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Performance Analysis of Clustering-Based Topology Generation and disable nodes for NoC

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***Abstract*—** Network-on-Chips (NoCs) are rapid promising for an on-chip alternative designed in support of many-core System-on-Chips (SoCs). In spite of this, developing an increased overall performance low latency Network on chips using low power overhead has always been a new challenge. Network on Chips (NoCs) by using mesh and torus interconnection topology have become widely used because of the easy construction. A torus structure is nearly the same as the mesh structure, however, has very slighter diameter. The performance of topology can be analyzed based on power and latency; the power consumption and the latency in Network-on-Chip (NoC) are two challenging objectives. In this paper, we proposed on Clustering-Based Topology Generation and disable nodes to construct routers a torus based clustered topology methods for power saving and performances aware on NoC. Experimental results show that the approach saves proposed method consume less power consumption on average in comparison with using torus topology and achieves significant topology performance improvement.

***Keywords*—** NoCs, Cluster, topology generation, disable notes, Routers.

I. INTRODUCTION

Network on Chip (NoC) is realized through the use of Torus structure [1]. They recommended a routing algorithm, router design as well as given solution to the challenge offered from the long wire connection within torus structure through pipe-lining both the long and short wire connection by increase the input buffers connected to the long wires. Because of the fact, gate delays will be scale down along with technology. Large-scale wire delays usually rise tremendously, linearly by including repeaters [3]. The delay may possibly meet or exceed restriction of a clock cycle or repeatedly, a number of clock cycles, in spite of repeater insertion. For ultra deep submicron methods, 75% or a lot of delay with crucial paths may be due to interconnects [4]. Nowadays, Networks on Chip are considered to be a scalable alterative used for on chip communication. Here, the past few decades Network on Chip has appeared like a developing and essential research field.

In Network on Chip, have been proposed to address the several researchers work on topology generation within reasonable time [5],[9],[10], and routing algorithm to improves the performance[8][9]. Mesh and torus are the most commonly used topology. The connection of nodes in the torus is a combination of mesh and regular ring topologies. Torus topology considered as the enlargement of mesh topology. The end nodes in the single column or in the single row are connected to each other directly in torus topology. The number of hop count is reducing in torus compared to mesh topology. The total power in NoC is going to increase with increasing core counts. Therefore, we proposed Clustering-Based Topology Generation using clustering based and disable nodes to construct routers a torus based clustered topology methods for power saving and performances aware. Clustering is dividing the nodes in the network into a different group according to the certain principle. For each group, a node is choosing as a header node which is responsible for the communication between clusters. Internal communication of a cluster is completed within its cluster.

The rest of the paper is organized as follows: section II describes the related work; section III presents methodology our topology generation approach with an example; experimental results are discussed in section IV, and finally the conclusion is made in section V.

II. RELATED WORK

Recently, network-on-chip (NoC) research has focused on the various aspects of on-chip networks, including topology [3], routing algorithms [4, 5], flow control techniques [6], and router architecture [7]. The disable nodes and routers

based on mesh based clustering methods are proposed [8]. This method has reduced the total area and total power consumption. However, in the previous work does not consider latency and throughput as a design objective simultaneously. Comparison of clustered and without cluster topology and introduce a traffic simulation for inter-NoC is done in [9]. The result shows the energy consumption is 50% lower compared to non-clustered cases. An efficient router with low power and low latency for NoC is proposed [10]. To reduce the latency, a wireless link is used between router for communication and a novel router is designed to reduce the total power consumption. The performance parameter is improved by proposed a minimum buffer router to reduce the total area and using the concept of marching memory to save the total power consumption [11].

III. METHODOLOGY

A. Topology Generation Approach

The main idea of our proposed approach is to assign high communicative cores to the same routers or nearby routers, and subsequently, determine the optimal connection between routers. The goal is to minimize the total communication hops for communication IP core pairs, as well as to reduce the number of used routers and links in the NoC topology.

Core clustering,

- **Algorithm Preparation-**the maximum number of cores in each cluster. Since IP cores in the same cluster will be mapped to different ports of the same router in a topology, and each router must be connected to the topology on at least one port. Then, we sort each communication trace ai,j in descending order according to the communication weight b(ai,j).
- **Clusters Initialization**-Clustering is to partition vertices of CCG(C, A) into k non-empty sets C1, C2, ..., Ck. Each cluster Ci (i = 1, 2 , ..., k) contains Nmax cores at most. In the initialization, each vertex of CCG(C, A) forms a cluster partition, that is CP={C1, C2, ..., Cn}, where Ci = {ci}, i = 1, 2 , ..., N, N is the number of vertices of CCG.
- **Clusters Merging-**According to the order of communication traces in step 1, we first process the edge ai,j with highest communication weight. Let ai,j=(ci, cj), if ci and cj belong to different clusters, and the core number in the new cluster is not greater than maxmum no.core after merging, then calculate the inter-cluster communication amount among clusters after merging. If the calculated amount is less than that of the previous, merge the clusters, otherwise not.
- **Results Output**-When all the edges have been processed in sequence, we can get the best number of clusters with minimum inter-cluster communication amount.

For example, we give a core communication graph (CCG) in Fig. 1a, and the labels of the edges in CCG denote the bandwidth requirement. Assuming the number of router port η is 4, each partitioned cluster contains Nmax =4-1=3 cores at most. According to the above clustering algorithm , the CCG can be divided into four clusters C1, C2, C3, C4, as shown in Fig. 1b.).

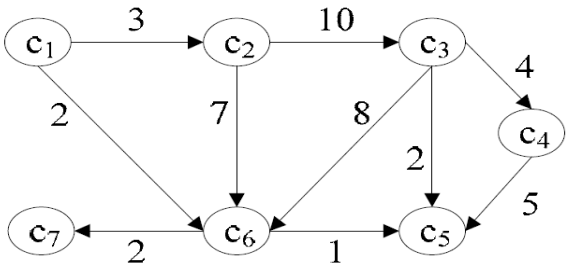


Fig.1a Core communication graph

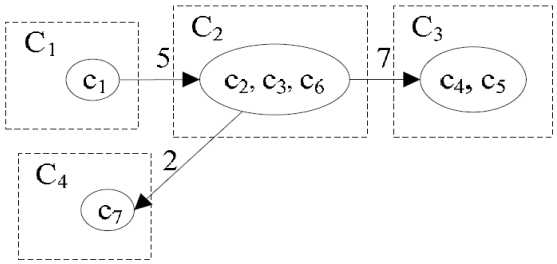
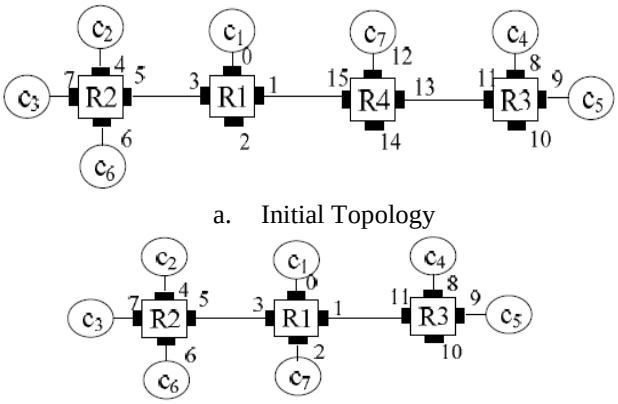


Fig.b Clustering result

Cluster and Router Mapping

Cluster and router map each cluster to a router. The router number used in the generated topology is equal to the number of clusters. Every IP core in the cluster is mapped to a port of a router randomly. For the core clustering results shown in Fig. 1b, the clusters need to be mapped to four routers, denoted by r1, r2, r3, r4 respectively. As shown in Fig. 2, the core c1 in the cluster C1 is mapped to port 0 in the router r1, and the cores in the cluster C2 are mapped to three ports in the router r2.



a. Initial Topology

b. Final Topology

Fig.2 Cluster and router mapping

Router Connection Construction

The routers mapped with IP cores are connected to form the initial topology. We sort the clusters in ascending order according to their number of cores. If the number of cores is the same, we sort them in descending order according to their communication amount. Then, we use a recursion based link construction algorithm to generate router connections.

B. Torus Based Clustered Topologies

Torus based clustered and disable cores and routers based on clustered topologies. The four steps to form a cluster of 16 nodes torus topology are:

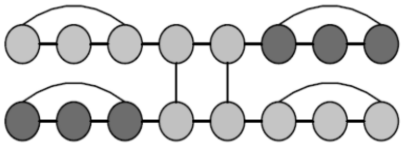
- The number of nodes in each cluster is equal. The following formula is used to determine the number of the cluster in torus topology. Number of cluster (n) is accepted as a number of cluster when no remainder from the following equation.
- Minimum one or more nodes is connected to the header cluster.
- Each header of clusters will be connected together form a torus topology.
- In each cluster, the edge of router is connected to another edge of router. When the number of hop count in each group is > 2.

C. Disable Cores and Routers in Torus Based Clustered Topologies

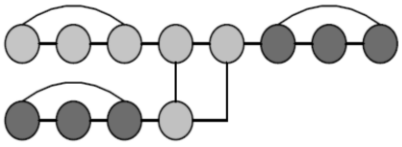
This paper proposed a disable nodes based on torus clustering method. The steps to disable a cluster are:

- Number of the clustered header is more than two
- Disable minimum one group of the cluster at each time.
- Limit Number of Disable Cluster = Number of Cluster Header – 2 Figure 2 shows the clustered header 4 torus topology and disable mode based on clustering method in clustered header 4 torus topology.
- The maximum number of disabling clustered in clustered header 4 topology is:

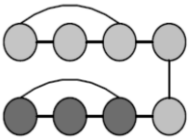
Maximum Number of Disable Clustered = 4 – 2 = 2 Cluster.



16 Nodes Torus Cluster Header 4



16 Nodes Torus Cluster Header 4 Disable 1 Group



16 odes Torus Cluster Header 4 Disable 2 Group

D. NoC Router Architecture

A Torus network can be a better model of essential mesh network. For torus structure is mostly a mesh structure wherein, the heads in the columns will be linked to the tail from the columns as well as the left sides used for the rows are linked to the right sides of the rows. The path selection for torus network is preferable to the mesh network, and in addition it provides minimum number of routers. From a mesh network all the hop count and also latency improves around linearly using on chip distance. At some level this is correct with torus networks, although a result of the cyclic design of the route structures, devices based adjacently on chip is often several hops separate along the network. It is unwanted in fact, however is traded off from minimized hop counts for medium distance communication.

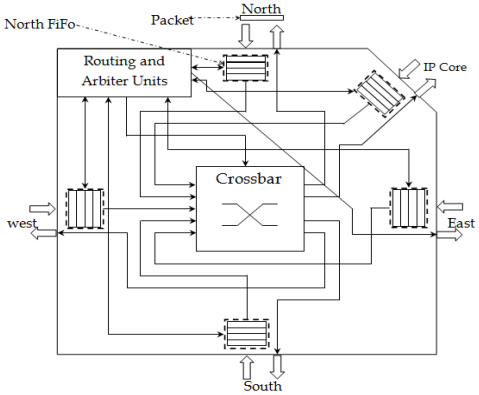


Fig.3 NoC Router Architecture

The router design plays an important role to decide the performance of NoC systems [1]. The structure of routers in a NoC depends on the network topology. In a topology router is composed of: buffers, crossbar, routing and arbiter units organized as in Fig.3 Generally, the router is consists of five bidirectional ports (North, South, East, West and Local), each input port have a FIFO buffer connected to the crossbar and the routing and arbiter units. The buffers are for storing the packets transmitted in the network. The role of crossbar is to connect input ports to output ports. A Routing and arbiter unit which ensures the switching function and manages conflict situations.

IV. EXPERIMENTAL RESULTS

In order to evaluate the total number of nodes and link. The number of link is reduced by applying clustering method in torus topology. Disable nodes in torus based clustering reduced the total number of nodes and link in torus topology.

Table 1. Number of Nodes and Links

Number of Nodes and Links		
16 Nodes Torus Topology	***No.of Nodes***	***No.of Links***
Cluster Header 4 Disable 1 Group	***12***	***15***
Cluster Header 4 Disable2 Group	8	9
Cluster Header 8 Disable6 Group	4	3

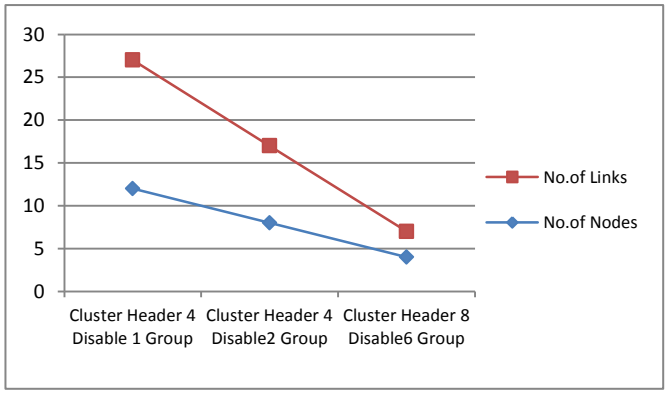


Fig.4 Number of Nodes and Links for 16 Nodes Torus and Clustered Torus Topology

V. CONCLUSION

In this paper, Clustering-Based routing algorithm and disable nodes have been discussed for NoC architectures. A new logical approach Clustering-Based routing algorithm and disable nodes to construct routers a torus based clustered topology called for NoC is introduced. It is based on a combination between the link state algorithm and the clustering based disable notes techniques. Our approach provides the minimization energy consumption, reduce the communication time between nodes, reduce the detection time and reporting failures in links and / or routers, optimizes the resources use and the routing is more efficient. The experiment analysis shows that the clustered and disable nodes based on clustering methods save the power and improve the performance.

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