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Performance Evaluation and Simulation of Network Parameters for NoC Architecture Using NS2

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ABSTRACT: Network on Chip (NoC) architecture attempts to address different component level architectures with specific interconnection network topologies and routing techniques, some of the topologies are CLICHE, Folded Torus, BFT. In this paper we proposed link state routing and compares (CLICHÉ, Folded Torus, BFT) NoC architectures to evaluate their performance using simulating tool NS-2. The 3x3,4x4 and 5x5 CLICHÉ, Folded torus, BFT topologies of NoC are examined. Best one topology is folded torus by comparing various parameters.

KEYWORDS*:* Network on Chip, Different Topologies and topology parameter**.**

I. INTRODUCTION

Network on Chip (NOC) is one solution for designing communication among components in the soc circuits with several billion transistors that will reach the market in approximately 5-10 years from now. Different topologies having various advantages according to their applications. This paper present brief idea about topologies depending on parameter.

Some of the topologies are discussed below:
(i) CLICHE architecture, (ii) Folded torus architecture, (iii) Butterfly fat tree architecture.
CLICHE: All switches are connected to the four closest switches and the target resource block, except those on the edge of the layout. The simplicity of such a mesh architectural layout allows for the division of the chip into processing or resource regions.

Folded torus: In folded torus architecture the long wrap around connection may result in excessive delay & this problem can be avoided by folding the torus.
BFT (Butterfly fat tree): The layout is modeled in the form of a tree. Each node in the tree is represented by a set of coordinates (level, position) where level is the level in the tree and position is the spot in right-to left-ordering. Each switch is allocated two parent ports, and four child ports, or connections. In this paper we compare the performance parameters (Latency, Packet delivery ratio and throughput) of topology networks and evaluation of these parameters using NS2 simulator.

II.LITERATURE SURVEY

Many topologies with different capabilities have been proposed for NoCs including Mesh [8], Torus [3], Octagon [4], SPIN [4], and BFT [7]. The performance of architecture is evaluated based on metrics of latency and throughput per channel under Constant Bit Rate (CBR) and Bursty traffic**.** The proposed architecture is 2 dimensional mesh topology and designed with Odd-Even (OE) routing algorithm. The simulation result is that the proposed architecture achieves balanced performance of latency and throughput under CBR and Bursty traffic[1].Saad Mubeen1,2 and Shashi Kumar1 have discussed Two routing algorithms(Source routing and distributed routing) are used for 2 dimensional mesh

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topology. Evaluation results show that source routing gives higher latency and throughput performance as compared to corresponding distributed routing.[2]
Lalit Kishore Arora, Rajkumar have analyze the packet loss during the link down in mesh interconnection network topology with source routing using simulation. They have analyzed 2D Mesh performance on the one down link for one second, and they have changed two parameters packet size and time interval and found that the ratio of packet loss on CBR traffic generator over UDP agent is constant in both cases.[4]

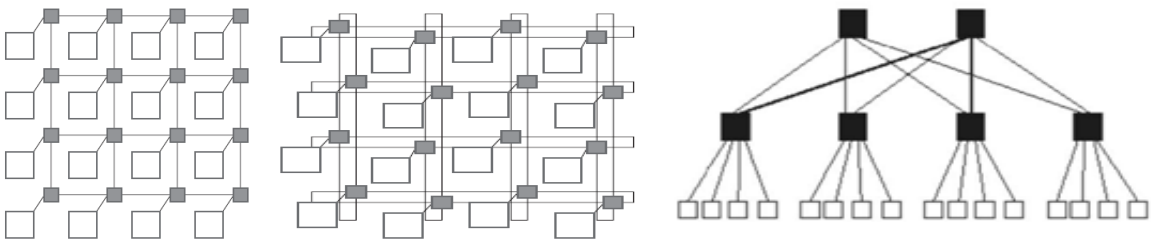
Pratiksha Gehlot, Shailesh singh Chouhan have compared five different topologies using distance vector routing algorithm. The SPIN and Octagon providing higher throughput and lower latency but it also has much higher drop probability which gives trade-off between low latency, high throughput and drop probability. BFT has lowest drop probability but also has lowest throughput.
In CLICHÉ (mesh) and Folded Torus has moderate value all parameters so here again a trade-off between latency, throughput and drop probability .[5]

Jie Cen and Cheng Li,Paul Gillared have described a simulation framework for mesh interconnection network has been designed, where the packet loss during the link down has been analyzed. Analysis and evaluation has been done on mesh interconnection networks on different traffic patterns using simulation on NS2. [6] Topologies such as mesh, torus, octagon, SPIN, BFT etc. according to various parameters and it gives comparatively study of delay parameter. So the work is to compare different topologies using delay parameter .[7] Source routing, i.e., the source node determines only its neighboring nodes that are involved in message delivery. For the tree-based architectures (SPIN and BFT) the routing algorithm applied is the least common ancestor (LCA) and, for CLICHE and Folded Torus, apply the e-Cube (dimensional) routing .In the case of Octagon, adopt the hierarchical address-based routing. BFT, CLICHE, and Folded Torus provide lower throughput than SPIN and Octagon.[8]

III.NOC TOPOLOGIES

Topology refers to the shape of the network. The different nodes in a network are connected to each other and how they communicate is determined by the topology.

We have used three topologies CLICHÉ, Folded torus, BFT of network size 3x3, 4x4 and 5x5. CLICHÉ (Chip Level Integration of Communicating Heterogeneous Elements) topology is a two dimensional mesh network layout for NoC design. Folded Torus layout was proposed by dally and Towles [4]. This topology is similar to the mesh architecture, except that the wires are wrapped around from the top component to the bottom and rightmost to the leftmost by doubling the bandwidth of a mesh network. When the number of nodes increases the wrap around links between the edge nodes becomes a drawback of torus topology. Hence, folded torus has a similar layout as torus, in which the links are arranged physically in a folded manner to equalize wire lengths. This can eliminate wrap around links unlike torus topology. Butterfly Tree Topology (BFT) has a central root node that is connected to one or more nodes of a lower hierarchy. In a symmetrical hierarchy, each node in the network has a specific fixed number of nodes connected to those at a lower level and position is the spot in right to left ordering.



(a) CLICHÉ (b) Folded Torus (c) BFT(Butterfly fat tree

Figure1.(a)CLICHÉ, (b) Folded Torus, (c) BFT

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IV.SIMULATION ENVIRONMENT

The simulation were carried out in NS2 simulator.NS-2 is an object-oriented, discrete event driven network simulator written in C++ and OTcl . It implements network protocols such as TCP and UPD; traffic source behaviour such as FTP, Telnet, Web, CBR and VBR; router queue management mechanism such as Drop Tail, RED and CBQ; routing algorithms.
For performance evaluation of Network on chip architecture following evaluation parameters has been selected.

1.Latency: It define as how much time it takes for a packet of data to get from source to destination and say that latency measures the amount of time between the start of an action and its completion.

2. packet delivery ratio: The ratio of the number of delivered data packet to the destination. This illustrates the level of delivered data to the destination.
3. Throughput: It is the number of packets/bytes received by source per unit time.

V.EXPERIMENTAL RESULT AND ANALYSIS

The simulation results are summarized in tables and graphs which shows various parameters. Figure 2 shows the 3x3 topologies output generated via codes. Table 1 and figure 3 shows the result and graph of 3x3 topologies (CLICHÉ, Folded Torus, BFT).In this the CLICHÉ has maximum latency 499.05ms, lower packet delivery ratio 0.572 and throughput 163.48Mbps.Folded torus topology providing moderate value of latency 47.76ms, higher packet delivery ratio 0.733 and higher throughput 211.09Mbps. BFT has lower latency17.02ms, moderate packet delivery ratio 0.608 and throughput 173.91Mbps.

Figure 4 shows the 4x4 topologies output generated by codes. Table 2 figure 5 shows the result and graph of 4x4 topologies. CLICHÉ topology providing moderate value of latency 113.69ms, higher packet delivery ratio 0.6117 and higher throughput174.78Mbps. Latency is lower 159.30ms with moderate packet delivery ratio0.6112 and throughput 174.63Mbps. BFT providing higher latency 159.30ms, lower packet delivery ratio 0.597 and throughput 170.75Mbps.
Figure 6 shows the 5x5 topologies output generated via codes.

Table 3 and figure 7 explain results and graph for 5x5 topologies. CLICHE topology has minimum latancy31.78ms with maximum packet delivery ratio and 0.627 and throughput 179.15Mbps. Folded torus has moderate values of latency 63.05ms, packet delivery ratio0.578, and throughput 165.15Mbps.BFT topology providing higher latency 83.72ms, lower values of packet delivery ratio 0.568 and throughput 162.326Mbps.

Table 4 and figure 8 shows average result of 3x3,4x4 and 5x5 topologies. From the result it is clear that the folded torus topology is better than CLICHÉ and BFT topology. Here CLICHÉ providing maximum latency 214.84ms with moderate throughpu172.47Mbps and packet delivery ratio 0.603.BFT has moderate value of latency 86.68ms, lower packet delivery ratio 0.591 and throughput 168.99Mbps. Folded torus topology has minimum latency 55.23ms with maximum packet delivery ratio0.642 and maximum throughput 183.62Mbps
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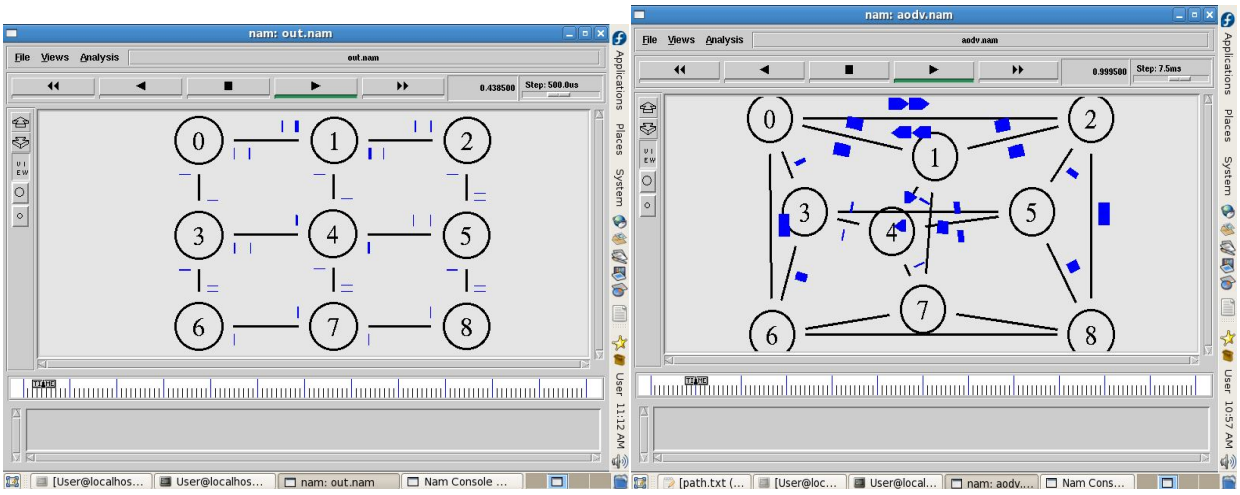
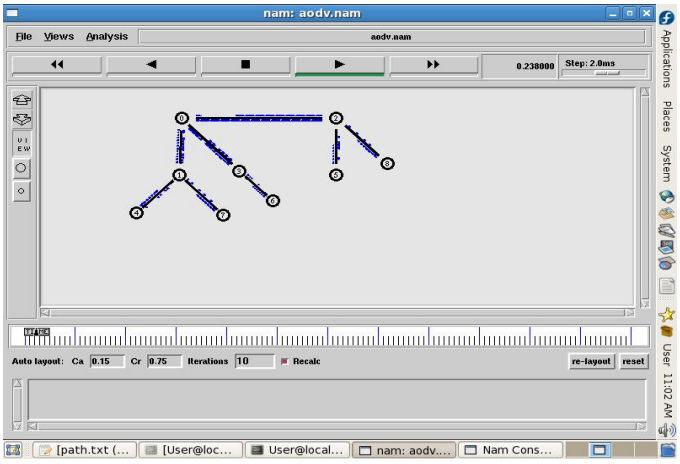


(a) CLICHE (b) Folded torus



(c) BFT(Butterfly fat tree

Figure2.3x3 topologies (a) CLICHÉ, (b) Folded torus, (c) BFT

TABLE1.Performance evaluation parameter of 3x3 topologies

Topologies	Latency	Packet delivery ratio	Throughput
CLICHE	499.05ms	0.572	163.48Mbps
Folded torus	47.76ms	0.738	211.09Mbps
BFT	17.02ms	0.608	173.91Mbps

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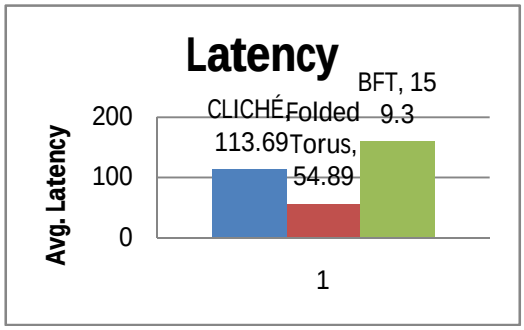
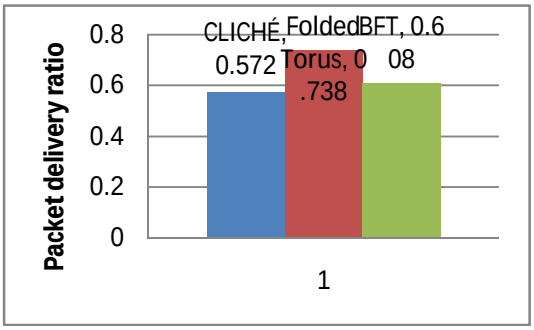
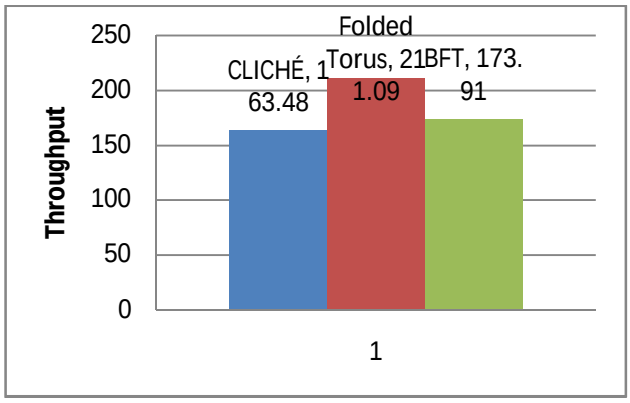


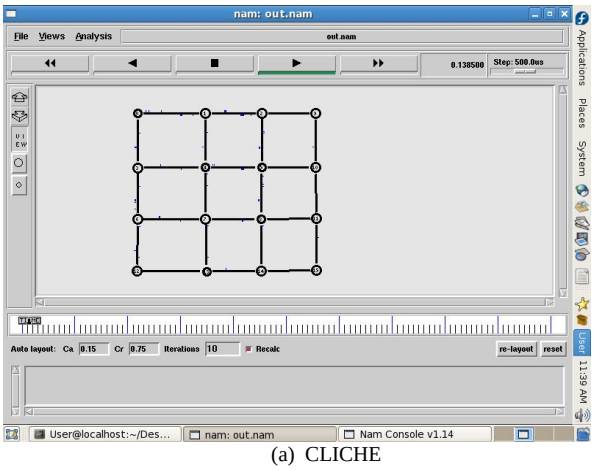


(b) Packet delivery ratio

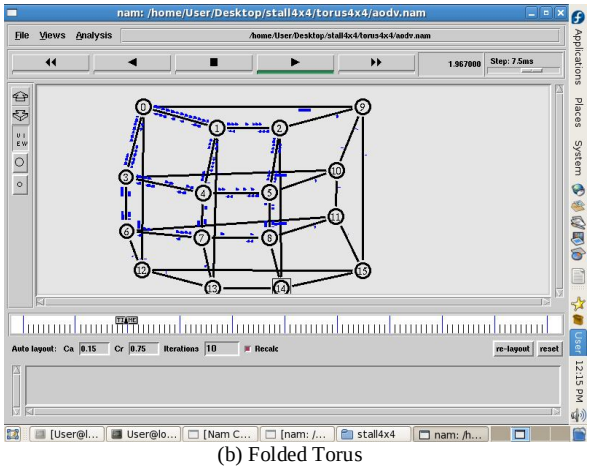


(c) Throughput

Figure3. Graph (a) Latency, (b) Packet delivery ratio, (c) Throughput



(a) CLICHE



(b) Folded Torus

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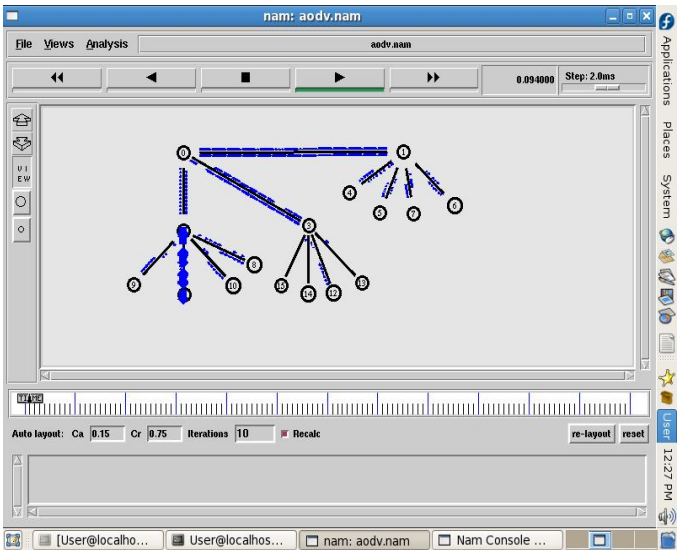
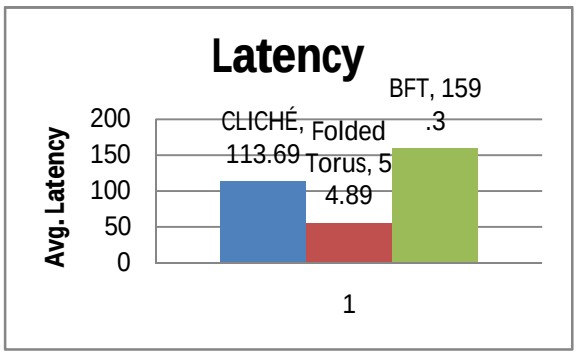


(c) BFT

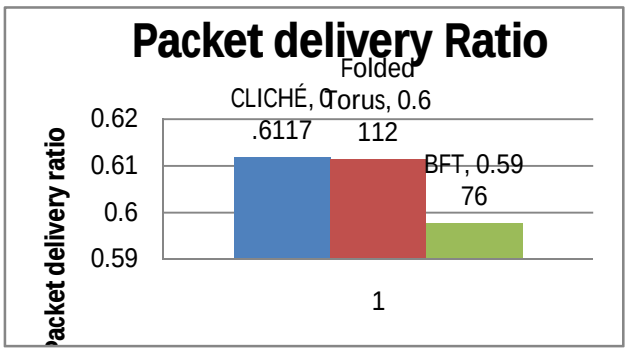
Figure 4.4x4 topologies (a) CLICHÉ, (b) Folded torus, (c) BFT

TABLE2.Performance evaluation parameter of 4x4 topologies

Topologies	Latency	Packet delivery ratio	Throughput
CLICHE	113.69ms	0.6117	174.78Mbps
Folded torus	54.89ms	0.6112	174.63Mbps
BFT	159.30ms	0.5976	170.75Mbps



(a) Latency



(b) Packet delivery ratio

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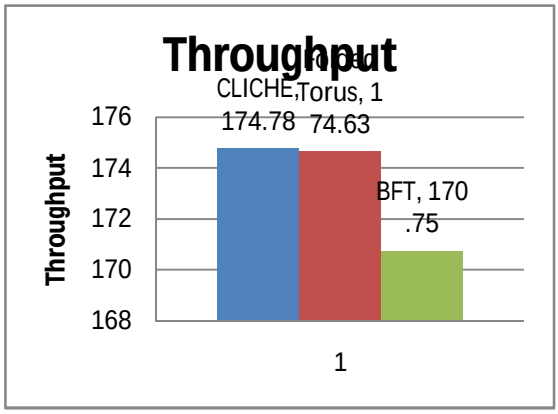
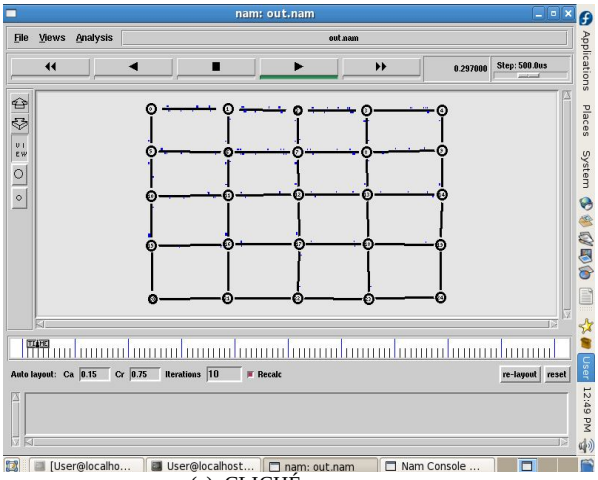
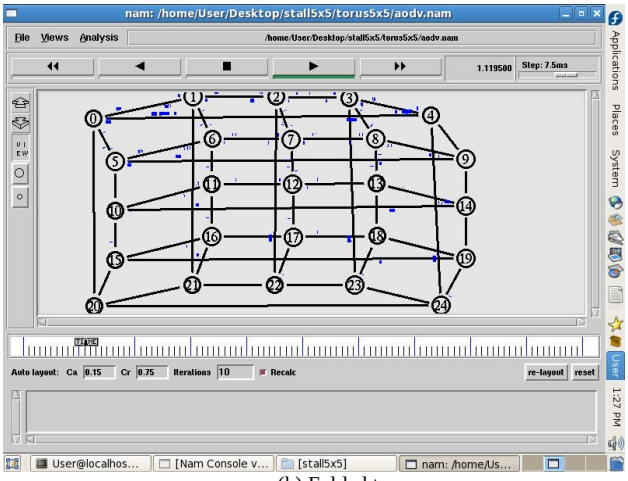


(c) Throughput

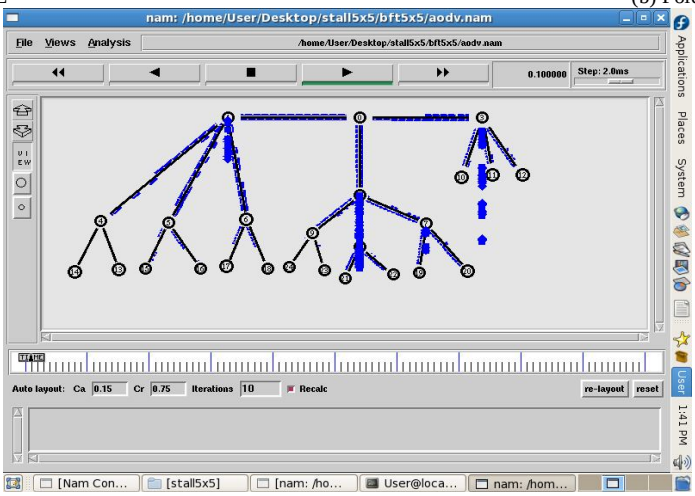
Figure 5. Graph (a) Latency, (b) Packet delivery ratio, (c) Throughput



(a) CLICHÉ



(b) Folded torus



(c) BFT

Figure 6. 5x5 topologies (a) CLICHÉ, (b) Folded torus, (c) BFT

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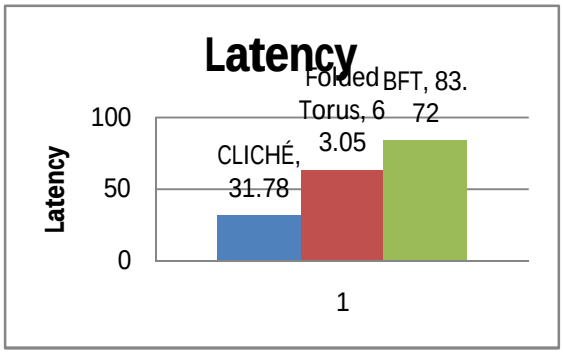
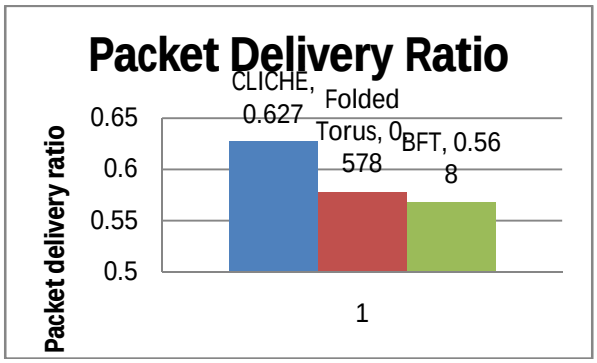
TABLE3.Performance evaluation parameter of 5x5 topologies

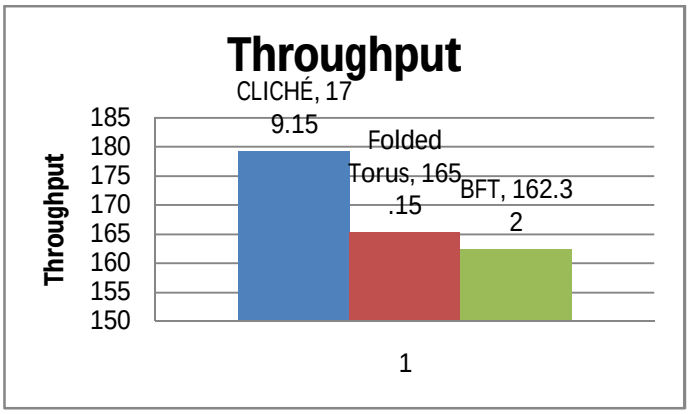
Topologies	Latency	Packet delivery ratio	Throughput
CLICHE	31.78ms	0.627	179.15Mbps
Folded torus	63.05ms	0.578	165.15Mbps
BFT	83.72ms	0.568	162.32Mbps



(a) Latency



(b) Packet delivery ratio



(c) Throughput

Figure 7. Graph (a) Latency, (b) Packet delivery ratio, (c) Throughput

TABLE4. Comparative performance evaluation for average values of parameter for 3x3,4x4,5x5 topologies

Topologies	Latency	Packet delivery ratio	Throughput
CLICHE	214.84ms	0.603	172.47Mbps
Folded torus	55.23ms	0.642	183.62Mbps
BFT	86.68ms	0.591	168.99Mbps

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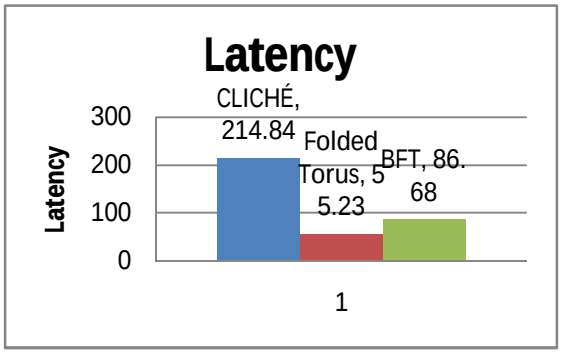
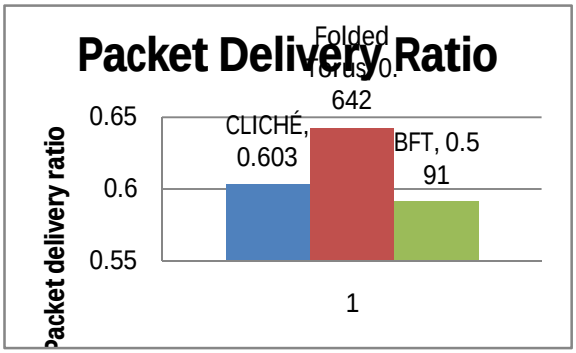
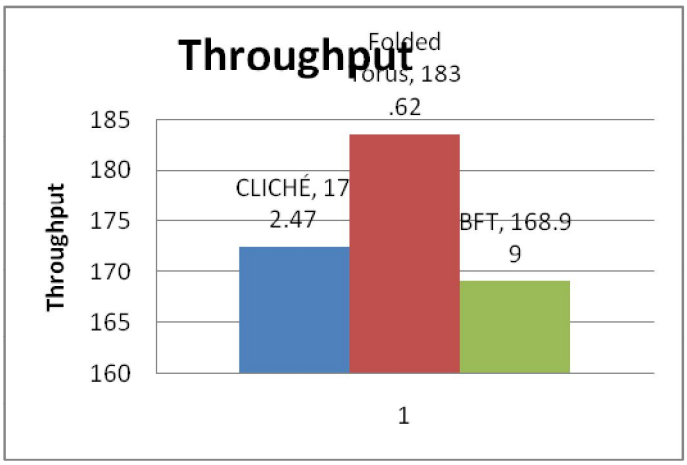


(a)Latency



(b) Packet delivery ratio



(c) Throughput

Figure 8. Graph (a) Latency, (b) Packet delivery ratio, (c) Throughput

VI.CONCLISION

Performance of CLICHE, Folded Torus, BFT topologies for various figure of merits (latency, throughput and packet delivery ratio) has been summarized. This comparison give interesting performance of parameters . The BFT has lowest Packet delivery ratio 0.591 and also has lowest throughput 168.99 Mbps. CLICHÉ has moderate throughput172.47Mbps and packet delivery ratio 0.603, higher latency 214.84ms and Folded Torus has lower latency 55.23ms and higher packet delivery ratio 0.642 and throughput183.62. From this result with the parameters the Folded torus is better topology than CLICHÉ and BFT.

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