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C^2Torus new interconnection network topology based on 2D torus

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Abstract: Mesh and Torus are most popular interconnection topologies based on 2D-mesh. Comparison between Mesh and Torus will be considered and new interconnection topology will be proposed to provide better performance. The C^2Mesh is an enhanced mesh interconnected network. This paper enhances the Performance of torus network based on the theme of C^2Mesh. Topological Properties of new network will be analyzed and implemented by simulation. The new routing Algorithm will be designed for new proposed network (C^2Torus).

Keywords: Mesh, Torus, Interconnection Networks, Routing

1. Introduction

A torus interconnected is a network topology for connecting processing nodes in a parallel computer system. It can be visualized as a mesh interconnected with nodes arranged in a rectilinear array of N=2, 3 or more dimension with processors connected to their neighbors, and corresponding processor on opposite edges of the array connected [1]. Torus and Mesh topologies are also found in more commercial architecture, like the Alpha 21364 (two-dimensional Torus), that are targeted at application domains such as database servers, web servers, and telecommunication [2].

Torus network are frequently utilized on top-performing supercomputers.

The paper is organized in 6sections: Section 1: Introduction, Section-2: Related work Section-3: Proposed network topology and its topological properties. Section-4: Routing algorithm for C^2torus. Section-5: Result Section-6: Conclusion.

2. Related Work

Torus network has a ring connection along each row & each column. A torus interconnected is a network topology for connecting processing nodes in a parallel computer system.

Mesh network is a simple network for the general purpose applications. But as the size of the Mesh increases, the network performance degrades dramatically due to the large network diameter and little bisection width [3].

The DMesh and DTorus networks are proposed in [4] to promote the performance and scalability of the both Mesh and Torus network. To satisfy the special need of the NoC, a Mesh-like Topology named XMesh, and its routing algorithm called XM are presented in [5].

The SD-Torus network [6] is a regular and symmetrical interconnection network.

3. C^2Torus Networks

C^2 Torus is Centre Connected Torus that is centrally connected torus with extra four links. In Torus, all corners nodes are connected in a Centre nodes i.e. C^2Torus.

Torus requires 2n edges in nxn matrices. C^2Torus requires 4 extra links in Torus, i.e. form any size of C^2Torus.

3.1. Definition (C^2Torus)

C^2Torus network are enhanced of Torus network, four corner nodes are connected to a center nodes of mesh which have degree 4.

3.1.1. Physical Connection

Design NxN C^2Torus for the following steps:-

- Firstly design NxN Torus Network (a). Where all the nodes having unique coordinates.

- Where first node start from (0, 0) then (0, 1) and the last node having (n,n) nodes.
- Totally number of nodes in a Torus network is NXN.
- After that find out the center of Torus Network.
  1. If even number of nodes then four nodes are considered as a center.
  2. If odd number of nodes then only one center are present in Torus Network.
- If the size C^2Torus are odd then we calculated the center of the following network are:

$$I=(n-2)/2 \; ; \; j=i$$

We are having a four corner nodes that are:-
- North-west corner node (0,0).
- North-east corner node(0,n-1).
- West-south corner node(n-1,0) .
- South-east Corner node(n-1,n-1).

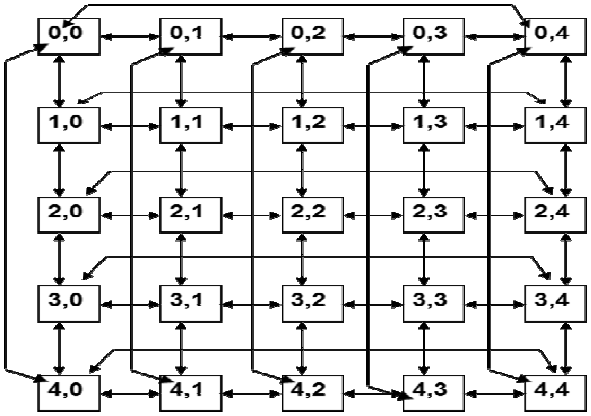

Fig. 1. *5x5 Torus (n is odd)*

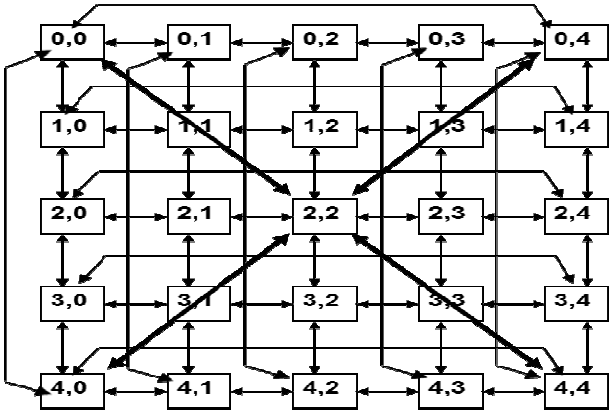

Fig. 2. *5x5 C^2Torus (n is odd)*

Work on C^2Torus, where number of nodes are odd:

Let's assume any node X(i,j), 0<=i<n, 0<=j<n, and any node Y(s, t), 0<=s<n, 0<=t<n, is connected, if it satisfies one of the following seven condition:

1. |s-i|+|t-j|=1
2. i=0, j=0 , s=(n-1)/2 ,t=s
3. i=0, j=n-1, s=(n-1)/2 ,t=s
4. i=n-1, j=0, s=(n-1)/2 ,t=s
5. i=n-1, j=n-1, s=(n-1)/2 ,t=s
6. i=0, j=t, s=n-1
7. i=s, j=0, t=n

If the size C^2Torus are Even then we calculated the center of the following network is:

Centre node [a] = node (n/2-1, n/2-1)
Centre node [b] = node (n/2-1, n/2)
Centre node [c] = node (n/2, n/2-1)
Centre node [d] = node (n/2, n/2)

We are having a four corner nodes that are:-
- North-west corner node (0, 0).
- North-east corner node (0, n-1).
- West-south corner node (n-1, 0).
- South-east Corner node (n-1, n-1).

Work on C2Torus, where number of nodes is Even:

Let's assume any node X(i, j), 0<=i<n, 0<=j<n, and any node Y(s, t), 0<=s<n, 0<=t<n, is connected, if it satisfies one of the following seven condition:

1. |s-i|+|t-j|=1
2. i= 0, j=0, s=(n-1)/2 ,t=s
3. i= 0, j=n-1, s=n/2-1 ,t=n/2
4. i= n-1, j=0, s=n/2 ,t=n/2-1
5. i= n-1, j=n-1, s=(n/2 ,t=n/2
6. i= 0, j=t, s=n-1
7. i= s, j=0, t=n

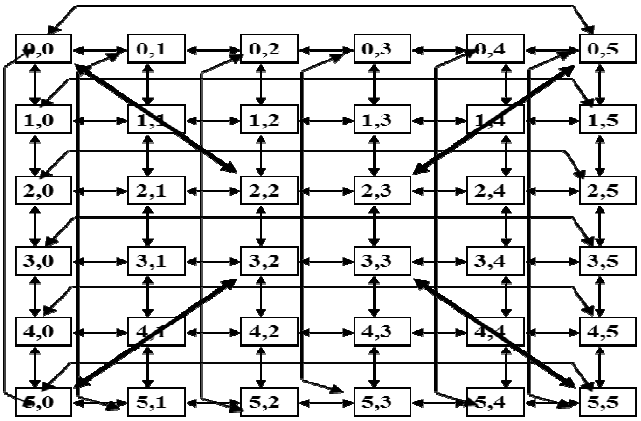

Fig. 3. *6x6 C^2Torus (n is even)*

Some of the terms that is used on this paper:
- Number of Links:The C^2Torus network having $2n^2+4$ links are present in all cases where n is even or odd. Link is a line over which data are transmitted.
- Number of nodes: The C^2Torus network having n^2 nodes are present in all cases. Nodes are a connection Points.
- Node Degree: In C^2Torus network node degree are 4 to 8. Node degree are maximum number of edges are connected present in single node.
- Diameter: In C^2Torus network diameter are (n-1) in all cases where n is even or odd. Diameter is the maximum paths between any two nodes in the network.

Bisection Bandwidth: In C^2Torus network bisection Width are (2n+2) in all cases where n is even or odd. Bisection Width is the minimum number of links that must be cut in order to divide the topology into two independent network of the same size.

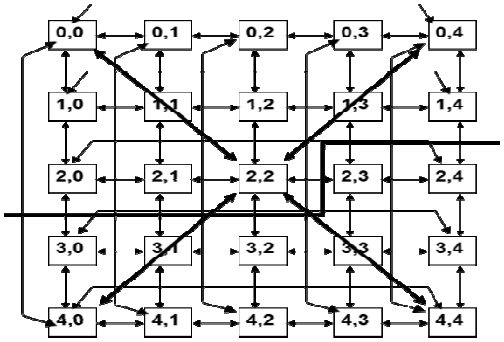

Fig. 4. *5x5 C²Torus (n is odd)*

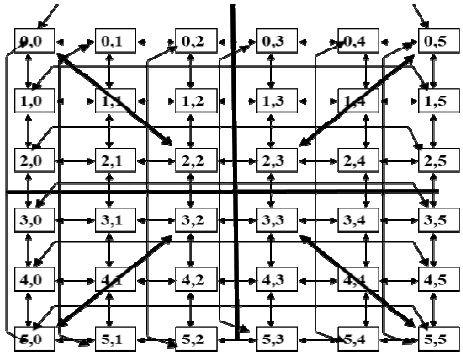

Fig 5. *6x6 C²Torus (n is even)*

4. Routing Algorithm for C²Torus: (CCT)

S-node =source node
D-node=destination node
C-node=center node
Routing_CCT(S-node, D-node)

- Firstly find the corner nodes of C²Torus.
- Find the centers of C²Torus.
- Find the sub-Torus1 for S-node and sub-torus2 for D-node.
- Then move towards D-node to C-node in sub-torus1
- if(corner node distance+1<c-node distance)
  move towards S-node to corner after directly move to C-node.
  Else
  Move towards S-node to C-node
- Then If (center of sub-torus1! = center of sub-torus2)
  then move towards center of sub-torus1 to center of sub-torus2
  Move current position to D-node
- if (corner node distance+1<c-node distance)
  move towards C-node to corner after directly move to D-node.
  Else
  Move towards C-node to D-node.

5. Result

C²Torus network are developed in the NS-2 Simulator, and check its performance, shortest path from any source to any destination node. Figure 6 shows the C²Torus Representation in Simulator and Figure 7 shows the Comparison between Mesh, Torus, C²Mesh and C²Torus. In Figure 7 Out1.dat represents C²Torus. Out2.dat and out3.dat represents C²Mesh and Torus. Out4.dat represents Mesh.

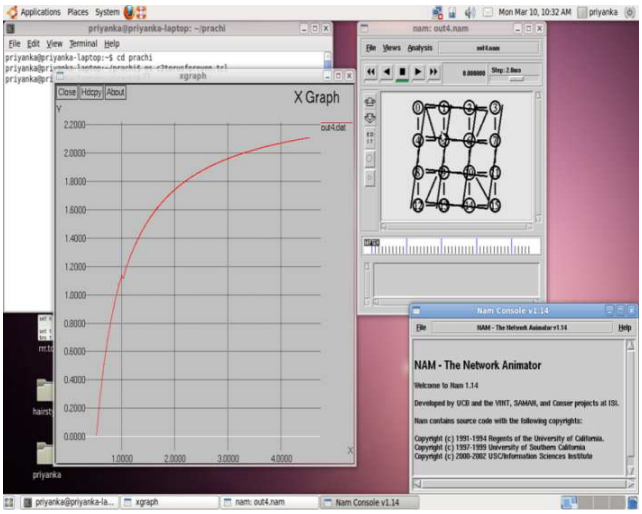

Fig. 6. *C²Torus Representation in Simulator*

Fig. 7. *Comparison between Mesh, Torus, C²Mesh and C²Torus*

6. Conclusion

The C²Torus network is a simple improved torus network where all four corner nodes are connected to the center of Torus. The performance analysis of new interconnected network topology will be good for previous topology (C²Mesh).It also provides good performance then C²Mesh.

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