**Number 1**

Crossbar networks allow any processor in the system to connect to any other processor or memory unit so that many processors can communicate simultaneously without contention. A new connection can be established at any time as long as the requested input and output ports are free. Crossbar networks are used in the design of high-performance small-scale multiprocessors, in the design of routers for direct networks, and as basic components in the design of large-scale indirect networks. A crossbar can be defined as a switching network with N inputs and M outputs, which allows up to min {N, M} one-to-one interconnections without contention

**Number 2**

The Cube interconnection network is a three-dimensional interconnection network, it has several features that makes it very attractive for parallel computation. It appears the same from every node, and no node needs special treatment. It also provides n disjoint paths between a and a destination.

The ability to have n alternative paths between any two nodes makes the cube interconnection network highly reliable if anyone (or more) paths become unusable. It was used in some early machines e.g.:

* Intel iPSC
* nCube

**Number 3**

The fat tree was proposed by Leiserson [LEI 85]. Fat trees are more like real trees in which the branches get thicker near the trunk. Proceeding up from the leaf nodes of a fat tree to the root, the number of communication links increases, and therefore the communication bandwidth increases. The communication bandwidth of an interconnection network is the expected number of requests that can be accepted per unit of time.

The structure of the fat tree is based on a binary tree. Each edge of the binary tree corresponds to two channels of the fat tree. One of the channels is from parent to child, and the other is from child to parent. The number of communication links in each channel increases as we go up the tree from the leaves and is determined by the amount of hardware available. For example, Figure 5.5 represents a fat tree in which the number of communication links in each channel is increased by 1 from one level of the tree to the next. The fat tree can be used to interconnect the processors of a general-purpose parallel machine. Since its communication bandwidth can be scaled independently from the number of processors, it provides great flexibility in design.