Proposed Fault Tolerant New Irregular Augmented Shuffle Network

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ABSTRACT

Multistage Interconnection Networks (MINs) are playing a vital role in real time applications. The MIN with N processors and N memory modules has the complexity as O (N log2 N). In real time applications it is important to consider time dependent reliability i.e. R (t) and mean time to failure i.e. MTTF. The imperfect coverage is defined as the probability that the system successfully reconfigures under component faults. This concept is important in considering the reliability of MINs because as the size of MIN increases the number of components increases and the probability for an occurrence of uncovered fault increase. In this paper a new class of Irregular Fault Tolerant MIN named as New Irregular Augmented Shuffle Network (NIASN) has been introduced and studied. This MIN provides better Bandwidth, Probability of acceptance, Processing Power, Processor Utilizations, Through Put and Permutation passable without Faults and with Faults in the Network and reliability as compared to popular MINs like IASN, ASEN-2 and ABN.

Keywords:* *Fault Tolerant Irregular Network, Construction procedure of MIN, Data Routing and Reliability.

1.0 INTRODUCTION

In today's era the Computation Speed and Computation Power are increasing constantly. The MINs are used in important applications like ATM Networks, High speed computations and in almost every field where instant result and calculations are required. There is more than one stage of small interconnection networks like Switching Elements (SEs) in MINs.

1.1 CONSTRUCTION PROCEDURE OF NIASN MIN

The size of the proposed network is N*N. It has N sources and N destinations. The MIN consists of k-1 stages ($k=\log_2 N$).

The network Comprises of two identical groups of switching elements (SEs), named as G0 and G1. There are N/2 sources and N/2 destinations in each group[7]. Both the groups are connected to the N inputs and N outputs. The inputs are connected through N multiplexers, and the outputs are connected through N. N no. of demultiplexers. In this network the switches are of size 2*2 in all the stages except the first stage where the switches are of size 3*3. The switches in the first stage have been connected to each other through links called as auxiliary links. The auxiliary links are used when the SE in the next stage is busy or faulty. This makes the network more fault tolerant and reliable.

The NIASN network has (2*n) no. of switches of size 3*3 and ((2*n)+3) no. of switches of size 2*2. Each source is connected to one switching element in each group with the help of multiplexers. The network of size 16*16 is shown in Fig. 1

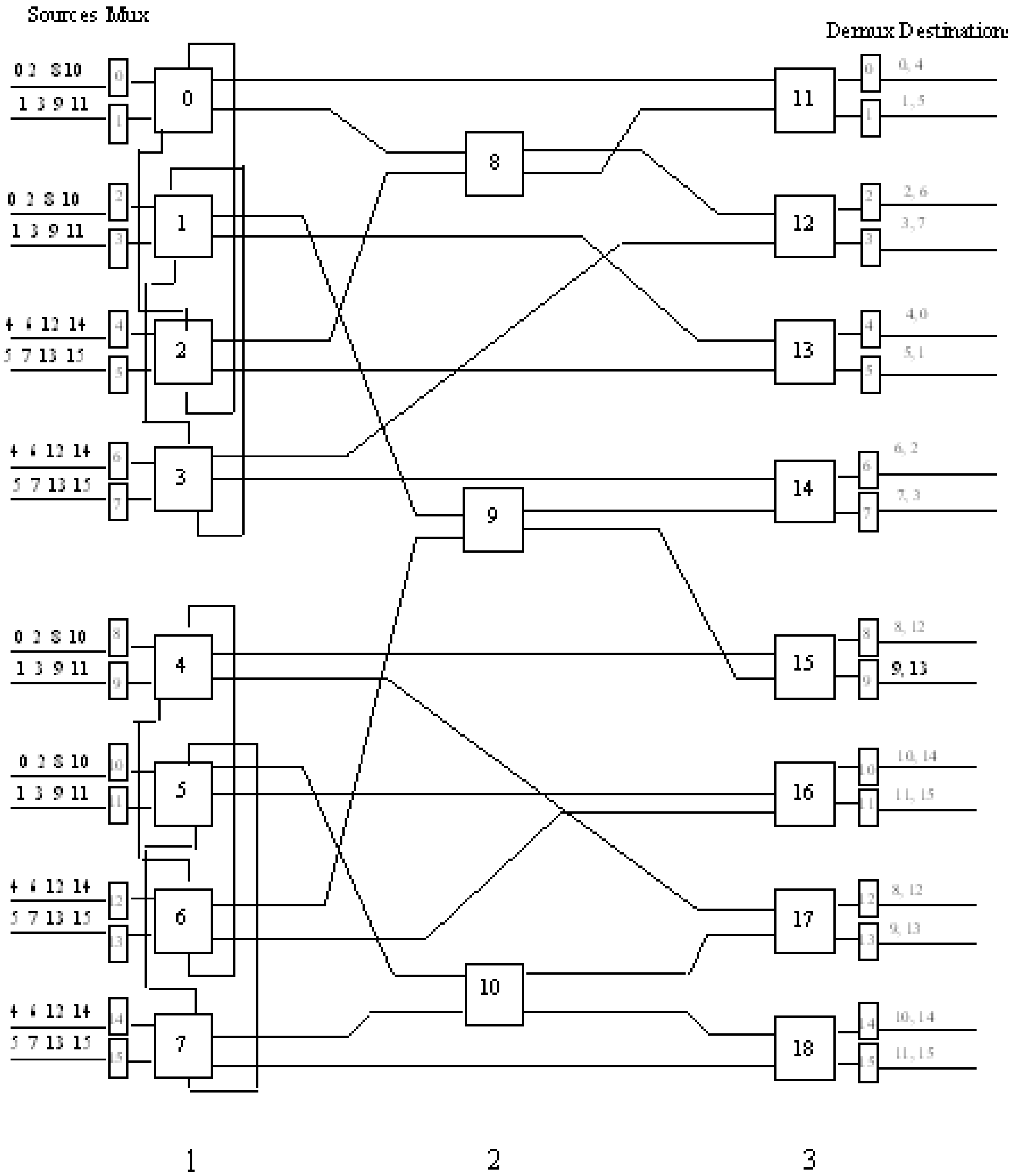

Fig. 1: Structural design of NIASN MIN

2.0 REDUNDANCY GRAPH

The Redundancy Graph shows all the possible paths from each source to every destination [11] [5]. In Fig. 2, the dark circles are the representation of the switching elements in the network. The arrows show the availability of the path to move data from source to destination in the network.

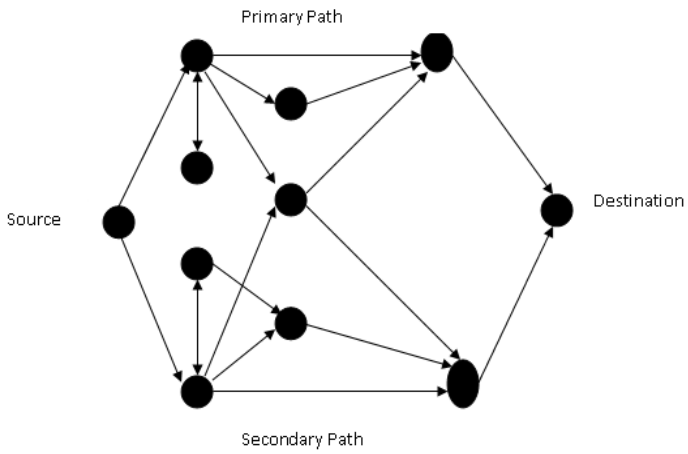

Fig. 2: Redundancy Graph of NIASN MIN

3.0 FAULT TOLERANCES AND REPAIR

If the network is able to work, of course with degraded efficiency, in the presence of faults in critical components then the network is called as fault tolerant[2][8]. If the network can work with full access in the presence of fault in single switching element, then it is called as a single fault tolerant network. The network is considered to be m fault tolerant, if it is able to connect all sources to all destinations in the presence of m faults, then this network is said to be m fault tolerant network.

The discussed MIN satisfies the fault tolerant criteria because it is able to function in the presence of some level of faults. The secondary path is considered in case of fault in the primary path. As there are multiple paths from one particular source to one particular destination, this network is a better choice in terms of Fault tolerance to other existing networks like IASN, ASEN2 and ABN Networks.

The presence of auxiliary links in the first stage helps to route the data through the alternate path [2] [6]. The critical case is when the fault is present in the SE in same loop. Some pair of source and destination will be disconnected.
The construction of the network has two benefits

1 The network is able to tolerate the failure of switches in conjugate.
Proof: The multiple paths from one type of source to one type of designation are available.
2 The NIASN Network provides on line repair and maintenance. The loop can be removed from the network, as well as can be replaced with the new.

4.0 EXPERIMENTAL RESULTS ON RELIABILITY ANALYSIS

Reliability R(t) is the probability that the system does not fail in the interval (0,t). The network is assumed to be faulty if any source destination pair cannot be connected because of the presence of faulty components in the network[9][10].

The reliability can be measured in terms of Mean Time To Failure (MTTF) [1]. It is defined as expected time elapsed before some source is disconnected from some destination.
Some of the assumptions used to calculate the reliability are as under [4] [8]

i. Switches are statistically identical and are either fully operational or failed.
ii. The Switch failure occur with a failure rate of $\lambda = 10^{-6}$ per hour.
iii. Failure rate of 2 x 2 Switching Element is considered as $\lambda_2 = \lambda$
iv. Failure rate of 3 x 3 Switching Element is taken as $\lambda_3 = 2.5\ \lambda$
v. For a m x 1 multiplexer, the failure rate is considered as $\lambda_m = m\lambda/4$.
vi. For 1 x m de-multiplexer the failure rate is considered as $\lambda_d = \lambda_m$.
vii. Switching elements in the last stage and corresponding demultiplexers are taken together as a series system having failure rate of $\lambda_{2d} = 2\ \lambda$.

4.1 Upper Bound Analysis

The network is operational if the critical set of switches is operational. The critical set is the set of k SEs, each from different module such that a failure occurs if all *k* SEs are faulty simultaneously. The expression for Upper Bound Reliability is [3].

$$R_{UB}(t) = [1-(1-e^{-\lambda_m t})^2]^{N/2}\,[1-(1-e^{-\lambda_2 t})^2]^{(N/4-1)+N/8*+-----1}\,[1-(1-e^{-\lambda_{2d} t})^2]^{N/4}$$

$$MTTF = \int_0^{\infty} R_{UB}(t)\,dt$$

The reliability block diagram for the Upper Bound has been shown in Fig. 3. [2]

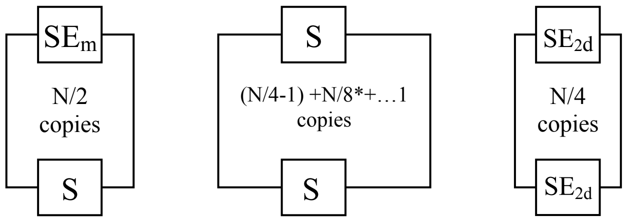

Fig. 3: Reliability Block Diagram for Upper Bound

The values calculated with Simpson's Trapezoidal Numerical Method have been shown in Table 1.

Table 1: Values of Upper Bound MTTF of NIASN MIN

Network Size	16X16	32X32	64X64	128X128	256X256	512X512	1024X1024
Upper Bound	215548	145114	99013	68242	47415	33516	25239

The values of Upper Bound MTTF for other networks are depicted in Table 2, 3 and Table 4.

Table 2: Values of Upper Bound MTTF of IASN MIN

Network Size	16X16	32X32	64X64	128X128	256X256	512X512	1024X1024
Upper Bound	132427	87067	58886	40599	29427	25385	20415

Table 3: Values of Upper Bound MTTF of ASNEN-2 MIN

Network Size	16X16	32X32	64X64	128X128	256X256	512X512	1024X1024
Upper Bound	134935	77685	47339	29855	19255	12611	8353

Table 4: Values of Upper Bound MTTF of ABN MIN

Network Size	16X16	32X32	64X64	128X128	256X256	512X512	1024X1024
Upper Bound	171627	91329	53434	32884	20867	13511	8872

Fig. 4 describes the comparative analysis for Upper Bound MTTF of NIASN, IASN, ASEN-2 and ABN Networks.

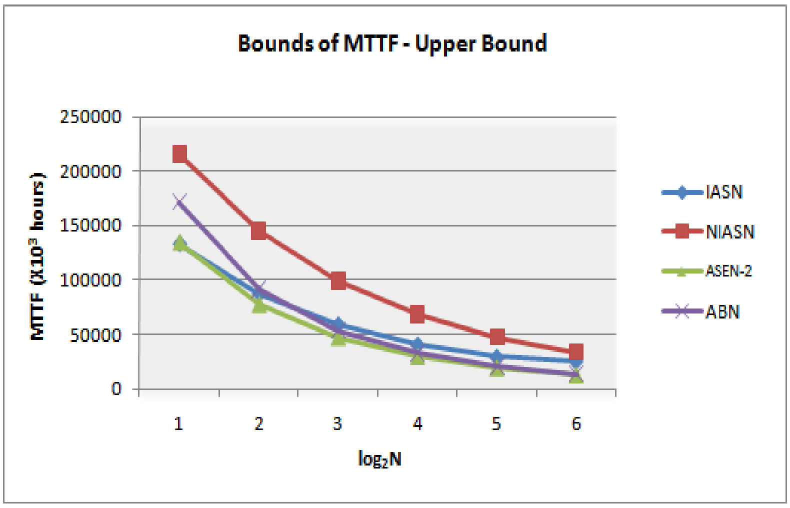

Fig. 4: Comparative Study for Upper Bound MTTF

It is clear from above mentioned Fig. 4 that proposed Network NIASN is reliable as compared to other discussed networks.

4.2 Lower Bound Analysis

In the Lower Bound Analysis the input side SEs and their corresponding multiplexers are considered as a series system and failure of any component leads to the failure of all three[8][14].

The expression for Lower Bound Reliability is

$$R_{LB}(t) = [1-(1-e^{-\lambda_{3m} t})^2]^{N/4} \, [1-(1-e^{-\lambda_2 t})^2]^{N/8*+----1} \, [1-(1-e^{-\lambda_{2d} t})^2]^{N/4+1}$$

The reliability block diagram for the lower bound has been shown in Fig. 5.

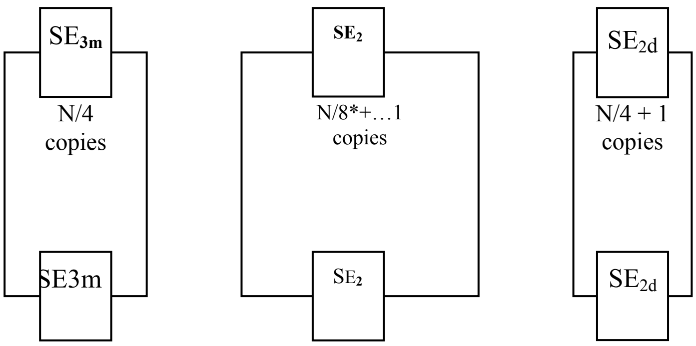

Fig. 5: Reliability Block Diagram for Lower Bound

The Lower Bound values of the proposed network, calculated with Simpson's Trapezoidal Numerical Method, have been shown in Table 5.

Table 5: Values of Lower Bound MTTF of NIASN MIN

Network Size	16X16	32X32	64X64	128X128	256X256	512X512	1024X1024
Lower Bound	100810	69750	48247	33971	26603	25052	22040

The Lower Bound values of the compared similar networks have been shown in Table 6 to Table 8.

Table 6: Values of Lower Bound MTTF of IASN MIN

Network Size	16X16	32X32	64X64	128X128	256X256	512X512	1024X1024
Lower Bound	90508	60377	41271	29858	25438	25003	21010

Table 7: Values of Lower Bound MTTF of ASEN-2 MIN

Network Size	16X16	32X32	64X64	128X128	256X256	512X512	1024X1024
Lower Bound	118383	69950	43375	27700	18035	11900	7928

Table 8: Values of Lower Bound MTTF of ABN MIN

Network Size	16X16	32X32	64X64	128X128	256X256	512X512	1024X1024
Lower Bound	94872	53944	32667	20546	13241	8676	5752

Fig. 6 shows the comparative analysis of Lower Bound MTTF of all the values for the networks discussed.

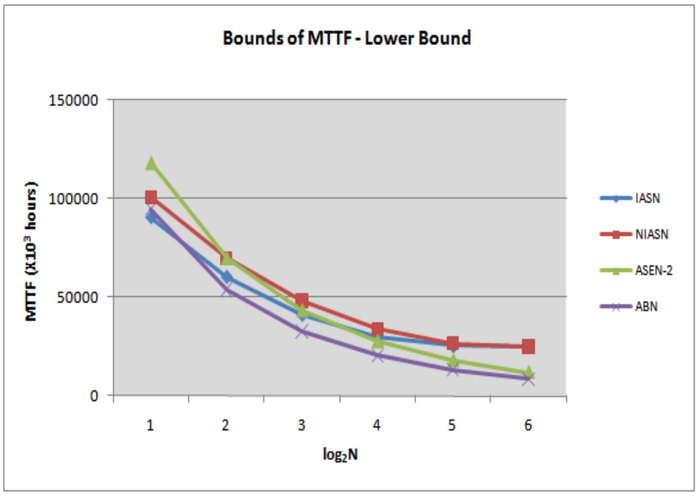

Fig. 6: Comparative Study for Lower Bound MTTF

Fig. 6 depicts that proposed NIASN MIN has better Lower Bound Reliability as compared to IASN and ABN MINs [15]. NIASN is less reliable as compared to ASEN-2 for smaller size network but is better for larger size ASEN-2 Network.

The reliability analysis has been calculated using Simpson's Trapezoidal Numerical Method simulator in c# in .Net platform.

5.0 CONCLUSION

The proposed Fault Tolerant New Irregular Augmented Shuffle Network (NIASN) MIN is better as compared to the other discussed Networks. It has more Upper Bound Reliability as compared to MINs like IASN, ASEN-2 and ABN. The proposed network has less Lower Bound Reliability as compared to ASEN-2 for smaller size Network but has more Lower Bound Reliability for large size Network. The proposed Network has better Lower Bound Reliability as compared to all other discussed Networks. At the same time the proposed network has variable shorter path lengths from source to destination as compared to other discussed networks. It has been observed that the proposed NIASN Network has better Mean Time to Failure and thus is reliable as compared to similar networks. Moreover the NIASN Network is cost effective as it has lesser no of Switching Elements (SEs) as compared to all the discussed Networks. Thus NIASN is preferable to the similar networks considered for comparison.

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