Evaluation of Over Looped 2d Mesh Topology for Network on Chip

A. SingaraRajivaLochana, K.Arthi

***Abstract:** The arrangements of nodes in the network identifies the complexity of the network. To reduce the complexity, a structural arrangements of nodes has to be taken care. The mesh topology yields attraction than the other traditional topologies. Making the opposite corner nodes to communicate with less hops and avoiding the centre of the networks traffic, Over-Looped 2D Mesh Topology is proposed. For a homogeneous systems the proposed work can be deployed without altering any of the switch component compositions. By making the flits, travel in the outer corner nodes with the help of looping nodes will make the journey from source to destination with less hops. For smaller network below 4x4 the looping is less responsive. For odd or even number of columns and rows the looping can be done. The number of columns and number of rows need not to be equal. The left over nodes will be looped accordingly. The hop count of the Over-Looped 2D Mesh Topology compared to 2D mesh decreases the journey by 25%. The wiring segmentation and the wiring length of the system more than 10 % from 2D mesh and less than 20% from 2D Torus.*

***Key word:** Mesh topology, Torus topology, hop count, homogenous, flits*

I. INTRODUCTION

The search of electronic devices with more features in a compact form is ruling the populaces. The Network-on-Chip (NoC) are the alternate to the bus based and point-to-point architecture. NoC has four components IP cores the local hosts, Network Interfaces which helps to connect the IP cores with the switches, Switches also referred as Routers acts as main communicator and Physical links for connecting the individual switches [1] and [2]. The structure of NoC is shown in Fig. 1.

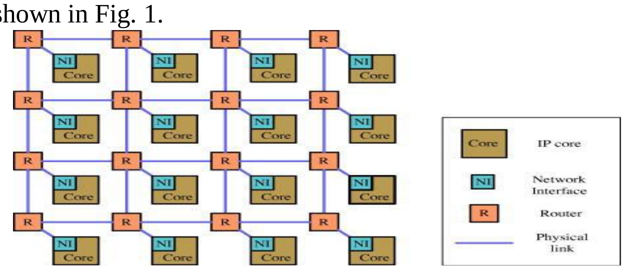

Figure 1: Network-on-Chip

II. Over-Looped 2D Mesh Topology(OLM)

2D mesh is identified as the best suit topology for NoC systems. The communication to the opposite end nodes will take more hops and neighbor nodes cannot be skipped in 2D Mesh and for a long end nodes distance in tours, needs repeaters. To increase the performance of the 2D Mesh and Tours, Over-Looped 2D Mesh Topology is proposed. To provide over-looping, few nodes in the 0^{th} and $(n-1)^{th}$ columns and rows are identified as Looping Nodes (LN) based on the (1) to (4) given below.

When X and Y axis values are different.

M= Round(X/3.075) (1)

N= Round(Y/3.075) (2)

LN (X axis nodes) = X, 3 (M – 1) , 3 (M – 2) , 3 (M – 3),………., 3 (M – X)

Where X == M, (3)

LN (Y axis nodes) = Y , 3 (N – 1) , 3 (N – 2) , 3 (N – 3) , …….., 3 (N - Y)

Where Y == N (4)

The LN nodes are preferred only at the terminal rows and columns because each switch in the network is provided with five interface lines. The switches in the 1^{st} to $(n-2)^{th}$ rows are interfaced with five links, out of five, four links are used for the (north, east, south and west) directions and one for its local downstream port (local line). Therefore only in the terminal rows and columns switches are available with one or two interface kept free, which is used for looping. The LN nodes are responsible for determining the looping structure of the proposed work. The end coordinate nodes are looped with the LN nodes as shown in Fig. 2 for 8x8 Over-Looped Mesh Topology.For a small 4x4 mesh there is no necessity to join the column and row end coordinates, since the hops is less than 6 to reach the end nodes. For a minimal distance, over-looping is not effective. When the network grows, the end coordinates will be far to communicate and wiring becomes lengthier, it is tough to maintain the signal strength and may need repeaters to strengthen the signal. Therefore, Over-Looping of switches will be the better solution.

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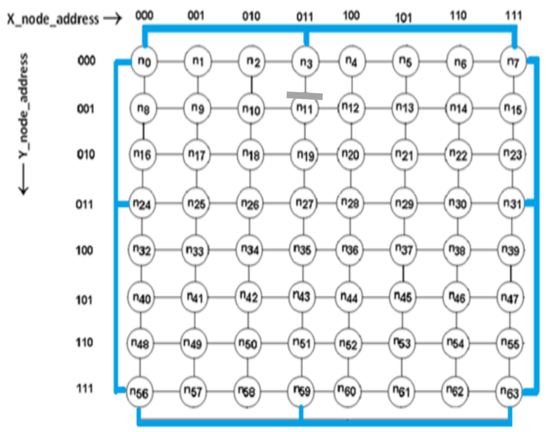

Figure 2 8x8 Over-looped Mesh Topology

When a 4x4 topology does not need Over-Looping, fix the limit of each row and column LN to be of four nodes. LN nodes are identified from the above (1) to (4). The LN nodes in a mesh are identified using the following steps, when X and Y coordinate values are different divide each X and Y by 3.075 and store it in M and N. To find the LN nodes in X coordinate axis, start the process in the reverse order (i.e) start plotting from the last node/ switch of the axis which is (X-1) to the switch 3(M-1) form loop in 4x4 matrix. For finding the next LN decrement M by 2 as 3(M-2). Form the next loop to 3(M-2) from 3(M-1) that gives the next 4x4 matrix. Decrement M until M and X are equal. The equalance shows that there is no more nodes in the X axis to get joined. Follow the same procedure in the Y axis. When X and Y axis values are same then perform equation 1 and 3 for both the sides and plot the loops accordingly.The OLM designed for NoC can be used for normal Local Area Networks. By over looping the in between nodes in the terminals, can eliminate the presser of the network in the middle and can eliminate the use of repeaters to strengthen the signal as in tours.Important factors that has to be considered in forming a topology in a NoC are area of occupancy, hop count and routing complexity of the design.

A. WIRING LENGTH

Wiring length reflects the area of occupancy and the conception of power in a topology. In Over-Looped 2D Mesh topology, the wiring length is less when compared to Tours [4]. The equations below gives the wiring length of OLM 2D Mesh topology.

For different X and Y axis nodes, the wiring of OLM is defined in (5),

Wire (OLM) = (2XY - (X + Y))+ (2 x Round(X/3.075))+(2 x Round(Y/3.075)) (5)

Reducing the equation for equal X and Y axis nodes are shown in (6),

Wire(OLM) = (2X (X - 1)) + (4 x Round(X/3.075)) (6)

While X and Y are the axis values, by finding the external wiring of LN nodes on all the four sides of the network and suming with the internal wiring of the mesh network will give the total wiring of OLM. The internal wiring is calculated by producting the mesh size that is with X and Y values. The external wiring is formrd by dividing the X axis value by the 3.075. Since the LN nodes are formed with the limit of 4 x 4 axis values and the loop of the intermediate LN nodes ends and starts with the same node the division is done with 3.075.

B. HOP COUNT

The next factor that affects the topology is the hop count. As the hop count increases, the latency increases and the throughput decreases. Maintaining the hops gives a better performance of the topology. For OLM the below (7) and (8) shows the hop count evaluation for the corner node to the diagonally opposit corner node.

For the different axis values, the (7) shows the maximum hop count value in Hmax

Hmax(OLM) = (2 x Round(X/3.075)) + (2 x Round (Y/3.075)) (7)

For the same axis values, the (8) shows the maximum hop count value stored in Hmax

Hmax(OLM)=4xRound(X/3.075) (8)

The hops from source to destination will give the total distance to be travelled by the packet/ flits. The reduced hops in the travel results better in all aspects like avoiding drop in packets, congestion, delay in delivery and on. Minimum hops in a journey will run the system even. The travel in the middle of the network for the packets from the terminal nodes to the diagonally opposite terminal node, needs more concentration than the nodes that travel nearby inside the network. For the travel of packets to the diagonally opposite corners, uses LN nodes. So that the congestion in the middle of the network is avoided and the terminal rows and columns are utilized than earlier. Finding the hop count to the diagonally opposite nodes in the network is by dividing the network's X and Y axis by 3.075 (since setted the limit of the LN nodes as 4x4) and round the value of the result to the nearest integer, when both the X and Y values are different. When X and Y values are same partition any one of the axis value by 3.075 and apply for the remaining axis.

C. WIRING SEGMENTS

This is another important parameter which governs the area and routing complexity of the design. If the design has more wire segments, it would increase the area, power consumption and also pose difficulty for developers to place and route the wire segments. The number of wire segments Wseg (OLM) for an X x Y order OLM 2D mesh is given in equations (9 and 10).

For different X and Y axis nodes, the wiring of OLM is defined in (9),

Wseg(OLM)=(2XY-(X+Y))+(2x Round(X/3.075)) + (2 x Round(Y/3.075)) (9)

For equal X and Y axis nodes, the wiring of OLM is designed in (10),

Wseg(OLM) = (2X (X-1)) + (4 x Round(X/3.075)) (10)

The segmentation is calculated by producting the axis values of the mesh and adding with the looping of the LN nodes. When the axis values are different calculate individual axis values and summate. When the axis values are same then clculate any one axis and product the value.

II. PERFORMANCE ANNALYSIS

Performance comparison has been made with 2D Mesh topology, 2D Torus and Over-Looped mesh topologies for different evaluation meters (end to end delay and throughput) VS. number of nodes. The modeled networks are simulated under the following assumption, all system nodes are distributed over 100x100 m2 area, ACK mechanism is not used, and all nodes are fixed. The destinations are randomly chosen from their neighbors.

A. THROUGHPUT

The flow in Fig. 3 below show throughput variation against number of nodes for the three topologies.

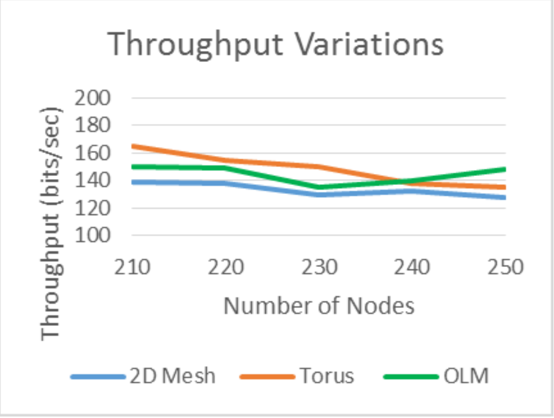

Figure 3 Throughput in OLM

By increasing number of nodes, the throughput fluctuate up and down in all the three topologies. The Torus and OLM starts with a better results compared to 2D Mesh. For more nodes to certain level of increase, Torus performs well. When extending X and Y values, there is a sudden drop in the flow of Torus than OLM. The reason is, Torus uses long wraparound channel to all the end nodes, when the length of the cable increases the signal strength decreases, which degrades its performance. For more nodes OLM functions better.

B. END TO END DELAY VARIATION

The End to End delay Variation against number of nodes for the three topologies are shown in Fig. 4.

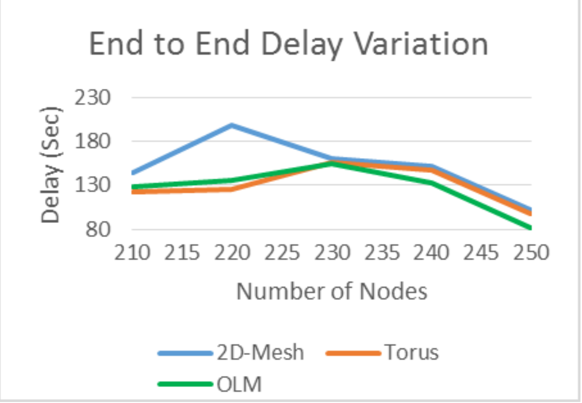

Figure 4 End to End Delay Variation

The increasing nodes has a better end to end delay for all the three topologies. The reason is, the shortest and less congested routes from source to destination are chosen always. In OLM the end to end delay increases as the number of nodes increases up to optimum level and decreases when the number of nodes increases beyond the optimum level.

IV. CONCLUSION

The flat arrangement of nodes in 2D Mesh, attracts developers to implement OLM in NoC. For a lengthy network, without repeaters the signal strength will be down in 2D Torus. To make the end nodes communicate with less hops without repeaters, Over-Looped 2D Mesh topology is used. The LNs are identified in the corner row and column of the X and Y Mesh and joined to reduce the hops of the end nodes. The end nodes need not travel in the middle of the network. The work is done without altering the homogeneous switches in the network. The throughput, Packet drop and end to end delay variation are the performance metrics, works healthy in OLM.

V. REFERENCES

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