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Briefly explain the following interconnection networks:

1. The Crossbar Networks

2. Cube Interconnection Network

3. Fat Tree Connection

1. **The Crossbar Networks**

A crossbar is a non-blocking switching element with N inputs and M outputs used for connecting multiple components of a computer where, typically, N = M. The crossbar can simultaneously transport input signals on any of the N inputs to any of the M outputs as long as multiple signals can do not compete for the same input or output port. Crossbars are commonly used as basic switching elements in switched-media network

1. **Cube Interconnection Network**

Cube networks are a type of network topology used to connect multiple processors with memory modules and accurately route data. Cube networks consist of 2m nodes. These nodes form the vertices of squares to create an internetwork connection. A cube is basically a multidimensional mesh network with two nodes in each dimension. Due to similarity, such topologies are usually grouped into k-ary d-dimensional mesh topology family where d represents the number of dimensions and k represents the number of nodes in each dimension.

1. **Fat Tree Connection**

Fat-Tree networks were proposed by Charles E. Leiserson in 1985. Such network is a tree, and processors are connected to the bottom layer. The distinctive feature of a fat tree Is that for any switch number of links going down to its siblings is equal to the number of links going up to its parent in the upper level. Therefore, the links get “father” towards the top of the tree, and switch in the root of the tree has most links compared to any other switch below it:

This set up is particularly useful for networks-on-chip. However, for enterprise networks that connect servers, commodity (off-the-shelf) switches are used, and they have a fixed number of ports.