International Journal of
Emerging Research in Management &Technology
ISSN: 2278-9359 (Volume-6, Issue-6)

Research Article | **June 2017**

Analysis the Performance of Interconnection Network Topology C^2 Torus Based on Two Dimensional Torus

Prachi Chauhan*
Computer Science and Engineering,
MIET, Greater Noida (U.P), India

Manish Bhardwaj
Computer Science and Engineering
SRM University, India

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 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). This manuscript performs Comparison between C^2Torus and C^2Mesh.

Keywords -Mesh, Torus, Interconnection Networks, Routing.

I. INTRODUCTION

Interconnection network provides connections between processing nodes in a parallel processing system. Interconnection networks can be classified as static or dynamic. A torus interconnection 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 neighbours, and corresponding processor on opposite edges of the array connected [3]. 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 6 sections:
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.

II. RELATED WORK

Torus network has a ring connection along each row & each column are connected each other. A torus interconnected is a network topology for connecting processing nodes in a parallel computer system but in C^2Torus is Centre Connected Torus that is centrally connected nodes with extra four links.

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 [1].

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.

III. 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.

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.

A. Physical Connection

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

- Firstly design NxN Torus Network. 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).

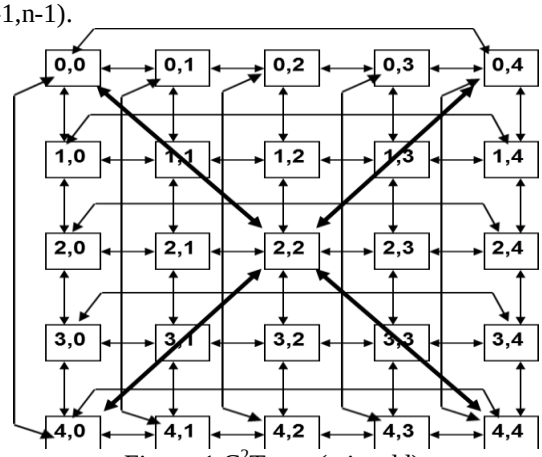


Figure-1 C^2Torus (n is odd)

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:

i) $|s-i|+|t-j|=1$
ii) $i=0,\ j=0\ ,\ s=(n-1)/2\ ,t=s$
iii) $i=0, j=n-1, s=(n-1)/2\ ,t=s$
iv) $i=n-1, j=0, s=(n-1)/2\ ,t=s$
v) $i=n-1, j=n-1, s=(n-1)/2\ ,t=s$
vi) $i=0, j=t, s=n-1$
vii) $i=s, j=0, t=n$

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 C^2Torus, 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:

i) $|s-i|+|t-j|=1$
ii) $i= 0, j=0, s=(n-1)/2\ ,t=s$
iii) $i= 0, j=n-1, s=n/2-1\ ,t=n/2$
iv) $i= n-1, j=0, s=n/2\ ,t=n/2-1$
v) $i= n-1, j=n-1, s=(n/2\ ,t=n/2$
vi) $i= 0, j=t, s=n-1$
vii) i= s, j=0, t=n

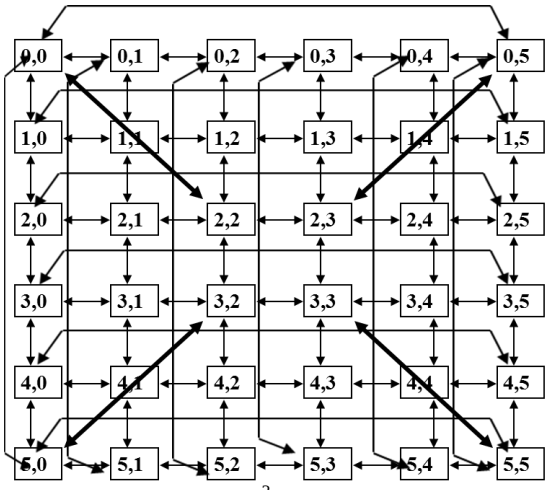
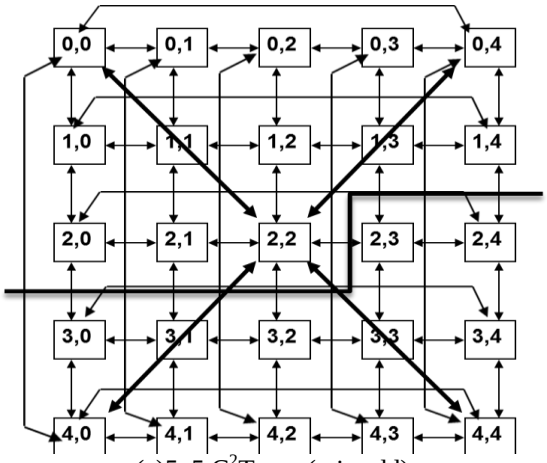


Figure-2: 6x6 C^2Torus (n is even)

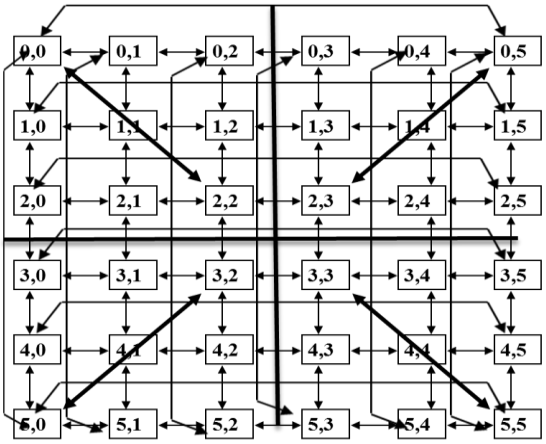
Some of the terms that is used on this paper:

- **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.



(a)5x5 C^2Torus (n is odd)

Figure-3: Bisection Bandwidth



(b) 6x6 C^2Torus (n is even)

Table 1: All Properties in C^2Torus and also compassion for Mesh, torus, DMesh, XMesh etc)

Properties	Mesh	Torus	DMesh	DTorus	XMesh	SD-Torus	C^2Mesh	C^2Torus
No. of Links	$2n^2$-2n	$2n^2$	$4n^2$-6n+2	$4n^2$-4n+2	$2n^2$	$3n^2$	$2n^2$-2n+4	$2n^2$+4
No. of Nodes	n^2	n^2	n^2	n^2	n^2	n^2	n^2	n^2
Node Degree	2 to 4	4	3 to 8	5 to 8	3 to 8	6	3 to 8	4 to 8
Diameter	2n-2	n	n-1	n-1	n-1	2n/3	n-1 (n if n=2 or 4)	n-1 (for all)
Bisection	n	2n	3n-2	4n-2	n+4	3n	n (n+2 if n is odd)	2n+2 (for all)
Throughput	<=b	<=2b	<=2b	<=2b	<=2b	<=2b	<=b	<=2b
Path Diversity	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Avg Distance	2n/3	2n/4	2n/4	2n/4	2n/4	2n/4	2n/4	2n/4

IV. IMPLEMENTATION FOR C^2TORUS IN NS2:

1) Firstly develop nodes by

 # create nodes

```
for {set i 0} {$i < 25} {incr i}
{
set n($i) [$ns node]
    }
```

2) Create a duplex Link

 # create links between the nodes

```
for {set i 0} {$i < 4} {incr i}
{
 $ns duplex-link $n($i) $n([expr ($i+1)]) 1Mb 10ms DropTail
$ns duplex-link $n($i) $n([expr ($i+5)]) 1Mb 10ms DropTail
}
```

3) Connect a link in circular manner:

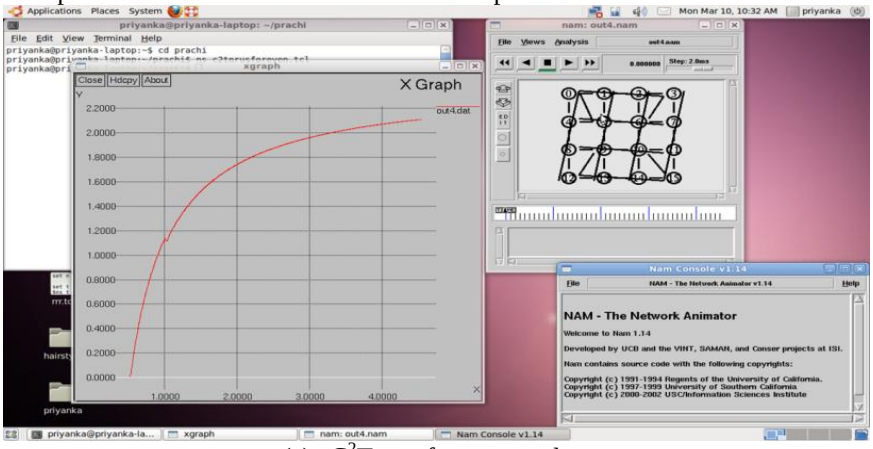
```
for {set i 5} {$i < 9} {incr i}
{
$ns duplex-link $n($i) $n([expr ($i+1)]) 1Mb 10ms DropTail
$ns duplex-link $n($i) $n([expr ($i+5)]) 1Mb 10ms DropTail
}
```

V. RESULT

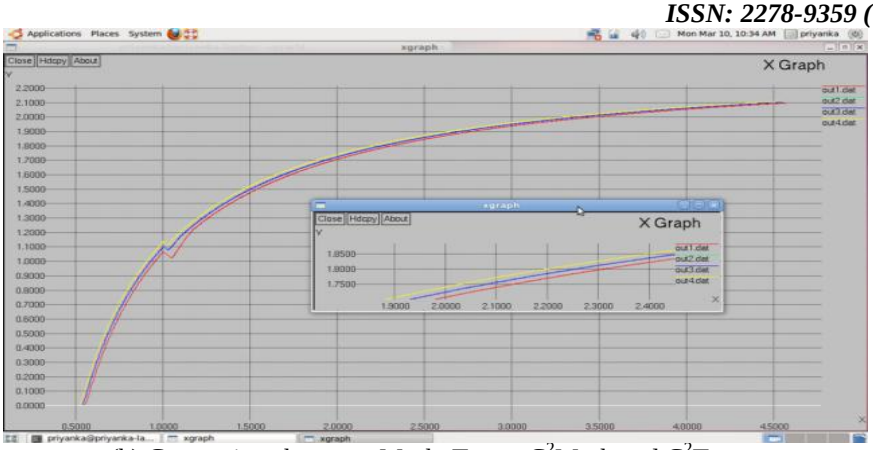
C^2Torus network are developed in the NS-2 Simulator, and check its performance, shortest path from any source to any destination node but its performance change in two cases remaining performance same as C^2Mesh.
Following Diagrams are-:

(a) Represent the C^2Torus.
(b) Comparison between Mesh, Torus, C^2Mesh and C^2Torus.

In (b) **Out1.dat** represents C^2Torus.
Out2.dat and **out3.dat** represents C^2Mesh and Torus. **Out4.dat** represents Mesh.



(a) C^2Torus for even nodes



(b) Comparison between Mesh, Torus, C^2Mesh and C^2Torus

VI. CONCLUSION

The C^2Torus network is a simple improved torus network where all four corner nodes are connected to the center of Torus.The performance analyses of new interconnected network topology will be good for previous topology (C^2Mesh).The best feature of C^2Torus network with n×n nodes, is the shortest path from any source to any destination is maximum n-1, it means the length of shortest path from any source to any destination node is not more than n it will be always less than n.

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