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Scheduling Methods Comparison Based Optical Multistage Interconnection Networks With Using Proposed Fast Window Methods

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***Abstract*— *Multistage interconnection networks (MIN) are popular in switching and communication applications. However, optical multistage interconnection network introduce crosstalk which outcome from coupling more than one signal within one switching element. Presented work deals with comparative study between methods of scheduling in (OMIN) window, improved window bitwise window method and our proposed methods for reducing the running time, and its effect on the running time of the ZeroX routing algorithm which the indicates that our fast shearing methods better time in Scheduling the messages in (OMIN) for a crosstalk free routing.*

Index Terms— *optical interconnection networks, running time, fast window method, and optimization performance.*

I. Introduction

Interconnection networks perform major functions in the initiation of modern parallel computers [1]. Multistage interconnection networks organize a reliable communication between the sources and destinations in parallel computing systems but now electro optic modulators have made optical communication a committed network alternative to stand up to the increasing demands of high-performance computing and communication applications such as, low communication latency, high channel bandwidth and parallel processing [2,3]. OMIN is a solution that offers a combination of large transition capacity, high bandwidth, , and low error probability [4].

An optical multistage interconnection network consists of N inputs, N outputs, and n stages, and each stage has N/2 switching element which involves two inputs and two outputs [4]. There are many challenges like load balancing, path dependent loss and crosstalk. The problem of crosstalk occurs when two signals interact with each other within at the same switching element. The main reason of crosstalk is link conflict and switch conflict, Switch conflict can be suffered, now many devices are available to avoid switch conflicts for example Noise resurrection device [5]. But, link conflict cannot be suffered because it is not able to send two messages along the same link at the same time [6]. The optical multistage interconnection network is frequently suggested as connections in high bandwidth network switches or in multiprocessor systems. Crosstalk problem in a switch is the most important reason, which limits the size of a network and reduces the signal to noise ratio [7].

There are two ways to solve crosstalk problem in Optical Networks these are: space domain approach and time domain approach. With the space domain approach, extra switching elements and links are used to guarantee that only one input and only one output of every switching element will be active at any time [8].

With Time domain approach deals with the crosstalk problem by permitting only one input and output link to be active at the same time within every switching element in the architecture. A set of permutation connection is allotments into several groups, within each group are crosstalk free [9].

Then, each group is routed to its corresponding destination in another time slot. The frame work of the Time domain approach Fig. 1 begins with the permutation before divided into its crosstalk free subsets, the source and destination addresses of the permutation are randomly generated.

A permutation refers to a one to one mapping from a source node to a destination node in the optical omega network OON, with checking the conflict using the window method before scheduling and routing the message in the network. Window method is a way used to find which messages cannot be sent in the same group to avoid crosstalk in the network [10].

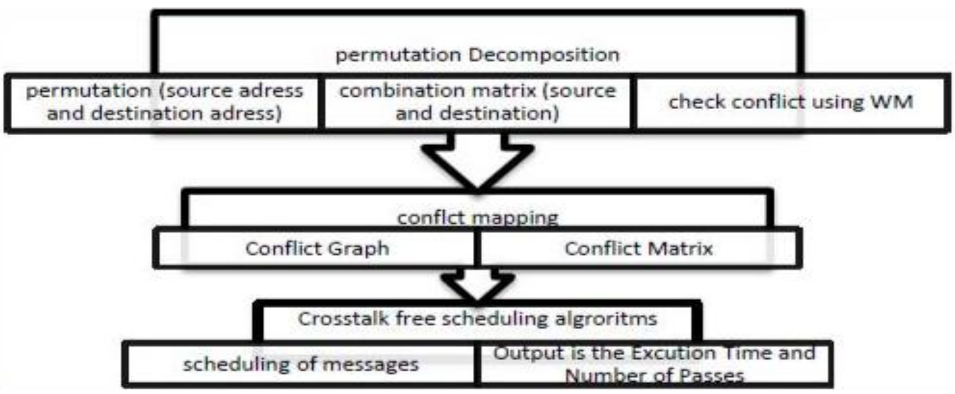

Fig. 1. Time domain approach frame work.

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II. Data Analysis

II.1. Window method (WM):

The window is applied on the combination matrix from the left to the right with the exception of first and last column. If two messages have the same bit pattern in the same window, they will be a reason for a conflict in the network. There for, they must be routed in different passes [11]. See following example to know how the WM works. Consider the network It can be described as, for network size N*N as mentioned in Ref. [4].

The optical Window to detect the conflict between the source messages and the destination message after combine it together. Step 1 the first window indicates the first window that message 000 has a conflict with the message 100 message 001 and message 101 have conflict, and the message 010 and message 110 have conflict and the message 011 and message 111 have conflict, step 2, message 000 and message 110 have the conflict, message 001 and message 011 have the conflict, message 101 and message 111 have the conflict and message 010 and message 100 have the conflict It is the same case for window 2 step in. Step 3, message 000 and message 101 have the conflict, message 001 and message 100 have the conflict, message 110 and message 111 have the conflict, and message 010 and message 011 have the conflict as mentioned in reference [8].

The conflict matrix is defined as a square matrix, M with matrix size of N x N where N is the network size. Similar to the conflict graph, the conflict matrix can be generated based on the results from the WM. The conflict matrix is defined as a square matrix, M with matrix size of N x N where N is the network size. Similar to the conflict graph, the conflict matrix can be generated based on the results from the WM. However, if there is an edge from some vertex i to some vertex j in the conflict graph, then the element $M_{i,j}$ in the conflict matrix is set to a value 1 to indicate conflict between the intersected messages, otherwise it is set to a value 0 [9].

II.2 Improved window method (IWM):

Improved window method was proposed as it eliminates checking for conflicts in the first optical window [12].This is because the first optical window has the same conflict pattern where the first N/2 inputs in sequence uses the same switching elements as the second half of the other N/2 inputs. Therefore, inputs 0 to (N/2–1) will have conflict with inputs N/2 to (N–1), which is always true for any size of network, N. The execution time is reduced approximately by 1/S as compared to the standard WM where S is the number of stages [13]. In addition, the parallel IWM was developed on shared memory multiprocessors and the results shown drastic improvement in execution time [14].

II.3 Bitwise Window Method (BWM):

Bitwise window method that significantly reduces the execution time of the WM. In BWM, each (n - 1) bit binary optical window of the standard WM where N is the network size and $n=\log_2 N$, be transformed into its equivalent decimal figuration using bitwise functionality. The number of columns used to compare each message for similar bit pattern is reduced to n, instead of $(n^2 – n)$ for an N x N Omega network [2].

Based on comparative analysis performed in [13], it was concluded that the time spent for identifying conflicts is very high compared to routing the messages, and ZeroX algorithm is used to routing the message because it routs the message in minimum number of passes in the networks as it use row to deliberate the message systematically [15].

II.4 Proposed Model Fast Window Method:

We have developed the window method, to obtain fast window method reduces the execution time of the WM by order each window before generating the conflict matrix, while maintaining the index of each value where the index represent the source address, each two consecutive values assimilate a conflict, Where the similarities occur only between two values and so after order the window we provide time taken it in two "for-loops" responsible for finding the similar values in the same window. We can call our proposed method as fast search method and apply it to the WM, IMW and BWM to be Fast WM, Fast IWM, and Fast BWM. Table 1 Illustrates the fast window method after applying the fast search process to the window method. As well as Table 2 represents the fast improved window method after enforcement with the fast search process to the improved window method, and Table 3 Shows the fast bitwise window method after implementation of the fast search process to the bitwise window method below.

Table 1. Fast Window Method.

Source address (Index of message)	Commination matrix	Original Window WM		
		W_0	W_1	W_2
000	000100	00	01	10
001	001011	01	10	01
010	010101	10	01	10
011	011111	11	11	11
100	100010	00	00	01
101	101000	01	10	00
110	110001	10	00	00
111	111111	11	11	11

Fast WM					
W_0		W_1		W_2	
000	00	100	00	101	00
100	00	110	00	110	00
001	01	000	01	001	01
101	01	010	01	100	01
010	10	001	10	000	10
110	10	101	10	010	10
011	11	011	11	011	11
111	11	111	11	111	11

The pseudo code of the proposed fast WM is shown in Fig. 2.

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```
Com_Matrix =[s_add d_add]          //combination matrix
Conflict_Matrix =zeros(N,N);       //initialization of conflict matrix NxN where N is network size
For i=1 to M        //number of stages
   For k=i+1 to i+M-1
     Window[k] =Com_Matrix [i][k];
     Sort (Window[k]);
   For j=1:2: N-1  //N is network size
       Conflict_Matrix [j][j+1]=1;      //conflict
   End for;
End for;
End for;
```

Fig. 2. Pseudo code of the FWM.

Table 2. Fast Improved Window Method.

Source address (Index of message)	Commination matrix	Original Window IWM	
		W_1	W_2
000	000100	01	10
001	001011	10	01
010	010101	01	10
011	011111	11	11
100	100010	00	01
101	101000	10	00
110	110001	00	00
111	111111	11	11

Fast IWM			
W_1		W_2	
100	00	101	00
110	00	110	00
000	01	001	01
010	01	100	01
001	10	000	10
101	10	010	10
011	11	011	11
111	11	111	11

The pseudo code of the proposed fast IWM is shown Fig. 3.

```
Com_Matrix =[s_add d_add]          //combination matrix
Conflict_Matrix =zeros(N,N);       //initialization of conflict matrix NxN where N is network size
For i=2 to M        //number of stages    //with eliminating the first window
   For k=i+1 to i+M-1
     Window[k] =Com_Matrix [i][k];
     Sort (Window[k]);
   For j=1:2: N-1  //N is network size
       Conflict_Matrix [j][j+1]=1;      //conflict
   End for;
End for;
End for;
```

Fig. 3. Pseudo code of the Fast IWM.

Table 3. Fast Bitwise Window Method.

Source address (Index of message)	Commination matrix	Original Window BWM		
		W_0	W_1	W_2
000	000100	0	1	2
001	001011	1	2	1
010	010101	2	1	2
011	011111	3	3	3
100	100010	0	0	1
101	101000	1	2	0
110	110001	2	0	0
111	111111	3	3	3

Fast BWM					
W_0		W_1		W_2	
000	0	100	0	101	0
100	0	110	0	110	0
001	1	000	1	001	1
101	1	010	1	100	1
010	2	001	2	000	2
110	2	101	2	010	2
011	3	011	3	011	3
111	3	111	3	111	3

The pseudo code of the proposed Fast BWM is shown in Fig. 4.

```
Com_Matrix =[s_add d_add]          //combination matrix
Conflict_Matrix =zeros(N,N);       //initialization of conflict matrix NxN where N is network size
For i=1 to M        //number of stages
   For k=i+1 to i+M-1
     Window[k] =Com_Matrix [i][k];
```


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```
    Window _dec=binary _to _decimal (Window[k])
    Sort (Window _dec[k]);
  For j=1:2: N-1  //N is network size
     Conflict_Matrix [j][j+1]=1;      //conflict
  End for;
End for;
End for;
```

Fig. 4. Pseudo code of the Fast BWM.

III. SIMULATION RESULTS AND COMPARATIVE ANALYSIS

This section discusses the evaluation of the three algorithms such as WM, IWM and BWM versus the new proposed fast WM's. The fast window method, fast improved window method and the fast bitwise window method take minimum time for searching the simulates in the same window, by dispending time taken in the for loops and sort the window. Hence, totally the execution time is decreased. Based on the MATLAP programming analysis and list of operating parameters, the obtained results including the running time in the series of Figs. (5-7).

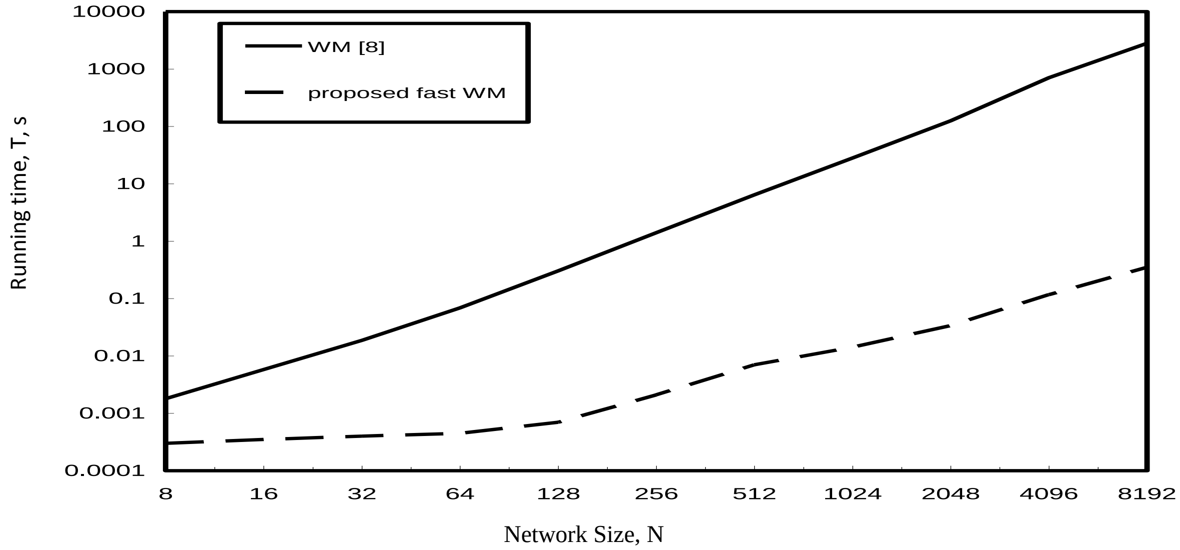

Fig. 5. Comparison between window method and fast window method in terms of time.

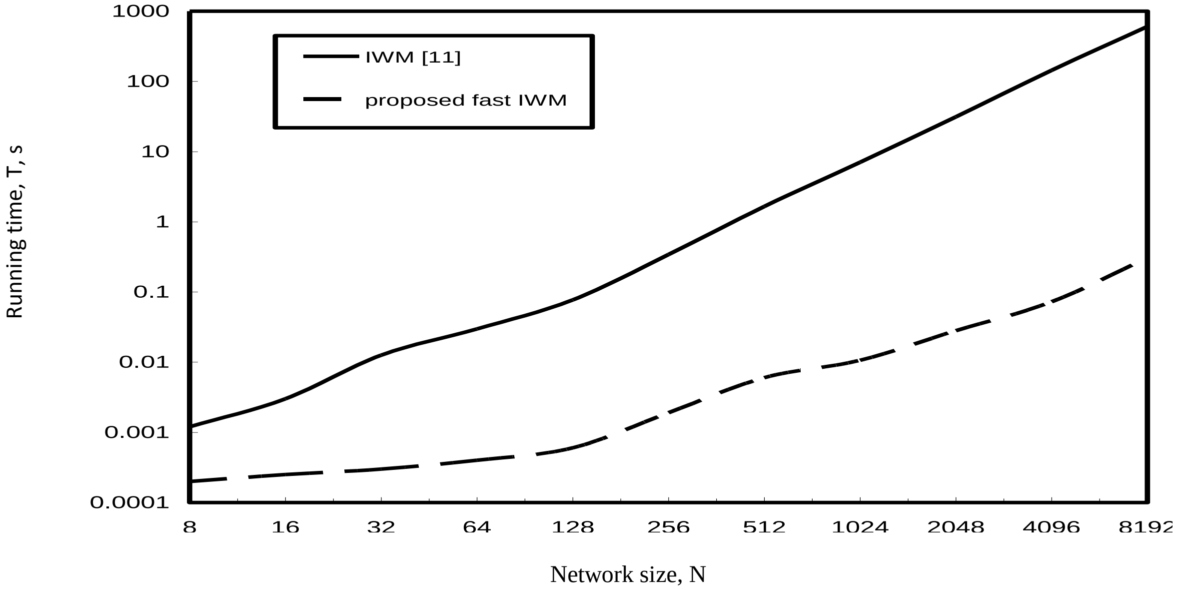

Fig. 6. Comparison between improved window method and the proposed fast improved window method in terms of time.

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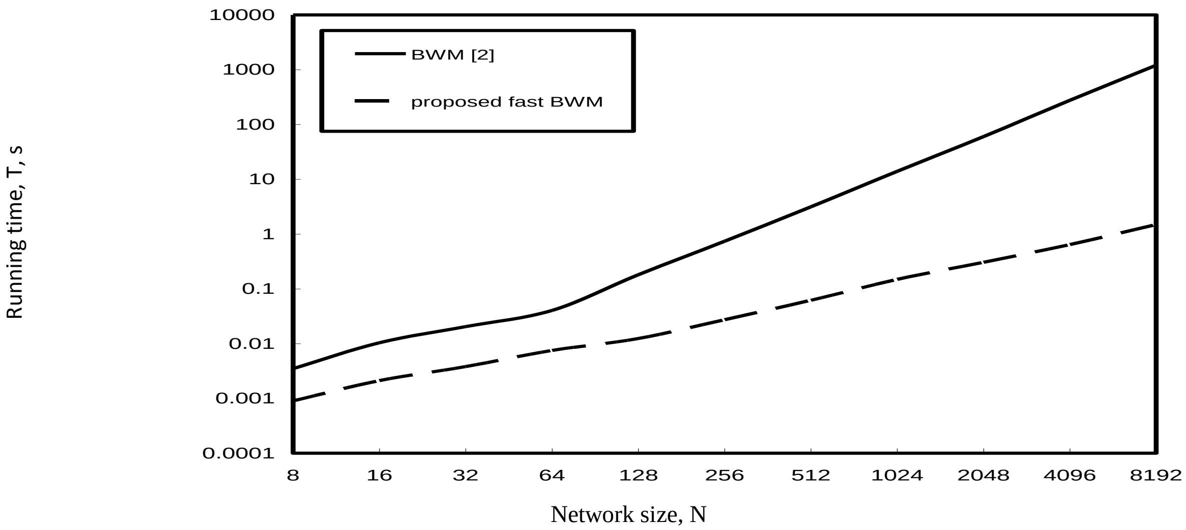

Fig. 7. Comparison between bitwise window method and fast bitwise window method in terms of time.

As illustrated that WM, IWM, and BWM represent the first step (scheduling step) of the routing algorithm, based on MATLAB programming we applied our proposed methods on ZeroX routing algorithm and Figs. (8-10) explain the difference between our fast WM's and the original WM's in term of the running time. By comparing the three proposed methods fast WM, fast IWM, and fast BWM, Fig. 10 shows the variations of the new scheduling technique in term of running time for different network sizes, and Fig. 11 Shows comparison the fast bitwise Zero, fast improved Zero, and fast Zero algorithms after implementation of the fast scheduling methods to the original zero algorithms.

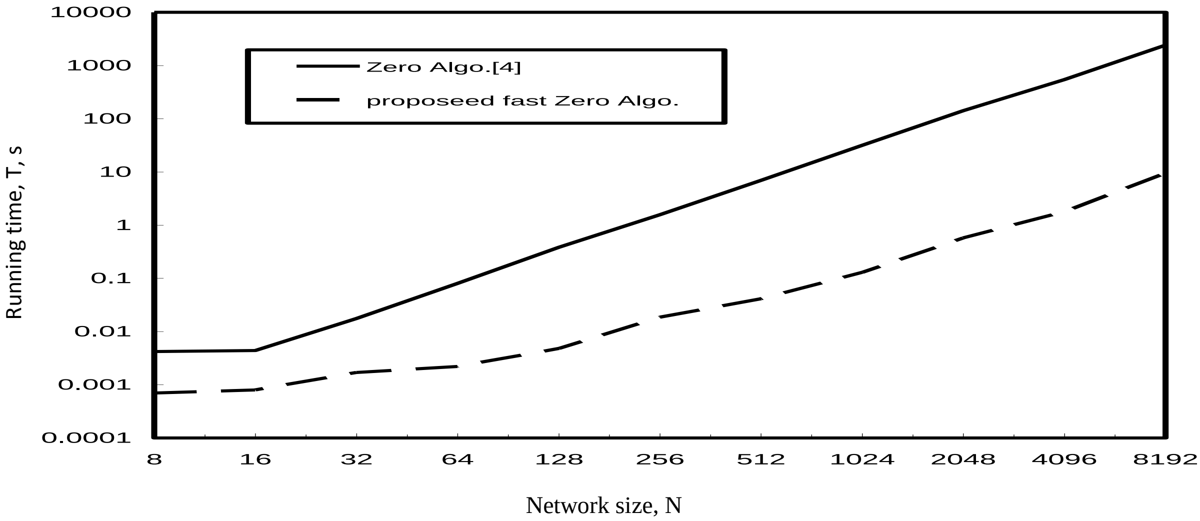

Fig. 8. Comparison between Zero algorithms before and after applying, fast window method, in terms of time.

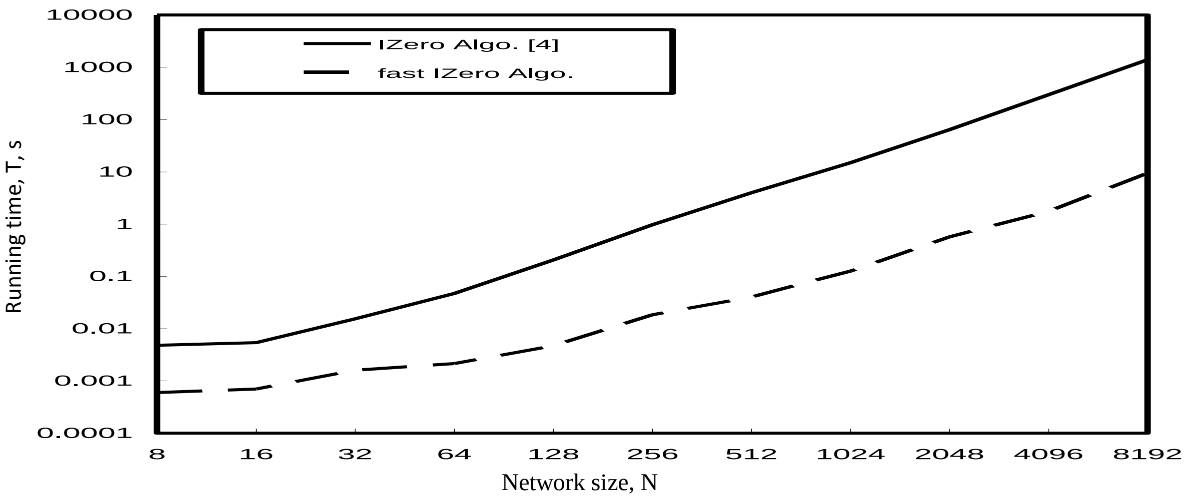

Fig. 9. Comparison between Zero algorithms before and after applying, fast improved window method, in terms of time.

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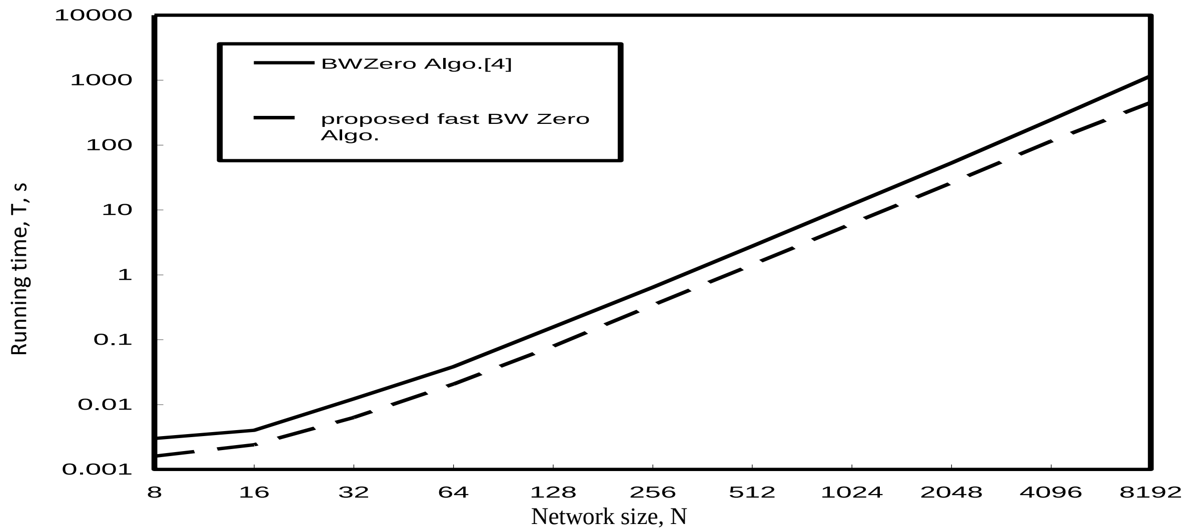

Fig. 10. Comparison between Zero algorithms before and after applying, fast bitwise window method, in terms of time.

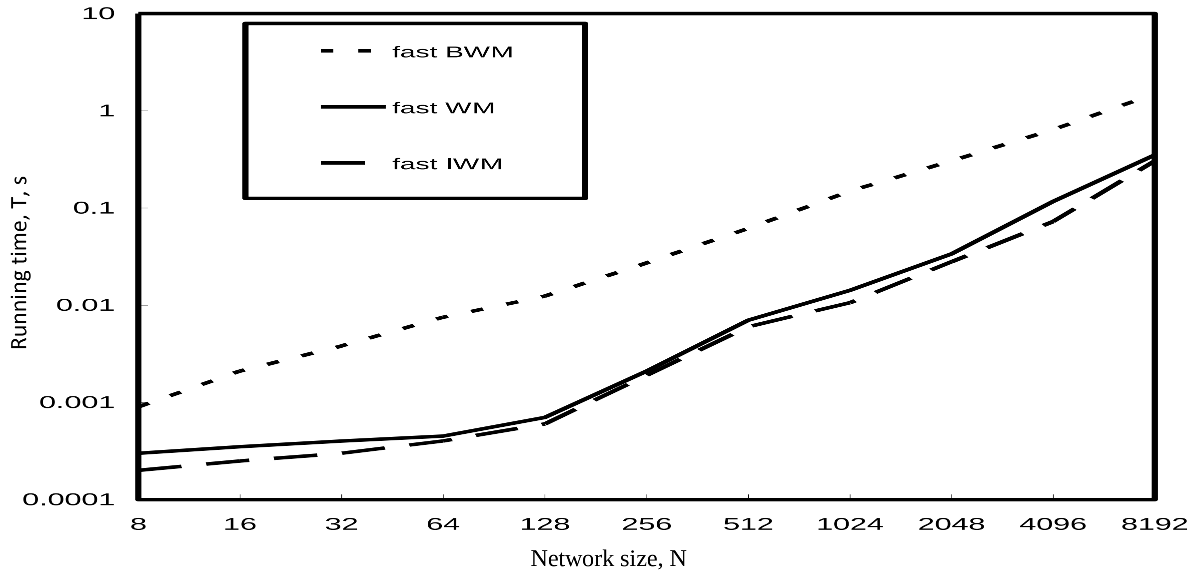

Fig. 11. Comparison between Comparison between fast BWM, fast IWM and fast WM in terms of time.

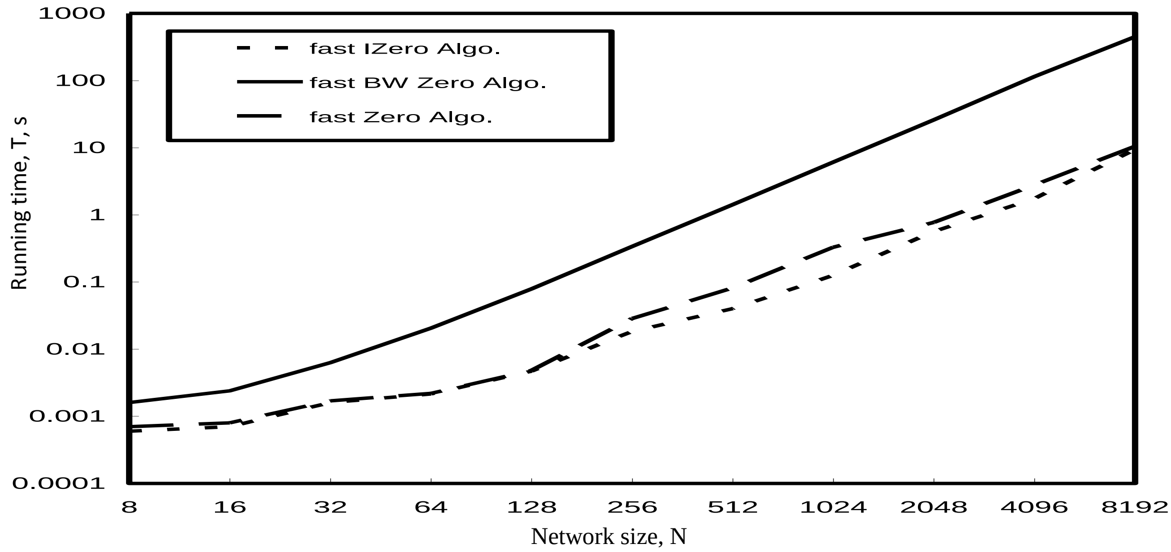

Fig. 12. Comparisson between the fast bitwise Zero, fast improved Zero, and fast Zero algorithms after implementation of the fast scheduling methods to the original zero algorithms

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IV. Conclusion

After examining past comparisons Figs. (5-7) shows that the proposed fast searching function that provide a lot of time in scheduling the messages and crating the conflict matrix, which represent the major time in routing the messages in the (MIN). In figure (8-10) illustrate the advantage of applying the new fast WM, fast IWM, and fast BWM on the Zero routing algorithm as it Reduce the time it taken in routing the message

Figs. (11, 12) show that the fast BWM achieves the worst time because it takes time in converting the window elements to decimal values, on the other hand the fast IWM achieves the best time in creating the conflict matrix, table 5, illustrates the difference in time between the fast WM, fast IWM, fast BWM So that the difference more obvious. Table 6. Shows the running time of the zero algorithms after applying the fast WM, fast IWM, and fast BWM as the scheduling step (first step) of the algorithm, which gives the same indication as discussed with the fast scheduling methods.

Table 5. Running time of fast WM, fast IWM, and fast BWM in sec

Network Size	Fast BWM	Fast WM	Fast IWM
8	0.0009	0.0003	0.0002
16	0.0021	0.00035	0.00025
32	0.0038	0.0004	0.0003
64	0.0075	0.00045	0.0004
128	0.0124	0.0007	0.0006
256	0.0272	0.0021	0.0019
512	0.0616	0.007	0.006
1024	0.1485	0.0142	0.0106
2048	0.3051	0.0337	0.028
4096	0.6398	0.1167	0.0725
8192	1.493	0.351	0.3052

Table 6. Running time of fast Zero, fast IZero, and fast BWZero in sec

Network size	Fast BWZero Algo.	Fast Zero Algo.	FI Zero Algo.
8	0.0016	0.0007	0.0006
16	0.0024	0.0008	0.0007
32	0.0063	0.0017	0.0016
64	0.0206	0.0022	0.00215
128	0.0788	0.0048	0.0047
256	0.3397	0.0186	0.0184
512	1.4233	0.0412	0.0402
1024	6.097	0.1294	0.1258
2048	26.0273	0.5737	0.568
4096	114.657	1.7936	1.7494
8192	450.476	9.5081	9.4623

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