An analysis of cross avoidance techniques in optical multistage interconnection networks

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Abstract
It is expected that users of telecommunication services such as Internet, Web browsing, and tele-education will increase dramatically. This has greatly increased the demand for high bandwidth and high capacity communication systems. Advances in electro-optic technologies have made optical communication a good networking choice for the increasing demands of high channel bandwidth and low communication latency of high-performance computing and communication applications. Optical Multistage Interconnection Networks (OMINs) are very popular in switching and communication applications and have been used in telecommunications and parallel computing systems. But there are some problems in optical multistage interconnection Networks such as the optical-loss during switching and the crosstalk problem in the optical switches. The major problem called crosstalk is caused by coupling of two signals within a switching element. A lot of work has already been done in designing various algorithms and methods so that good quality solution can be obtained. In this paper, some methods to avoid crosstalk are compared and checked.

Key words:
Multistage, Optical, Interconnection, permutation

1. Introduction

Multi-stage interconnection networks (MINs) [3,4] consist of more than one stages of small interconnection elements called switching elements and links interconnecting them. Multi-stage interconnection networks are described by three characteristic features: the switching elements, network topology and control structures. A multistage interconnection network is actually a compromise between crossbar and shared bus networks. MINs are popular in switching and communication applications. It consists of more than one stages of small interconnection elements called switching elements and links interconnecting them. Multistage networks are described by three characteristic features: the switching elements, and network topology and control structures. In OMIN, optical signal is converted to/from electrical signal at the network input/output. But the OMIN suffers from the optical crosstalk problem. Window method is the method that is used to find the messages that are not in the same group because it causes crosstalk in the network. Then comes Improved window method in which the first window is eliminated for this we make the conflict matrix initialized to 0, here number of windows is M-1, where M=log2N and N is size of network. It takes less time to find conflicts than the windows method. Then comes the most efficient method called Bitwise Window method. In this method, source and destination address is in decimal format. There is only one decimal number in each row and each window for comparison and finding a conflict. Bitwise window method is the best method as its execution time is very less in comparison to other methods.

II. Optical MIN

Optical interconnections have the potential of becoming an appealing alternative to electrical interconnections. For long and medium range distances (e.g., local area networks and telecommunication), optical technology (fibers) is the technology of choice, offering better performance and lower costs than electrical wires [20]. There is a trend for optics to replace electronics for shorter distances and larger connectivity applications. Optical interconnections are insensitive to radio wave interference effects, are free from transmission line capacitive loading, do not have geometrical planar constraints, and can be reconfigurable (circuit-switched).Due to the difference in speeds of the electronic and optical switching elements and the nature of optical signals, optical MINs also hold their own challenges.

2.1 Path Dependent Loss

Path dependent loss means that optical signals become weak after passing through an optical path. In a large MIN, a big part of the path-dependent loss is directly proportional to the number of couplers that the optical path passes through. Hence, it depends on the architecture used and its network size. Hence, if the optical signal has to pass through more no of stages or switches, the path dependent loss will be more.

2.2 Optical Crosstalk

Optical crosstalk occurs when two signal channels interact with each other. To reduce the negative effect of crosstalk, various approaches which apply the concept of dilation in either the space or time domain have been proposed. With the space domain approach, extra SEs are used to ensure that at most one input and one output of every SE will be used at any given time. For an Optical network without crosstalk, it is needed to divide the messages into several groups, and then deliver the messages using one time slot (pass) for each group, which is called the time division multiplexing. Window Methods are based on Time dilation approach.

CHARACTERISTICS	ELECTRONIC MULTISTAGE NETWORKS	OPTICAL MULTISTAGE NETWORKS
Energy Transmitted	Electricity	Light
Bandwidth	Used for less bandwidth applications	Used for high bandwidth applications
Latency	High	Less
Error Probability	High	Less
Weight	More	Less
Cost	Less	More
Switching	Packet Switching	Circuit Switching
Path	Provide Multi path from source to destination.	Provide single path from source to destination
Complexity	More Complex	Less Complex
Structure considered	2-dimensional	3-dimensional

Table 1: Comparison

III. Window Method

Window method is the method that is used to find the messages that are not in the same group because it causes crosstalk in the network. If we consider the network of size N*N, there are N source and N destination address. Combination matrix is formed by combining source and its destination address. From this, optical window size is M-1, where M=log2N and N is size of network. In window method, number of windows is equal to number of stages [15].

Algorithm WM.

1. Initialize the conflict matrix with value 0.If there is conflict between data sent then corresponding value is changed to 1 in conflict matrix.
2. Input or initialize the number of source-destination pairs from the user.
3. Calculate the no of windows and window size.
4. Make the window to see where the conflict in the data is.
5. Access the window to see where the conflict in the sent data is.
6. If any conflict occurs change that particular value in conflict matrix to 1.
7. Go to step 4 if any more window is there else go to step no 8.
8. Converts integer number into binary number to show the conflict.
9. Finally, display the source-destination and conflict matrix as output.

msg	000	1	0	1	0	1	0	1
0	0	0	0	0	1	0	1	0
1	0	0	0	0	1	1	0	0
0	0	0	0	0	1	1	1	0
1	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0

Table 2: Conflict Matrix [15]

IV. Improved Window Method

In this method the first window is eliminated for this we make the conflict matrix initialized to 0, here number of windows is M-1. It takes less time to find conflicts than the windows method. Therefore, it is called improved window method [13, 15].

Algorithm IWM.

1. Initialize the conflict matrix with value 0.If there is conflict between data sent then corresponding value is changed to 1 in conflict matrix.
2. Input or initialize the number of source-destination pairs from the user.
3. Calculate the no of windows and window size. Decrement window size 1 as there is one window less as was in window method.
4. Make the window to see where the conflict is there in data.
5. Access the window to see where the conflict is in sent data.
6. If any conflict occurs change that particular value in conflict matrix to 1.
7. Go to step 4 if any more window is there else go to step no 8.
8. Converts integer number into binary number to show the conflict.
9. Finally, display the source-destination and conflict matrix as output.

V. Bitwise Window Method

In this method, source and destination address is in decimal format. Number of windows is log2 N. Thus, from combination matrix, the optical window size is only one for a different network size and the number of window is log2 N

[13]. In other words, there are only one decimal number in each row and each window for comparison and finding a conflict.

Algorithm BWM.

1. Initialize the conflict matrix with value 0.If there is conflict between data sent then corresponding value is changed to 1 in conflict matrix.
2. Input or initialize the number of source-destination pairs from the user.
3. Calculate the no of windows and window size. Decrement window size 1 as there is one window less as was in window method.
4. Here the window size will be smallest i.e. window size is of one column size.
5. Access the window to see where the conflict in the sent data is.
6. If any conflict occurs change that particular value in conflict matrix to 1.
7. Go to step 4 if any more window is there else go to step no 8.
8. Finally, display the source-destination and conflict matrix as output.

Table 3: Input with corresponding Output Matrix

A0	A1	A2	A3	A4	A5
0	0	0	1	0	0
0	0	1	0	1	1
0	1	0	1	0	1
0	1	1	1	1	0
1	0	0	0	1	0
1	0	1	0	0	1
1	1	0	0	0	0
1	1	1	1	1	1

Table 4: Combined Matrix

A1+A2	A2+A3	A3+A4
0	1	2
1	2	1
2	1	2
3	3	3
0	0	1
1	2	0
2	0	0
3	3	3

VI Conclusions

In this paper various techniques are used to find conflicts between the messages. In this paper, various methods have been compared and all are implemented. It has been observed that the improved window method take lesser time to find conflicts as compared to window method. The bitwise Window Method reduces the time taken than the other algorithms even when the network size is large.

VII Future Work

For future research, the Bitwise Window Method can be implemented on the distributed parallel computers. The study can be extended to irregular OMINs.

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