Mesh of Trees, Pyramid
- Hypercubes, cube connected cycles
- Shuffle Exchange
- Star
- De Bruijn

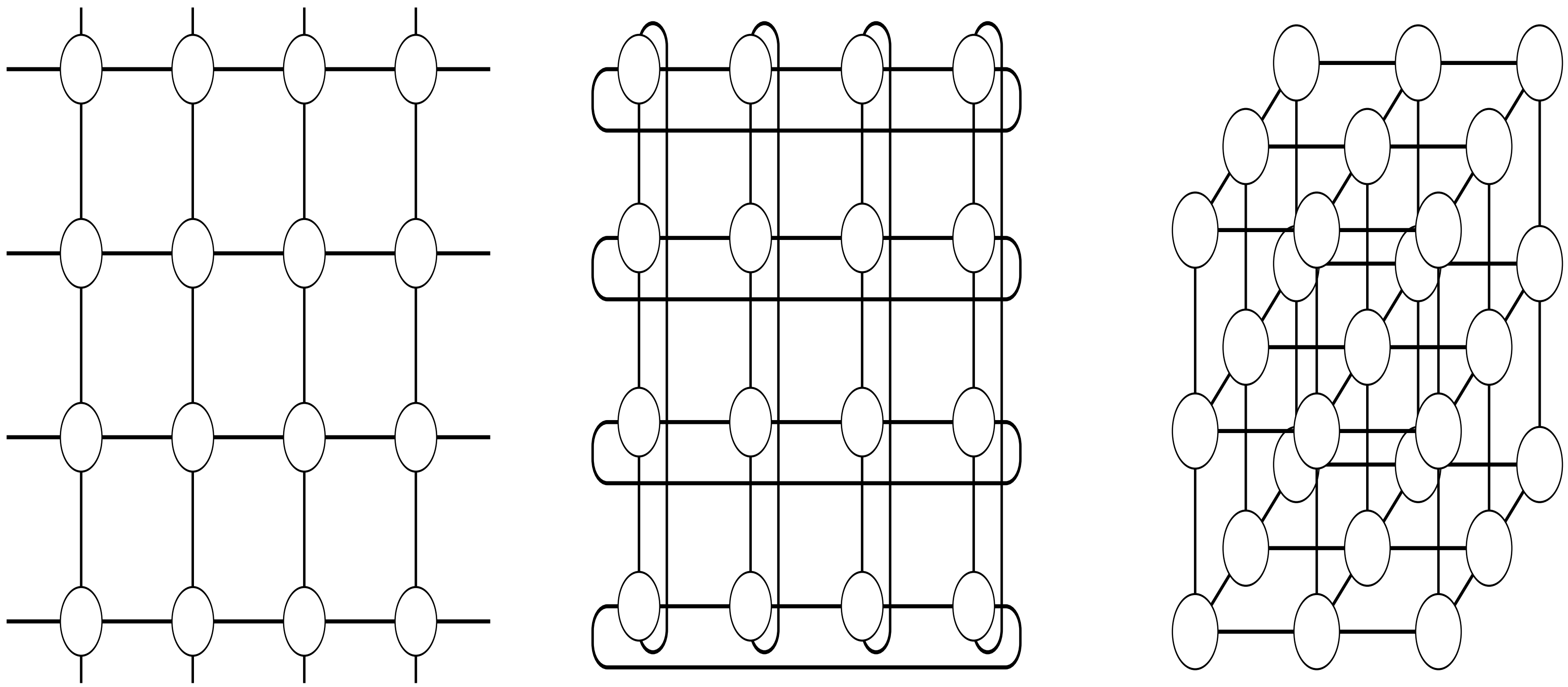
Linear Arrays, Meshes, and *k-d* Meshes

- In a linear array, each node has two neighbors, one to its left and one to its right. If the nodes at either end are connected, we refer to it as a ring.
- A generalization to 2 dimensions has nodes with 4 neighbors, to the north, south, east, and west.
- A further generalization to *d* dimensions has nodes with *2d* neighbors.
- A special case of a *d*-dimensional mesh is a hypercube. Here, $d = \log p$, where *p* is the total number of nodes.

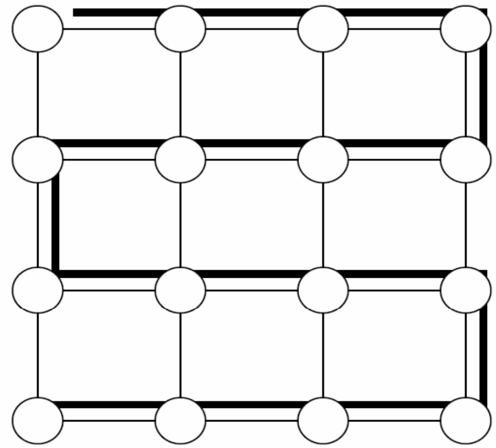
Linear Array and Ring



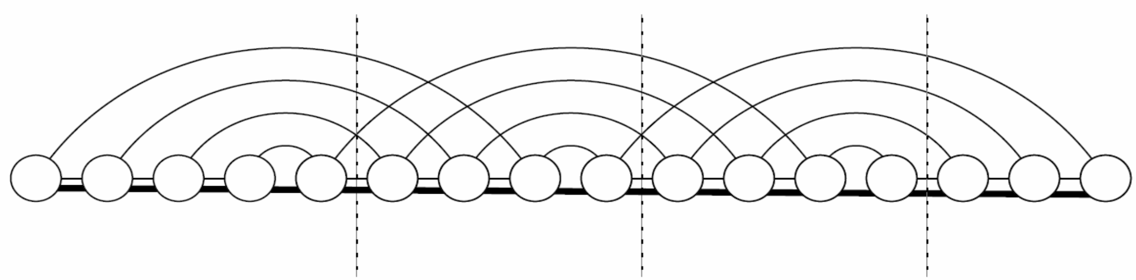
2-D Mesh, Mesh with rings, 3-D Mesh



(a) (b) (c)



(a) Mapping a linear array into a 2D mesh (congestion 1).



(b) Inverting the mapping − mapping a 2D mesh into a linear array (congestion 5)

Figure 2.32 (a) Embedding a 16 node linear array into a 2-D mesh; and (b) the inverse of the mapping. Solid lines correspond to links in the linear array and normal lines to links in the mesh.

Mesh of Trees

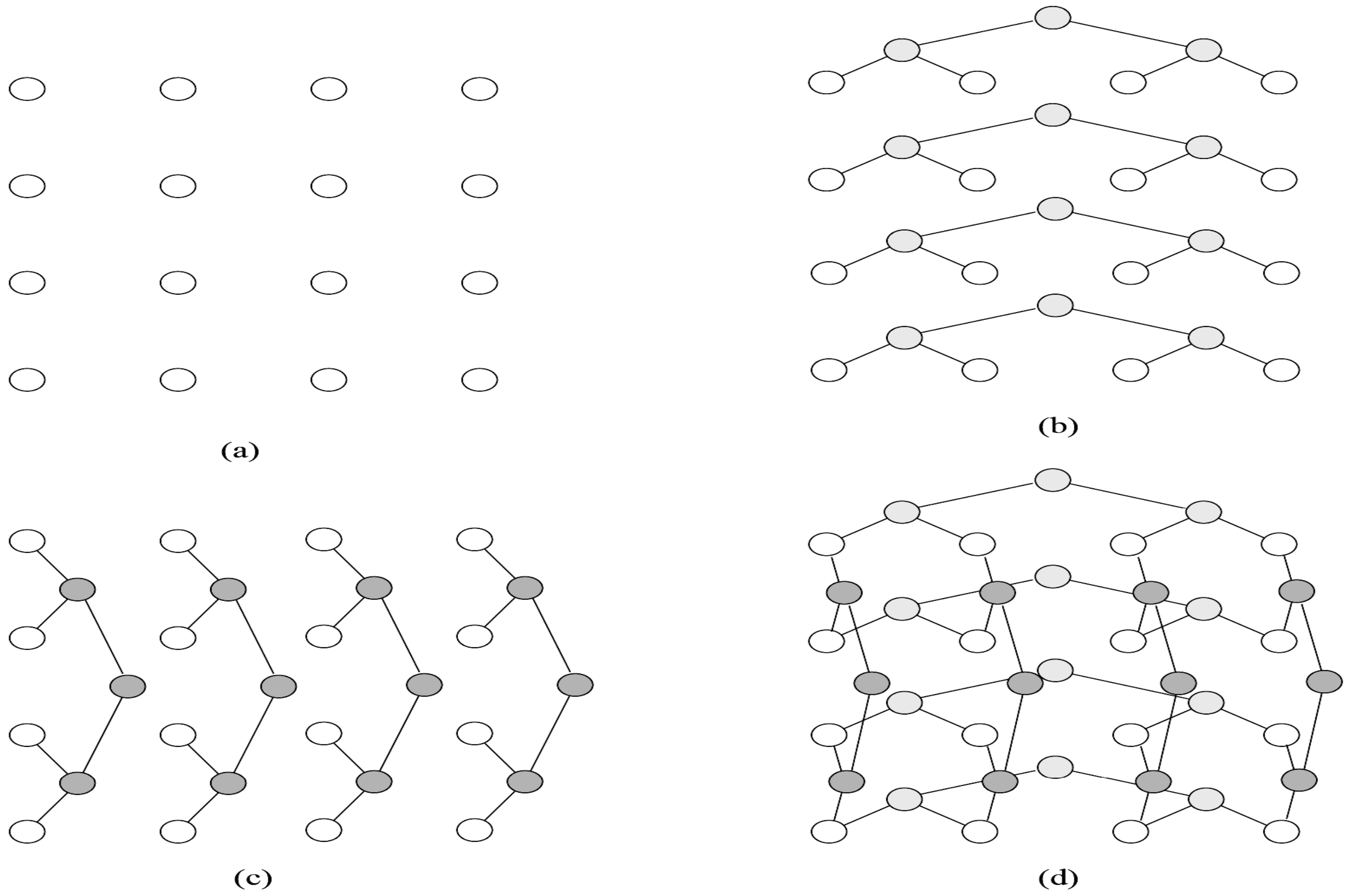


Figure 2.36 The construction of a 4 × 4 mesh of trees: (a) a 4 × 4 grid, (b) complete binary trees imposed over individual rows, (c) complete binary trees imposed over each column, and (b) the complete 4 × 4 mesh of trees.

Pyramid

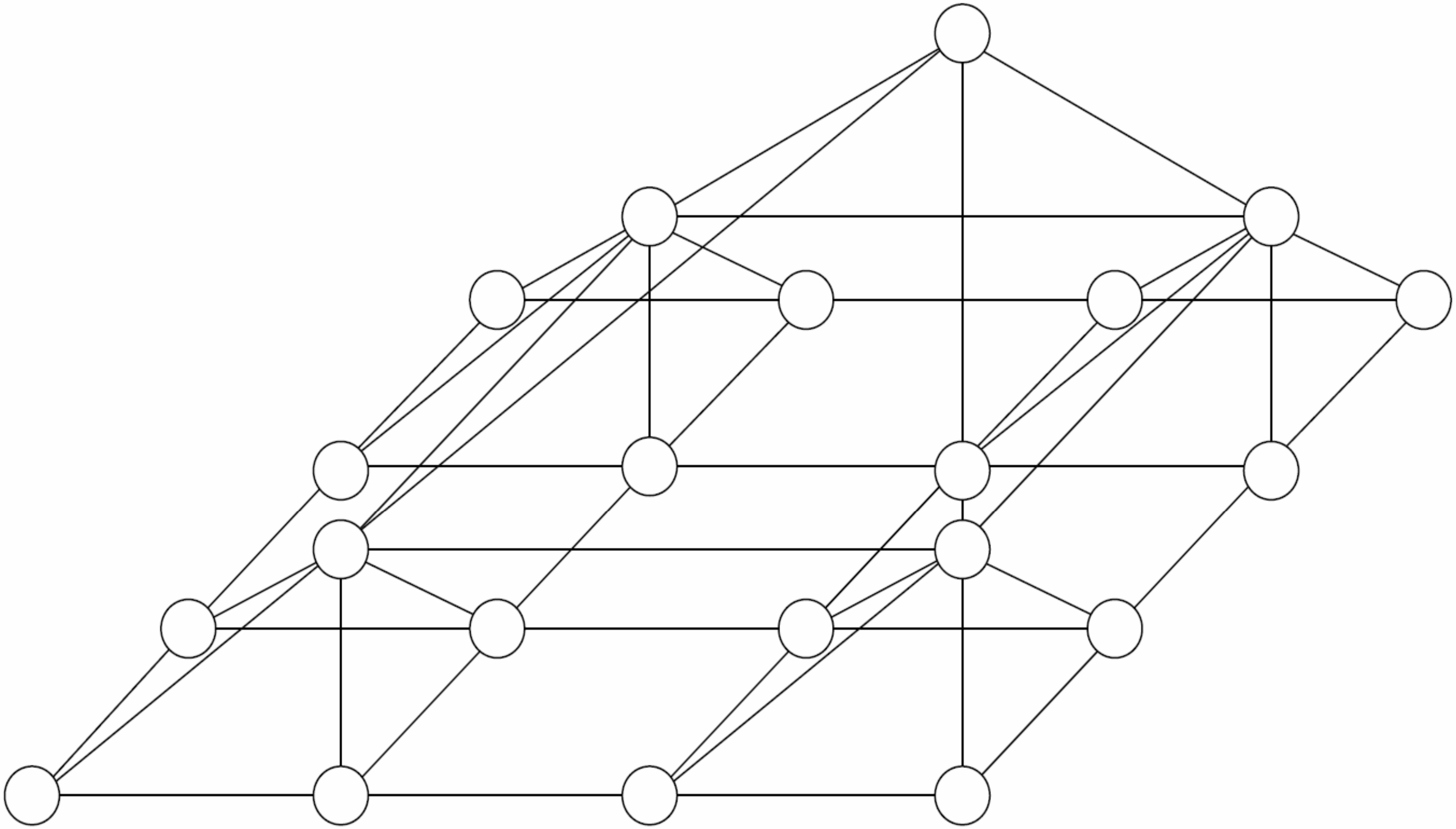


Figure 2.37 A 4×4 pyramidal mesh.

Hypercubes

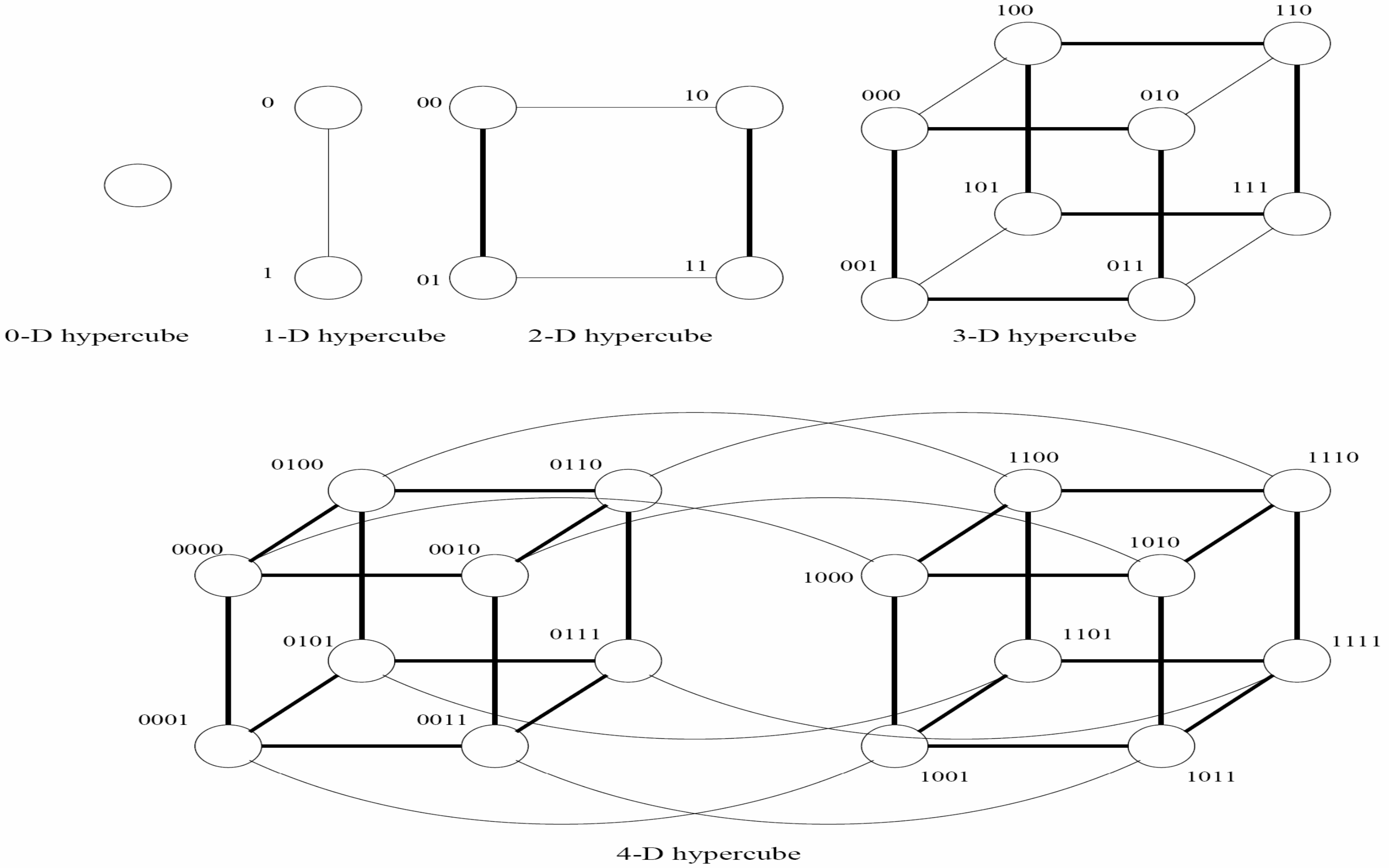
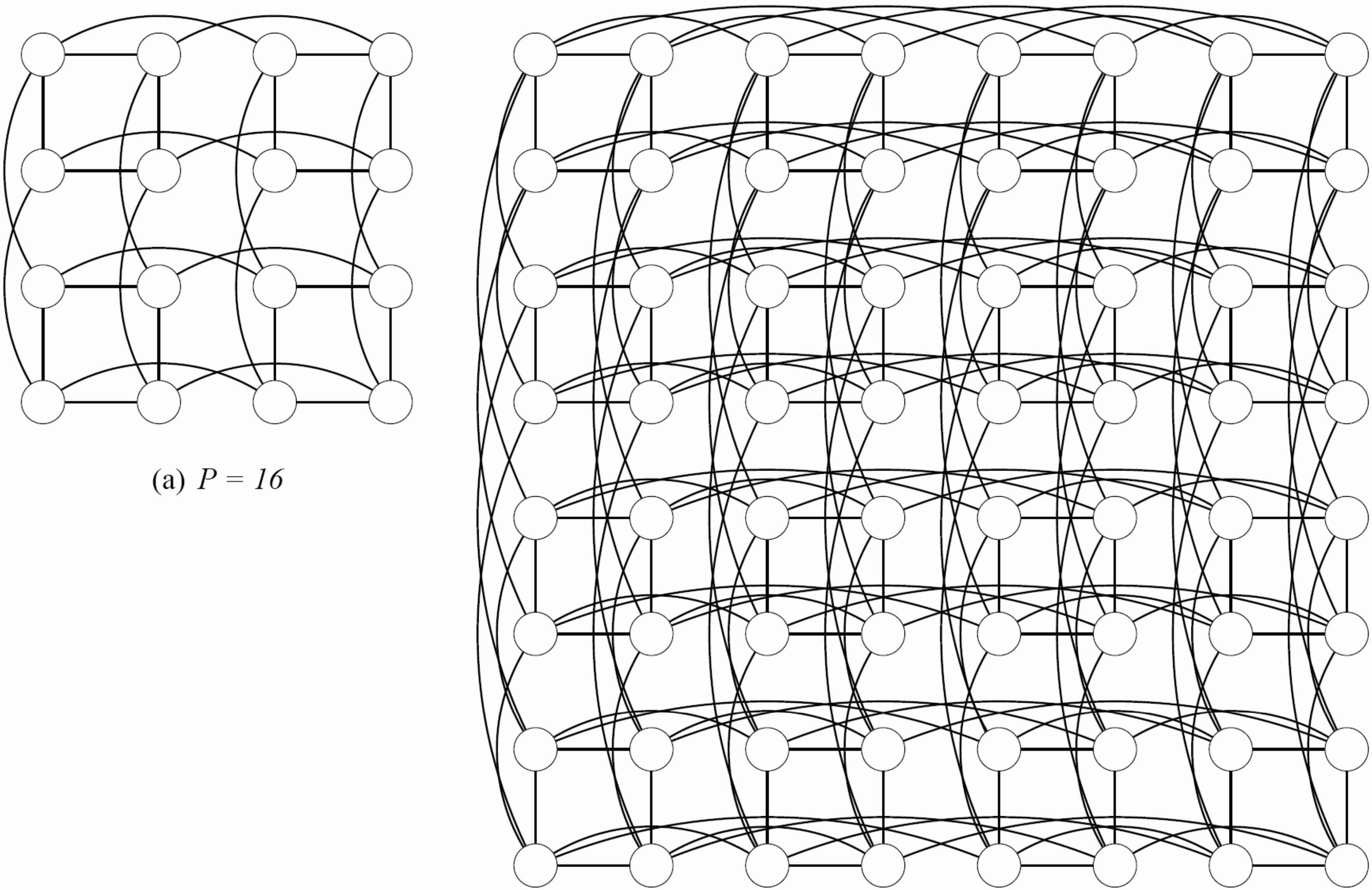


Figure 2.17 Construction of hypercubes from hypercubes of lower dimension.



(a) $P = 16$

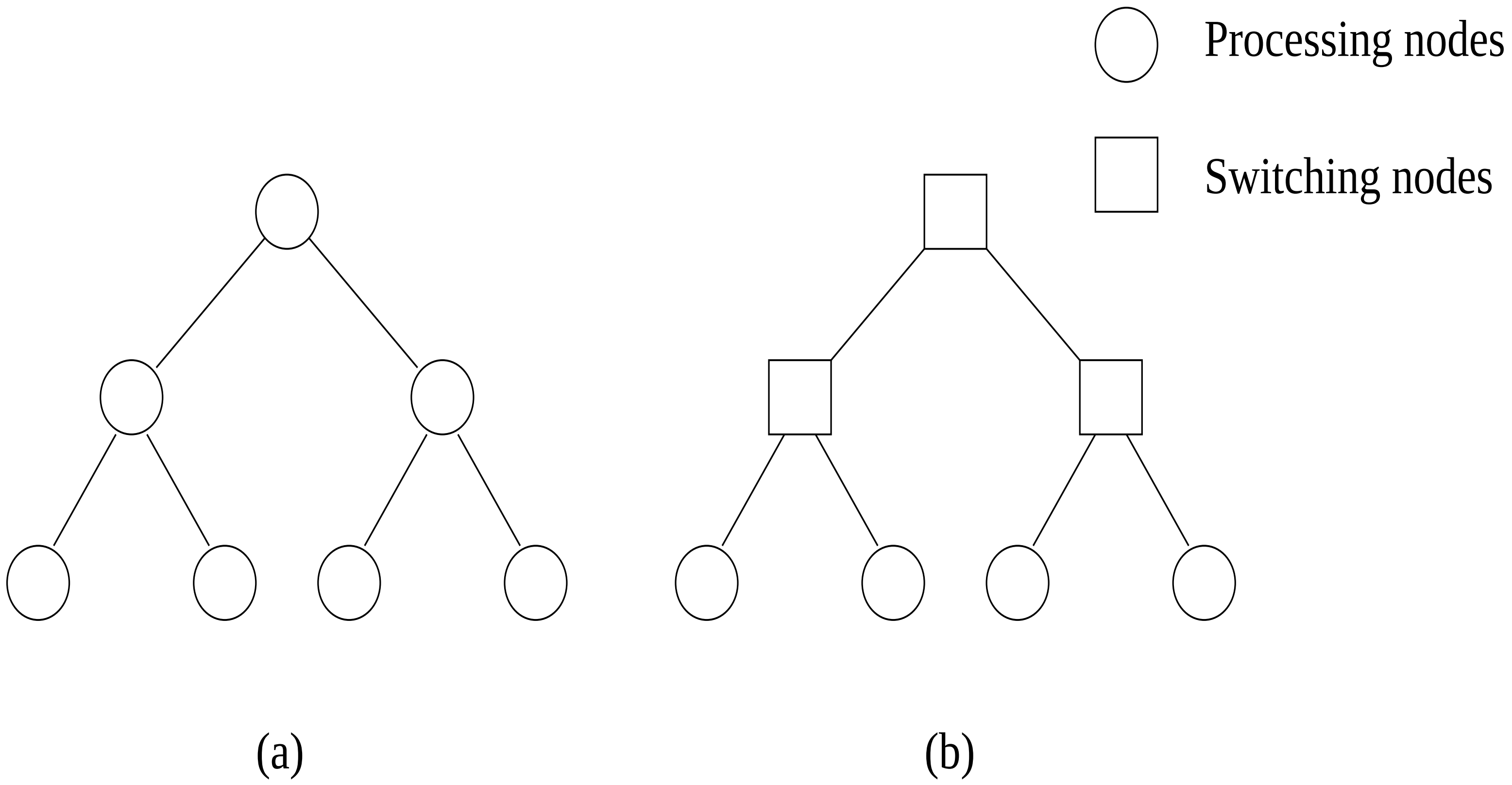
(b) $P = 32$

Figure 2.33 Embedding a hypercube into a 2-D mesh.

Properties of Hypercubes

- The distance between any two nodes is at most *log p*.
- Each node has *log p* neighbors.
- The distance between two nodes is given by the number of bit positions at which the two nodes differ.

Trees

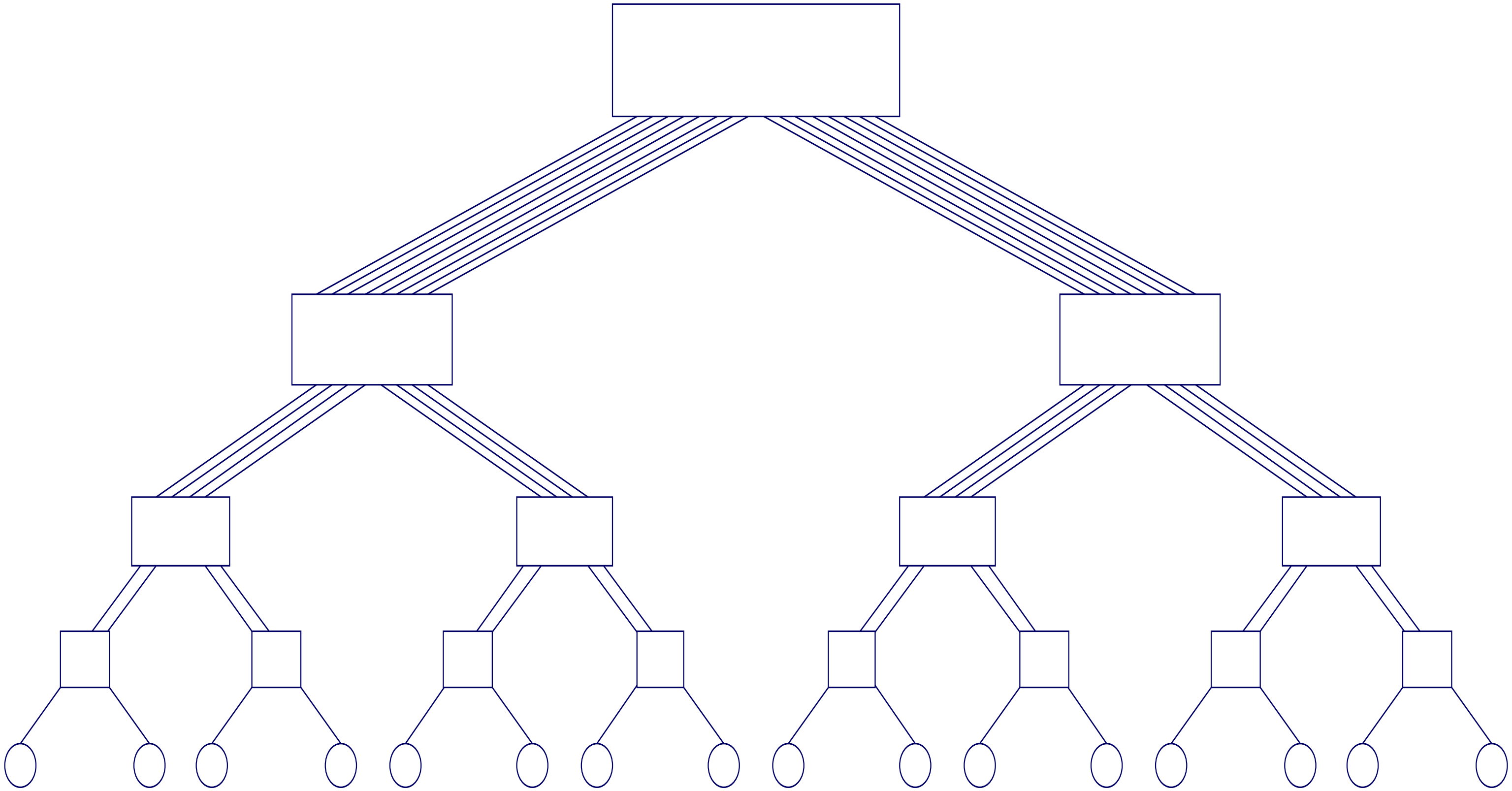


Complete binary tree networks: (a) a static tree network; and (b) a dynamic tree network.

Network Topologies: Tree Properties

- The distance between any two nodes is no more than *2logp*.
- Links higher up the tree potentially carry more traffic than those at the lower levels.
- For this reason, a variant called a fat-tree, fattens the links as we go up the tree.
- Trees can be laid out in 2D with no wire crossings. This is an attractive property of trees.

Fat Trees



A fat tree network of 16 processing nodes.