Improved Irregular Augmented Shuffle Multistage Interconnection Network

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Abstract

Parallel processing is the information processing that emphasized the concurrent manipulation of data elements belonging to one or more processors to solve a single problem. The major problem to achieve high-level parallelism is the construction of an interconnection network to provide interprocess communication. One of the biggest issues in the development of such a system is to developed fault tolerant architecture and effective algorithms to analyze its characteristics. An irregular class of Fault Tolerant Multistage Interconnection Network (MIN) called Improved Irregular Augmented Shuffle Network (IIASN) is proposed. The characteristics of some popular irregular class of Multistage Interconnection Networks along with proposed IIASN network which is based on IASN[11] Network are also analyzed in this paper.

Keywords: Augmented Shuffle Network (IASN); Fault Tolerant MIN; Four Tree Network; Multistage Interconnection Network; Routing; Permutation.

1. INTRODUCTION

In the era of parallel processing the multistage interconnection networks are frequently projected as connections in multiprocessor systems to interconnect several processors with several memory modules or processors. A multistage network is capable of connecting an arbitrary input terminal to an arbitrary output terminal [8]. In general a typical MIN consists of more than one stage of small interconnection networks called switching elements (SEs)[10][2]. The stage and number of switching elements may vary from network to network. There are many parameters like path length, cost, and permutation passable that are deciding factor for the whole system performance [9]. In this paper an irregular class of multistage interconnection network named

IIASN is designed and analyzed. This paper organized as follows: Section 2 describes the construction procedure of proposed network. Section 3 provides a brief introduction to cost effectiveness and its analysis. Section 4 discuses the path length analysis of various networks along with proposed network. Section 5 describes the permutation passable analysis of some popular MINs. Finally conclusions are given in Section 6.

2. CONSTRUCION PROCEDURE OF IIASN NETWORK

A typical IIASN is an Irregular Multistage Interconnection Network of size 2^n x 2^n is constructed with the help of two similar groups; lower and upper, each group consisting of a sub network of 2^{n-1} x 2^{n-1} size and has 2^{n-2} –1 stages, both stages at $\log_2 N$ –3 and $\log_2 N$ –1 have 2^{n-1} switches (where $N=2^n$ of N x N network). The centre stage has exactly 2^{n-3} switches. The switches in the first stage form a loop to provide multiple paths if a fault occur in the next stage. Each source is connected to two different switches in each group with the help of multiplexer and each destination is connected with demultiplexer. In case the main route is busy or faulty, requests will be routed through alternate path in the same sub-network. The advantage of this network is that if both switches in a loop are simultaneously faulty in any stage even then some sources are connected to the destinations. IIASN network of size 16x16 is illustrated in Figure 1.

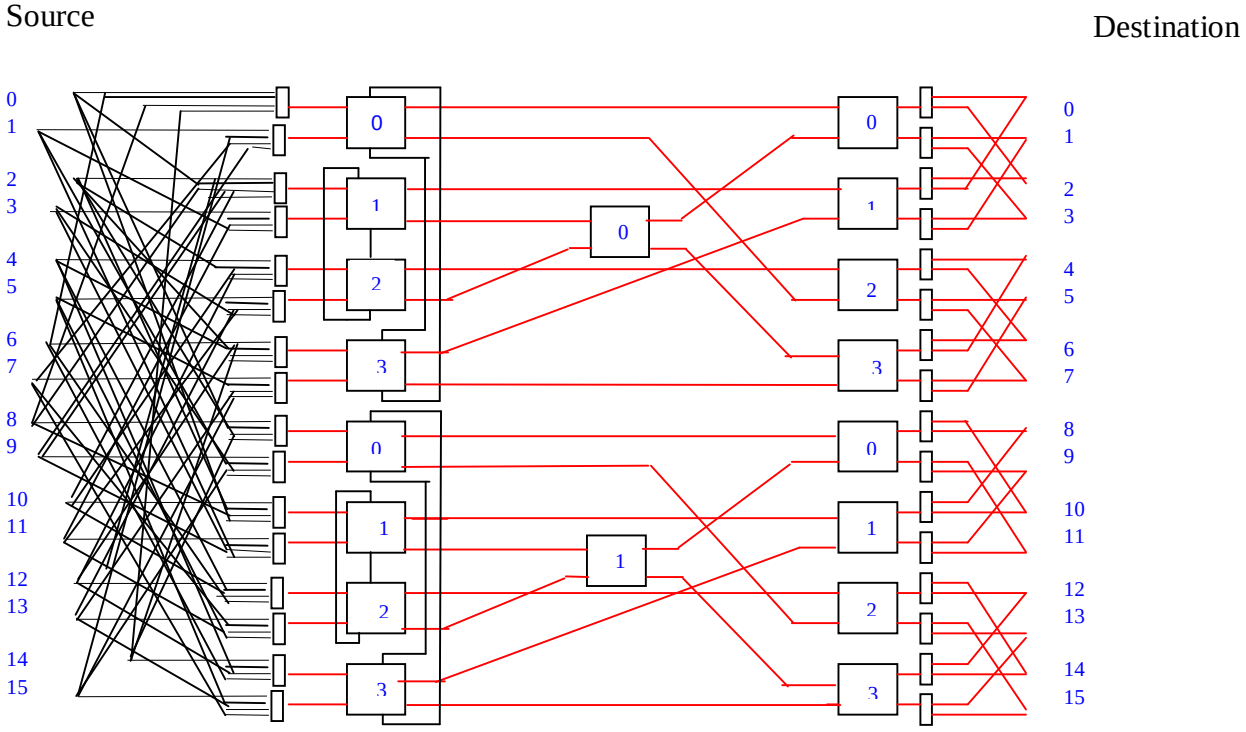

FIGURE 1: IIASN MIN of size N=16

3. COST-EFFECTIVENESS ANALYSIS

A common method is used to estimate the cost of a network that is to calculate the switch complexity with the assumption that the cost of a switch is proportional to the number of gates involved, which is roughly proportional to the number of 'cross points ' within a switch [1][10]. So in this way the cost of n x n switch comes out to n^2. For an interconnection network that contains

multiplexers and demultiplexers, it is roughly assumed that each Mx1 multiplexers or 1xM demultiplexers has M units.[3] . Hence the cost of IIASN network is

Total number of 3x3 switches = 2^{n-1}
Total number of 2x2 switches = $2^{n-1}+2$
Total number of multiplexer =2^n
Total number of demultiplexer =2^n
Overall cost of network is = 208

Network	Cost
IIASN	208
IASN	236
FT	258
MFT	276

TABLE 1: Cost comparison of various networks

4. PATH LENGTH ANALYSIS

Path length refers to the length of the communications path between the source to destination. Multiple paths of different path lengths are possible in a network .It can be measured in distance or by the number of intermediate switches. The possible path lengths [4] between a particular pair of source to destination may vary from 2 to maximum number of stages. The various path lengths of some popular networks along with proposed network is calculated to route a data from given source (let S=0 i.e 0000) to all destination is shown in table 2.

Source	Destination	Path length of IIASN	Path length of IASN	Path length of FT	Path length of MFT
00000	0000	2,3	2,3	2,4,5	2
	0001				
	0010			4,5	5
	0011				
	0100		3	5	
	0101				
	0110				
	0111				
	1000		2,3	2,4,5	2
	1001				
	1010			4,5	5
	1011				
	1100		3	5	
	1101				
	1110				
	1111				

TABLE 2: Comparison of path lengths of IIASN and other networks

5. PERMUTATION PASSABLE ANALYSIS

Permutation [6] is the one to one association between source to destination pair [7][5]. Path length and the routing tags parameters are the major backbone to evaluate the permutation. There are two ways to evaluate the permutation:

Identity Permutations

A one-to-one correspondence between same source and destination number is called Identity Permutation. For example correspondence between 0..0 , 1..1 and so on .In terms of source and destination this can be expressed by:

$$S_i = Di$$

Where i = 0,1…….N-1

For example: connectivity between source to destination for identity is represented by:

$S_0 - D_0$, $S_1 – D_1$,---------- $S_{15} - D_{15}$

Incremental Permutations

A source is connected in a circular chain to the destination in incremental permutation as shown below:

$S_0 – D_4$, $S_1 – D_5$,---------- $S_{15} – D_3$

We are considering the best possible cases to find out the permutations

- Non-Critical Case : If a single switch is faulty in any stage
- Critical case : If the switches are faulty in a loop in any stage (if it exists)

Permutation evaluation requires the path length of given source to destination (path length can be more than one, from a given source to destination if multiple paths exists) and the routing tags. The analysis of some popular network from given source to destination to evaluate incremental (S0 to D4, S1-D5...) permutations along with proposed network is as follows.

Stage	Switch / Faults	Total path length	Total no of request passes	Average Path Length	(%)passable
	WITHOUT	30	13	2.3	81
	MUX	30	13	2.3	81
1	S0 / A	26	11	2.36	68
	S0 / B	24	10	2.4	62
2	S0	24	11	2.18	68
3	S0	25	11	2.27	68
	DEMUX	30	13	2.3	81

A – Non critical B – Critical Case

TABLE 3: Incremental permutation measures of IIASN

Stage	Switch / Faults	Total path length	Total no of request passes	Average Path Length	(%) passable
	WITHOUT	28	11	2.5	68
	MUX	28	11	2.5	68
1	S0 / A	26	10	2.6	62
	S0 / B	21	8	2.6	50
2	SA /A	25	10	2.5	62
	SA/B	19	8	2.3	50
3	S0	26	10	2.6	62
	DEMUX	28	11	2.5	68

TABLE 4: Incremental permutation measures of IASN

Stage	Switch / Faults	Total path length	Total no of request passes	Average Path Length	(%) passable
	WITHOUT	20	4	5	25
	MUX	20	4	5	25
1	S1 / A	20	4	5	25
	S1 / B	20	4	5	25
2	S2 / A	15	3	5	18
	S2 / B	10	2	5	12
3	S3 / A	10	2	5	12
	S3 / B	0	0	0	0
4	S4 / A	15	3	5	18
	S4 / B	10	2	5	12
5	S5	20	4	5	25
	DEMUX	20	4	5	25

TABLE 5: Incremental permutation measures of FT

Stage	Switch/Faults	Total path length	Total no of passes	Average path length	(%) passable
	WITHOUT	40	8	5	50
	MUX	40	8	5	50
1	S1 / A	35	7	5	43
	S1 / B	30	6	5	37
2	S2 / A	30	6	5	37
	S2 / B	20	4	5	25
3	S3 / A	30	6	5	37
	S3 / B	20	4	5	25
4	S4 / A	30	6	5	37
	S4 / B	20	4	5	25
5	S5	35	7	5	43
	DMUX	40	8	5	50

TABLE 6: Incremental permutation measures of MFT

6. CONCLUSION

An irregular class of Fault Tolerant Multistage Interconnection Network called Improved Irregular Augmented Shuffle Exchange Network has been proposed and analyzed. It has been observed from table 1 that IIASN has lesser cost in comparison to existing irregular fault tolerant networks. It has been also analyzed from table 2 that IIASN has unique and better path length in comparison to IASN and other popular irregular networks. . It has been also observed from the analysis that the permutation passable of IIASN is much better that existing IASN, FT and MFT networks.

7. REFERENCES

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