On Performance Evaluation of Advance Irregular Alpha Multi-Stage Interconnection Network-2

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ABSTRACT

In this paper, the author has proposed a new multi-stage interconnection network named as advance irregular alpha multi-stage interconnection network-2 (AIAMIN-2). The AIAMIN-2 is a single switch fault tolerant network. It is compared with modified alpha network (MALN) and irregular modified augmented baseline network (IMABN). Results show that AIAMIN-2 performs better than the MALN and IMABN in faulty and non-faulty conditions.

Keywords

Interconnection Network; Multi-Stage Interconnection Network; MALN; IMABN, AIAMIN-2; Fault

1. INTRODUCTION

Multi-stage interconnection (MIN) provides the reliable and fast communication to the parallel processing applications. Faults in MIN prevent the data transmission process [1-14]. Therefore, designing a good fault tolerant MIN is the key concern. In this paper the author has proposed the AIAMIN-2 which is single switch fault tolerant. Single switch fault tolerant means network can sustain a faulty switch in stage simultaneously. Further, performance of AIAMIN-2 is compared with MALN [13] and IMABN [14] in faulty and non-faulty network conditions. Here, "faulty" means single switch is faulty in every stage of network [15-30].

2. PROPOSED INTERCONNECTION NETWORK

The structure of AIAMIN-2 is shown in Figure 1. This network has 16 sources and 16 destinations. In Figure 1, the source, destination, multiplexers and demultiplexers are represented by S, D, Mux and Demux respectively. There are 16 Mux and 16 Demux in AIAMIN-2. The size of each Mux and Demux is 2×1 and 1×2 respectively. Each stage consists of 8 switching elements (SEs) except the second stage. The size of each SE in first and last stage is 2×3 and 5×2 respectively. The second stage consists of 4 SEs and size of each SE is 4×8.

In Figure 1, it can be observed that the SEs of first stage are connected with sources through Mux and the SEs of second stage. The SEs of second stage connects the first and third stage. Further, the SEs of third stage are connected with the destinations through Demux. In AIAMIN-2, SEs are categorized in 3 category i.e. main SE, first alternate SE and second alternate SE as each source is connected with 3 SEs via Mux e.g. source 0 is connected with SE a, e and f. It shows a, e and f are the main SE, first alternate SE and second alternate SE respectively.
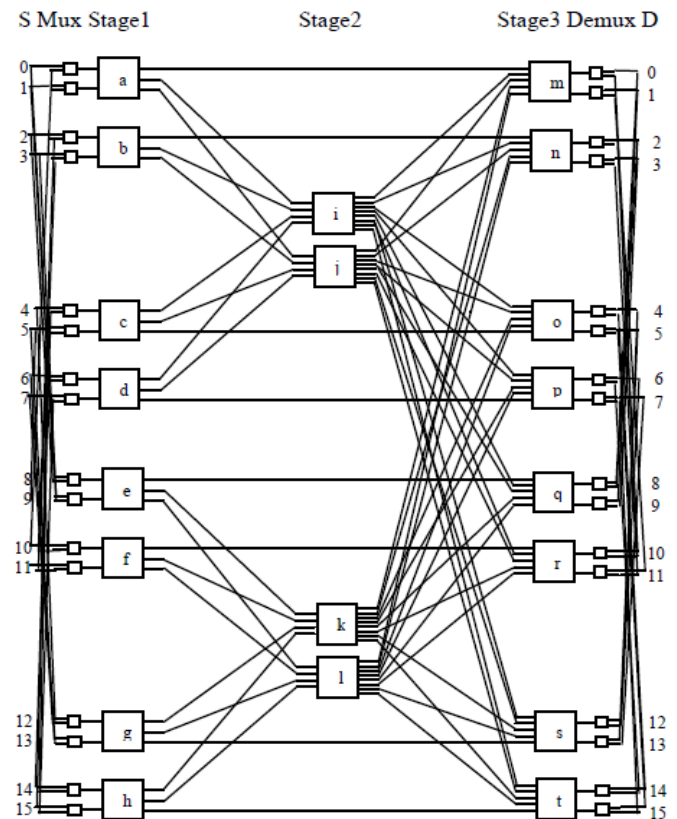

Fig. 1: 16*16 AIAMIN-2

Similarly, the main SE, first alternate SE and second alternate SE for other sources can be obtained. In second stage, SEs i and j are primary and secondary SEs respectively for the SEs a, b, c and d. Similarly, SEs k and l are primary and secondary SEs for SEs e, f, g and h. Further, in third stage we have main SE, first alternate SE and second alternate SE e.g. for destination 0, SEs m, q and r are the main SE, first alternate SE and second alternate SE respectively. Similarly, the main SE, first alternate SE and second alternate SE for other destinations can be obtained.

Table 1 shows the various symbols and their meaning which are used throughout the paper.

Table 1. Symbol table

Symbol	Meaning of Symbol
MSE_1	Main SE of first stage
FAS_1	First alternate SE of first stage
SAS_1	Second alternate SE of first stage
PSE_2	Primary SE of second stage
SSE_2	Secondary SE of second stage
MSE_3	Main SE of third stage
FAS_3	First alternate SE of third stage
SAS_3	Second alternate SE of third stage.

2.1 Routing Algorithm of AIAMIN-2

Algorithm_AIAMIN-2 is the routing algorithm of AIAMIN-2. According to this algorithm, initially data packets arrive on the main SE of first stage. If it is faulty then data packets will be received by the first alternate SE of first stage. If it is also faulty then data packets will be collected by the second alternate SE of first stage. If all the required SEs are faulty then network will fail otherwise anyone of the SE i.e. MSE_1 or FAS_1 or SAS_1 will collect the data packets.

```
BEGIN
     1.    if MSE₁ == F
     2.         FAS₁
     3.              if FAS₁==F
     4.                   SAS₁
     5.              else
     6.                   send data packets to PSE₂
     7.              if SAS₁==F
     8.    Network Fails
     9.              else
    10.                   send data packets to PSE₂
    11.    else
    12.         send data packets to FSE₂
    13.    if PSE₂==F
    14.         SSE₂
    15.         if SSE₂ ==F
    16.              Network Fails
    17.         else
    18.              send data packets to MSE₃
    19.    else
    20.         send data packets to MSE₃
    21.    if MSE₃ == F
    22.         FAS₃
    23.              if FAS₃==F
    24.                   SAS₃
    25.              else
    26.                   send data packets to given D
    27.              if SAS₃==F
    28.                   Network Fails
    29.              else
    30.                   send data packets to given D
    31.    else
    32.         send data packets to given D.
END
```

Further, data packets will be sent to primary SE of second stage. If it is faulty then data packets will be sent to secondary SE of second stage. If both of the SEs are faulty then communication is not possible and network will fail otherwise data packets will be sent to appropriate SE of third stage. In third stage, data packets will be collected by the non-faulty SE. If all the required SE are faulty then network will fail otherwise data packets will be transmitted to the given destination through Demux.

3. PERFORMANCE EVALUATION PARAMETERS

These are the basic factors which are used in order to measure the performance of any network:

3.1 Bandwidth (BW)

It can be defined as follows:

"BW is defined as the mean number of active memory modules in a transfer cycle of interconnection networks (INs) and therefore, BW is the total number of request matured [11, 13]".

If there are a^n sources and b^n destinations then bandwidth will be as follows:

$$BW = b^n \times p_n$$

Here p_n is the request generation probability or load factor. Probability equations for MALN are:

$$p_1 = 1 - (1 - p_0/3)^{\wedge}3$$

$$p_2 = 1 - (1 - p_1/6)^{\wedge}3$$

$$p_3 = 1 - (1 - p_2/3)^{\wedge}3$$

$$p_4 = 1 - \{(1 - p_3) \times (1 - p_1/2)\}^{\wedge}2$$

$$BW\_MALN = N \times p_4$$

Probability equations for IMABN are:

$$p_1 = 1 - (1 - p_0/3)^{\wedge}3$$

$$p_2 = 1 - (1 - p_1/10)^{\wedge}5$$

$$p_3 = 1 - \{(1 - p_2) \times (1 - p_1/2)\}^{\wedge}2$$

$$BW\_IMABN = N \times p_3$$

Probability equations for AIAMIN-2 are:

$$p_1 = 1 - (1 - p_0/3)^{\wedge}2$$

$$p_2 = 1 - (1 - p_1/8)^{\wedge}4$$

$$p_3 = 1 - \{(1 - p_2) \times (1 - p_1/2)\}^{\wedge}5$$

$$BW\_AIAMIN\text{-}2 = N \times p_3$$

3.2 Probability of Acceptance (PA)

It can be defined as follows:

"PA is defined as ratio of bandwidth to the expected number of requests generated per transfer cycle [13, 14]". Formula for PA is:

$$PA = (BW/N \times p)$$

3.3 Throughput (TP)

It can be defined as follows:

"TP means average number of cells delivered by a network per unit time [11-14]".

Formula for TP is:

TP=(BW/N×t)

Here t is the transmission time of data packets. Transmission time is the time which is taken by the data packets from the given source to the given destination.

3.4 Processor Utilization (PU)
It can be defined as follows:

"PU is defined as percentage of time the processor is active doing computation without accessing the global memory [11-14]".

Formula for PU is:

PU= (BW/N×p×t)

3.5 Processing Power (PP)
It can be defined as follows:

"PP is defined as sum of processor utilization over the number of processors [11-14]".

Formula for PP is:

PP= (N×PU)

4. RESULTS AND DISCUSSIONS
On the basis of above discussed formulas the author has measured the performance of MALN [13], IMABN [14] and AIAMIN-2. The transmission time is also the important factor in this simulation. The author has assumed that a data packet takes 1 second from one node to another node. Here node may be any source or destination or SE. The other thing is that, if a node is faulty then data packet takes one second extra to reach from one node to other node. Based on this assumption, the author has obtained the following results:
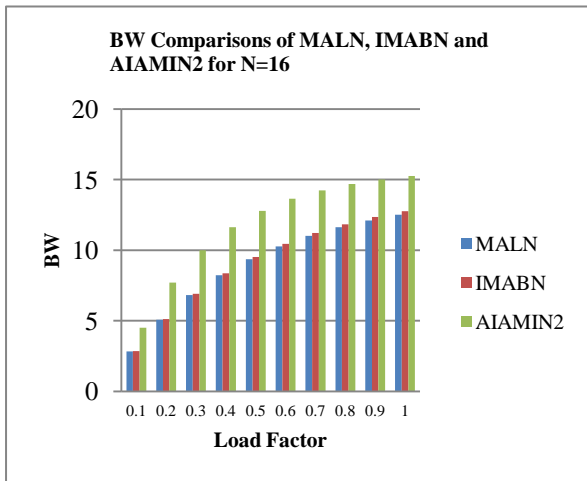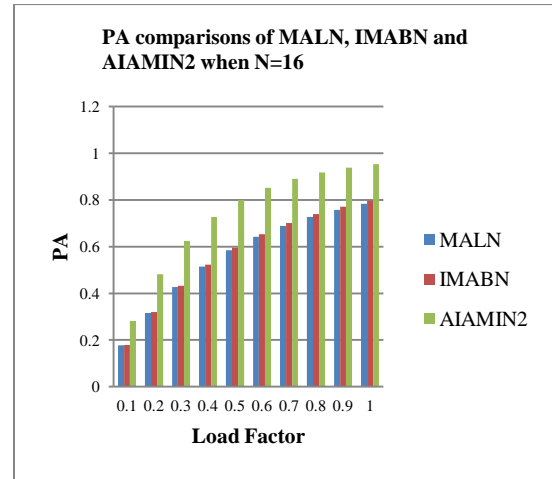

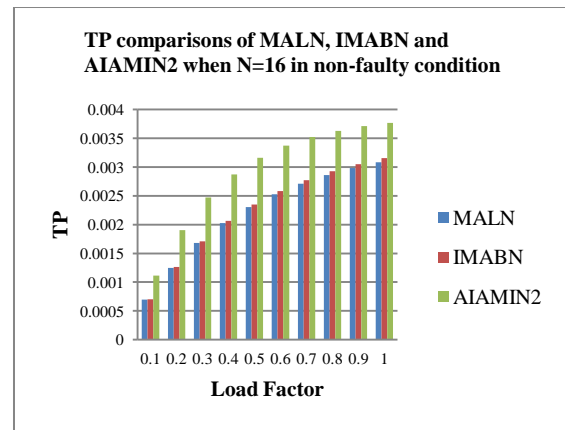**Fig.2: BW Comparisons**

Fig.3: PA Comparisons

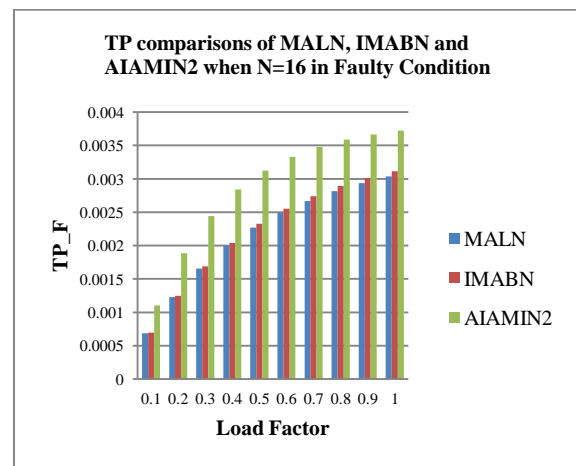**Fig.4: TP Comparisons in Non-Faulty Condition**

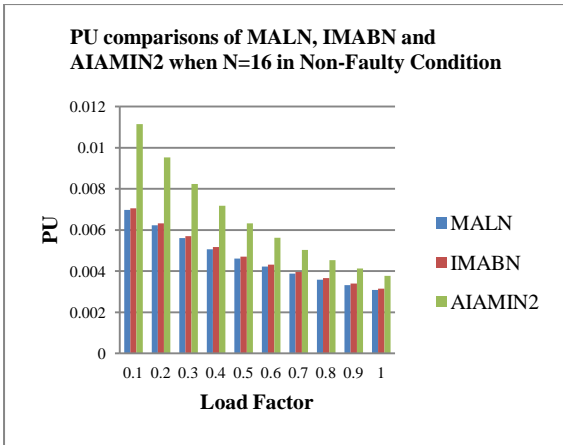**Fig.5: TP Comparisons in Faulty Condition**

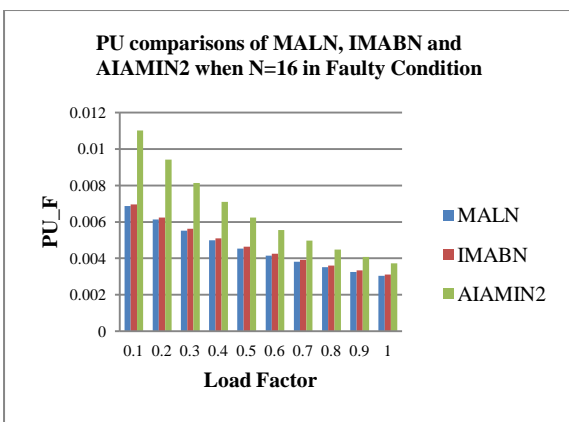**Fig.6: PU Comparisons in Non-Faulty Condition**

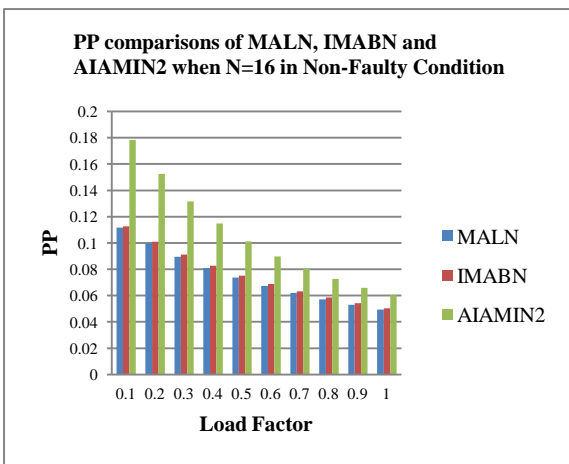

Fig.7: PU Comparisons in Faulty Condition

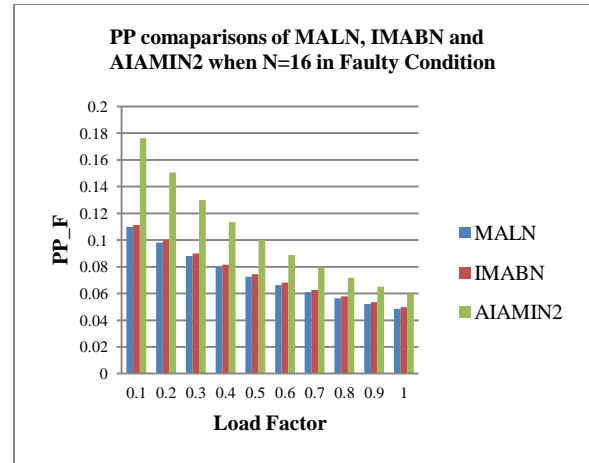**Fig.8: PP Comparisons in Non-Faulty Condition**

Fig.9: PP Comparisons in Faulty Condition

In all the figures i.e. from figure 2 to 9, it is observed that the AIAMIN-2 gives better results than the MALN and IMABN in faulty and non-faulty network situations.

5. CONCLUSION AND FUTURE SCOPE OF WORK

In this research work, the author has shown the comparison of performance of MALN, IMABN and AIAMIN-2. On all the factors of performance, AIAMIN-2 performs better than the MALN and IMABN in faulty and non-faulty condition. Further, AIAMIN-2 is a good fault tolerant network; it can sustain single faulty SE in each simultaneously and does the data transmission process perfectly. In future, the proposed network model can be developed and analyzed in a generalized way.

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