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A Review on Comparison on Network on Chip(NOC) Using Simulation Tool NS2

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Abstract- In the world of advance technology, Network on Chip (NOC) is widely used as communication architecture. It supplies a high quality of integration of immense amount of storage on chip blocks as well as calculation. NOC have been developed in terms of power, performance, scalability and integration capacity and literature include many relevant studies of NOC proposals and contribution.

The main aim of this paper is to build a reliable study about the available design, simulation a implementation NOC tools. We assemble a significant amount of information and characteristics about NOC dedicated tools that we will extant throughout this paper. Topology plays a huge role in network for connecting computers.

"Topology" word comes from the Greek word Topos means "Place" and Logos mean "Study". Topology is intended for both tiny and huge networks. In this review paper, I will discuss about how the topology works, analyze and compare that different topology and calculate and compare the performance of the different topologies in wired network. Numerous studies has been done using NS2 and AWK script in order to analyze result which are evaluated for performance metrics like latency, bandwidth, throughput, end-to- end delay and many more. The effect of variations in bandwidth link, number of nodes on the network performance is analyzed over a wide range of their values. Different topologies have numerous advantages according to their application and presents brief ideas about different topologies depending on number of parameters. Best topology can be identified by comparing various parameters and result describes the network performance of different topology in the end.

Keywords -: NOC, AWK Script, Latency, Bandwidth, Different Topology, parameter, throughput, NS2 tool

INTRODUCTION

In the present world, an integration of different types of cores and accelerators into a working system is a major challenge. The design of such complex systems includes several challenges to be addressed. Among others, one challenge is to design an on-chip interconnection network that should be able to efficiently connect the IP cores. Another challenge is to derive such an application mapping that will make efficient use of the available hardware resources [2, 3]. The bottleneck has now been shifted from computation towards communication and in this way the future System-on-Chip (SoC) architectures are predicted to become a communication bound. Getting the right data at the right place at the right time has now become the need of hours. Dally and Towles (2001) proposed replacing dedicated, design specific wires with general purpose, (packet-switched) network, hence marking the beginning of network-on-chip (NoC) era. An architecture that is able to accommodate such a high number of cores, satisfying the need for communication and data transfers, is the NoC architecture [4, 5]. A NOC is a packet switched on chip interconnect. It is embodied by a set of routers that are connected to each other and the network endpoints by point to point links. Such network differs from larger scale networks because the channels are short and the data rate is very high. The performance of most digital system is limited by communication so technology improves, memory processors become small, fast and inexpensive. Thus, NoCs are a better answer to the both hardware and software integration challenges. NoCs facilitate a modular design approach which addresses the hardware challenges in designing such a system.

The most important step in design architecture of NOC is traffic modeling & performance evaluation of a NOC that depends on many factors. The three important factors in design architecture of NOC are topology, core selection & routing algorithm. Topology is the one of the most important feature in the design of NOC because of the design of router depends on it. The network topology dictates the number of router and channel and their connectivity. The routing function determines the path that a packet takes from source to destination. The flow control scheme determines when packets (or fixed size parts of packets called Flits) can be forwarded from one router to the next. Such vast number of NoC parameters are an inherent problem in design and comparison, for example, in defining the topology, switching and flow control policy, and routing algorithm. The design space, that is the number of possible combinations of parameter values, is way too large to allow a complete, brute-force exploration.

Good topology utilizes the feature of the existing packaging technology in order to achieve the required application like bandwidth and latency. Choosing an appropriate network topology is the basic step in designing a network as the flow controls and routing strategy methods is governed heavily by the topology. Selection of a topology also helps in designing of the router to be used in the NOC, as clarified in the ways in which different nodes in a network are connected and communicates with each other are controlled by the network topology.

Again the choice of architecture has a large impact on performance and performance of NOC is evaluated by many factors like throughput, number of hopes, latency, end-to-end packets, Probability of packets drop, fault tolerance and many more. Hence, advanced design methods and heuristics are needed to obtain a functional, preferably optimized system in finite time. No optimal NoC exists in the general case. However, benchmarking allows identifying the parameters that are most significant for certain application scenarios. This reduces the design space once the major characteristics of the system and its requirements are known. Naturally, the benchmarking must be done with care and by following strict scientific principles both in measurements and in reporting.

This paper concentrates purely on how NoCs are by examining the topologies and comparison between them based on their properties like throughput, packet delivery ratio (PDR), end-to- end delay, data packet loss, packet drop probability, latency, etc. with respect to several different scenarios like – by varying the number of nodes, varying the number of mobility of the nodes, varying the number of connecting nodes at a time and at a pause time. The comparison of a topology in NOC has been a significant area of focus for researchers as its structure is simpler and it can incorporate regular-sized processing elements easily. This study also identify the mainstream approaches, how NoCs are currently evaluated, and shows which aspects have been covered and those needing more research effort.

Objectives:

- To identify the best network topology by comparing topologies and analyzing NOC architecture parameters like throughput, latency, Packet delivery and packet drop probability and many more using network simulation tools like NS2.
- To identify the well- balanced network on chip by analyzing and evaluating the performance of various topologies of different networks in terms of network metrics.
- To design and implement a well-balanced network-on-chip with best topology.

LITERATURE REVIEW

Nickra et al. (2005) introduced an algorithm based on genetic algorithm for optimizing power consumption and delay of applications which are mapped on fat tree topology. Algorithm consists of Vertex mapping to PEs, Node mapping and Delay optimization. These steps map task graphs into a fat-tree NOC how had been minimum power consumption. The proposed algorithm could be applied to various derivatives of fat-tree topology and could be extended with achieving to more accurate model for power.

Elmiligi et al. (2009) proposed a topology-based model to calculate the average NoC delay, which is caused by links and routers. The proposed model could be used to select the optimal topology that achieves the minimum network delay for a given NoC application. They also presented a case study to show how this model could be used to improve the delay of a given NoC application at early design phases.

Gehlot and Chouhan (2009) compared different five topologies using distance vector routing algorithm. The Spin and Octagon provided higher throughput and lower latency but it also had higher drop probability. Butterfly Tree had lowest drop probability as well as lowest throughput. Mesh and Folded torus had moderate value for all parameter.

Mahmoud et al. (2009) described the spidergon topology and analyzed the traffic in the architecture. They presented a model to compute the mean message latency in the spidergon architecture employing wormhole switching. An application of extensive simulation experiments showed that the analytical model predicted the message latency with a good degree of accuracy in a wide range of traffic rates. In particular the model well predicts the saturation points in the networks with different configurations. Further they are extending study to analytically compare the spidergon NoC with other topologies in the domain including mesh and torus.

Mubeen and Kumar (2010) described 2 routing algorithms i.e (Source routing and Distributed routing) used for 2D mesh topology. Their result showed that the source routing gave higher latency and throughput performance compared to the corresponding distributed routing.

Zhang et al. (2010) discussed the performance of NOC that was evaluated based on latency and throughput per channel under Constant Bit Rate (CBR) and Bursty Traffic. 2D Mesh topology was used to design the architecture with Odd-Even(OE) routing algorithm. The simulation result of the proposed model achieved balanced performance of latency & throughput under Constant Bit Rate and Bursty Traffic

Arora and Rajkumar (2012) analyzed the packet loss during the link down in mesh interconnection network topology with source routing using simulation. They also analyzed the 2D mesh topology performance on the one down link for 1 seconds and changed two parameters packet size and time interval and found that ratio of packet loss on CBR traffic generator over User Datagram Protocol (UDP) agents was constant.

JieCen et al.(2012) discussed a simulation framework for mesh interconnection network, in which the packet loss during the link down was analyzed. Analysis and evaluation were done on mesh interconnection networks on different traffic patterns using simulation on NS2.

Tangl and Chunhui (2012) described methodology based on divide and conquer strategy to design routing algorithm for mesh NOC. They observed that this new routing algorithm could degrade the average packet delay upto 54.5% than the Odd-Even model.

Umamaheswari et al.(2011) described about the comparative analysis of the performance measure of irregular application specific network against the regular topological structure by focusing on throughput and energy consumption.

Bhople and Gaikwad (2013) presented different topologies and compare them using delay parameters.

MATERIAL AND METHODS

This section discusses parameters and methodologies used for analyzing and comparing the different topologies for building the well balanced NOC utilizing the best topology. Following parameters of the different topologies are to be considered for assessing the performance of the topologies and comparing between them.

Parameters for evaluating topology

1. Average end-to-end delay (AED)

AED means that the average time taken by the packets to pass through the network. This is the time from the generation of the packet by the sender upto their reception at the destinations and is expressed in seconds. It is measured in milliseceonds.

$$\boldsymbol{AED} = \frac{\sum_{i=0}^{n}(time\ of\ received\ packet - time\ of\ sent\ packet\ )}{total\ \ no.of\ received\ data\ packets}$$

A higher value of end-to-end delay means that the network is congested and if the lower end-to-end delay better then the application performance.

2. Packet Delivery Ratio (PDR)

PDR is the ratio of total number of packets received by the destination nodes to the number of packets sent by the source nodes by CBR. It is also called Packet Delivery Fraction. It represents how reliable the communication is. A high Packet delivery ratio indicates the most of the packets are being delivered to the higher network.

$$\boldsymbol{PDF}\ \% = \frac{\Sigma\ no.of\ data\ packets\ received}{\Sigma\ no.of\ data\ packets\ send} x\ 100$$

3. Throughput

It represents the average rate of packet deliver per unit time over a communication channel and expressed in bits seconds. Factors that influence throughput is that topology changes, unreliable communication, limited bandwidth and limited energy.

$$\boldsymbol{Throughput} = \frac{\Sigma\ Received\ data\ packets}{transmition\ time}$$

4. Data Packet Loss / Data Dropped

It is defined as the difference between the number of packets send by the source and packets received by the sink. Lower the packet loss better the performance of the protocol.

$$\boldsymbol{NRL} = \frac{\Sigma\ routing\ \ packets\ send}{\Sigma\ \ data\ packets\ \ received}$$

In two cases a packet is dropped-:

a. Buffer is full when the packet is needs to be buffered.

b. Time that the packet has been buffered exceeds the limit

5. Routing overhead

It is the number of routing packets required for network communication

Routing Overhead = RoutingPacketsCount

Simulation program for designing of simulation model

In order to design the simulation model to identify the best topology and implement the best topology for the design of the well balanced network on chip, a simulation study of the parameters would be done using the network simulator program NS-2. NS-2 is a well chosen simulation tool among the others simulation tools, which is highly preferred by research and educational communities. Ns-2 is quite suitable for designing new protocols, comparing different protocols and traffic evaluations. It is distributed freely and open source. A large amount of institutes and people in the development and research use NS-2 for marinating and developing network. Versions of NS-2 are available for Linux, Windows, Mac OS X. NS-2 also provides substantial support for simulation of TCP, UDP, routing and multicast protocols over wired and wireless networks.

The simulation in NS-2 accepts a scenario file as input that describes the exact motion of each node and the exact packets originated by each node, together with the exact time at which each change in motion or packet origination is to occur. The detailed trace file created by each run is stored to disk, and analyzed using a variety of scripts, particularly one called file *.tr that counts the number of packets successfully delivered and the length of the paths taken by the packets, as well as additional information about the internal functioning of each scripts executed. This data is further analyzed with AWK file and Microsoft Excel to produce the graphs.

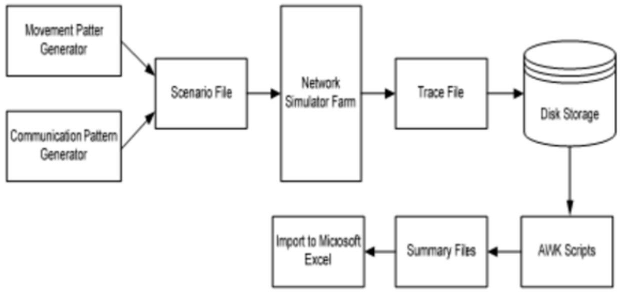

Fig:1 Logical view of the simulation process

Expected outcome

1. The best evaluated topology obtained after analyzing the network metrics
2. A well balanced optimized NOC architecture designed using the best topology

CONCLUSIONS

In order to meet the complex specifications presented by modern sophisticated networks, network simulation provides a reliable alternative to calculate the performance of a given wired network. The NS2, which is a open source simulation software predicts the behavior of a wired network which is wide spread over a range of kilometers. NS2 checks the functioning of any given network virtually and presents the performance characteristics of the network, which is a better alternative to tedious calculation of performance characteristics such as throughput, end to end delay and average number of packets received at each node.

In the project, It has been designed a node with wired network with TCL script as front end to the simulator. The TCL script uses compiled C++ hierarchy to achieve efficiency in simulation and faster execution time.After defining the topology using tool command language, agents such as FTP over TCP and CBR over UDP are attached to the respective nodes of the network. The traffic flow between the nodes allows us to calculate the performance of the network.

Investigation of performance of Mesh,Star, Ring and Torus topologies for various figure of merits (latency, throughput and packet drop probability) has been summarized. The Mesh has lowest drop probability but also has lowest throughput. But 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 (Mesh, Ring, Star and Torus).

Link bandwidth and nodes are varying factors respectively. Packet delivery ratio is much better in TCP than of UDP. In case of link band width, TCP shows better link throughput than that of UDP.

Depending on application requirement one has to decide the suitable protocols. This study can be extended for other traffic generators namely exponential On/Off, Pareto On/Off and Traffic Trace. More over experiment can be carried out for wireless networks as a future work.

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