International Journal of Communication Networks and Security

Volume 1 | Issue 2 Article 7

July 2011

Star varietal cube: A New Large Scale Parallel Interconnection Network

Binod Nag
Dept. Of CSE, Sambalpur University, Odisha, India, nag.binodb@gmail.com

Debendra Pradhan
Dept. Of CSE, Sambalpur University, Odisha, India, dpradhan@gmail.com

Nirmal Keshari Swain
Dept of MCA, DAMITS, Rourkela, Odisha, swain.nirmal6@gmail.com

Nibedita Adhikari
Dept. of CSE, Purusottam Institute of Engineering & Technology., head.csepiet@gmail.com

Recommended Citation

Nag, Binod; Pradhan, Debendra; Swain, Nirmal Keshari; and Adhikari, Nibedita (2011) "Star varietal cube: A New Large Scale Parallel Interconnection Network," *International Journal of Communication Networks and Security*: Vol. 1 : Iss. 2 , Article 7.
DOI: 10.47893/IJCNS.2011.1018
Available at: https://www.interscience.in/ijcns/vol1/iss2/7

Star varietal cube: A New Large Scale Parallel Interconnection Network

[1]Binod Nag, [2]Debendra Pradhan, [3]Nirmal Keshari Swain, [4]Nibedita Adhikari
[1,2] Dept. Of CSE, Sambalpur University, Odisha, India
[3] Dept of MCA, DAMITS, Rourkela, Odisha
[4]Dept. of CSE, Purusottam Institute of Engineering & Technology.
head.csepiet@gmail.com

***Abstract:** This paper proposes a new interconnection network topology, called the Star varietalcube SVC(n,m), for large scale multicomputer systems. We take advantage of the hierarchical structure of the Star graph network and the Varietal hypercube to obtain an efficient method for constructing the new topology. The Star graph of dimension n and a Varietal hypercube of dimension m are used as building blocks. The resulting network has most of the desirable properties of the Star and Varietal hypercube including recursive structure, partionability, strong connectivity. The diameter of the Star varietal hypercube is about two third of the diameter of the Star-cube. The average distance of the proposed topology is also smaller than that of the Star-cube.*

***Keywords:** Interconnection topology; fault tolerance; cost factor;*

I. INTRODUCTION

With the great advances in computer technology, Multi computer systems have become more and more popular nowadays. It is feasible to increase the execution speed of a computer system by utilizing a large number of processors simultaneously. However, when a collection of processors are executing a program parallels to solve a problem, there is usually a need for one processor to communicate with other processors, e.g., to share the data with them. Much of the computation power may be wasted if the processors spend a considerable amount of time in the communication. Thus, it is necessary for the processors to communicate efficiently with one another. The interconnection network is the means to connect the various processors. In parallel systems, as the number of the machines increases, the interconnection network may become a dominant factor in determining both the cost and the performance of the system.

In 1992, J. M. Kumar [3] proposed the Extended hypercube interconnection network which retains the positive features of k-cube at different levels of hierarchy and possesses some additional advantage like less diameter and constant degree. In 1994, variant of hypercube called Varietal hypercube (VH) was proposed by S. Y. Cheng et al. [2]. This network has the same number of links, nodes but low diameter and small cost-factor. The diameter of VH is about two third of that of hypercube and enjoys less communication cost than hypercube. So the cost of the network is reduced.

Another popular Cayley graph called the Star graph has been an alternative to the Hypercube. It has some positive features like reduced diameter and constant degree of nodes [3].

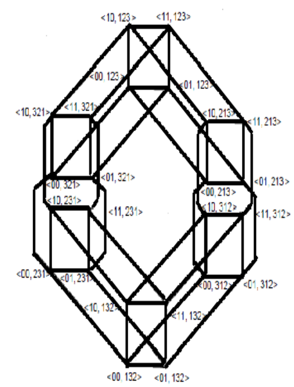

Figure 1: Star-cube, SC(3,2)

The n-dimensional Star is called n-star is a node-symmetric and edge-symmetric graph consisting of n! nodes and $(n!)\times(n-1)/2$ number of edges. Each vertex in an n-star has n - 1 incident edges. In spite of its admitted superiority, the n-star has a major disadvantage that is, it grows to its next higher dimension by a very large value. For example, the 4-dimensional star has 24 nodes where as, for constructing a 5-star 5! = 120 nodes are needed. The significant gap between the two consecutive sizes of the n-star is considered to be major drawback and therefore needs further attention for its improvement.

In January 2004, C. R. Tripathy [4] introduced a new interconnection topology called Star-cube (SC). The Star-cube (SC) as shown in Fig.1 possess better diameter than the hypercube. Also the mean distance between vertices is shorter than that of the hypercube [6].

Hence, the problem of designing a communication efficient and low cost Star-based network with lesser hardware complexity, better reliability and improved fault-tolerance is yet open. This demand motivates the present study to propose a new hierarchical network called Star varietal cube (SVC). The proposed topology exploits most of the attractive properties of Star and Varietal hyperube. The various topological properties of the SVC such as degree, diameter, average distance, routing, broadcasting and the performance parameters such as fault-tolerance, message traffic density and cost factor have been analyzed in this paper.

The rest of the paper is organized as follows: the proposed Star varietal cube interconnection network is defined in Section II. Section III presents some basic properties of the Star varietal cube. Then section IV describes the proposed routing and broadcasting algorithms. Performance analysis is done in Section V. Results are discussed in Section VI. At last Section VII presents the concluding remarks.

II. PROPOSED INTERCONNECTION NETWORK

A. *System Architecture*

The interconnection network will be viewed as an undirected graph, in which the vertices correspond to processors and edges correspond to the bi-directional communication links between processing elements.

Definition: The interconnection network is represented by a finite graph G = {V , E} where V is a set of vertices or nodes representing the processing elements and E is the set of edges which connects the elements in V to form communication links between the processing elements, where; V = { v1, v2 ,...,vn } and E = {e1, e2 ,..., em} . The degree of a vertex v in G, denoted as dv , is the number of edges incident on v. The distance between two nodes is the length of the shortest path between them. The diameter of a graph G denoted by D(G). The distance between the nodes is the length of the shortest path between them.

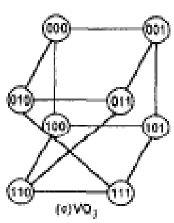

Figure 2: Varietal hypercube dimension 3

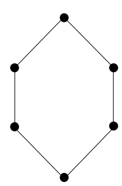

Figure 3: Star graph of dimension 3

B. *Star Varietal cube(SVC):*

The proposed interconnection topology is an undirected graph in which vertices correspond to the processing elements and edges correspond to the bidirectional links of the interconnection network.

*Construction:*The most popular and well-known network topologies is indeed the Varietal hypercube[6] Fig 2. Its popularity stems from the fact that a large number of processors can be interconnected using a small number of communication links. It also permits the use of identical processors since every vertex plays an identical role in the topology. The most important candidate of such a family of graphs is the star graph Fig 3. The Star graph has been introduced in [2] as an attractive alternative for the hypercube . It has many desirable properties such as topological symmetry, low diameter, low degree, and recursive structure. After studing above two networks, we proposed a network Star varietal cube in which Varietal hypercubes are connected in Star graph fashion. An m-dimensional Varietal hypercube can be modeled as a graph with the node set V_m and edge set E_m, where $|V_m| = 2^m$ and $|E^m| = m\times 2^m$. The 2^m nodes are distinctly addressed by m-bit binary numbers, with values from 0 to $2^m - 1$. Each node has link at m-dimensions, ranging from 1 (lowest dimension) to m (highest dimension), connecting each node to m neighboring nodes.

The n-dimensional star graph S (n) consists of the set of nodes $\{x_0\ x_1 \ldots\ldots x_{n-1}\}$. Hence, the total number of vertices in a n-star is n!. There is an edge between any two vertices, if their labels differ in the first and in one other position. Considering two nodes x and y of S (n) and starting from x, it is possible to reach y in atmost $\lfloor 3/2(n-1) \rfloor$ hops.

Both the Varietal hypercube VC(m) and the Star(n) are regular, vertex (edge) symmetric. SVC(n, m) of order (n, m) is the product graph of S (n) and VC (m). Given a node < x, y > of the SVC (n, m), x will be called the varietal hypercube part label and y the star-graph part label. It is noteworthy that the nodes with the same varietal hypercube part label form an n-star whereas the nodes with the same star-graph-part label form a varietal hypercube of order m.

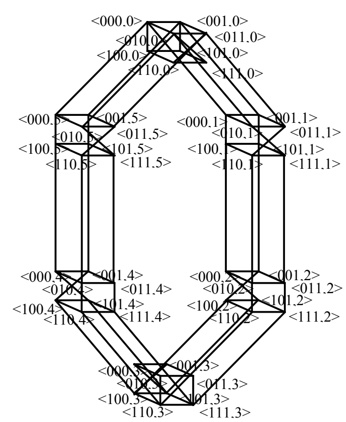

Figure 4: Star varietal cube of dimension 3, SVC (3,

It follows that there are n! varietal hypercube sub graphs VC (m) in the SVC(n, m) where, the nodes in each VC (m) have the same star-graph-part label. These sub graphs can be identified by their corresponding star-part-label as shown in Fig.4.

III TOPOLOGICAL PROPERTIES OF THE PROPOSED NETWORK

In this section, we show some of the topological properties of the Star varietal cube that make it attractive.

A. Degree

The degree of a node in a graph is defined as the total number of edges connected to that node. Similarly, the degree of a network is defined as the largest degree of all the vertices in its graph representation. Because of the symmetry of each node in the Star varietal cube, the degree of any node in the SVC(n,m) is identical. It can be seen easily from the definition of the varietal hypercube , that the degree of G,denoted as deg(G), is equal to m+n-1. The advantage of this is that networks of larger sizes can be designed with same hardware complexity, thereby significantly reducing the cost of implementation.

Theorem1: The degree of SVC(n,m) is (m+n-1).

Proof: The degree of a Star, S(n) topology is n-1 and the degree of Varietal hypercube, VC(m) is m. Therefore, the degree of SVC is addition of both topologies. Thus the degree of SVC(n,m) is

D= m+n-1.

B. Number of Nodes

*Theorem 2:*The total number of nodes in a SVC(m,n) denoted by p is given by $n!.2^m$.

Proof: The Varietal cube(m) topology has 2^m nodes and the Star topology has n! nodes. The Star varietal hypercube being a product graph , the total number nodes in Star varietal cube (n,m) becomes $n!.2^m$.

Hence p= $n!.2^m$.

C. Number of Edges/Links

Theorem 3: A Star varietal cube,SVC (n,m) has $n!2^{m-1}(m+n-1)$ edges.

Proof: From the above description this can be treated as n! Varietal hypercube of order-m connected in Star-graph fashion. So the total number of links in Varietal hypercube part is n! $m.2^{m-1}$. However, each varietal hypercube part is connected to n-1 neighbor's in Varietal hypercube. So the total number of links interconnecting these nodes is given by

$$n!.[(n-1)/2].2^m$$

Hence, the total number of links in Star varietal cube is

$$m2^{m-1}+n!\left[\frac{(n-1)}{2}\right]2^m = n!2^{m-1}(m+n-1).$$

E. Diameter

The distance *d(u , v)* between two distinct vertices *u* and *v* is the length (in number of edges) of a shortest path between these vertices. The diameter of *G*, denoted as *D(G)*, is defined to be $\max\{d(u,v) \mid u,v \in V\}$. In a network system, max of such diameter represents the worst case communication delay between two processors of the network. The following theorem gives the diameter of SVC(n,m), which is proved by induction.

Theorem 4: The diameter of Star varietal cube(n,m)) denoted by D(G) is $\lceil 2m/3 \rceil + \lfloor 3/2(n-1) \rfloor$.

Proof: Considering from the node (u, v), one can reach the node (u', v') in atmost $\lceil 2m/3 \rceil$ hops. This follows from the description given above that all the nodes with the same Star-neighbors form a Varietal cube of order $\lceil 2m/3 \rceil$. Then, proceeding from the node (u', v') , one can reach the node (u', v') in atmost $\lfloor 3/2(n-1) \rfloor$ hops. This again follows from the description given above, that nodes with same Varietal cube-neighbors form a Star graph of order n. It is known that the diameter of the Star graph S (n) is $\lfloor 3/2(n-1) \rfloor$. Hence, in atmost $\lceil 2m/3 \rceil + \lfloor 3/2(n-1) \rfloor$ hops, we can reach (u', v') from (u, v), ie, the diameter of SVC (n, m) is $\lceil 2m/3 \rceil + \lfloor 3/2(n-1) \rfloor$.

According to the above result, proposed structure has smaller diameter then Star-cube. Therefore, with the same cost, proposed structure will have better performance in communication than that of the Star-cube.

F. Average Distance

Although the diameter reflects the worst case communication delay, the average distance conveys the actual performance of the network better in practice. The summation of distances of all nodes from a given node (source) over the total number of nodes determines the average distance of the network. Let $\bar{d}_k$, denote the average distance in SVC. The following theorem gives the general formula for the average distance of SVC(n,m).

Theorem 5: The average distance of the SVC (n, m) is $\bar{d}_k = \left(\frac{11x+4y}{8}\right) + n - 4 + \frac{2}{n} + \sum_{i=1}^{n}\frac{1}{i}$, where *k=3x+y*, *y<3* and *x, y* are integer values.

Proof: The average distance of SVC(n, m) is addition of Varietal hypercube and Star-graph. Hence, the average distance of Varietal hypercube is $\frac{11x+4y}{8}$ and the Star-graph is $\bar{d} = n - 4 + \frac{2}{n} + \sum_{i=1}^{n}\frac{1}{i}$.

G. Message Traffic Density

Assuming that each node is sending a message to a node at a distance *d*, on an average, it may be required to analyze the performance of the network in handling the message traffic. Thus, the message traffic density is defined by $\rho = \frac{\bar{d}Nt}{E}$.

Where E is the total number of communication links, *Nt*, is total number of nodes

$Nt = n!.2^m$ and $\bar{d}$ is the average message distance.

H. Extensibility

The SVC(n, m) is hierarchical in nature and can be built by extension of the number of levels without affecting the basic structure. The most important advantage of this property is that degree of a node remains the same , independent of the total number of nodes and hence allows for further expansion. Thus the SVC(n, m) architecture is well suited for hierarchical expansion of multiprocessor system.

I. Comparison with Other Topologies

Table 1 summarizes some of the parameters of the hypercube, varietal hypercube, Star, Star-cube, and the proposed Star varietal cube networks. In general, for a desirable interconnection structure, the number of links per node, the total number of edges, the average distance and the diameter should all be as small as possible. By comparing the properties of above structures, one can see that these structures all have their own advantages and disadvantages. Among these structures, we find the Star varietalcube SVC(n,m), offers a good balance for the parameters listed in Table 1. This balance will make it suitable for large scale multicomputer systems.

Table 1. Comparison of properties for different topologies.

Network	Degree	Edge	Diameter
Star,S(n)	n-1	$\frac{n!.(n-1)}{2}$	$\left\lfloor \frac{3}{2}(n-1) \right\rfloor$
Hypercube(m)	M	$m2^{m-1}$	M
Star-cube SC(n, m)	m+n-1	$n!2^{m-1}(m+n-1)$	$m + \left\lfloor \frac{3}{2}(n-1) \right\rfloor$
Varietal Hypercube VH(m)	m	$m2^{m-1}$	$\left\lceil \frac{2m}{3} \right\rceil$
Star Varietal cube, SVC(n, m)	m+n-1	$n!2^{m-1}(m+n-1)$	$\left\lceil \frac{2m}{3} \right\rceil + \left\lfloor \frac{3}{2}(n-1) \right\rfloor$

IV. ROUTING AND BROADCASTING

In multi computer networks, communication is an important issue regarding how the processors can exchange messages efficiently and reliably. An optimal routing algorithm is to find a shortest path between two nodes communicating with each other. In fault free Star varietal cube(SVC) network, routing can be done in a fairly straight forward manner by using the existing routing algorithms for varietal cube and star graph.

A. Routing Algorithm for SVC Network

An interconnection network is modeled as an undirected graph. The vertices correspond to the processors and the edges correspond to the communication links. An Star varietal cube graph, denoted by SVC(n, m) is an undirected graph consisting of $n!2^m$ vertices labeled with the $n!2^m$ permutations on n*m symbols . there is an edge between any two vertices (u,v) if, and only if, their star part labels differ only in the first (leftmost) and in any (one) other position or their varietal part label differs. Let X , Y and Z be three nodes in the SVC(n,m),then route can be done in two ways.

Step 1: Using algorithm of Varietal hypercube.

Step 2: Using algorithm of Star-graph.

Suppose X and Y are two nodes of a Varietal hypercube and Z node belong to another Varietal hypercube. Then, message from X to Y route using an algorithm for self routing in Varietal hypercube and message from Y to Z route using self routing algorithm for the Star graph. Hence, length of the path from X to Z is the sum of the lengths of X to Y and Y to Z nodes.

B.Fault Tolerant Routing:

Failure Assumptions. We make the following failure assumptions:

1) All the node faults are full-stop, i.e., there are no malicious faults.

2) Fault detection and diagnosis algorithms exist. Each node knows exactly the failure status of all its neighbors.

3) Node failures and repairs may happen at any time, but the total number of faulty nodes does not exceed m+n-2 at any time.

We assume that each node's information about the failure status of its neighbors is updated dynamically using the fault detection and diagnosis algorithms.

C. Broadcasting

Broadcasting is a communication pattern frequently seen in a network in which a data set is to be copied from a node to all other nodes. Broadcasting has applications in a number of linear algebra algorithms, database operations, as well as a variety of other algorithms [10]. For a network to be considered as a general purpose architecture, it is quite essential that it must broadcast messages efficiently to other nodes. In this section, two such situations are considered: one-to-all broadcasting and all-to-all broadcasting.

i) One-to-all Broadcasting

Let SVC (n, m) represent a star-cube consisting of n! Varietal hypercube sub-graphs VC (m), where the nodes in VC (m) have the same star graph part label. Alternatively, it can be thought of as having 2^m star sub graphs S(n), where the nodes in each S(n) have the same Varietal hypercube[4].

Theorem 6: The one-to-all broadcasting on a star Varietal cube SVC (n, m) takes at most m + nlog2 n steps.

ii) All-to-all Broadcasting

The all-to-all broadcasting problem is considered here, in

which every node in the network has a message to broadcast to all other nodes.

Theorem 7: In a star varietal cube graph, SVC (n, m), the time complexity of all-to-all broadcasting is O (M + nlog2 n)[4].

V. PERFORMANCE COMPARISON

The various performance measures done here for comparison include: degree, diameter, network cost, cost of one to all and all-to-all broadcasting, Cost effectiveness factor and Time cost effectiveness factor.

A. Cost Factor

Theorem 3: The cost of SVC(n, m) is given by $(m+n-1).\left(\left\lceil \frac{2m}{3} \right\rceil + \left\lfloor \frac{3}{2}(n-1) \right\rfloor\right)$

Proof: Cost of a network is given by the product of node degree and diameter. In SVC(n, m) the degree of SVC(m, n) is $(m+n-1)$ and the diameter is $\left\lceil \frac{2m}{3} \right\rceil + \left\lfloor \frac{3}{2}(n-1) \right\rfloor$.

Hence the result.

B. Fault Diameter

Fault diameter d^f of the graph *G* with fault tolerance *f* is defined as the maximum diameter of any graph obtained from *G* by deleting at most f vertices. If an interconnection network is to be used as a multi computer communication medium, it is very important that its fault diameter is close to its normal diameter. Small fault diameter values ensure acceptable communication delays in the presence of faults. Consequently, a family of graphs $\{G_n\}$ is defined to be strongly resilient if the fault diameter of any member of the family G_n is at most $d^f = d_n + c$, where d_n, is the normal diameter of G_n, and c is a constant independent of graph. So, the fault diameter of SVC(n,m) is $d^f = \left\lceil \frac{2m}{3} \right\rceil + \left\lfloor \frac{3}{2}(n-1) \right\rfloor + c$

C. Fault Tolerance

The fault tolerance of a graph is defined as the maximum number of vertices that can be removed from it provided that the remaining graph is still connected. Hence, the fault tolerance of a graph is defined to be one less than its connectivity. For symmetric interconnection networks such as the cube or star graph, the connectivity is equal to the node degree, and their fault tolerance is one less than their degree, i.e., they are maximally fault tolerant[6]. According to this concept the fault tolerance of SVC(n, m) is m+n

D. Cost Effectiveness Factor

The success of any parallel algorithm design relies on two measures namely: cost effectiveness and time-cost effectiveness [16]. The cost effectiveness of a parallel algorithm considers not only the cost of the processors but also the cost of communication links. It takes into account the cost of the entire multiprocessor as well as the processor utilization by the parallel algorithm.

Theorem 6: The cost effectiveness of SVC(n, m) is derived as $CEF(p) = \frac{1}{1 + p(m+n-1) \times 0.5}$

Proof: In general the number of links is a function of the number of nodes that is E=f(p).

The total number of processor is p= $n!.2^{m}$ And the total number of links in SVC(n,m) is $E = n!2^{m-1}(m+n-1)$ or

$$E = \frac{p}{2}(m+n-1)$$

So, $g(p) = \frac{f(p)}{p} = \frac{m+n-1}{2}$

Where g(p) is the ratio of number of links to the number of processor and *p* is the ratio of link cost to processor cost

$CEF(p) = \frac{1}{1 + p \times g(p)}$ then $CEF(p) = \frac{1}{1 + p(m+n-1) \times 0.5}$.

E. *Time Cost Effectiveness Factor*

This measure takes into account the time for solution of a problem as a parameter. TCEF considers that a delayed solution is not at all beneficial. Rather a faster solution is more rewarding. For SVC(n, m) the TCEF is as follows:

$$TCEF(p, T_p) = \frac{1 + \sigma T_1^{\alpha-1}}{1 + p \times g(p) + T_1^{\alpha-1}\alpha / p}$$

Where T_1 is the time required to solve the problem by a single processor using a fastest sequential algorithm. T_p is the time required to solve the problem by a parallel algorithm using a multiprocessor system having p processors and *p* is the cost of penalty / cost of processors. For tabulation α and σ are taken as 1. [13]

VI.RESULTS AND DISCUSSIONS

This section gives attention to various computed results and their comparisons among the proposed and other networks.

The diameter of SVC is compared with that of Star, VH and SC(n,m) . The result is shown in Fig. 5. The SVC is found to have least diameter. Fig 6. shows the comparison of cost of SVC with that of Star, VH and SC. It does not rapidly increase when compared with SC[4]. It is observed that cost of SVC is the least. The degree of SVC is compared with that of Star, VH and SC (n, m). The result is shown in Fig 7. It is lowest for SC. Fig.8 depicts a comparative study of the routing time of SVC and SC. The result shows that routing time of SVC is lesser than SC. Table 1 compares the degree, edges and diameter of Hypercube, Star graph, Star-cube, Varietal hypercube and Star varietal cube.

Table 2 below shows the various parameters of Star cube and Star varietal cube. In Table 3 and 4 computed values of *CEF* and *TCEF* are shown. The SVC network possesses better values.

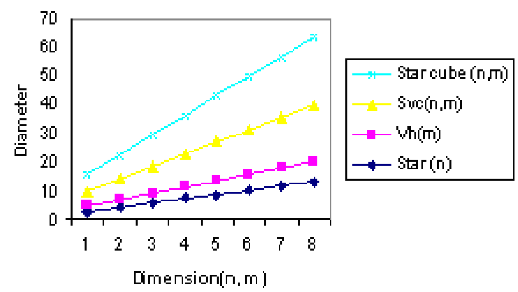

Figure 5 Comparison of Diameter

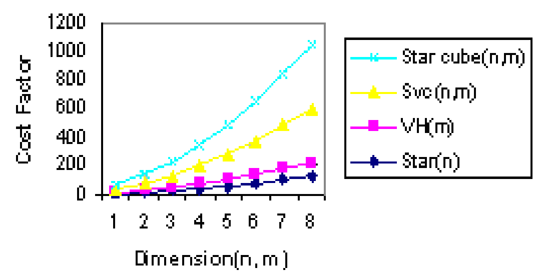

Figure 6 Comparison of Cost

Dimension	Varietal cube (m)	Star(n)	SVC(n,m=3)
3	1.5686274	1.5789474	1.5737705
4	1.5841584	1.6783217	1.5323224
5	1.5609756	1.6551724	1.4803392
6	1.5201900	1.5982242	1.4283943
7	1.4729574	1.5382268	1.3792868
8	1.4245965	1.4814543	1.3333333
9	1.3774549	1.4285686	1.2903223
10	1.3325658	1.3793101	1.2500000

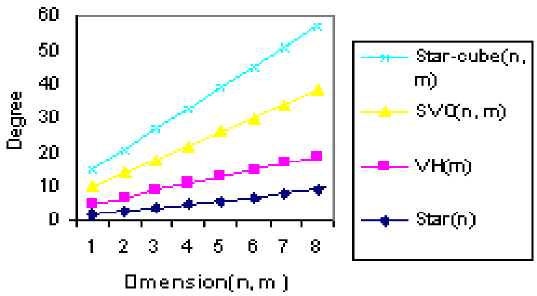

Figure 7 Comparison of Degree

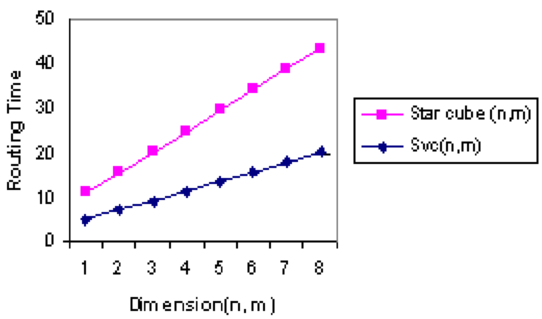

Figure 8 Comparison of Routing Time

Table 2: Comparison of Starcube and SVC Parameters

Graph Parameters	Star-cube	Star varietal cube
Size/Nodes	$n!.2^m$	$n!.2^m$

Network	Dimen-sion	With p=0.1	With p=0.3	With p=0.5	With p=1.0
Star varietal cube SVC(n,m)m=3	n=3	0.8000000	0.5714285	0.4444444	0.2857142
	n=4	0.7692307	0.5263157	0.4000000	0.2500000
	n=5	0.7407407	0.4878048	0.3636363	0.2222222
	n=6	0.7142857	0.4545454	0.3333333	0.2000000
	n=7	0.689551	0.4255319	0.3076923	0.1818181
	n=8	0.666666	0.4000000	0.2857142	0.1666666
	n=9	0.6451612	0.3777358	0.2666666	0.1538461
	n=10	0.6250000	0.3571428	0.2500000	0.1428571

Average distance	$\frac{m}{2} + n - 4 + \frac{2}{n} + \sum_{i=1}^{n} \frac{1}{i}$	$\left(\frac{11x+4y}{8}\right) + n - 4 + \frac{2}{n} + \sum_{i=1}^{n} \frac{1}{i}$
Fault Diameter	$m + \left\lfloor \frac{3}{2}(n-1) \right\rfloor$ +C	$\left\lceil \frac{2m}{3} \right\rceil + \left\lfloor \frac{3}{2}(n-1) \right\rfloor + c$
Cost	$(m+n-1) \times \left(m + \left\lfloor \frac{3}{2}(n-1) \right\rfloor \right)$	$(m+n-1) . \left(\left\lceil \frac{2m}{3} \right\rceil + \left\lfloor \frac{3}{2}(n-1) \right\rfloor \right)$

Table 3:Cost effectiveness factor of SVC(n,m)

Table 4: Time cost effectiveness factor p=0.1,σ=1

VII CONCLUSION

In this paper a new interconnection network called Star varietal cube has been proposed. It is hierarchical, recursive network and is robust to node faults. This network retains most of the properties of the Star as well as Varietal hypercube. The Star varietal cube is better suited for variable node size applications. The topological properties of the Star varietal cube indicate that the proposed network is maximally fault-tolerant. So the proposed network performs well in terms of diameter, average distance, constant degree of connectivity, fault diameter, and cost factor. The various topological parameters of the proposed topology have been analyzed and evaluated. The routing and broadcasting algorithms are also proposed for the new network with less cost . The result establishes the proposed network to be quite effective, reliable and fault-tolerant and hence a better candidate for parallel systems.

ACKNOWLEDGMENT

Authors thank Prof(Dr). C. R. Tripathy, Dept. of CSE & IT for his encouragement and technical guidance throughout the research work.

REFERENCES

[1]. Y Saad and M H Schultz. .Topological Properties of Hypercubes.. IEEE Transactions Compuers, vol 37, 1998, p 867.

[2] S. B. Akers, D. Harel, and B. Krishnamurthy, "The Star Graph: An Attractive Alternative to the n-Cube,,,in Proc. Int. Conf. Parallel Processing, 1987,

pp. 393-400.

[3]. J M Kumar and L M Pattnaik. 'Extended Hypercube : A Hierarchical Interconnection Network of Hypercubes'. IEEE Transactions on Parallel and Distributed Systems, vol 3, no 1,1992, p 45.

[4] Tripathy C.R., " Star-cube: A New Fault Tolerant Interconnection Topology For Massively Parallel Systems", IE(I) Journal, ETE Div., vol.84, no 2, pp. Jan 2004, 83- 92.

[5]. S B Akers and B Krishnamurthy. .The Fault-tolerance of Star Graphs.. Processing International Conference on Supercomputing, 1987, p 270.

[6]. S Y Cheng and J H Chuang. 'Varietal Hypercube – A New Interconnection Network Topology for Large Multi-computers', Proceedings of the International Conference on Parallel and Distributed System, IEEE Computers Society Press, 1994, p 703.

[7]. P Ramanathan and K G Shin. 'Reliable Broadcast in Hypercube Multi-computers', IEEE Transactions on Computers, vol 37, 1988, p 1654.

[8] Avizienis A., " Fault Tolerant System", IEEE Transactions on Computers, vol. 25, no 12, 1976, pp.1304-1312 .

[9] Latif S, "On The Fault Diameter of Star Graphs", Information Processing Letters, Vol 46, 1993, pp. 143-150.

[10] S. L. Johnsson and C.-T. Ho, "Optimum broadcasting and personalized communication in

hypercubes," IEEE Trans. Cornput., vol. 38, pp, 1249-1268, Sep. 1989.

[12]. S W Graham and S R Seidel. .The Cost of Broadcasting on Star Graphs and k-ary Hypercubes.. IEEE Transactions on Computers, vol 42, 1993, p 756. 15.D Sarkar. .Cost and Time-cost Effectiveness of Multiprocessing.. IEEE Transactions on Parallel and Distributed Systems, vol 4, 1993, p 704.

[13]. D Sarkar. "Cost and Time-cost-effectiveness of Multiprocessing". IEEE Transactions on Parallel and Distributed Systems, vol 4, no 6, 1993, p 704

[14] Adhikari Nibedita and Tripathy C.R, " Folded Dualcube : A New interconnection for Parallel Systems", Proceedings of 11th Int. Conf. on Information Technology, 2008, 17-18 Dec, pp.-75-78, IEEE, Comp. Society