Cost Effectiveness Analysis of a 2D Twin Torus

Afolabi Alausa
Department of Computer Science
International Islamic University, Malaysia
alausaafolabi@gmail.com

Mutiu Adeleye
Department of Computer Science
International Islamic University Malaysia
adeleyemutiu1982@gmail.com

Abstract

In different papers, different network hierarchies ranging from (2D torus, Mesh etc.) have been evaluated based on the 7 major parameters (node degree, average distance, diameter, bisection width, wiring complexity and arc connectivity) and some others parameters (packing density, traffic density, cost effective, time cost effective factor). The new conventional network (2D twin torus) has been evaluated based on the parameters and was compared to the performance of the previous hierarchical networks. This paper shows the evaluation of different hierarchical networks with the new conventional network showing the most effective of the networks. Although all network connections are good but this is just to show their performances in other to choose the most effective in terms of the parameters and to know the most effective.

Unlike the previous networks we introduce 2port cards for the 2D twin torus making each port card with 3connecting physical links, which makes the performance effective and more preferable to other hierarchical networks. The routing system which start from the y-vertical axis then compare to the x-horizontal axis leaving the output to be the shortest path.

1. Introduction

Hierarchical connection of computers is the best option when it involves the connection of computers massively. The [8x4] 2D twin torus is a new conventional connection that output lesser diameter and other parameters compare to other previous and new hierarchical and conventional network connections. The [8x4] 2D twin torus which consist of [2] port cards representing one node, connecting each port cards together in the node and also connecting to other port cards in other nodes.

The 2D twin torus also consist of total of 32 port cards representing 16 nodes labelled from (0-31). In the basic module (BM) of the 2D twin torus there is a conventional connection network that supports more connection of computers massively and also ensuring effective performances from the network connection.

The 2D twin torus which was propose in other to achieve [2] port cards connection in one single node that represents total of 16nodes in other network connections but in this new conventional network the 16nodes is in form of [32] nodes that represents 32 port cards in the basic module of the network connection.

When the new conventional network was first proposed and totally evaluated, the output was first evaluated based on the [7] major parameters and other parameters follows which then was compared to other hierarchical network connections but it was effective which makes it more preferable than others because of the performances, connection of massive computers which can be well achieved using the new connection. After evaluation and comparing with other hierarchical connections we can say our main objective was totally fulfilled from the level 1 (basic module) of the [8x4] 2D twin torus and also to other higher levels of the network connection.

The routing of the connection was first linked through the vertical path then also to the horizontal path then decide the shortest path which can then be recorded as the hop of the particular source to the destination. The routing follows specific path which is the only the recommended path for it to move in the conventional network connection. In the (BM) the static performances were the most essential factors considered which is the level 1 of the new conventional network connection that makes it unique compare to other hierarchical networks connection. The architecture of the BM is explained and shown in section 2.1 and Fig.2 below and static performances are also explained.

2. Interconnection of 2DTT

2.1 Architecture of 2DTT

The [8x4] 2D twin torus is a conventional interconnection network consisting of Basic Module BM that are interconnected. In this paper the basic module represents the Level 1 of the new conventional 2D twin torus network. The BM consist of [32] port cards forming [16] nodes, with 3 physical links connected to each port card. The BM consist of [8] port cards vertically and [4] port cards at the horizontal path.

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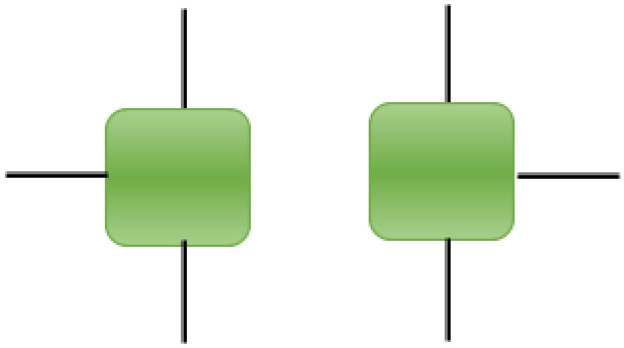

Figure 1. Port cards

The BM is evaluated resulting to the performances of the Conventional network at the first level which then increase to higher levels of the network connection.

The [8x4] twin torus Level 1 (basic module) consist of 32nodes with 48 connecting wires called wiring complexity that connects all port cards together. The port card with 3 physical links leaving one extra link at the port for connection of higher level networks. In the level 2 free links from the level 1 are used for the connection. The level 2 comprises of 512nodes making the level 2 4x4 i.e. (the BM in 4x4) making the level 2 comprise of 16 basic modules. The level will increase to level 3 then connect to level 4 making level 5 the highest and the last of the new conventional network.

The Basic Module being the first level and the major level of the conventional network connection is always the first in which the static performance will be evaluated. The basic module comprises of all level in multiples way i.e. the BM is the multiple of itself in forming more levels in the hierarchical connection of the 2D twin torus. The nodes increase by 32 x 42 in each level ranging from level1 to level5.

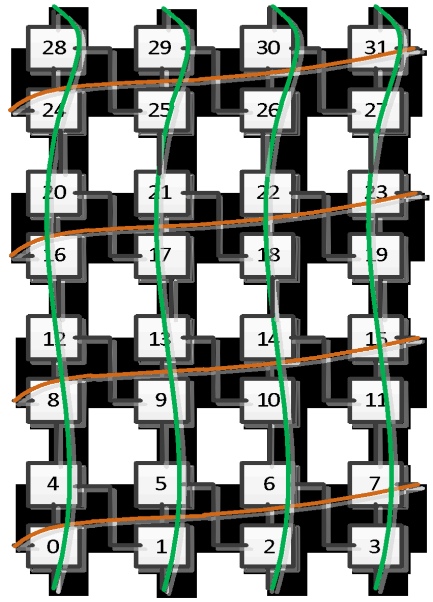

Figure 2. The basic module of 2DTT

Fig. 2 is showing the basic module of the 2D twin torus. As shown in the Fig the basic module connecting two port cards working as 2nodes but can represent 1node. There are 3 physical links for connection to each other and one free link for the higher connections. In the basic module of the 2DTT the routing of source to destination is unique which makes source 0 travel to destination with one hop unlike previous network which you have to go through the path step by step. From the Diagram the highest hop which makes the diameter of the basic module is 5hops which can be gotten from the node degree routing. From the evaluation it was shown that the total hops for a node is equal which is 98hops i.e. from node 0-1...31, 1-0…31 is equal which makes the static performance more efficient because of equal distance.

From the result gathered from some hierarchical networks, it was shown that the path from each node differs to other unlike the 2DTT. The routing system which output the smallest hops make performance more efficient unlike having larger hops from the source to the destination. Each port card in the basic module is connected to 3 other different port cards which makes those connecting nodes a single hop for the source to destination path i.e. (node 1 to node 5 = 1 hop, also node 1 to node 4 = 1 hop and node 1 to node 29 = 1 hop). The basic module which will now split into 16 parts (4x4) for the level 2 which increases the BM into 16 places in level2 and increasing like that in other levels.

The level 2 of the network connection will be shown in the fig.4 of the paper.

2.2 Routing Path

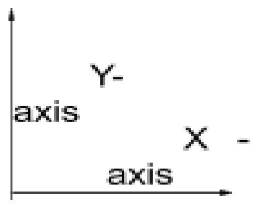

Figure 3.

The routing path is the direction path that the source to destination follows. In the 2D- Twin Torus Network the path followed first is the vertical axis then the horizontal axis checking for the shortest path in which the source to destination follows.5. Second and following pages

3. Static Network Performance

The static network performance of the 2D- Twin Torus Network is the key feature that makes the network connection effective and more preferable. The topology of the conventional network is compared with the mesh and tori torus based on their different parameters. These parameters evaluated are:

3.1. Node Degree

Node degree is the number of physical links emanating or connected to each port card. In the 2D torus the node degree is 3 because 3 physical links are connecting or emanating from each port card. The node degree is the total amount of physical links that can be found on each node. Each node of a 2D- Twin Torus Network has 3 links, therefore, its degree is 5. The node degree of an 2D Twin Torus Network is lower than the node degree in TESH Network which has 6 degrees. Due to this lower node degree, the 2D-Twin Torus Network is less expensive than previous higher performance hierarchical interconnection networks. In order to get the node degree, count the number in each of the nodes.

3.2. Diameter

The diameter is the maximum distance of hops gotten from the path of any of the source node to the destination, i.e. The maximum hop gotten from the shortest path when any source node travel to its destination in the conventional network connection.

It can be defined as the maximum number of links or inter-node distance that must be travel across to send and receive a message to and from any node in a shortest path. Networks with small diameter are the best. The smaller the diameter the smaller to send and receive from and to node farthest away from it. The Twin Torus Network has a smaller diameter than the previous Torus Network, this means that Twin Torus Network will be appropriate to send and receive message within networks. According to the definition, the diameter is Max(hops) from the smallest node to the highest node. Hops is the path distance from the source to destination.

3.3. Cost

Cost of a Twin Torus Network is the product of both the diameter of the network and the node degree. The network with smaller node degree is cost effective than others with higher degrees. An interconnected network with lower diameter has a very high message passing bandwidth. Cost = Diameter × Node degree.

3.4. Average Distance

This is the mean distance between all the distinct pairs of the nodes in a network. A very small average facilitates the quick transfer among path and reduces cost. Can be calculated the total number of path form node 0 to N (highest number of node) divided by the total number of node path. That is the average distance is the mean of all hops of all nodes in the network. i.e. All the addition of all hops of node (node 0 to node 31) divided by total of the source to the destination which is in the level 1of the 2D twin torus network connection.

3.5. Arc Connectivity

Arc connectivity of a network is the shortest number of physical links that will be disconnected if at least one port card is disconnected from the connection.

This is when we consider removing one port card from the connection and checking the number of physical links that will disconnect with the node. This is the total minimum number of links needed to be removed to make the network nodes disconnect from one another and make it into two incomplete halves. This is computed by where E(L) is the total number of links, q is the number of links removed and |s| is the absolute value of the result.

3.6. Bisection Width

Bisection width is the total number of physical links that is lost when then network connection is divided in to two equal partitions both horizontally and vertically.

The Bisection Width of a network is the minimum number of links that must be removed from the network to make the network divided into two equal halves. Unlike the arc connectivity which will result into two disjoint halves. This can be computed by $E(l)-q=\frac{E(N)}{2}$ $E(l)-q=\frac{E(N)}{2}$, where $E(l)$ $E(l)$ is the total number of links, q is the number of links removed, $\frac{E(N)}{2}$ $\frac{E(N)}{2}$ is the total number of nodes divided into two equal sizes.

3.7. Wiring Complexity

Wiring complexity is the total number of wires connecting all port together from node 0 to node31. The wiring complexity of each level is different from each other because extra links are added to higher networks.

This is the total number of links used for the interconnection networks. In the case of 8*4 interconnected network, this is calculated as follows: when $k=2^{2(L-1)}x\left(2k^2+4(2^q)(L-1)\right)$ $k=2^{2(L-1)}x\left(2k^2+4(2^q)(L-1)\right)$. Wiring complexity also determine the speed of a network. For a TTN hierarchical connection, the length of the links is must be with high length links to yield a better performance.

3.8. Packing Density

The network cost is the product of the network diameter and the node degree. Having high packing density is one of the most effective features for the network, the packing density is defined as the ratio of the number of nodes of a network to its cost. When we have high packing density, the area necessary for the chip will be small.

$$Packing\ Density=\frac{Total\ number\ of\ nodes}{Node\ Degree\ x\ Diameter}$$

3.9. Traffic Density

The performance of a network topology for the message traffic can be evaluated by the average distance from one source node to the other. Network efficiency also lies on the traffic density which makes traffic congestion low. The message traffic density is the ratio of the multiplication between the total number of nodes and its average distance to its total number links. A network with low Traffic density is effective.

$$Traffic\ Density=\frac{averge\ density\ x\ Total\ no\ of\ nodes}{wiring\ complexity}$$

3.10. Cost Effective Factor

Fast performance and efficiency are parameters also measured in all network connections. They don't consider communication in the network but also necessary in networks. The cost effective factor shows cost effectiveness of a network.

$$CEF=\frac{1}{1+(\pi)\left(\frac{wiring\ complexity}{Total\ no\ of\ nodes}\right)}$$

Where $\pi=0.1$

3.11. Time Cost Effective Factor

This parameter considers the total time for the execution of a program. When the solution of a network is fast, it's expected to have a low cost effectiveness. This highlight profitable use of the network.

$$TCEF=\frac{wiring\ complexity}{Total\ number\ of\ nodes}$$

4. Performance Evaluation

From table 1 below, it shows the performance of the 2D twin torus and comparing it to other networks performances. It is said that low diameter increase performance of a network connection which the 2D twin torus diameter is low compare to others. Secondly, the node degree and the average distance are of the same value which makes the static performance more effective and also the cost for having this kind of effective connection is cheaper than other networks.

The wiring complexity that is the total wires for connecting the 2D twin torus are few making the connection to look neat than looking clumsy with wires.

In the table 2, the most essential factors are packet density and Time cost effective factor that deals with size and rate of time respectively and it is very good compare to others. some parameters of the 2D twin torus might not be effective compare to other network but the most and essential parameters are preferable than other networks and the better ones ranging from the high packet density and time cost effective factor are even the best and major parameters.

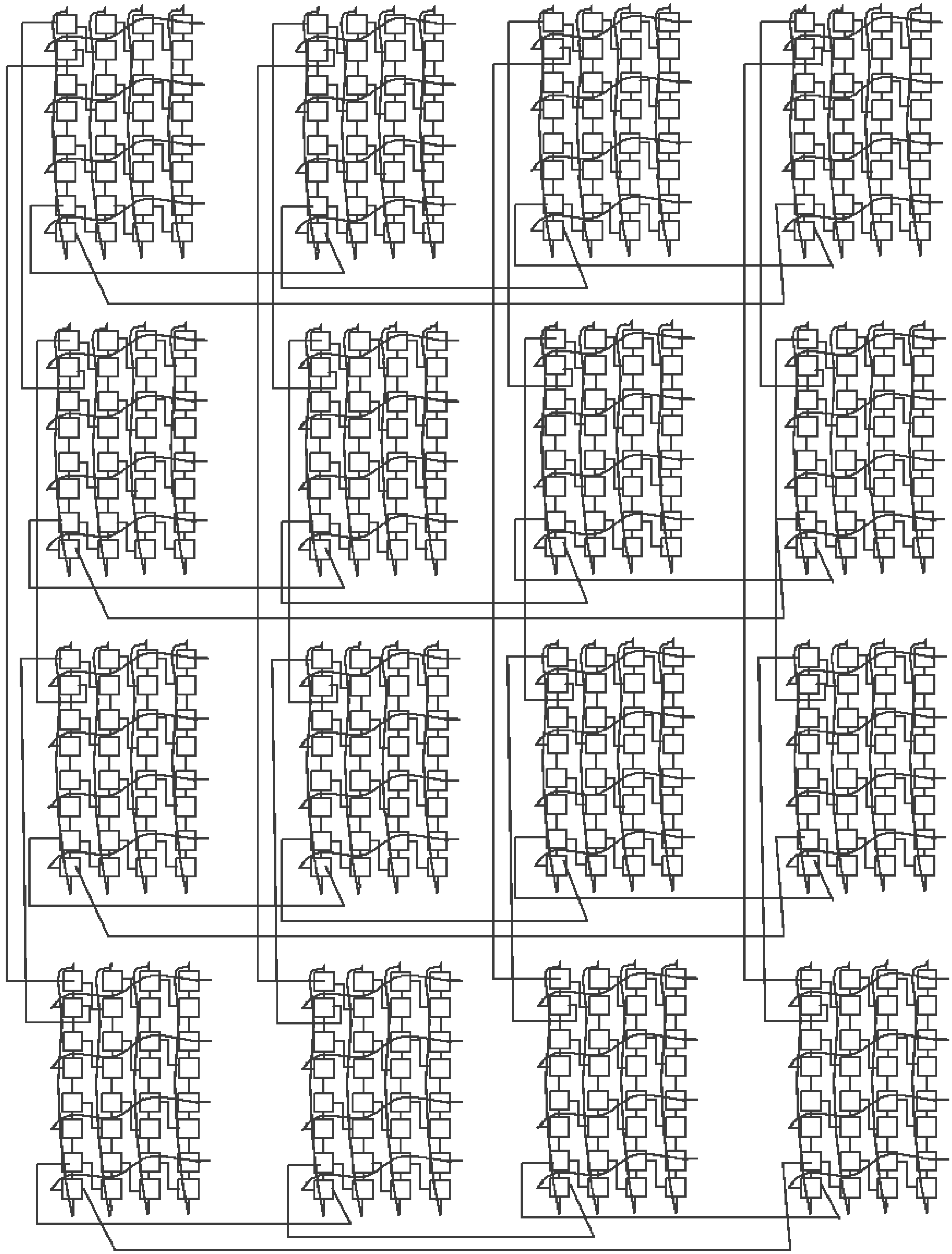

Table: Comparison of static network of different networks

Table 1

	Node degree	Diameter	Average distance	Cost	Arc connectivity	Bisection width	Wiring complexity
4x8 2D mesh	4	10	4	40	4	8	52
4x8 2D torus	4	6	3.10	24	4	16	64
8x4 2DTwin torus	3	5	3.16	15	3	8	48

Table 2

	Packet density	Traffic density	Cost effective factor	Time cost effective factor
4x8 2D mesh	0.8	2.46	0.8602	1.63
4x8 2D torus	1.3	1.55	0.830	2
8x4 2DTwin torus	2.13	2.11	0.869	1.5

5. Conclusion

In this paper we have evaluated node degree, diameter, cost, average distance etc. Comparing all parameters of the 2D twin torus conventional network with other hierarchical network connection (2D mesh and 2D torus), we were able to prove that the new conventional network proposed outperformed the other networks connection in most of the parameters which can be concluded that it's more preferable than others.

With the result of the 2D twin torus, the future of connecting massive computers can rely on it in other to do it in and effective and affordable way. When we need to connect massive computers, why should we go for expensive and not very effective network when we can have a good network in and affordable way.

In This summary we can say the 2D twin torus is the modern way of connecting massive computers in and effective and affordable factors to be considered. With the evaluation of different networks, we can see that the 2D twin torus is more preferable compare to other network.

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DR. Hafizur Rahman

Afolabi Alausa 1510201 Adeleye Mutiu 1512797

Poster ID : SD-07-2
Contact No : 0105098102
01137111360
Email : hafizur@iium.edu.my
afolabialausa@gmail.com
adeleyemutiu1982@yahoo.com

INTRODUCTION

OBJECTIVE:
Comparing the effectiveness and performance of the 2D twin torus new conventional network to other hierarchical network.

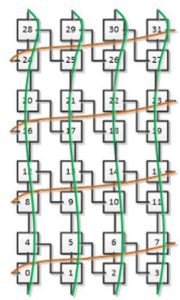
The 2D twin torus consist of total of 32 port cards representing 16 nodes labelled from (0-31).

The 2D twin torus which was propose in other to achieve [2] port cards connection in one single node that represents total of 16nodes

PARAMETERS

Node degree
Diameter
Average distance
Cost
Arc connectivity
Bisection width
Wiring Complexity

ARCHITECTURE



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Conclusion: In This summary we can say the 2D twin torus is the modern way of connecting massive computers in and effective and affordable factors to be considered

Merits of the New Network over existing networks.

1. Low diameter
2. It is cost effective.
3. Equivalent node-degree and average distance value.
4. High packet density
5. Equal hops at every node.

FYP BCS