Performance Evaluation & Simulation of Network Parameters for NOC Architecture Using NS2

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Abstract— **A typical NoC consists of computational processing elements (PEs), network interfaces (NIs), and routers. The NI is used to packetize data before using the router backbone to traverse the NoC. Each PE is attached to an NI which connects the PE to a local router. When a packet was sent from a source PE to a destination PE, the packet is forwarded hop by hop on the network via the decision made by each router .Performance of a NOC is evaluated by many parameter such as throughput, link load distribution number of hops, latency, packet drop probability etc.**

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. Only one distance vector routing used for different topologies. The work has not done with one routing for (CLICHE, Folded Torus and BFT) topologies. In this project we proposed link state routing and compares (CLICHE, Folded Torus, BFT) NoC architectures to evaluate their performance using a simulating tool NS-2.Simulation provides relationship among latency, throughput and packet drop probability for NoC architectures. Best one topology can be identifying by comparing various parameters.

***Keywords*- NoC, Topology, Latency, Throughput**

I. Introduction

System on chip utilized topologies based on shared buses. NoC is being considered as the most suitable candidates for implementing interconnection in core based soc design. In NOC paradigm, cores are connected to each other through a network of router and communicate among themselves through packet switched communication.

The main steps of a NoC design are architecture specification, traffic modeling, and performance evaluation. Performance of a NOC depends on many factors. Three main factors are topology, core selection and routing algorithm. Topology is very important feature in the design of NOC because design of a router depends on it.

Network topology refers to the organization of the shared router nodes and channels in an On chip network. The topology of a NoC can be compared to a roadmap. The channels (similar to roads) transport packets (similar to vehicles) from one router node (crossing) to another A good topology utilizes the features of the existing packaging technology to achieve required application bandwidth and latency. Choosing a network topology is the principal step in designing a network as the routing strategy and flow control methods are governed heavily by the topology. Deciding on a topology also helps in designing of the router to be used in the NoC, as clarified in The ways in which the different nodes in a network are connected and communicate with each other are controlled by the network topology. Some of the topologies for NoC are Mesh ,Folded Torus, and Butterfly Fat Tree (BFT), which are discussed below

The following are the list of popular NoC architectures: (i)CLICHE architecture, (ii)Folded torus architecture, (iii)butterfly fat tree architecture.

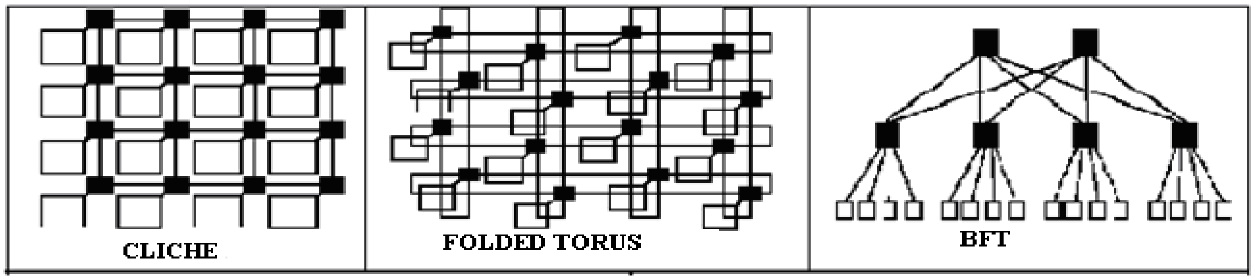
CLICHE: All switches are connected to the four closest switches and the target resource block, except those on the edge of the layout. The simplicity of such a mesh architectural layout allows for the division of the chip into processing or resource regions.[1]

Folded Torus: In torus architecture the long wrap around connection may result in excessive delay & this problem can be avoided by folding the torus.[2]

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.[3]

The choice of architecture has a large impact on performance. Performance of NoC is evaluated by many parameters such as throughput, link load distribution, number of hops, latency, packet drop probability, Fault tolerant, router area etc.

Latency is the average delay required to transfer a packet from source to destination. Throughput is the total number of packets reaching their destination per unit time. Packet drop is also used to evaluate performance of routing algorithm in NOC. It is defined as the probability of losing the packet in the network In this project we compare the performance parameters of topology networks and evaluation of these parameters using NS2 simulator



II. LITERATURE SURVEY

Wang Zhang, Ligang Hou, Lei Zuo, Zhenyu Peng, Wuchen Wu.have described 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 Kumar1have discussed two routing algorithms(Source routing and distributed routing) are used for 2 dimensional mesh topology. Evaluation results show that source routing gives higher latency and throughput performance as compared to corresponding distributed routing.[2]

Minghua Tangl, Chunhui have described a methodology based on divide conquer strategy to design routing algorithms for mesh NoC. they obtain 266 routings which outperform OE routing in transpose traffic. The plentiful routings increase the available research material of routing objects. The new routing algorithm can decrease the average packet delay up to 54.5% than the Odd-Even turn model.[3]

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]

III.SIMULATION ENVIRONMENT

In the research for design and evaluation of public domain computer network, to evaluate various design options for NOC architecture, including the design of router, communication protocol, routing algorithm Network Simulator2 (NS2) has been extensively used. NS2 provides also the routing strategies and the basic network transmission protocols, such as UDP and TCP, routing strategies (Static and Dynamic) and many mechanisms for modeling traffic generation. .For on chip network we can utilize the modified OSI model for the communication protocols between IPs.

NS-2 network simulator

NS-2 is an object-oriented, discrete event driven network simulator developed at UC Berkely and written in C++ and OTcl . NS-2 is a very common tool used for simulating local and wide area networks. It implements network protocols such as TCP and UPD; traffic source behavior such as FTP, Telnet, Web, CBR and VBR; router queue management mechanism such as Drop Tail, RED and CBQ; routing algorithms such as Dijkstra, and a lot more.

NS-2 also implements multicasting and some of the MAC layer protocols for LAN simulations. The simulator is open source, hence, allowing anyone and everyone to make changes to the existing code, besides adding new protocols and functionalities to it. This makes it very popular among the networking community which can easily evaluate the functionality of their new proposed and novel designs for network research. The simulator is developed in two languages: *C++ and OTcl*1. C++ is used for detailed implementations of protocols like TCP or any customized ones.

TCL scripting, on the other hand, is the front-end interpreter for NS-2 used for constructing commands and configuration interfaces. For example, if you want to develop a new routing protocol, you have to write it in C++ and add it into the NS-2 library. In order to check the functionality of this protocol, you use TCL scripting through which you can create the required topology, define parameters for links and nodes, and perform simulations to realize your own protocol in action. Besides above-mentioned functionality of NS-2, a Network AniMator (NAM) is also provided with NS-2 in order to visualize and interact with the system at run-time. Finally, graphs can be created from the produced results to evaluate and analyze the performance of the system.

Following evaluation parameters has been selected for performance evaluation of Network on Chip architectures
3.1. *Throughput*: It is the rate at which a network sends or receives data or amount of data that is transferred over a period of time. It is measure of the channel capacity of a communications link, and connections .
(Number of IP) x (Total Time) *TP* = (Total messages completed) x (Message Length) Where total messages completed refers to the number of whole messages that successfully arrive at their destination
IPs, Message length is measured in flits, Number of IP blocks is the total number of IP blocks present in the system, Total time is the time (in clock cycles) that elapses between the occurrence of the first message generation and the last message reception.
3.2. *Latency*: In a network latency is a synonym fort time delay along a path. 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 . Latency can be affected by interconnecting devices. it is fundamental measures of network performance. = Sender Overhead + Transport Latency + Receiver Overhead .
3.3. *Drop probability*: Drop Probability is the probability of number of packets dropped. A Drop Probability has 0 value means that a packet will never be dropped, and value 100 signifies that all packets will be dropped . The drop probability is very sensitive to communication load. As the communication load increases the drop probability or say number of dropped packet is also increases.

IV.OBSERVATION AND IDENTIFICATION:

Observation:
In the literature review it has been observed that different routing algorithms are discussed for different topologies(CLICHE, Folded torus, BFT).

1. CLICHE- XY routing, ODD-EVEN routing
2. Folded torus- distributed routing, e-cube(dimension) routing.
3. BFT- Turn around routing, least common ancestor (LCA).

The CLICHÉ (mesh) and Folded Torus has moderate value of all parameters, hence trade-off between latency, throughput and drop probability is needed. BFT also has lowest throughput.

Identification:
From literature it has been identified that the performance of NOC architecture for CLICHÉ, Folded Torus, BFT topologies has been evaluated by using various routing protocols. Hence there is a need to propose common routing protocol for all topologies of NOC architecture to check the performance efficiency of NOC architecture topology. We have proposed link state routing protocol for different NOC architecture topologies like CLICHÉ, Folded Torus, BFT.
We have identified CLICHÉ, Folded Torus & BFT NOC topologies for performance evaluation. Proposed link state routing algorithm for CLICHÉ, Folded Torus and BFT.

V.OBJECTIVES

To evaluate performance of link state routing algorithm. To reduce the packet drop probability, we use encryption decryption method.
To evaluate the performance the parameters like maximum throughput, minimum latency, maximum packet delivery and minimum packet drop probability of NOC architecture. To identify the best topology comparing three topologies with parameters latency, throughput and packet drop probability.
We will observe the effects of topological design choices on performance evaluation. We have Proposed encryption decryption method to reduce the packet drop probability (Due to noise or attack of the packet , more packets loss). We will Compare the following parameter of topologies (CLICHÉ, Folded Torus, BFT)

1)Latency

2)Throughput

3)Packet drop probability
The simulation will be done using Network Simulator NS-2, which is an open source simulation tool that runs on Linux or windows. We have proposed the link state routing algorithm & encryption decryption method which improve the performance.

VI.CONCLUSIONS

Investigation of performance of CLICHE, Folded Torus, BFT, topologies for various figure of merits (latency, throughput and packet drop probability) has been summarized. This comparison give interesting trade-offs. The BFT has lowest drop probability but also has lowest throughput. In CLICHÉ and Folded Torus has moderate value all parameters so here again a trade-off between latency, throughput and drop probability. If higher throughput and lower latency is a criterion, it is proposed to evaluate performance by using link state routing algorithm for all topologies(CLICH, Folded Torus, BFT).

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