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# Review on Network on Chip (NoC) Topology

Suyog K. Dahule[1], Pallavi D. Tiware[2] , Sagar Soitkar[3]

Asst. Prof, Department of E&TC, D.M.I.E.T.R. , Wardha, India. [1]

M Tech (Elect. & Comm.), Department of E&TC, D.M.I.E.T.R, Wardha, India [2]

Asst. Prof, Department of E&TC, R.G.C.E.R. , Nagpur, India. [3]

**ABSTRACT***:* Number of processing elements on single chip called system on chip (SoC). As the system on chip having bus based communication, with increasing this processing elements form very complicated structure of SoC. To reduce this complexity Network on chip (NoC) is best , it provides high level of parallelism in communication and improves the performance of on chip communication. Topology is the interconnection of network, there are number of topology for NoC to connect core to each other, This paper reviews some topology for NoC which defines the NoC interconnection.

**KEYWORDS***:* system on chip, network on chip, topology

## I. INTRODUCTION

Number of processing elements on single chip called system on chip (SoC). System on chip having very complicated structure it supports bus base communication. Network on Chip (NoC) has been proposed and has replaced the System-on- Chip of bus structure. It reduces complexity of designing wires and also increases speed and reliability.Topology shows the connectivity and distribution of nodes. The performance of a NoC is extremely sensitive to its topology because topology determines the system cost, as well as performance bounds for the network by setting the average message hop count and network bisection bandwidth. Finding a proper topology for an application in which the number of intermediate routers between communicating cores with heavy Communication demand is minimized [8].

## II. OVERVIEW OF NoC TOPOLOGY

Topology is important parameter of NoC. It is the interconnection of network, it defines how the network nodes are connected to each other and determines system cost, as well as performance for the network. It has a great impact on the system performance and reliability. Selection of appropriate topology can help to improve the performance of on chip communication. Overviews of some topologies are given here.

Mesh:

In a full mesh network, each network node is connected to every other node in the network. Due to this arrangement of nodes, it becomes possible for a simultaneous transmission of data from one node to several other nodes. The nodes of a mesh network require some kind of routing logic so that the data traveling over the network take the shortest path during each of the transmission. Mesh shape network consists m columns and n rows and at each intersection router is situated and this router is connected to the adjacent router, it is simple type of topology and easy to implement. 4X4 mesh architecture for NoC is as shown in fig.1.

Generally mesh network has M rows and N columns, the parameters of mesh network is as follows[6]

Diameter: (M+N-2)

Bisection Width: min(M,N),

Number of Routers required: (M × N),

Node Degree: 3(corner),4(boundary), 5(central)

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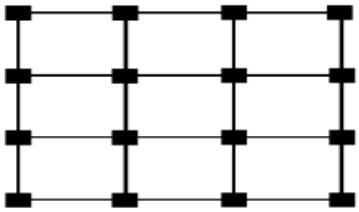

Fig 1: Mesh network

Torus :

Torus network is same as mesh, each node is connected to the nearest neighbors, But in torus network all end node are also connect together. Torus network has better path diversity than mesh network[2], it has minimal routes to transfer data from source to destination node. Torus architecture for NoC is as shown in fig. 2.

Torus topology takes less time as compare to mesh topology to reach destination.[3]

It has also M rows and N columns, the parameters of torus network is as follows[6]

Diameter: [M/2] + [N/2],

Bisection Width: 2 × min (M,N),

No of Routers required: (M × N),

Node Degree: 5.

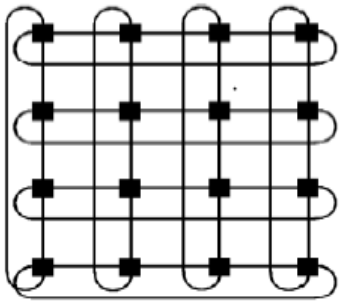

Fig 2: Torus network

Ring:

In ring Topology every node in the network is connected to two other nodes and the first and the last nodes are connected to each other. The data that are transmitted over the network pass through each of the nodes in the ring until they reach the destination node. Ring architecture for NoC is as shown in fig.3.

The parameters for ring network are as follows

Ring network having fix node degree 2.

Bisection width:2.

Diameter

N is even: N/2

N is odd: (N-1)/2

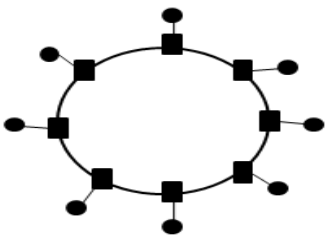

Fig 3: Ring network

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Octagon:
Octagon consisting of 8 nodes and 12 bidirectional links. There exists one direct link between two adjacent nodes in interconnect network [9]. If in interconnect network design a system consisting of more than eight nodes octagon can be extended to multidimensional space, however with a significantly increased wiring complexity. Octagon architecture for NoC is as shown in fig.4.
For a network having N number of nodes parameters are as follows [6]
Diameter: 2[N/8],
Bisection width: 6 for N=8 or 6(1+[N/8]) for N>8,
No of router required: 8 for N=8 or and (1+[N/8])−[N/8] for N>8.
Node Degree: 4(member node), 7(bridge node)

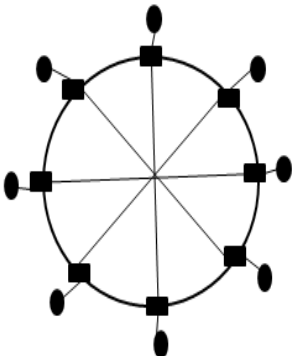

Fig 4: Octagon network

Butterfly flat tree:
In tree network, router is present at the node of tree and computational resources is at the leaves of tree[2], butterfly flat tree network is also same as tree network, in this butterfly flat tree network hierarchy is maintain, upper nodes are connected to the lower nodes in hierarchy and level of it depends on the number of IP [9]. fig.4 shows the butterfly flat tree network.
For N number of IPs the network has following parameters [6]
Diameter: log2N,
Bisection Width: $\sqrt{N}$,
Number of router needed N/2,
Node Degree: 6(non root),4(root).

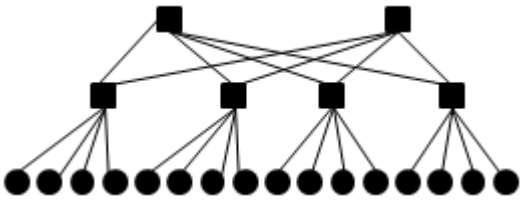

Fig 5: Butterfly network

Star:
A star network consist large capacity of central router in the middle position of the star, and other computational resources or sub networks in the spikes of the star. Traffic between the all spikes goes through the central router and because of this capacity requirements of the central router are quite large. Traffic between the all spikes goes through the central router causes a possibility of congestion in the middle of the star [2]. Star architecture for NoC is as shown in fig.6.

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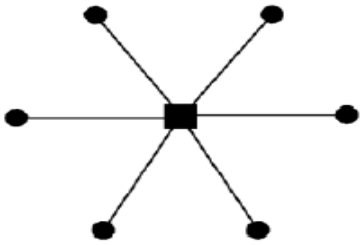

Fig 6: star network

## III. TOPOLOGY PARAMETERS

The Topology is the interconnection of network; it defines how the network nodes are connected. There are some Topology parameters; It has a great impact on the network performance and reliability. This parameters are network diameter it defines length of the maximum shortest path between any two nodes, link capacity is the number of links of the network and node degree number of input/output ports for any network.

*1)Node Degree:*
The number of ports connected to a node called node Degree, it shows input output complexity of a node. A network is called regular if all nodes have the same degree; otherwise, it is irregular network. Node degree can be constant or varied according to size of the network. High node degree reduces the average path length but increases complexity of network and smaller node degree requires less hardware cost on links. In most cases, there is a constraint on node degree, which is the number of direct neighbors of a node. Smaller and fixed node degree is effective for topological characteristics. For example simple mesh network has node degree 5 it may vary according to type of mesh network but ring has fixed node degree 2.

*2) Diameter:*
The diameter of a network is the distance between inter nodes , the maximum number of links that should be traversed to send a message to all nodes along the shortest path. The maximum shortest path between all pairs of nodes. If there is no direct connection between two nodes, the message has to travel through some intermediate nodes which will introduce hop delay, it cause message delay and it proportional to the number of hops, the length of the maximum shortest path becomes an important . small diameter of network can also help to provide low and predictable latency, predict routing paths, traffic flow. The smaller the diameter of a network, the less time it takes to send a message from one node to the farthest node.

*3) Link Complexity:*
There are links to connect nodes to each other in network. As the network scales, the link complexity increases. Adding more links to a network can reduce network diameter and provide better communication among nodes. But links are expensive, Higher link complexity may induce higher hardware complexity and area. In all topologies, fully connected network has the highest link complexity.

*4) Bisection Width:* Bisection width and the bisection bandwidth of interconnection networks are two important parameters of a network. Bisection width reflects Number of links that are split the network to obtain separate network, it divide the topology into two networks with the approximate equal size. Large bisection width provides more paths between two sub-networks, and thus improves overall performance of network. The bisection width has been a typical excellent parameter to evaluate and compare interconnection networks for parallel architectures. only ring, star and tree have fixed bisection width, regarding of the size of the network[5].

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## IV. CONCLUSION

NoC contain number of processing elements on single chip connected in network fashion, managing on chip communication in many elements is a fundamental challenge. Topology defines interconnection of network and it determines the performance for the network, In these paper we studied various NoC topology and different topology parameters **,** topology parameters taken in to account is also important when carrying out a study of topology, it defines performance of NoC topology.

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