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Comparison between Mesh and Custom Topologies of Network-on-Chip Architectures

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ABSTRACT

System-on-Chip (SOC) is a microchip consisting of different components such as processor, memory and logic circuitry all on the same chip and for providing communication between these components on the chip Network-on-Chip (NOC) is required as the conventional interconnects are not suitable to fulfil the demands. The application of traditional network technologies in the form of Network-on-Chip is a possible solution. In this paper 4x4 mesh and 4x4 custom topologies of Network-on-Chip are examined and finally reached a conclusion that custom topology 2 is better than mesh topology as well as all the other custom topologies as custom 1 and custom 3 in terms of transmission time, throughput and packet delivery ratio.

I. INTRODUCTION

The development in the field of integrated circuits has enhanced designers to accommodate billions of transistors on the chip [1]. The integration level improved computational power extremely [2]. The exponential decrease in the feature size has enabled integration of heterogeneous IP cores on a single chip leading to a new era of integration circuits known as System-on-Chip.
According to Moore's law approximately every 18 months the number of transistors on a chip doubles. Network-on-Chip is an alternative of traditional bus-based and point-to-point communication structures

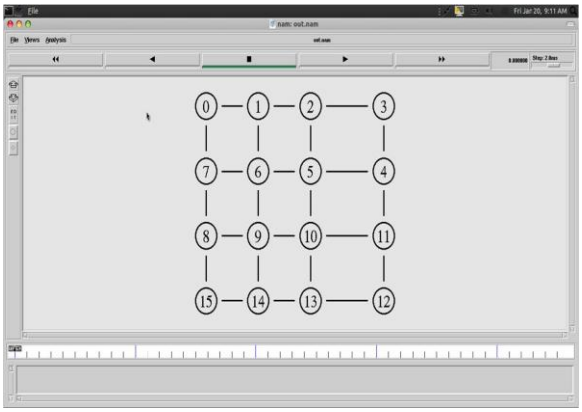
[3], [4], [5], and [6]. Although NoCs can borrow concepts and techniques from the
well-established domain of computer networking, it is impractical to blindly reuse features of classical computer networks and symmetric multiprocessors. The early work and basic principles of NoC paradigm were outlined in various seminal articles, for example [7-8]. In particular, NoC switches should be small, energy-efficient, and fast. NoCs need to support quality of service, namely achieve the various requirements in terms of transmission time, throughput, and packet delivery ratio. NoC is the layered design of reconfigurable micro networks. It exploits methods and tools used for general network and can achieve better communication in SoCs. Basically NoC is micro networks based on the ISO/OSI model. NoC architecture consists of Data link, Network and Transport layers.
This paper reports some experimental results based on the simulation of NoC using ns-2. Section II gives a description for our implementation results and in section III corresponding analyses are presented. Finally, we draw some conclusion in section IV.

II. IMPLEMENTATION RESULTS

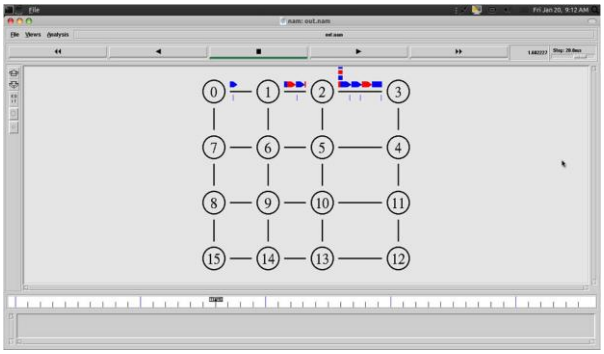
In this paper we have implemented two types of topologies, one is mesh topology and the other is proposed (Custom) topologies. We have selected number of attributes for the simulation; these attributes are transmission time, throughput and packet delivery ratio. The topologies run one by one on the same machine configuration, and then the snap shots and results are taken which are shown in the next section.

A Mesh Topology:

A.1 Output Generated Via Code

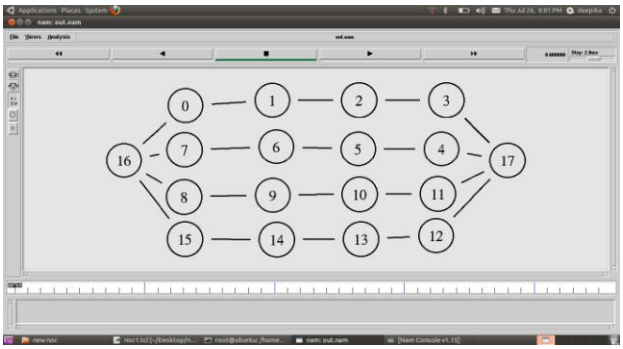


A.2 Flow of Data Generated in Mesh Topology

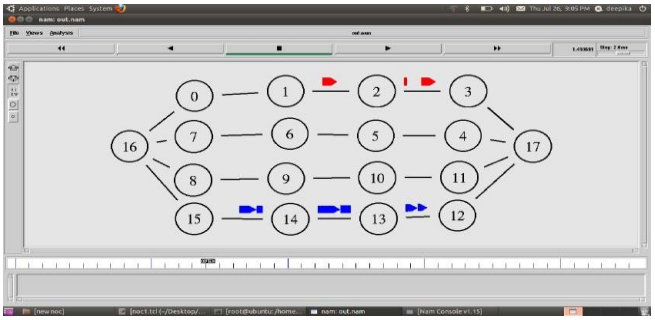


B Proposed (Custom 1) Topology

B.1 Output Generated Via Code

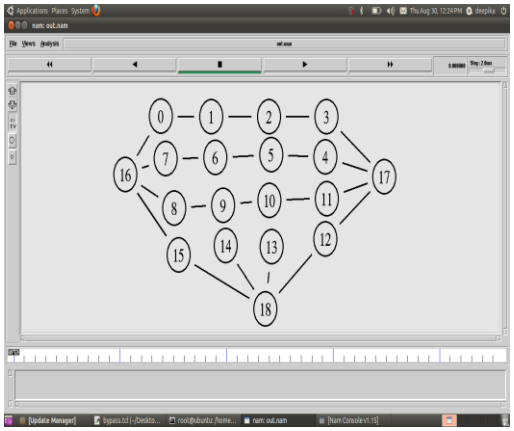


B.2 Flow of Data Generated in Proposed (custom 1) Topology

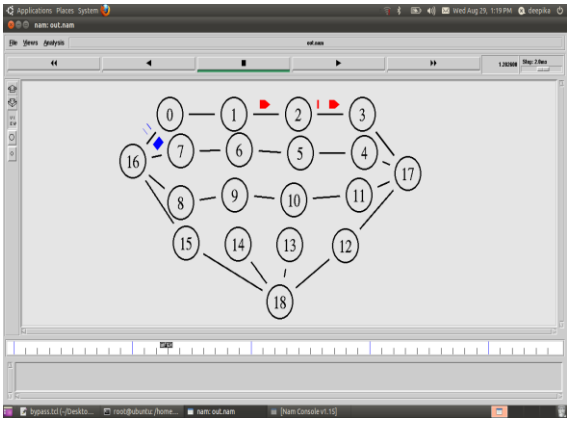


C Proposed (Custom 2) Topology

C.1 Output Generated Via Code

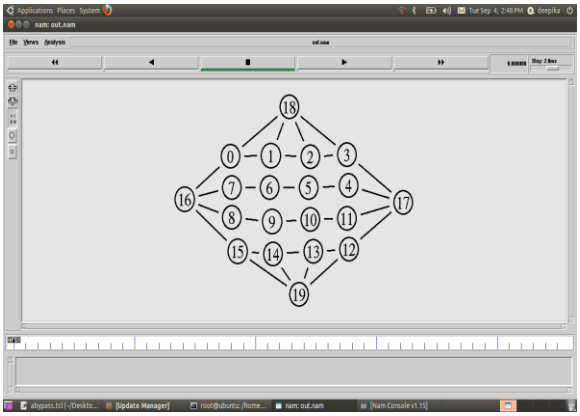


C.2 Flow of Data Generated in Proposed (custom2) Topology

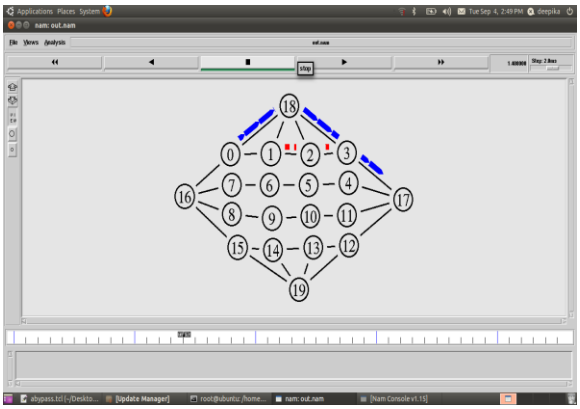


D Proposed (Custom 3) Topology

D.1 Output Generated Via Code



D.2 Flow of Data Generated in Proposed (custom 3) Topology



E Outcome

Table 1: Results for transmission time (ms)

Packet No.	Mesh	Custom 1	Custom 2	Custom 3
1	0.13	0.11	0.19	0.09
3	0.14	0.11	0.07	0.09
5	0.149	0.101	0.08	0.09
7	0.15	0.11	0.08	0.11
10	0.15	0.13	0.09	0.1

Graph 1: Transmission time of the packets

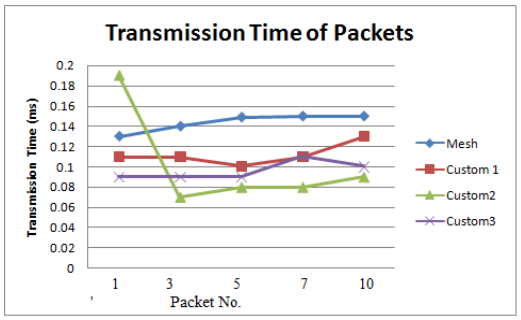


Table 2: Results for throughput of sent packet

Time (sec)	Mesh	Custom 1	Custom 2	Custom 3
0.5	52	50	50	50
1	114	114	120	115
1.5	170	215	250	250
2.0	258	328	405	405
2.5	308	390	475	475
3.0	360	442	572	520
3.5	361	445	575	523
4.0	271	439	525	500

Graph 2: Throughput

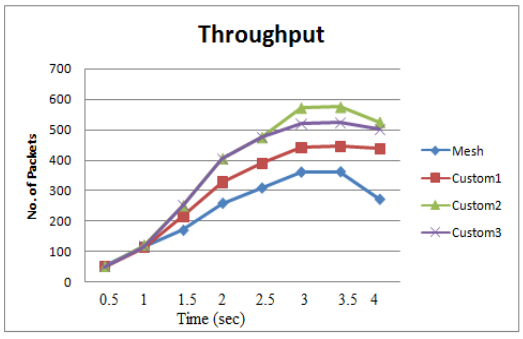
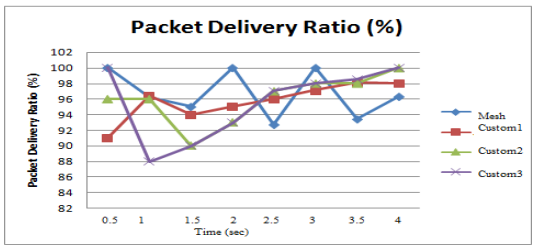


Table 3: Results for packet delivery ratio (%)

Time (sec)	Mesh	Custom 1	Custom 2	Custom 3
0.5	100	91	96	100
1	96.2	96.4	96	88
1.5	95	94	90	90
2.0	100	95	93	93
2.5	92.7	96	97	97
3.0	100	97.1	98	98
3.5	93.4	98.1	98	98.5
4.0	96.3	98	100	100

Graph 3: Packet delivery ratio (%)



III. ANALYSES

Presented results in tables 1, 2, and 3 shows the performance of all the topologies. From the results it is clear that the performance of the proposed (custom 2) topology is better than mesh topology. Performance of all the topologies are compared on the basis of transmission time, throughput and packet delivery ratio and finally it is found that the proposed (custom 2) topology is better than the mesh topology.

A. Transmission time:

Transmission refers to the act of sending a packet over a network link. In telecommunication networks, the transmission time, is the amount of time from the beginning until the end of a message transmission. In the case of a digital message, it is the time from the first bit until the last bit of a message has left the transmitting node. It is also defined as the time it takes a message to reach its destination from the source. It is the time between the first bit leaving the sender and the last bit arriving the receiver. The first bit leaves earlier and arrives earlier; the last bit leaves later and arrives later. The transmission time of packets for the mesh topology and the proposed (custom) topologies as calculated in table 5.1 is analyzed. Graph 5.1 is showing the performance of the topologies. Moreover the x-axis of the graph represents the number of packets as packet 1, packet 3, packet 5, packet 7 and packet 10 and the Y-axis of the graph represents their respective transmission time in ms. It is clear from the graph that the transmission time of packets for the proposed (custom 2) topology lies between 0.07 to 0.19 shown by the green line and that of mesh topology lies between 0.13 to 0.150 shown by the blue line. Thus proposed (custom 2) topology is better than mesh topology. Also it is better than the other custom topologies as the transmission time of packets for the proposed (custom 1) topology lies between 0.101 to 0.13 shown by the red line and that of the proposed (custom 3) topology lies between 0.09 to 0.11 shown by the purple line. Thus proposed (custom 2) topology is better than all the topologies as it gives the lowest transmission time.

B. Throughput:

It refers to the average rate of successful message delivery over the communication link. The throughput of sent packets for the mesh topology and the proposed (custom) topologies as calculated in table 5.2 is analyzed. Graph 5.2 is showing the performance of the topologies. Moreover the x-axis of the graph represents the time (sec) and the Y-axis of the graph represents the respective no. of packets. It is clear from the graph that the curve shown by the green for the proposed (custom 2) topology is higher than that of mesh topology shown by the blue line. Also it is higher than the curves for the other custom topologies as for the proposed (custom 1) topology shown by the red and that for the

proposed (custom 3) topology shown by the purple. Thus proposed (custom 2) topology is better than all the topologies as it gives the higher throughput in comparison to all the topologies.

C. Packet Delivery Ratio (%):

It is defined as the ratio of number of received packets and the number of sent packets. It is expressed in percentage (%).The packet delivery ratio for the mesh topology and the proposed (custom) topologies as calculated in table 5.3 is analyzed. Graph 5.3 is showing the performance of the topologies. Moreover the x-axis of the graph represents the time (sec) and the Y-axis of the graph represents the packet delivery ratio (%). It is clear from the graph that the curve shown by the green for the proposed (custom 2) topology is giving good packet delivery ratios (%) than that of mesh topology shown by the blue line. Also it is better than the packet delivery ratios (%) for the other custom topologies as for the proposed (custom 1) topology shown by the red and that for the proposed (custom 3) topology shown by the purple. Thus proposed (custom 2) topology is better than all the topologies as it gives better packet delivery ratios (%) in comparison to all the topologies.

IV. CONCLUSION

The results achieved in terms of transmission time, throughput and packet delivery and finally we concluded that custom topology 2 having three bypass nodes as shown above in the section II is better than mesh topology as well as all the other custom topologies: custom 1 and custom 3.

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