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Studying the Performance of a Local Area Network through a Statistical Results of a Simulation Program

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Abstract: *The ring topology was selected among several topologies,since in the ring topology easy to isolate faults and it has good performs under heavy network load, but the most problem that face in the ring topology is the system delay. Two ways offdecreasing the time delay have been proposed. The first way is changing the address field, a modification in both the hardware and the software are essential to implement that. The second way is utilizing combination of twoor more topologies at same time such ring and bus or double ring ..etc. in order to reduce as much as possible. The simulation of the system is conducted by using register insertion technique.Register insertion technique is a technique used to design a station protocol for a ring topology of a Local Area Network (LAN). Through this technique we developed a powerful and simple program to deal with transmitter and receiver of a ring topology for the standby and double ring topologies and different types of probability distributions to give statistical output figures of any network performance.*
Keywords: *Standby ring, Double ring, Self-heal technique, Optical fiber*

I. Introduction

A huge study was made to select the best topology and access protocol for a Local Area Network under a certain conditions and requirements [1], [2], [3],[4]. In that study different network media's as well as different topologies were discussed and analyzed.

The optical fiber can provide more secure and more reliable channel with better quality performance[4], [5], [6], so the optical fiber media was the oneselected for this type of LAN to be used for the data transfer between the stations. The ring topology, shown in Figure 1, was selected after several topologies (star, bus ,..,etc.) were considered and discussed and analyzed found ring topology easy to isolate faults and it is very organized and it has good performs under heavy network load. The star topology, shown in Figure 2, was an alternative choice. The star topology requires either a central controller or a passive star coupler which implies the use of some random access protocol. The problems with star topology are summarized as follows [2], [7],[8]:

- High insertion losses.
- Limited number of channels.
- Spurious reflection of signal.
- Random access protocols such as CSMA are very inefficient especially at high traffic density.
- More fiber cables are required.

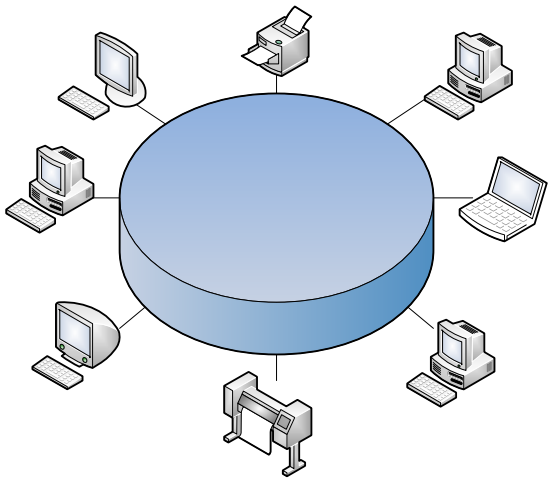

Figure1. Ring Topology

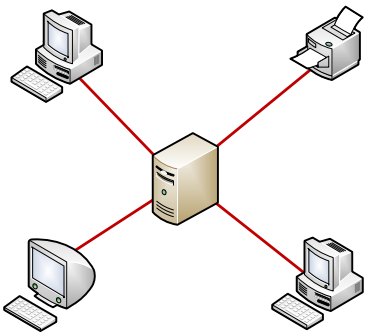

Figure2. Star Topology

The active ring network topology is a unidirectional point - point link [10], it has no power limitation problem, it has no routing problem and it has a wide choice of access protocols with fully distributed control capability.

The passive ring topology has a problem mostly related with the use of optical T- Couplers [9], so the active ring topology has been selected.

A various techniques of a ring reliability control as follows:

1. Node skipping: All nodes in the network are connected in normal ring topology with extra "skip" link added to the next but one node in separated route for maximum protection (Figure 3). If no signal detected from main link, station automatically switches its input to the skip link. The disadvantages of this technique:
   - Three times fiber length
   - Skip link should have the same amount of delay as the main link to keep the ring delay constant in presence of failure
   - If two adjacent nodes failed, then complete failure occurs.

2. Double loop: Two loops available, one carries the signal and the other acts as 'standby' loop (Figure 4). Two isolation techniques can be adopted: Bypass technique and Self-heal technique.
   a. Bypass technique: A failure of a line section is bypassed by the standby loop (Figure 5). If both loops between two nodes fail results total failure.
   b. Self-heal technique: On a failure of a line section or a node, the fault is isolated by 'back looping' through the standby loop (Figure 6). Similar to node skip technique but with better performance if two adjacent or non-adjacent nodes fall at fault at the same time as follows:
      i. Self-heal technique with adjacent node failure: Both nodes at fault bypassed (Figure 7).
      ii. Self-heal technique with non-adjacent node failure: Multiple node failure may cause the loop to be segmented but some communication at least is retained amongst surviving stations (Figure 8).

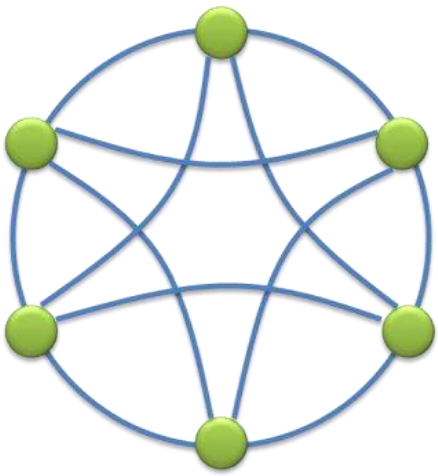

Figure 3. Node skipping

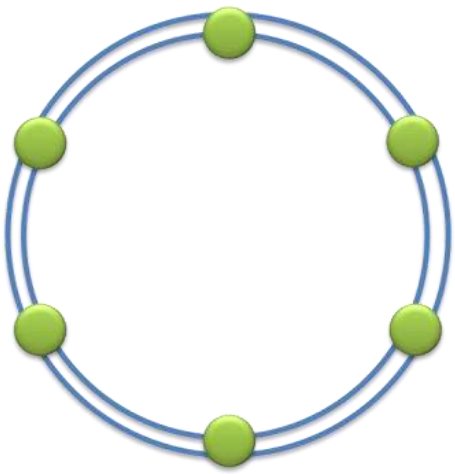

Figure 4. Double loop

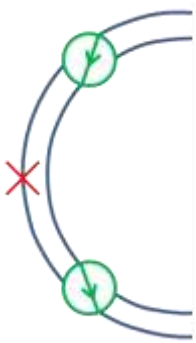

Figure 5. Bypass technique

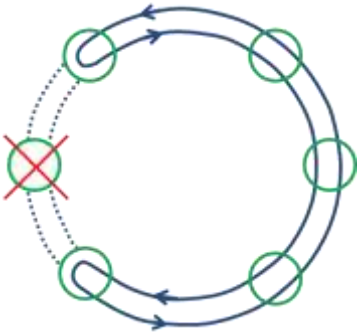

Figure 6. Self-heal technique

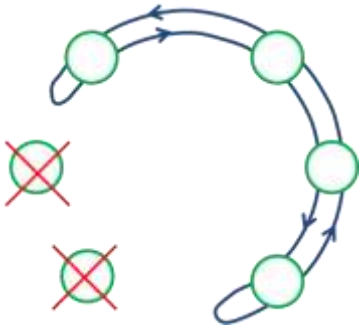

Figure 7. Self-heal technique with adjacentnode failure

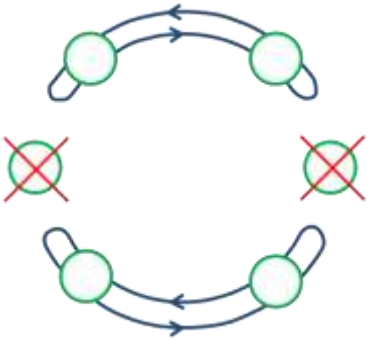

Figure 8. Self-heal technique with non-adjacent node failure

The most economic method with least problem was selected to be the double - loop with a self- heal technique.An analytical comparative study for live ring access protocols (token ring, slotted ring, register insertion ring, CSMA-CD ring and variable multiple ring) was performed to select the best protocol for LAN station design [11], [12]. The analysis were performed under similar conditions and consistent assumptions throughout. The performance of the live protocols have been compared with one another for the variation of several parameters such as the line rates, message lengths, number of stations and ring sizes. The register insertion protocol was found the best performance over the whole range of traffic intensity for all line rates when the message size is equal to the register size. The register insertion protocol is fully distributed control and easy hardware station design, for that reason the register insertion protocol was selected to be used to design the LAN station or node.Other protocols have good performance under a certain conditions, for example the slotted ring has overall performance when the ring size is large and the message length is small.

After this brief explanation for the LAN topologies and protocols, it is found that the active ring topology with a fully distributed control and with register insertion protocol is applicable to satisfy the required specification.The most serious problem that faces the ring topology is the system delay. There are two ways to decrease the time delay or the propagation delay. The first way is by changing the address field or adding sonic hit in a such way that when the station receive the address field will pass the message the next station without reading the hole message. This means time was saved. To do this; modification in the both hardware and the software should be make. The second way, by using two or more topologies at same time such ring and bus or double ring ..etc. in order to reduce as much as possible, but on this the expense of the cost of each station and installation of the system, but the propagation delay will decrease.

II. Software Analysis

We deal with the ring network local area. We assume that we have a network and subscribers want to access to the network. The mean idea of measurement is we have a many subscribers and 1-single ring to transmit the information and messages between two subscribers.To do this, we must first build a SLATE that contains the following data:

1. The original message.
2. The address of the station.
3. Flag ON, to indicate the front,
4. Flag OFF, to indicate the end.
5. Acknowledgement bit.
6. Parity check bit.

Double Ring instead of using single ring, we use double rings in parallel to increase the efficiency of the system. Here we improve the initialization of the system. But in actual live system, the noise enters the system with while spectrum. Here in digital system the noise either changes 1 bit, 2 bits, 3 bits..etc.In case that the noise changes one bit only, the system can detect the error bit and correct it else if two or more changes the system can detect them but cannot correct them and ask the transmitter to send the message again.

In Standby Ring the topology changes a little bit and instead of using the two rings we just use one ring, and make the other ring as a standby.These kinds of topologies are used in the systems that need an important communication like in the military application.In the simulation, we use a randomly noise switch that indicates whether the ring 1 is life or it has an error or it is out of service. In this case, the switch will automatically activate the standby ring and the communication between the station is still work.

The program mainly can be divided into several procedures and functions which gives the flexibility to the user to understand the main program easily (Figure 9). These procedures and functions are:

1. Queue system,
2. Starting state,
3. Message library,
4. New stations generation,
5. Noise generator,
6. Decision procedure,
7. Poison distribution random number,
8. Output.

At the beginning, the user is asked to identify the network factors; size of the network, number of iterations to be used, probability distribution to be used in the queueing analysis and clock rate. Then, accordingly, the maximum number of stations that can ask the transmission service at one time; the optimum number of the queue length will be determined by the program.

A random streams of characters will be randomized and designed in a serial slags (nine characters per each slag which corresponds to 72 bits). Transmitter and receivers will be randomized by the program while the messages are ready to be transmitted.

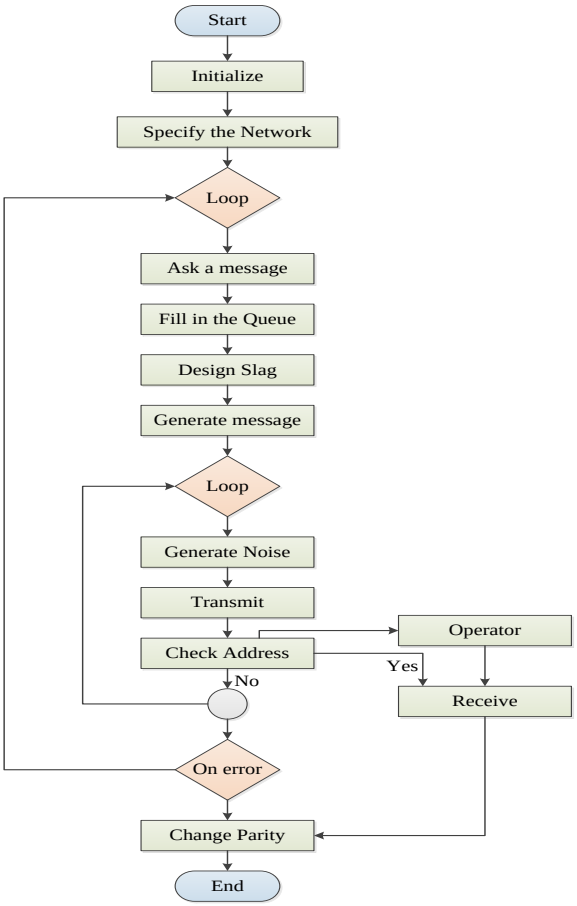

Figure 9. Simulation program flowchart

The register length is chosen to be 72- bit purely for the reason simplicity in implementation. The register format is as shows in Figure 10. It consists of an 8- bit front-flag, 8-bit address field "extendible", 3 bytes of data, also extendible, plus provision for maximum zero-insertions, 16-bit CRC checksum, 8-bit end-flag and an even parity bit which check, the whole packet including the flags, and finally an Acknowledgement (ACK) bit. The Parity bit was coded so that the error performance at the physical level could easily be monitored. The numbers in(Figure 10) represents the number of digits for each block.

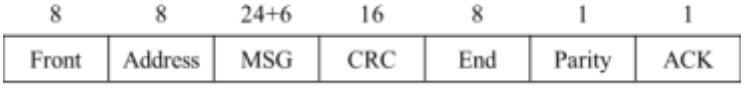

Figure 10. The register format

Before transmitting, the mixer will add random noises to the messages according to the probability of errors in the network either in one digit or two digits (the corresponding character will change accordingly). Single or double ring topologies will occur here as a servers for these transmissions. Then the program will count both the number of transmitted messages with one error or two errors, and the refused messages which caused by the failure in all rings or by disability to correct the errors occur in the messages from the mixer, will be counted.Note that, the Chick Parity digit and the Acknowledgment digit will be changed automatically in case of correct transmission. And one more feature of the program is that, the operator whichhas a special code can transmit a certainmessage, if he wants, to all nodes once.Finally, the obtained statistical resultscan be represented as follows:

- Number of acceptedstations in the queue.
- Number of refusedstations in the queue.
- Number of messagesreceived correctly.
- Number of messagesreceived with one error.
- Number of incorrectmessages.
- Total number ofstations asked for a service.
- Number of unit times thesystem is idle.

The following brief descriptions of the main program procedures and functions give an idea of the statistical variables.

2.1 Queue System

This queue represents a list of stations need the transmission service. The following sub-procedures belong to this system:

a. Add-queue ..which adds a station to the queue.
b. Serve ..which serves the first come station in the queue.
c. Empty ..function to check whether the queue is empty or not.
d. Full ..function to check whether the queue is full or not.
e. Size ..function to give the number of station in the queue.
f. Initialize ..which resets the queue.

2.2 Starting State

This procedure does the following initializations:

a. Reset the queue.
b. Reset the statistical numbers.
c. Ask the number of running time for the overall simulation.
d. Ask the expected value of incoming stations to the queue (λ).
e. Ask the size of LAN, i.e., the number of working stations.
f. Randomize the CPU.

2.3 Message Library

This procedure contains a lot of random messages which are used to check the transmission operations. The selecting of any message of this library depends on the uniform random distribution.Then, the messages will be produced.

2.4 New Stations Generator

This procedure contains a uniform random distribution and select a couple of stations, one of them is for transmission the random message, which had been pointed before, while the another station is to receive it. Finally, the procedure increase the total number of stations asked for a service.

2.5 Noise Generator
Mainly, this procedure changes one, two or three characters randomly (uniformly) and returns it as an index value.

2.6 Decision Procedure
Each of the variables in this procedure increases a corresponding parameter toit. These variables are:

a. Refuse increases when the queue is full.
b. Receive increases when no error occurred.
c. Correct increases when one error occurred.
d. Re-trans increases when two errors occurred.
e. Idlequeue increases when no stations ask for a service.

2.7Poisson Distribution Random Number

This distribution is a normal one for this simulation. We recommend to use it here because it simulates the real live actions. The random generator in all computers is a uniform distribution; hence we use it in subroutine to generator Poisson. The expected value of this distribution is λ and the formula for this distribution is given by:

$$f(x) = \frac{(\lambda t)x\ exp(\lambda tx)}{x!}$$

2.8 Output
This procedure finally the statistical results for this simulation.

III. Implementation of the simulation program

The implementation of the simulation software using the flowchart for both standby ring and double ring as shown in Figure 11 and Figure 12, which is implemented into a web page using ASP.net web programming and C#.

3.1 Input parameters
The following parameters should be entered by the user (Figure 13):

- Select standby ring or double ring
- No. of Stations (Numbers of stations are there in the LAN).
- No. of Units (Numbers of units of time will the simulation run).
- Expected No. (Numbers of units of time will the simulation run).

After that the user press "Simulate", error massage will appear if expected number not accepted (Figure 14 and 15)

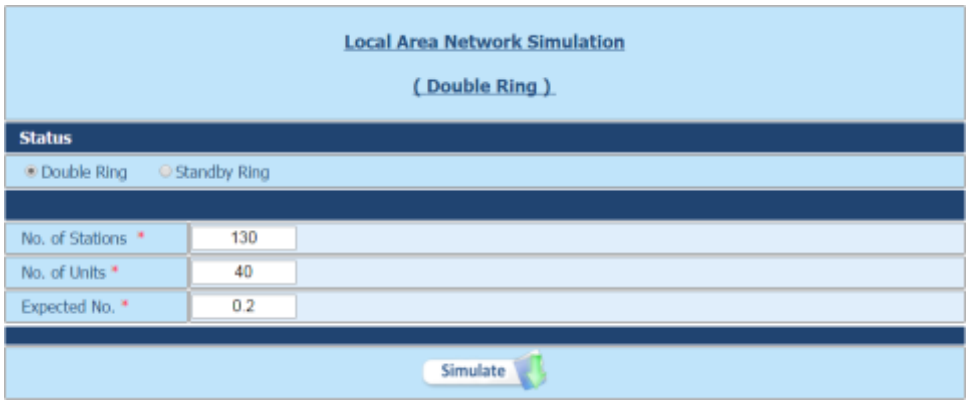

Figure13. Software input parameters

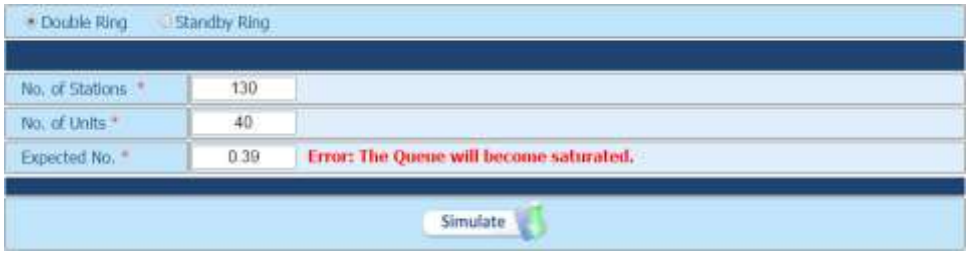

Figure 14. Error message: The queue will become saturated

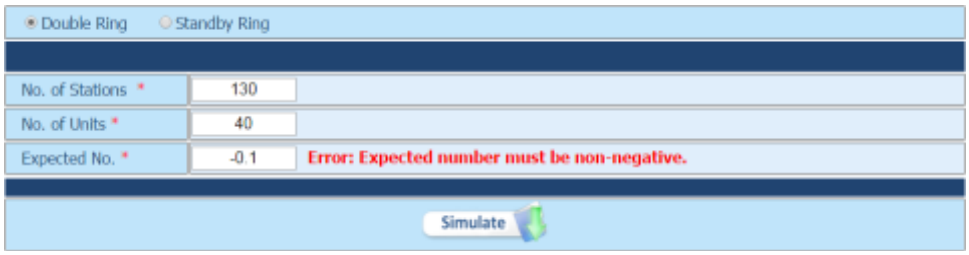

Figure 15.Error message: Expected number must be non-negative

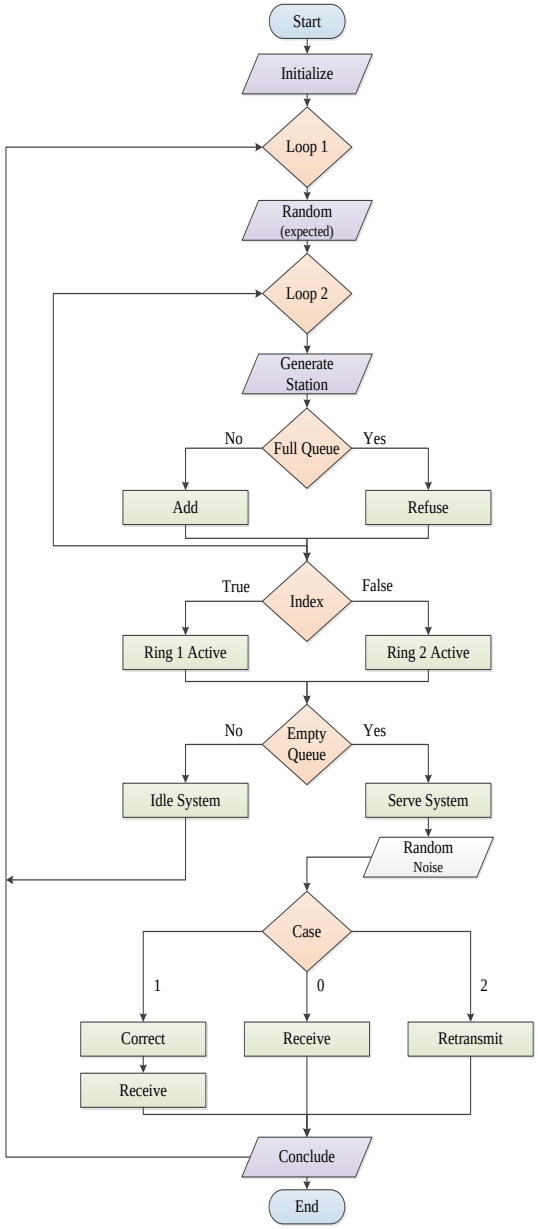

Figure 11. Standby ring flowchart

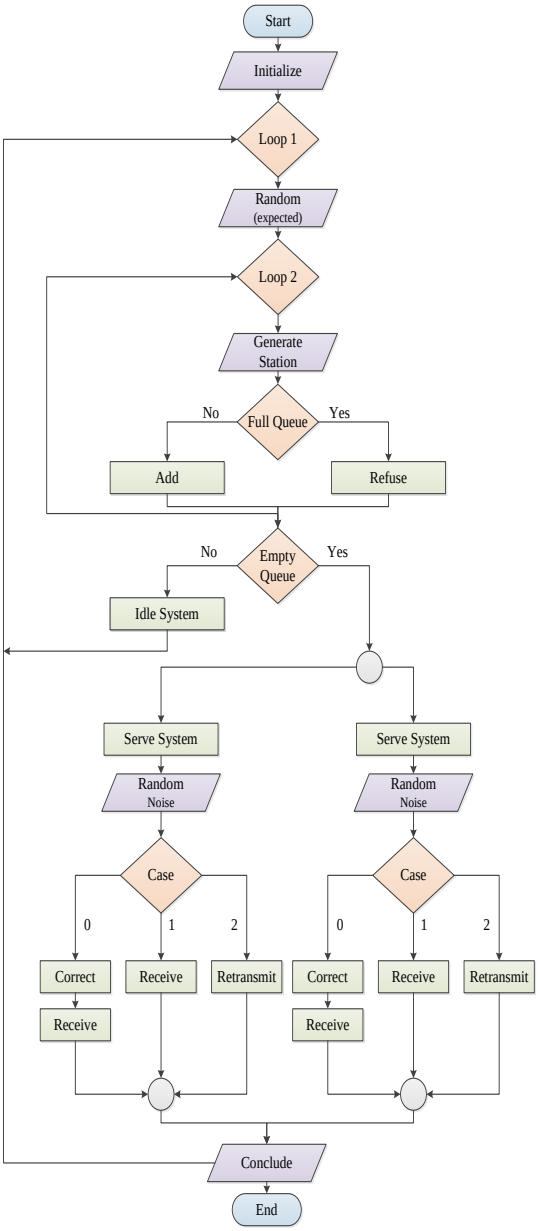

Figure 12. Double ring flowchart

3.2 Simulation Result

The standby ring simulation result is shown in Figures(16a, 16b and 16c) and the double ring simulation result is shown in Figures (17a, 17b and 17c).

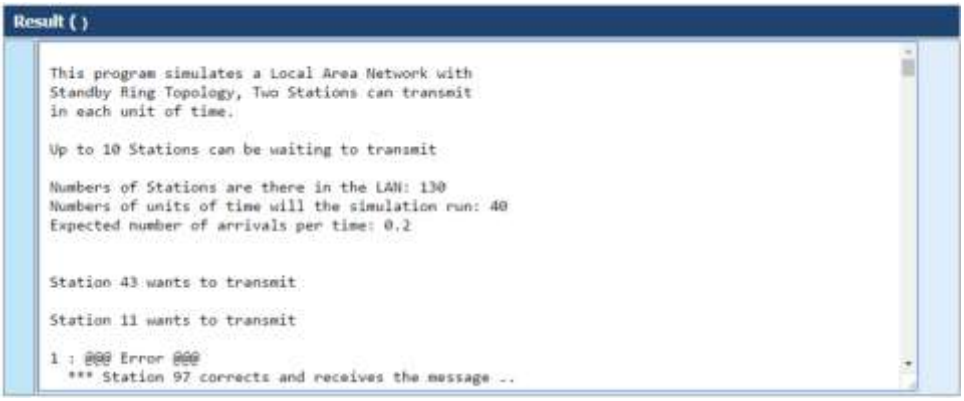

Figure 16a. The standby ring simulation result

Figure 16b. The standby ring simulation result

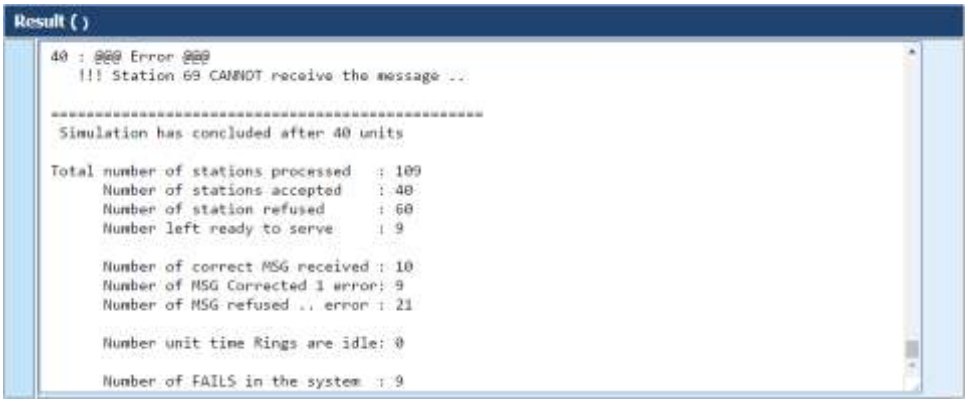

Figure 16c. The standby ring simulation result

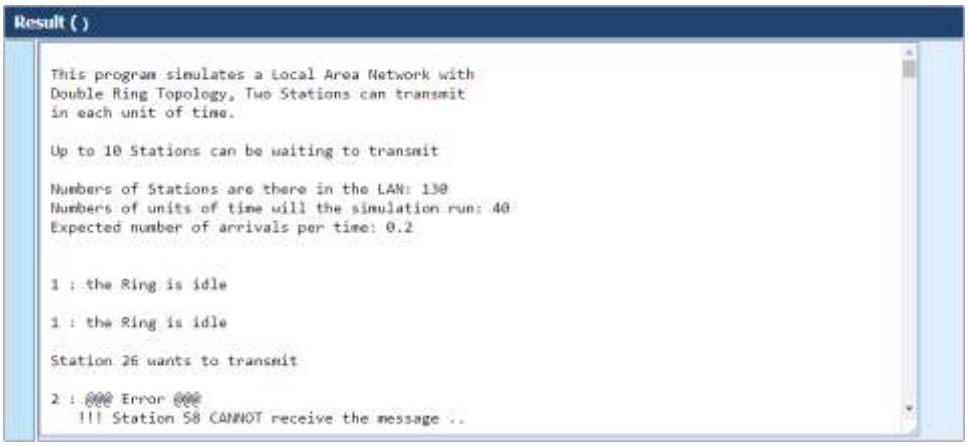

Figure 17a. The double ring simulation result

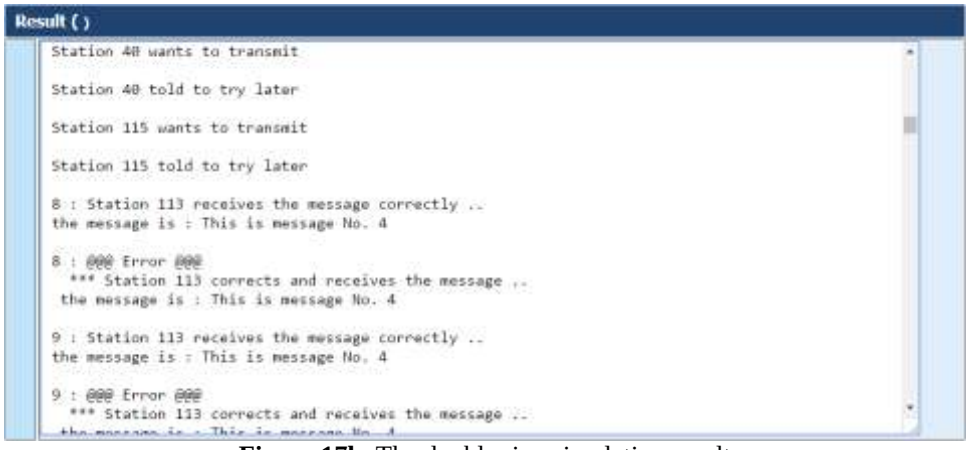

Figure 17b. The double ring simulation result

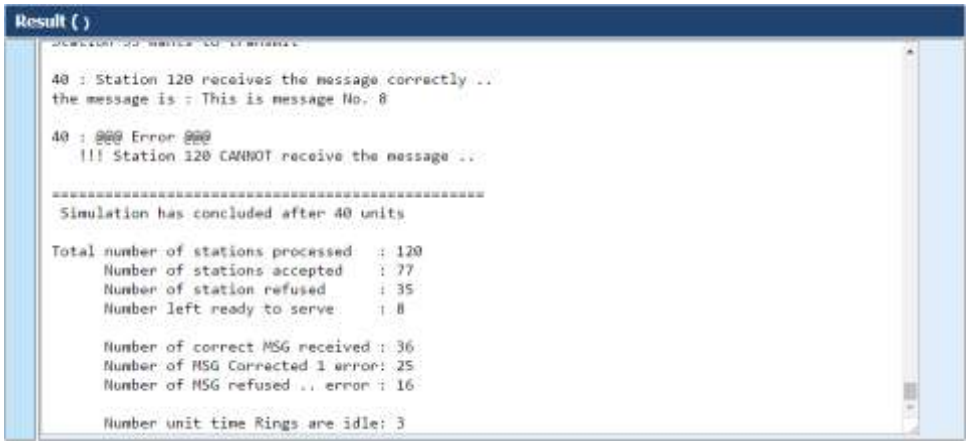

Figure 17c. The double ring simulation result

3.3Analysis of the results

System was simulated for long run (1000 iterations), to see the effect of changing each parameters individual. The parameters are:

- Numbers of stations are there in the LAN.
- Numbers of units of time will the simulation run.
- Expected number of arrivals per time.

Tables (1-6) respectively,show the effect of changing each parameters individual for Double Ring and Standby Ring. Each table shows the effect of changing one parameter for following result:

- Total number of stations processed.
- Total number of stations accepted.
- Total number of station refused.
- Total number left ready to serve.
- Total number of correct message received.
- Total number of message corrected (1 error).
- Total number of message refused (Error).
- Total number unit time rings are idle.
- Total number of fails in the system.

Table 1. Effect of changingnumbers of stations in Double Ring

Numbers of stations are there in the LAN	20	40	60	80	100	120	140	160	180	200
Total number of stations processed	16.025	31.909	48.125	63.842	79.981	95.924	112.492	127.853	143.596	159.33
Total number of stations accepted	16.018	31.838	47.781	62.381	73.571	78.017	79.189	79.593	79.758	79.845
Total number of station refused	0	0	0.003	0.164	2.686	11.611	26.036	40.619	56.129	71.648
Total number left ready to serve	0.007	0.071	0.341	1.297	3.724	6.296	7.267	7.641	7.709	7.837
Total number of correct MSG received	5.352	10.508	16.056	20.701	24.687	26.198	26.573	26.801	26.56	26.72
Total number of MSG Corrected 1 error	5.298	10.682	15.856	20.674	24.513	25.972	26.477	26.502	26.488	26.285
Total number of MSG refused .. Error	5.368	10.648	15.869	21.006	24.371	25.847	26.139	26.29	26.71	26.84
Total number unit time Rings are idle	63.982	48.162	32.219	17.619	6.429	1.983	0.811	0.407	0.242	0.155

* Numbers of units of time will the simulation run = 40, Expected number of arrivals per time = 0.2

Table 2. Effect of changingnumbers of stations in Standby Ring

Numbers of stations are there in the LAN	20	40	60	80	100	120	140	160	180	200
Total number of stations processed	15.848	31.772	48.124	63.652	80.272	95.814	111.98	127.825	143.858	160.25
Total number of stations accepted	15.709	30.397	38.138	39.452	39.749	39.852	39.917	39.956	39.961	39.977
Total number of station refused	0	0.033	3.499	15.797	31.78	47.086	63.133	78.92	94.936	111.293
Total number left ready to serve	0.139	1.342	6.487	8.403	8.743	8.876	8.93	8.949	8.961	8.98
Total number of correct MSG received	5.204	10.18	12.693	13.198	13.131	13.013	13.215	13.304	13.35	13.279
Total number of MSG Corrected 1 error	5.23	10.076	12.694	13.009	13.389	13.553	13.329	13.176	13.289	13.398
Total number of MSG refused .. Error	5.275	10.141	12.751	13.245	13.229	13.286	13.373	13.476	13.322	13.3
Total number unit time Rings are idle	24.291	9.603	1.862	0.548	0.251	0.148	0.083	0.044	0.039	0.023
Total number of FAILS in the system	3.617	3.684	3.645	3.604	3.572	3.676	3.641	3.532	3.625	3.691

* Numbers of units of time will the simulation run = 40, Expected number of arrivals per time = 0.2

Table 3. Effect of changingnumbers of units of time in Double Ring

Numbers of units of time will the simulation run	20	40	60	80	100	120	140	160	180	200
Total number of stations processed	47.941	96.239	143.446	191.947	240.221	287.993	336.794	383.008	383.008	480.554
Total number of stations accepted	38.349	77.957	117.589	157.782	197.502	237.113	277.12	316.551	316.551	396.494
Total number of station refused	3.779	11.978	19.61	27.949	36.664	44.637	53.475	60.253	60.253	77.816
Total number left ready to serve	5.813	6.304	6.247	6.216	6.055	6.243	6.199	6.204	6.204	6.244
Total number of correct MSG received	12.83	25.853	39.125	52.499	65.786	79.528	92.688	105.907	105.907	131.786
Total number of MSG Corrected 1 error	12.845	25.764	39.436	52.675	65.423	78.625	92.374	105.295	105.295	131.71
Total number of MSG refused .. Error	12.674	26.34	39.028	52.608	66.293	78.96	92.058	105.349	105.349	132.998
Total number unit time Rings are idle	1.651	2.043	2.411	2.218	2.498	2.887	2.88	3.449	3.449	3.506

Numbers of stations are there in the LAN = 120, Expected number of arrivals per time = 0.2

Table 4.Effect of changingnumbers of units of time in Standby Ring

Numbers of units of time will the simulation run	20	40	60	80	100	120	140	160	180	200
Total number of stations processed	48.494	96.037	144.145	192.514	241.294	288.857	336.014	383.591	431.237	480.42
Total number of stations accepted	19.854	39.859	59.876	79.862	99.829	119.865	139.858	159.86	179.897	199.867
Total number of station refused	19.769	47.336	75.433	103.811	132.588	160.106	187.296	214.848	242.481	271.698
Total number left ready to serve	8.871	8.842	8.836	8.841	8.877	8.886	8.86	8.883	8.859	8.855
Total number of correct MSG received	6.647	13.398	19.984	26.596	33.218	40.071	46.657	53.19	60.033	66.687
Total number of MSG Corrected 1 error	6.572	13.253	20.005	26.763	33.228	39.99	46.751	53.248	59.925	66.477
Total number of MSG refused .. Error	6.635	13.208	19.887	26.503	33.383	39.804	46.45	53.422	59.939	66.703
Total number unit time Rings are idle	0.146	0.141	0.124	0.138	0.171	0.135	0.142	0.14	0.103	0.133
Total number of FAILS in the system	1.839	3.682	5.34	7.334	9.212	10.954	12.651	14.509	16.3	17.943

Numbers of stations are there in the LAN = 120, Expected number of arrivals per time = 0.2

Table 5. Effect of changingexpected number of arrivals per time in Double Ring

Expected number of arrivals per time	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4
Total number of stations processed	0	24.066	47.697	71.739	96.037	119.991	143.953	167.73	191.115
Total number of stations accepted	0	24.027	47.402	68.501	77.936	79.395	79.759	79.881	79.926
Total number of station refused	0	0	0.001	0.863	11.846	33.184	56.423	79.985	103.254
Total number left ready to serve	0	0.039	0.294	2.375	6.255	7.412	7.771	7.864	7.935
Total number of correct MSG received	0	8.103	15.778	22.798	25.8	26.665	26.449	26.802	26.635
Total number of MSG Corrected 1 error	0	8.053	15.911	22.702	26.153	26.229	26.571	26.56	26.546
Total number of MSG refused .. Error	0	7.871	15.713	23.001	25.983	26.501	26.739	26.519	26.745
Total number unit time Rings are idle	80	55.973	32.598	11.499	2.064	0.605	0.241	0.119	0.074

* Numbers of stations are there in the LAN =120 , Numbers of units of time will the simulation run = 40

Table 6.Effect of changingexpected number of arrivals per time in Standby Ring

Expected number of arrivals per time	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4
Total number of stations processed	0	24.289	47.756	71.732	95.729	120.13	144.19	167.644	191.673
Total number of stations accepted	0	23.835	37.967	39.582	39.867	39.925	39.966	39.983	39.993
Total number of station refused	0	0	3.364	23.51	46.979	71.258	95.261	118.678	142.691
Total number left ready to serve	0	0.454	6.425	8.64	8.883	8.947	8.963	8.983	8.989
Total number of correct MSG received	0	7.974	12.65	13.525	13.435	13.356	13.425	13.322	13.337
Total number of MSG Corrected 1 error	0	7.985	12.778	13.094	13.226	13.363	13.287	13.328	13.172
Total number of MSG refused .. Error	0	7.876	12.539	12.963	13.206	13.206	13.254	13.333	13.484
Total number unit time Rings are idle	40	16.165	2.033	0.418	0.133	0.075	0.034	0.017	0.007
Total number of FAILS in the system	3.659	3.615	3.64	3.608	3.656	3.63	3.61	3.633	3.593

* Numbers of stations are there in the LAN =120 , Numbers of units of time will the simulation run = 40

Figures (18-25) respectively,show the comparison between Double Ring and Standby Ring result of changing the numbers of stations.Figures (26-33)respectively, show the comparison between Double Ring and Standby Ring result of changing the numbers of units of time. Figures (34-41) respectively, show the comparison between Double Ring and Standby Ring result of changing the expected number.

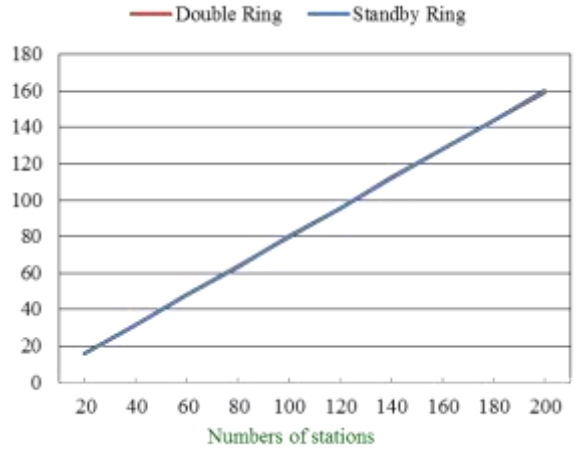

Figure 18. Total number of stations processed result of changingthe numbers of stations

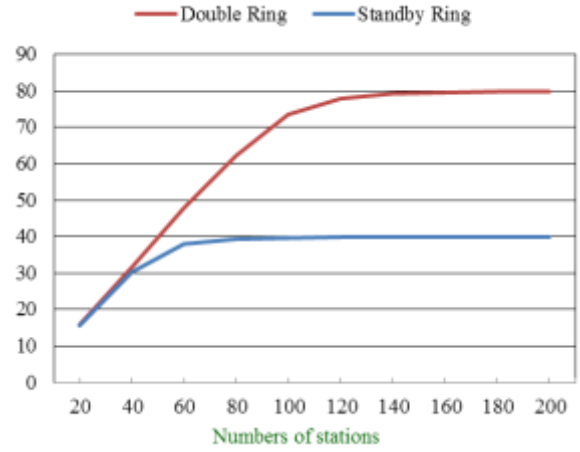

Figure 19. Total number of stations accepted result of changingthe numbers of stations

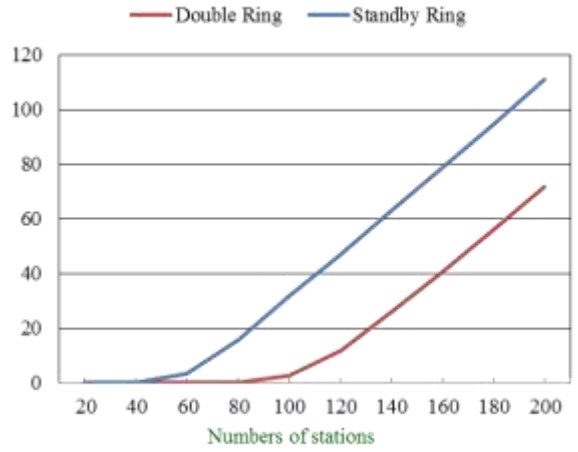

Figure 20. Total number of station refused result of changingthe numbers of stations

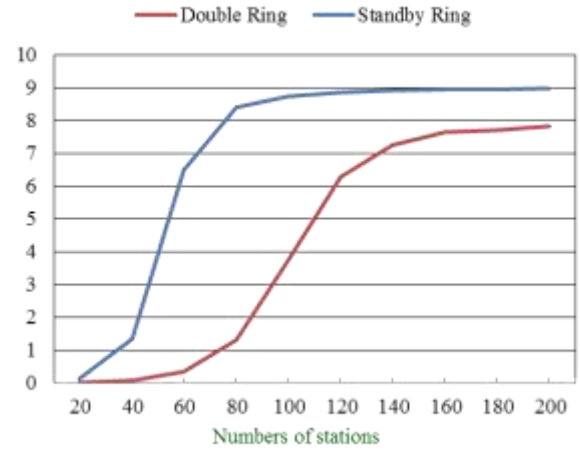

Figure 21. Total number left ready to serve result of changingthe numbers of stations

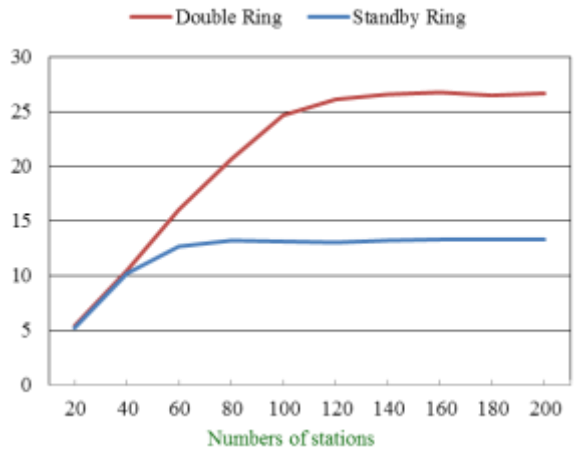

Figure 22. Total number of correct message received result of changingthe numbers of stations

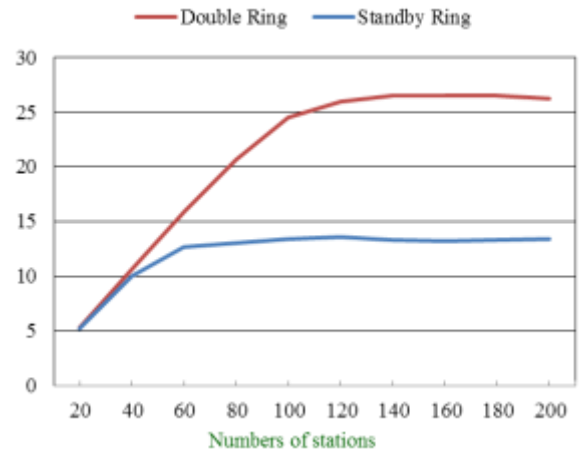

Figure 23. Total number of message corrected (1 error) result of changingthe numbers of stations

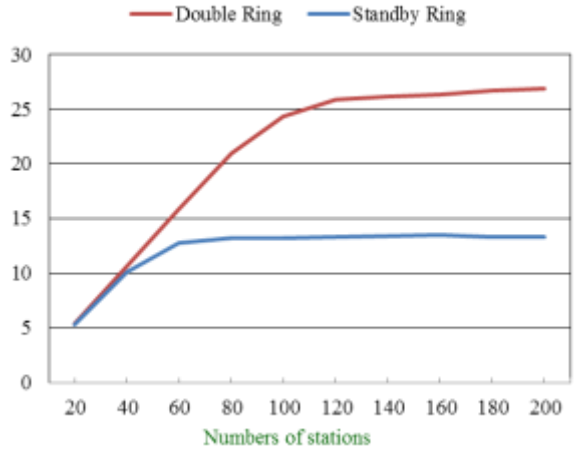

Figure 24. Total number of message refused (Error) result of changingthe numbers of stations

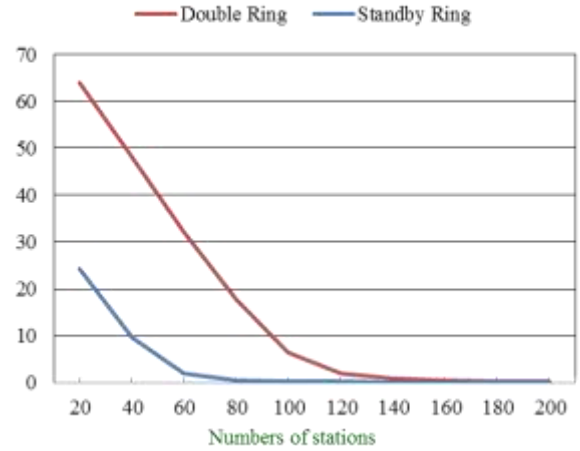

Figure 25. Total number unit time rings are idle result of changingthe numbers of stations

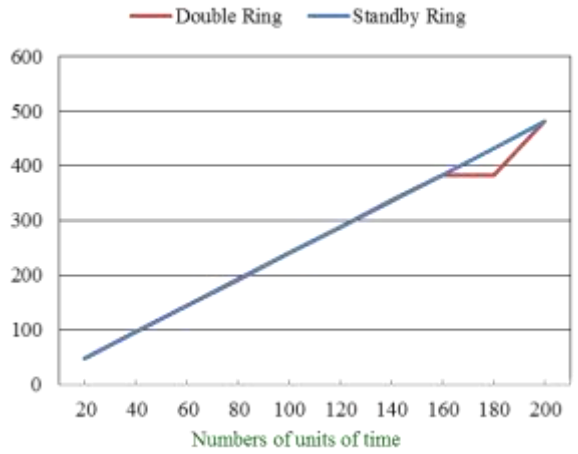

Figure 26. Total number of stations processed result of changingthe numbers of units of time

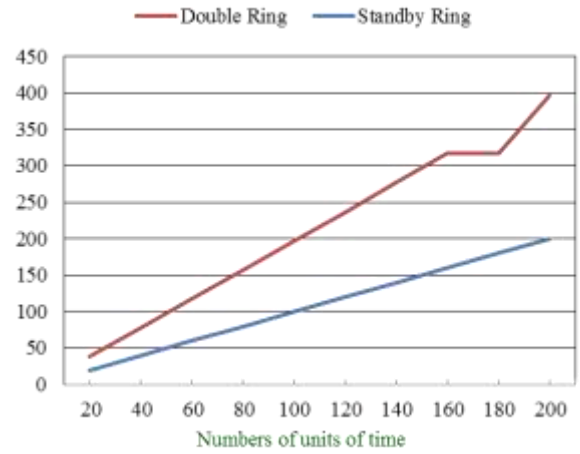

Figure 27. Total number of stations accepted result of changingthe numbers of units of time

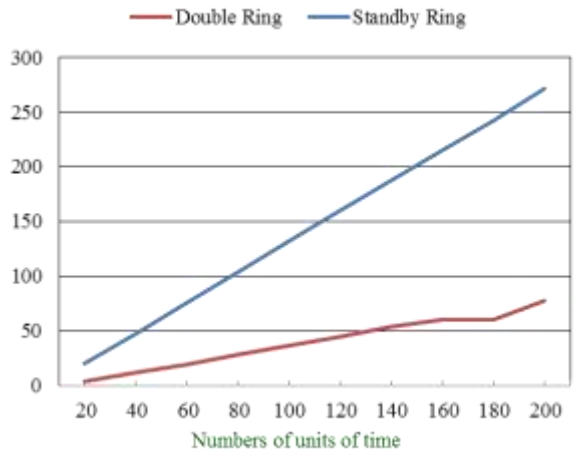

Figure 28. Total number of station refused result of changingthe numbers of units of time

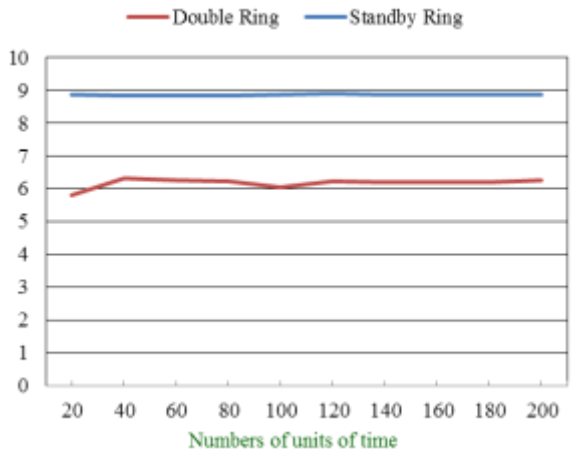

Figure 29. Total number left ready to serve result of changingthe numbers of units of time

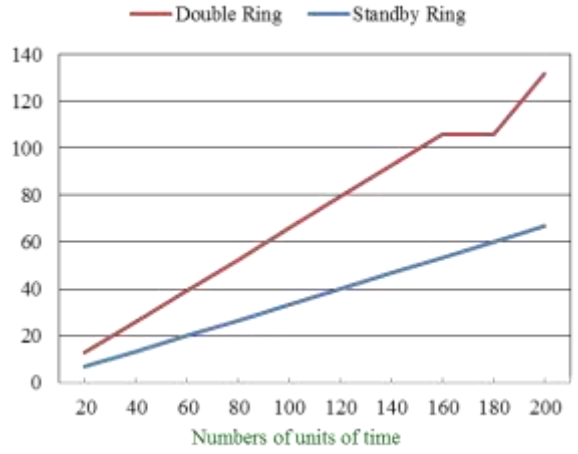

Figure 30. Total number of correct message received result of changingthe numbers of units of time

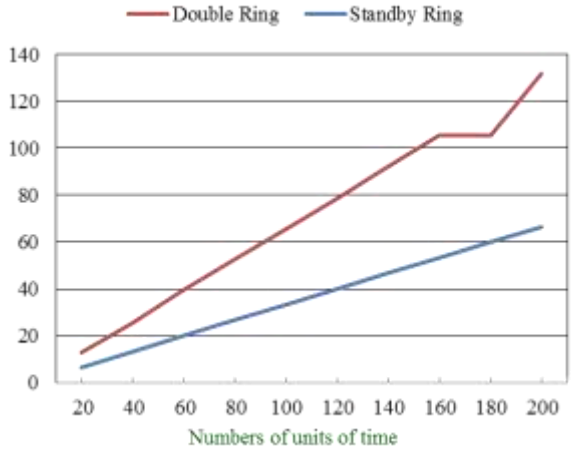

Figure 31. Total number of message corrected (1 error) result of changing the numbers of units of time

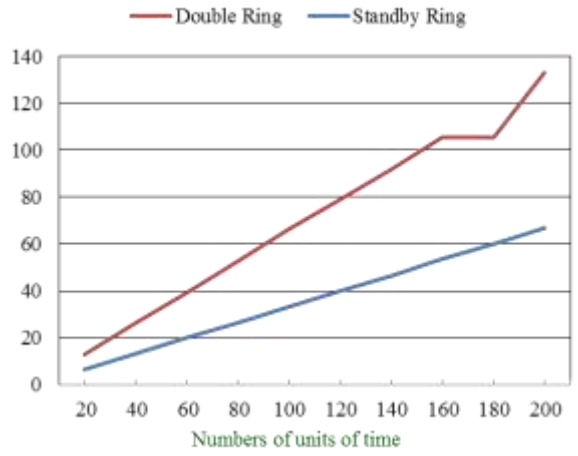

Figure 32. Total number of message refused (Error) result of changingthe numbers of units of time

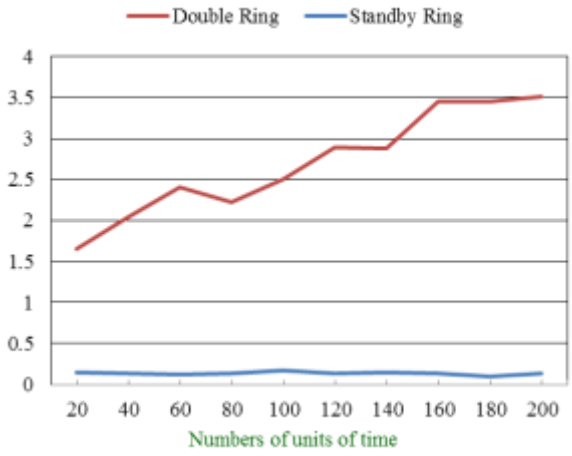

Figure 33. Total number unit time rings are idle result of changingthe numbers of units of time

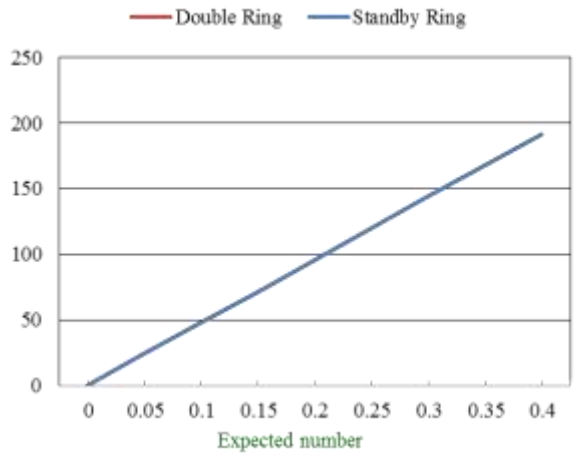

Figure 34. Total number of stations processed result of changingthe expected number

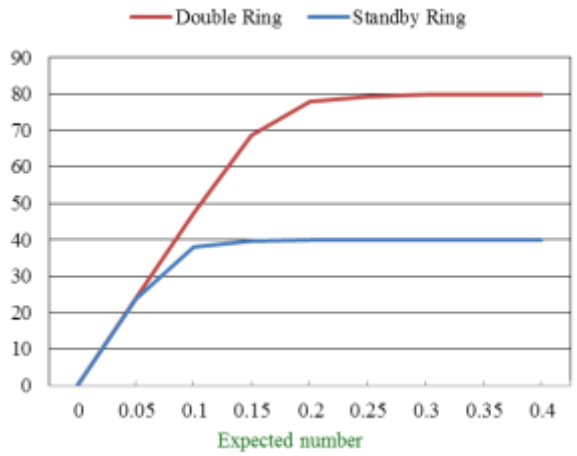

Figure 35. Total number of stations accepted result of changingthe expected number

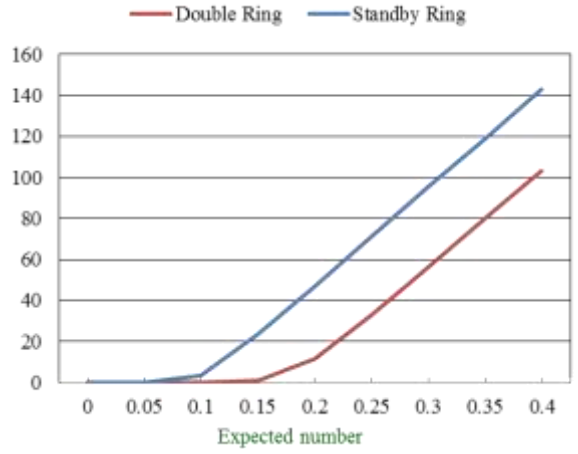

Figure 36. Total number of station refused result of changingthe expected number

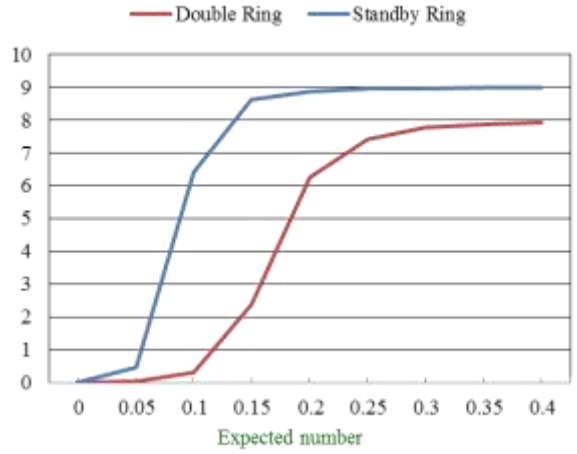

Figure 37. Total number left ready to serve result of changingthe expected number

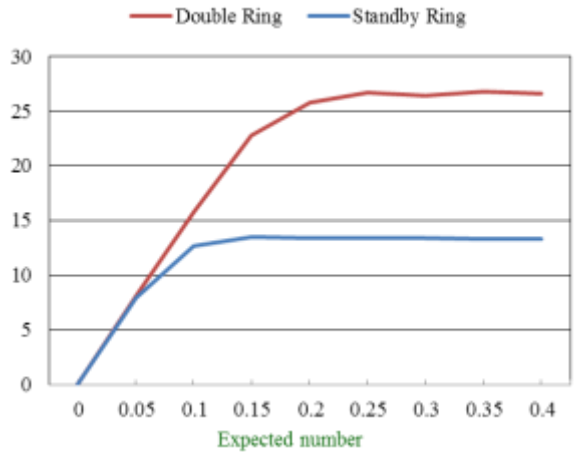

Figure 38. Total number of correct message received result of changingthe expected number

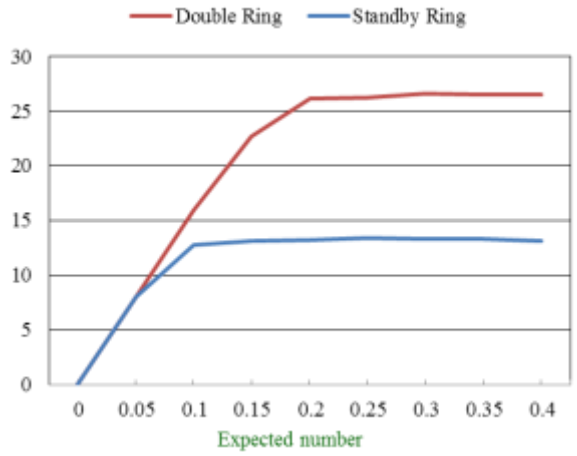

Figure 39. Total number of message corrected (1 error) result of changingthe expected number

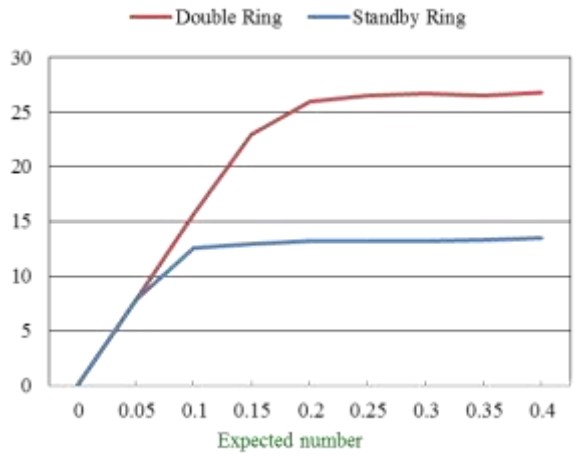

Figure 40. Total number of message refused (Error) result of changingthe expected number

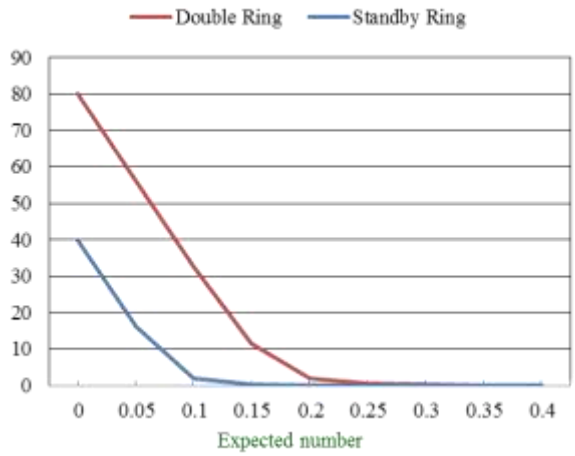

Figure 41. Total number unit time Rings are idle result of changingthe expected number

The total numbers of stations processed increased by the same amount for both double ring and standby ring with the increase in any of the parameters, as shown Figures (18, 26 and 34)respectively. The total numbers of stations accepted increase more in double ring than standby ring with the increase in any of the parameters, as shown Figures (19, 27 and 35)respectively. The total numbers of stations refused increase more in standby ring than double ring with the increase in any of the parameters, as shown Figures (20, 28 and 36)respectively. The total number left ready to serve increase more in standby ring than double ring with the increase numbers of stations or increase expected number, as shown Figures (21and 37)respectively. But if numbers of units of time are increase, the total number left ready to serve are fixed does not change, as shown Figures (29). The total number of correct message received increase more in double ring than standby ring with the increase in any of the parameters, as shown Figures (22, 30 and 38)respectively. The total number of message corrected 1 error increase more in double ring than standby ring with the increase in any of the parameters, as shown Figures (23, 31 and 39)respectively. The total number of message refused increase more in double ring than standby ring with the increase in any of the parameters, as shown Figures (24, 32 and 40)respectively. The total number unit time rings are idle decrease more in double ring than standby ring with the increase numbers of stations or increase expected number, as shown Figures (25 and 41)respectively. But if numbers of units of time are increase, the total number unit time rings are idle fixed does not change for standby ring and increase for double ring, as shown Figures (33).

IV. Conclusion

The ring topology is found to be more easier than other topologiesto isolate faults and it has good performs under heavy network load;but the most problem in the ring topology is the system delay. Double ring and Standby ring used to decrease the time delay or the propagation delay. A powerful software ware have been developed to investigate the effect of changing each parameters individually. This proposes software has been subjected to a real test with realistic examples. These developed softwares were found to operate successfully.

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