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Simulation and Analysis of Packet loss in Mesh Interconnection Network with Source Routing

Lalit Kishore Arora*
Assistant Professor,
Ajay Kumar Garg Engg College, Ghaziabad, UP.
l_k_a2000@yahoo.com

Rajkumar
Assistant Professor,
Gurukul Kangri University, Haridwar, UK.
rajbhatiagkv@gmail.com

Abstract— **To evaluate the interconnection topology, data loss is the measure performance parameter. This paper analyze the packet loss during the fault in mesh interconnection network topology with source routing using network simulator NS2. The designed framework considers two parameters packet size and packet generation interval to evaluate the performance of mesh interconnection topology. The mesh simulation network uses both with and without acknowledgement transmissions. The results describe the network performance of mesh in the end.**

Keywords— **Mesh Topology, Torus topology, interconnection networks, source routing.**

I. Introduction

Meshes and torus based interconnection networks have been utilized extensively in the design of parallel computers in recent years. Computer architects have always strived to increase the performance of their computer architectures. High performance may come from fast dense circuitry, packaging technology, and parallelism. As the density of processor package increases; the length of the link connecting a certain number of processors decreases [1].

Although numerous studies have examined NoC implementation and performance, few have examined packet loss. Flow control in interconnection networks has mainly been an issue to prevent buffer overflow and packet loss. Packet loss occurs when one or more packets of data traveling across a network fail to reach their destination. Packet loss can be caused by a number of factors including buffer overflow, congestion, corrupted packets rejected in-transit, faulty link, faulty nodes or deadlocks. In addition to this, packet loss probability is also affected by down of links and distances between the transmitter and receiver [18].

In this paper, 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.

The remainder of this paper is organized as follows. In section II, related literatures are discussed. Section III, describes the system model of mesh interconnection network, which implemented and designed in NS2 and section IV, evaluate the performance and shows the results of simulation. Finally some conclusion has been drawn in section V .

II. Related Work (Motivation)

The numerous studies have done related to simulation on Mesh topologies. Recently, the NoC has been introduced as a new research area that emphasis on modeling and analyzing the on-chip interconnect. Sophisticated networks that have specialized switches and routers and defined topologies are the main NoC points for analysis and optimization[17]. Recently, NoC architectures

have been surveyed and compared for different performance metrics. In the paper [11], a simulation-based approach using the NS-2 simulator was used to analyze a NoC mesh interconnect topology. It is based on the Chiplevel Integration of communicating Heterogeneous Element [12].

NS-2 is used to construct the topology and generate different traffic scenarios using an exponential traffic generator [18]. Packets are sent at a fixed rate during ON periods, and no packets are sent during OFF periods. Using this traffic generator, common network performance metrics such as drop probability, packet delay, throughput and communication load are analyzed against different buffer sizes and traffic injection rates [18].

Another paper [13], about the Mesh NoC has been presented, it is similar to [11] but with different results. Metrics such as latency and packet loss rate were presented as a function of the communication load and the buffer size, using the NS-2 simulator. In [14] authors compared the Ring, Irregular Mesh and Spidergon topologies using a discrete-driven simulator (OMNET++) based on the wormhole switching technique. Their analysis has shown that the Spidergon NoC outperforms others, including average latency and throughput. The type of traffic has not been mentioned despite of its prime importance in NoC. In [15], an

Application Specific NoC (ASNoC) design methodology was proposed, that is, using a customized topology to fit the requirements of specific applications. In that work, the OPNET simulator is used to compare the proposed structure with a Mesh topology, using a HDTV decoder SoC as application example. An analytical model using queuing theory is introduced in [16] to evaluate the traffic behavior of the Spidergon NoC. Simulations to verify the model for message latency under different traffic rates and variable message lengths are presented in that work.

III. SYSTEM MODEL

The simulation interconnection architecture model consists of m × n mesh of switches. Switches consists a slot for a resource. A resource may be a processor core, a memory block, an FPGA, a custom hardware block or any other peripheral devices, which fits into the available slot and compiles with the interface with the network. We assume switches in network have buffers to manage data traffic. Figure-1 shows the architecture of simulation model with 16 nodes where connection of switches (S) and resources (R) are shown.

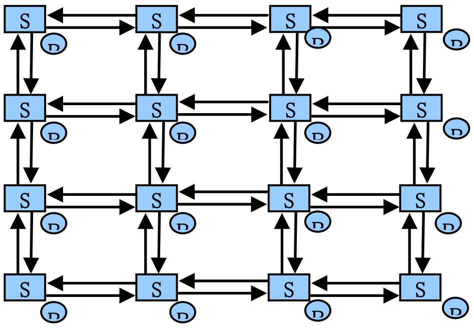

Figure-1 4 x 4 Mesh Architecture

A. Topology

A 4 x 4 two-dimensional mesh topology was modeled and simulated using network simulator NS2. This topology is easily scaled to different sizes. Different resources have their unique communication addresses, so here assumed that all switches has attached processor core as resources therefore treated similarly except that a traffic generator can be attached to resources. Switch, resource and link are three basic elements in the topology. Assume that the each resources has infinite buffer size but finite in switches. It means that the packet being dropped or lost cannot occur in resources but only take place in switches.

B. Communication Links

An inter-communication path between the switches is composed of links. Each node is connected with point-to-point bidirectional links. The bandwidth and latency of the link is configurable. When any link down between two nodes it implies that the packet cannot be travel between these nodes in any direction. This assumption was used in [10] and is realistic, because bidirectional links are actually implemented by using a single wire.

C. Routing

An inter-communication path is composed of set of links identified by the routing strategy. This simulator models a 16-node 2-D mesh (4x4) in which routing decision will be takes at source node using source routing methodology. A shortest communication path have been selected for each traffic pair before a simulation starts.

IV. PERFORMANCE EVALUATION

To evaluate the performance of the mesh interconnection networks, a simulation model has been developed in NS2 with only built-in options. Tcl is used for specifying the Mesh interconnection network simulation model and running the simulation. The existing routing algorithm to compute the path and for packet generation is used.

The implementation of mesh interconnection networks uses the source routing to send packets from source node to destination node. In source routing the information about the whole path from the source to the destination is pre-computed and provided in packet header [3][4][5].

A. Simulation Environment

For the evaluation, a detailed event-driven simulator has been developed. This simulator models a 16-node 2-D mesh (4x4) in which routing decision will be takes at source node using source routing methodology. Each node is connected with point-to-point bidirectional serial links. The bandwidth of link is set to 1 Mb and latency/delay is set to the 10 ms. All these topology parameters can be describe as a script file in Tcl, as shown below:

```
  #Default Values for topology
  set n 16;  # Total number of nodes
  set max_bw 1Mb;# maximum link band width
  set linkDelay 10ms; # delay on each link
  #configuration for links
  $ns  duplex-link  $n($i)  $n([expr  ($i+1)])
$max_bw $linkDelay DropTail
```

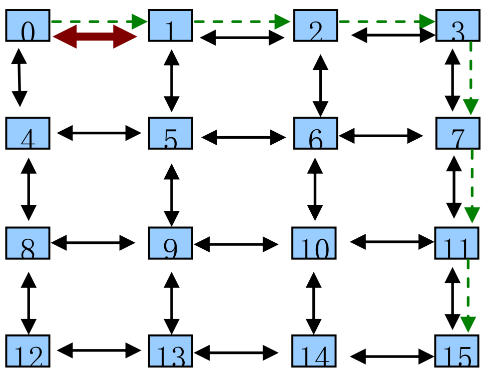

Figure-2: Mesh Simulation Environment

In simulator also fixed the source-destination pairs (node(0)-node(15)) and link for down (node(0)-node(1)) are fixed, Figure-2. The time of simulation window is fixed by 5.0 seconds and time of link down and link up is 1.0 and 2.0 second after the starting the simulation respectively. Assume that when link is down, this link can not be used in any of its directions. This assumption was used in [10] and is realistic, because bidirectional links are actually implemented by using a single wire.

Scenario-1 Packet generation with different intervals and fixed packet size

In this experiment, the packet size is of 500 bytes and interval of traffic generation is varying but the packets are generated from source in uniform rate. Here source node not received any acknowledgement by the destination node for receiving the packets.

Scenario-2 Packet generation with different intervals and fixed packet size with acknowledgement

The acknowledgement plays a major role therefore this experiment added the acknowledgement mechanism for transmission in the scenario-1. Both the packet size and interval of traffic generation is same as scenario-1 where packets are generated by source using uniform traffic rate.

Scenario-3 Packet generation with different packet size and fixed interval

In this scenario instead of fixing packet size interval of traffic generation is fixed by 0.250 sec and the size of packet to be travel from source to destination node is varying. This experiment is not uses acknowledgement mechanism therefore no need of acknowledgements.

Scenario-4 Packet generation with different packet size and fixed interval with acknowledgement

Again emphasizing on the acknowledgement, this experiment added the acknowledgement mechanism for transmission in the scenario-3 and fixed the interval of traffic generation by 0.250 sec with uniform traffic and varying the size of packets to be travel from source to destination node. Now the source node received acknowledgements for all received packets by the destination node.

B. Simulation Results

In the first scenario due to decrement of interval for packet generation increases the rate of generation of packets as shown in Figure-3. According to increase of packet generation also increases the packet loss but the ratio of packet loss is fixed, which is 25% of the packet generation by the source.

In the second scenario after changing the traffic agent which works on acknowledgement and remain parameters are same. Like above experiment, decrement of interval for packet generation increases the rate of generation of the packets. But the result shows that packet loss in this scenario is zero, it means the source node never sends any packet without receiving the acknowledgement of previous sent packet.

In the third scenario, the packet generation interval fixed by 0.250 sec and the packet size varying its length. Due to the decrement of packet size the number of packet is also decreases. According to decrease of packet size also decreases the packet loss but the ratio of packet loss is fixed, which is 25%, Figure-4.

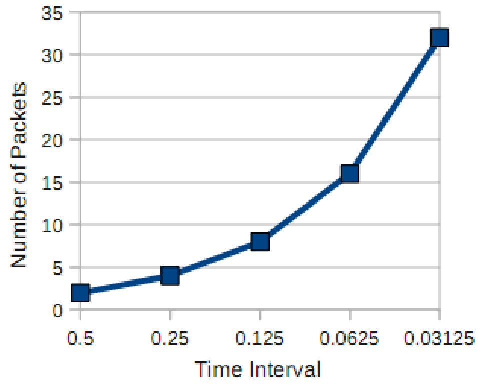

Figure-3: Result of scenario-1

In the last experiment we changed the traffic agent works on the acknowledgement and remaining parameters are same. Like above experiment, decrement of packet size also decreases the rate of generation of the packets. But the result shows that packet loss in this scenario is zero like scenario-2, it means the source node never sends any packet without receiving the acknowledgement of previous sent packet.

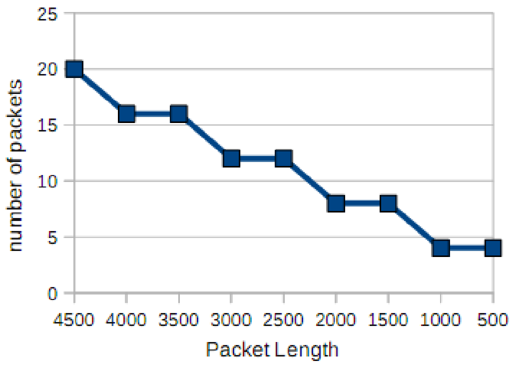

Figure-4: Result of scenario-3

V. Conclusion & Future Scope

In this paper, the 2D Mesh topology performance on the one down link for one second is analyzed, and changed two parameters packet size and time interval and found that the ratio of packet loss is constant in those cases where traffic generator uses acknowledgement mechanism.

But on the other hand when acknowledgement mechanism is added then found that the packet loss is gone in the both cases. Therefore the mesh network with the traffic agent which uses acknowledgement mechanism is more reliable. But the delay of transmission due to the link down will be occur.

In the next step we are going the analyze the packet loss on the case of more than one parallel communication at same time, which following the path with some common nodes. And also we are trying to implement these concept to torus interconnection networks.

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