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Fault Tolerant Routing in Irregular Modified Shuffle Network

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ABSTRACT*:* Interconnection networks (IN) play very important role in various parallel processing applications. The connectivity pattern used in interconnection networks greatly determines the performance of the system. Multistage Interconnection Network is also an IN. The interconnection pattern used also determines the fault tolerance of the network. This paper introduces a new irregular fault tolerant multistage interconnection network named Irregular Modified Shuffle Network (IMSN). IMSN is analyzed in terms of fault tolerance and it has been observed that IMSN provides more alternate paths than existing networks such as Improved Four Tree Network (IFTN), Modified Alpha Network (MALN) and New Irregular Augmented Shuffle Network (NIASN).

KEYWORDS*:* Multistage Interconnection Network (MIN), Routing, Fault Tolerance, Switching Element, Irregular Modified Shuffle Network (IMSN).

I. INTRODUCTION

Parallel computing is employed in multiprocessor systems to solve large computational problems. Interconnection networks are fast means of interconnecting resources in multiprocessor systems. Most of the networks belong to a class of direct networks meaning processors are directly connected to other processors via their communication links. But there are some other networks which do not directly connect the processors. Such networks are multistage interconnection networks. Multistage interconnection networks connect various processors and memory modules by using swtiches arranged in various stages which map any input to output. It offers valuable way of decreasing exexution time and cost, increasing concurrency and overcoming memory constraints. In this paper, a new irregular fault tolerant multistage interconnection network named Irregular Modified Shuffle Network (IMSN) is proposed and analyzed in terms of routing. Fault Tolerance implies that the network is capable of servicing requests even when there is some failure such as switch failure at any stage. IMSN is irregular network because there are unequal number of switches at every stage. This paper entails discussion about routing procedure of IMSN that how data packets are routed from source to destination using various alternative paths available in non-faulty and faulty case. Therefore, IMSN is multipath in nature.

The Rest of the paper is organised as follows: Section 2 describes redundancy graphs of existing networks like IFTN [7], MALN [8] and NIASN [9]. Section 3 discusses the structure of the proposed network. Section 4 shows redundancy graph of IMSN which depicts pictorially various alternative paths available to route data packets. Section 5 discusses the routing algorithm for IMSN. Section 6 illustrates routing algorithm using example and it is followed by results in Section 7 and conclusions in Section 8.

II. RELATED WORK

Various Irregular Multistage Interconnection Networks have been proposed in literature. Some of MINs are described here which includes Improved Four Tree Network (IFTN) [7], Modified Alpha Network (MALN) [8] and New Irregular Augmented Shuffle Network (NIASN) [9]. Redundancy Graph of a network helps in depicting the fault tolerance of the network i.e. number of alternate paths available in case of any fault. Redundancy graphs of various networks proposed in literature are shown below.

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A. REDUNDANCY GRAPH OF IMPROVED FOUR TREE NETWORK (IFTN)

An Improved Four Tree Network (IFTN) [7] of size 16x16 contains total (2n+2 -8) switches, where n= log2N. There are 2n-1 switches of size 2x2 and rest of size 3x3. Every 3 x 3 SE (switching element) in a stage forms a loop with the corresponding numbered 3 x 3 SE of other sub-network in the same stage. An IFTN network being an irregular network supports multiple paths of different path lengths. A redundancy graph of IFTN is shown in Fig. 1 which depicts all the available paths between a source and a destination. Redundancy graph of IFTN shows that there exist eight paths between a given source and destination pair in IFTN network.

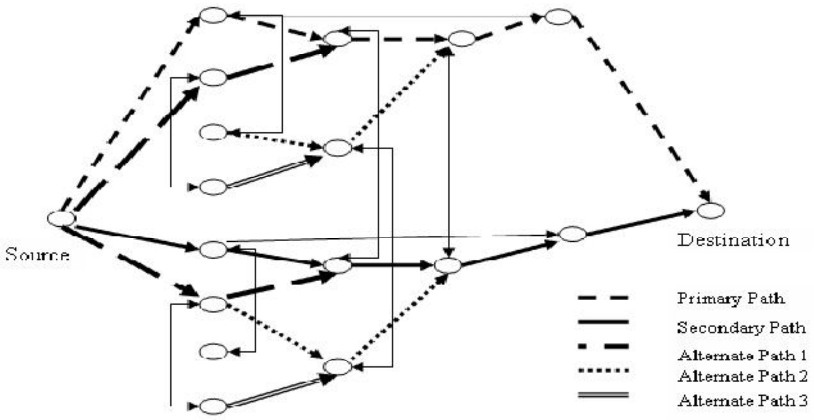

Fig. 1. Redundancy Graph of IFTN

B. REDUNDANCY GRAPH OF MODIFIED ALPHA NETWORK (MALN)

Modified Alpha Network (MALN) [8] of size N*N has N sources and N destinations. MALN consists of n stages (n=log2 N). The switches in all the stages are of size 3*3 except the last one. The switches in the stages n-3, n-2 and n-1 have been connected to each other through links called as auxiliary links. Use of these links makes the network fault tolerant. The modified Alpha network of size 2n * 2n consists of (2m- 2) stages where m=log2(N/2).This network has 2n no. of switches of size 3*3 and 2n-1 no. of switches of size 2*2. The redundancy graph of the MALN pictorially represents all the paths available from all sources to all destinations. Fig. 2 shows that there are eight alternative paths available in Modified Alpha Network.

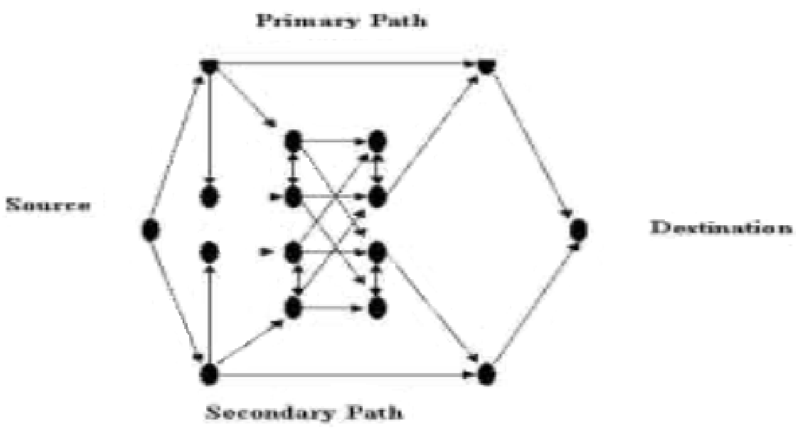

Fig. 2. Redundancy Graph of MALN

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C. REDUNDANCY GRAPH OF NEW IRREGULAR AUGMENTED SHUFFLE NETWORK (NIASN)

New Irregular Augmented Shuffle Network (NIASN)[9] is a NxN (2n x 2n) network (where N is the number of sources and destinations, n = log2 N) which consists of m stages (where m = log2 N/2). The first and the last stage of the network consist of equal number of switching elements (SEs) that is 2n -1 each whereas the intermediate stages consist of less number of switching elements equal to (2n-2+2) each. The switches in the last stage are of size 2x2 and the rest switches from stage 1 to (m-1) are of size 3x3. There are 2n multiplexers of size 2 x 1 and 2n demultiplexers of size 1 x 2.The redundancy graph of NIASN is shown in Fig. 3 which defines that in NIASN there exists 6 alternative paths.

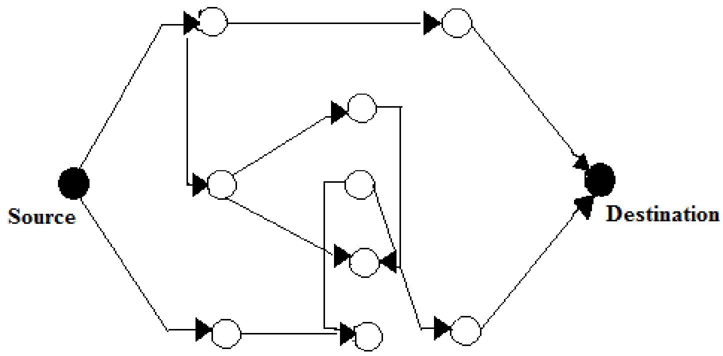

Fig. 3. Redundancy Graph of NIASN

Table 1: Symbol Table

Symbol	Meaning of Symbol
SE	Switching Element
PSE_1	Primary Switching Element of Stage 1
$FASE_1$	First Alternate Switching Element of Stage 1
$SASE_1$	Second Alternate Switching Element of Stage 1
PSE_2	Primary Switching Element of Stage 2
$FASE_2$	First Alternate Switching Element of Stage 2
PSE_3	Primary Switching Element of Stage 3
$FASE_3$	First Alternate Switching Element of Stage 3
$SASE_3$	Second Alternate Switching Element of Stage 3
PSE_4	Primary Switching Element of Stage 4
$FASE_4$	First Alternate Switching Element of Stage 4
$SASE_4$	Second Alternate Switching Element of Stage 4

III. PROPOSED INTERCONNECTION NETWORK (IMSN)

The structure of Irregular Modified Shuffle Network (IMSN) is shown in Fig. 4. IMSN is an irregular multistage interconnection network of size NxN (2^nx2^n) where N=16 as it has 16 sources and 16 destinations (and n=$\log_2$N). IMSN consists of $\log_2$N stages and as N=16, it has 4 stages. This network consists of 2^n multiplexers and 2^n demultiplexers of size 2x1 and 1x2 respectively. The first and last stage of the network consists of 2^{n-1} switching elements (SEs) and intermediate stages consists of less number of switching elements. The second stage of the network consists of 2^{n-3} switching elements and third stage contains 2^{n-2} switching elements. The first stage of the network has N/2 switches of size 3x3, the second stage of the network contains N/8 switches of size 5x5, the third stage of the network contains N/4switches of size 2x8 and the last stage of the network has N/2 switches of size 5x2.

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The SEs of first stage are linked to SEs of second and last stage, the SEs of second stage are connected to SEs of third stage, the SEs of third stage are connected to SEs of fourth stage as shown in Fig. 4. Each source is connected to SEs of first stage using multiplexers and each destination is linked to SEs of last stage using demultiplexers. The SEs at first and second stage form auxiliary links to avail more paths to each source-destination pair. This network is double switch fault tolerant at first, third and fourth stage and single switch fault tolerant at second stage. In this network, each source is connected to 3 SEs like source 4 is connected to switching elements C, G, H. Thus each source has 1 PSE_1 like C to which it is directly connected and 2 alternate SEs like $FASE_1$ i.e. G and $SASE_1$ i.e. H to which it is connected indirectly. Fig. 4 shows the proposed network named Irregular Modified Shuffle Network (IMSN). Various sources, destinations, multiplexers, demultiplexers and stages are shown in figure.

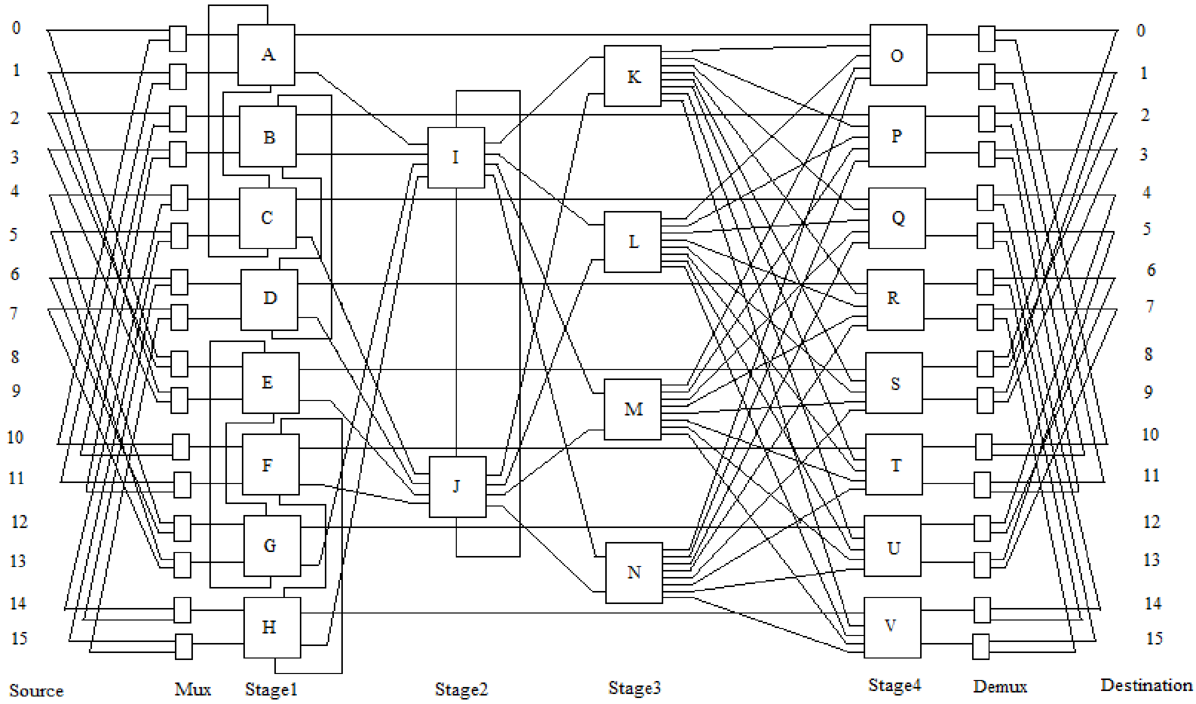

Fig. 4. Irregular Modified Shuffle Network (IMSN)

IV. REDUNDANCY GRAPH OF IMSN

Redundancy graph is pictorial representation of the network. It shows all the possible paths available from one source to one destination [11]. It offers a covenient way to study multipath nature of the MIN. Therefore, it also helps in depicting the faults tolerated by MIN and rerouting possible when fault occurs [6]. Source, Destination and various nodes or switching elements are shown in Fig. 5.The redunadancy graph of IMSN shows various alternative paths available from one source to destination and it has been observed that it has more number of alternate paths than IFTN [7] , MALN [8] and NIASN [9].

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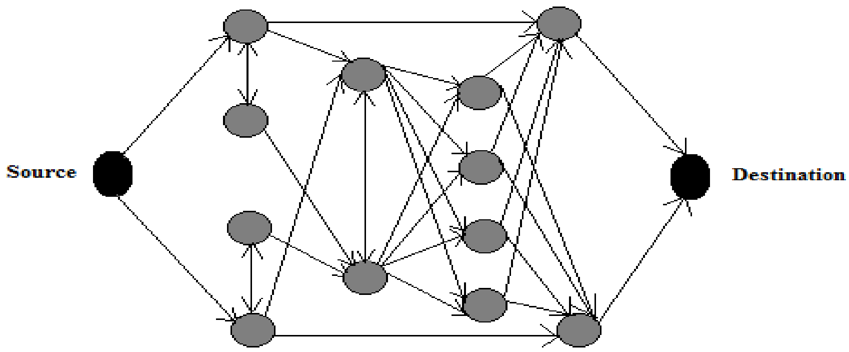

Fig. 5. Redundancy Graph of IMSN

V. ROUTING ALGORITHM FOR IMSN

Routing algorithm is proposed for IMSN. It describes how data packets are routed from source to destination when there is no failure and when failure occurs such as switch failure. In case of failure it describes how data packets are routed to alternative paths [5]. Various steps are described below:

1. Start.
2. Acquire source and destination address. Based on the source address route the request to PSE_1 through multiplexer. If PSE_1 is unavailable or found to be faulty then route the request to $FASE_1$. If $FASE_1$ is also busy or faulty then route the request to $SASE_1$ through multiplexer's connectivity. If $SASE_1$ is also busy or faulty then request is simply dropped otherwise route the request to appropriate SE of second stage and follow Step 3.
3. On arrival of request on one of the input links of PSE_2, it is checked for faults. If PSE_2 is found to be faulty or busy route the request to $FASE_2$. If $FASE_2$ is also busy or faulty drop the request otherwise route the request to appropriate SE of third stage and follow Step 4.
4. Request is received on one of the input links of PSE_3 and it is checked for faults. If PSE_3 is found to be faulty or busy route the request to $FASE_3$. If $FASE_3$ is also busy or faulty then send the request to $SASE_3$. If $SASE_3$ is also found to be busy or faulty then drop the request otherwise route the request to appropriate SE of fourth stage and follow Step 5.
5. On arrival of request on one of the input links of PSE_4, it is checked for faults. If PSE_4 is found to be faulty or busy route the request to $FASE_4$. If $FASE_4$ is also busy or faulty then send the request to $SASE_4$. If $SASE_4$ is also found to be busy or faulty then drop the request otherwise route the request to appropriate destination through demultiplexer.
6. End.

VI. IMPLEMENTATION OF ROUTING PROCEDURE FOR IMSN

Example: Let source is 6 and destination is 9. This implies that we have to route the data packets from source address 0110 to 1001. Generally 2 cases are considered. Case 1 entails description of paths followed by data packets when there is no fault i.e. no SE is faulty. Case 2 discusses the path followed by data packets during their transmission process when 1 SE is faulty at every stage [4].

Case 1: When SEs are non-faulty or not busy at every stage of MIN.

1. Start.
2. As source is 6, SE D will receive the request through multiplexer on one of its input link and will forward the request to SE of next stage.
3. SE D will route the request received to SE J of second stage which will forward the request to appropriate SE of next stage.
4. SE J will send data packets to SE K of third stage and will proceed to Step 5.
5. SE K will forward the request to SE S which will forward the data packets to destination address 9 through demultiplexer.

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6. End.

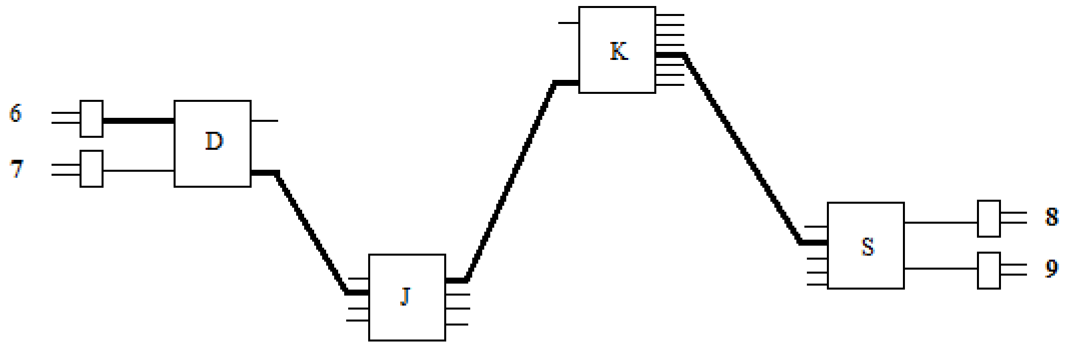

Fig. 6. Routing of data packets from source 6 to destination 9 in non-faulty case

Case 2: When 1 SE is faulty or busy at every stage. Like in the example discussed above suppose SE D, J, K and L are faulty, then path followed by data packets is given below:
1. Start.
2. Given source is 6 but as SE D is faulty, request will be routed to FASE$_1$ through multiplexer i.e. SE G. SE G will then route the request to next SE of second stage.
3. Now SE J of second stage is found to be faulty and SE G is linked to SE I of second stage. Therefore, request will be received by SE I and next step is followed.
4. As SE K is also faulty, request will be routed to SE L of third stage by SE I of second stage and step 5 is followed.
5. On receiving request, SE L will route the request to SE O of fourth stage finding that SE S is faulty. Therefore, SE O will route the data packets to the intended destination through demultiplexer.
6. End

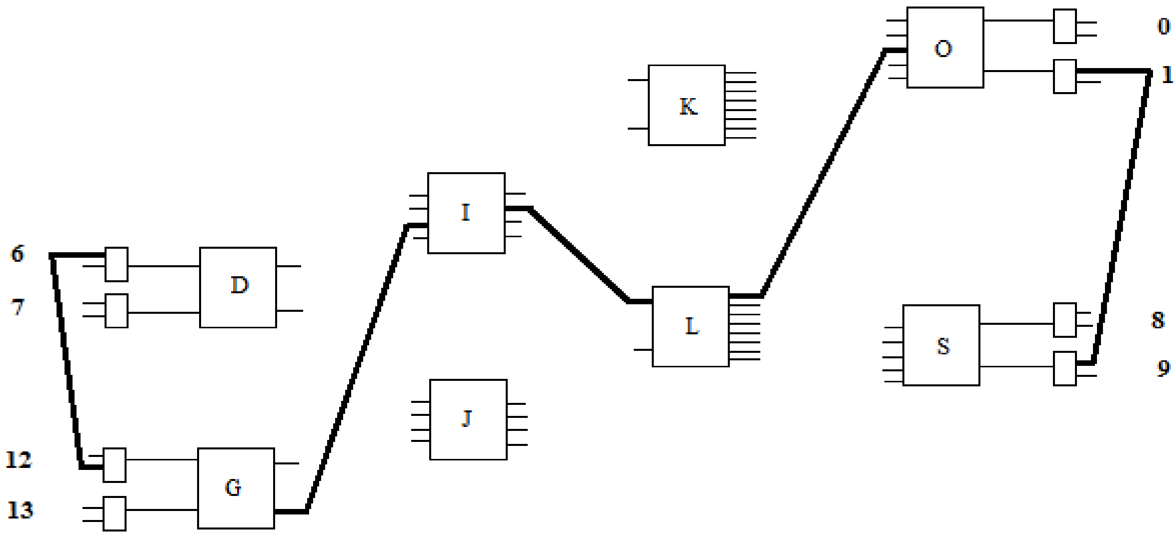

Fig. 7. Routing of data packets from source 6 to destination 9 in faulty case

VII. RESULTS

A new fault tolerant multistage interconnection network named Irregular Modified Shuffle Network (IMSN) is proposed and analysed in terms of alternate paths availability. Its Routing Algorithm and its implementation is explained with the help of example and it has been observed that multiple alternate paths are available for each source-destination pair to transmit data. Therefore, there are maximum 16 paths available from one source to one destination in IMSN. For example to route the request from source 6 to destination 9 there are 16 available paths.

Path 1: D → J → K → S
Path 2: D → J → L → S
Path 3: D → J → M → S
Path 4: D → J → N → S
Path 5: D → J → I → K → S
Path 6: D → J → I → L → S
Path 7: D → J → I → M → S
Path 8: D → J → I → N → S
Path 9: D → B → I → K → S
Path 10: D → B → I → L → S
Path 11: D → B → I → M → S
Path 12: D → B → I → N → S
Path 13: D → B → I → J → K → S
Path 14: D → B → I → J → L → S
Path 15: D → B → I → J → M → S
Path 16: D → B → I → J → N → S

Therefore, IMSN is more fault tolerant with more alternate paths as compared to existing networks like IFTN [7], MALN [8], NIASN [9]. Table 2 shows comparison of alternate paths available in various networks.

Table 2: Number of Paths Comparison of various Multistage Interconnection Networks in non-faulty case

Multistage Interconnection Network	Number of available paths from one source to one destination
IMSN	16
IFTN	8
MALN	8
NIASN	6

VIII. CONCLUSION

In this paper, a new fault tolerant multistage interconnection network named Irregular Modified Shuffle Network (IMSN) is proposed and analyzed. It has been observed that IMSN has 16 alternative paths. In case of faults it routes the data packets to various alternative paths available. Therefore, the proposed network has more alternate paths available when compared with existing networks like IFTN [7], MALN [8], NIASN [9] which have 8, 8 and 6 alternate paths respectively. Hence IMSN is more fault tolerant than IFTN [7], MALN [8] and NIASN [9].

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REFERENCES

[1] Ved Parkash Bhardwaj and Nitin, " Message Broadcasting via a New Fault Tolerant Irregular Advance Omega Network in Faulty and Non faulty Network Environment", Journal of Electrical and Computer Engineering, Hindawi Publishing Corporation, vol 2013, pp. 1-17, 2013.

[2] Ved Parkash Bhardwaj and Nitin, "On Performance Analysis Of IASEN-3 in faulty and non-faulty network conditions", AASRI conference on Intelligent Systems and Control, Elsevier, pp. 104-109, 2013.

[3] Nitin and Durg Singh Chauhan, "A New Fault–Tolerant Routing Algorithm for IMABN–2", Proceedings of the 2nd IEEE International Conference on Advances in Computing and Communications, Kerala, INDIA, pp. 215–218, August 9–11, 2012.

[4] Ved Prakash Bhardwaj & Nitin, "A New Fault–Tolerant Routing Algorithm for IASEN–2", Proceedings of the 2nd IEEE International Conference on Advances in Computing and Communications, Kerala, INDIA, pp.199-202, August 9–11, 2012.

[5] V.P. Bhardwaj and Nitin, "A New Fault Tolerant Routing Algorithm for Advance Irregular Augmented Shuffle Exchange Network", Proceedings of the 14th IEEE International conference on Computer Modeling and Simulation (IEEE UKSIM), Emmanuel College, Cambridge, UK, March 28-30, 2012.

[6] Rinkle Rani Aggarwal, "Design and Performance Evaluation of a New Irregular Fault Tolerant Multistage Interconnection Network", International Journal Of Computer Science Issues, Vol 9, Issue-2, No 3,March 2012.

[7] Rinkle Rani Aggarwal, "Design And Reliability Analysis of a class of Fault-Tolerant Multistage Interconnection Networks", International Journal of Computer Applications, Volume 39– No.8, February 2012.

[8] Amardeep Gupta & Dr. P. K. Bansal, " Fault Tolerant Modified Alpha Network and Evaluation Of Performance Parameters", International Journal Of Computer Applications, Volume 4-No.1, July 2010.

[9] Kanwarpreet Kaur, Pawandeep Kaur, Dr. Harsh Sadawarti, " Performance Analysis of New Irregular Multistage Interconnection Network", International Journal Of Advanced Engineering Sciences And Technologies, Vol No. 9, Issue No. 1, 082 - 086.

[10] Dr. Harsh Sadawarti, Pawandeep Kaur, Kanwarpreet Kaur, "Performance Analysis Of Irregular Augmented Four Tree Network", International Journal Of Advanced Engineering Sciences And Technologies, Vol No. 9, Issue No. 1, 091 – 096.

[11] Harsh Sadawarti and P.K.Bansal, "Fault Tolerant Irregular Augmented Shuffle Network", Proceeding of the 2007 WSEAS International Conference on Computer Engineering and Applications, Australia, pp. 7-12, January 17-19,2007.

[12] Bataineh, S.M., B.Y. Allosl, "Fault-tolerant multistage interconnection network." J. Telecomm. Syst., 17, pp. 455-472, 2001.

[13] Jose Duato, Sudhakar Yalamanchili and Ni Lionel, "Interconnection Networks: An Engineering Approach", IEEE Computer Society, 1997.

[14] Vijay P. Kumar, Andrew L. Reibman, "Failure Dependent Performance Analysis of a Fault-Tolerant Multistage Interconnection Network", IEEE Transactions On Computers, Vol. 38, No. 12**,** December 1989.

[15] Kruskal Clyde P. and Snir Marc, "The Performance of Multistage Interconnection Networks for Multiprocessors", IEEE Transactions on Computers, vol. c-32, no. 12, pp. 1091-1098, December 1983.