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Simulation of Office Automation Communications on WAN Networks to Maintain Unfailing Communication

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Abstract

The emergence of WAN communication technologies can be considered a revolution for business institutions. These networks eliminate distances and allow for convergent implementation of many geographically distant tasks. National Iranian Copper Industries Co. intends to set up business relations internally and with counselors and contractors using similar networks (WAN), and benefit from them in national projects. In deployment, a problem that negatively influences efficiency of the system is its inability to maintain unfailing communication. The maximum efficiency is achieved if WAN systems provide maximum accessibility and eliminate disconnection and slowing down.In this essay, investigating existing infrastructures in Iran, the choice as to the way of implementing this wan system is studied and then a lab simulation is conducted using Opnet software to test this connection. In different stages of the research, an attempt has been made to retain logical relation between deployment costs and system efficiency so that to be used as a practical solution. The problems concerning internal system and office automation in National Iranian Copper Industries Co. were investigated to practically demonstrate maximum efficiency in this WAN system.

Keywords: Simulation, office Automation, WAN, unfailing communication.

Introduction

With increased prevalence of communication and emergence of a variety of communication forms, communication networks have overshadowed all aspects of our lives and business in all its forms (production or service) all around the world is no exception. As business communication is getting more advanced and complicated, to avoid losing one of their main sources of data gathering, organizations have developed systems inside themselves to enable them to optimally use available information and after adopting the proper processing procedure, reporting it to customers to gain their satisfaction. Competitive business environment and changes in it in 1990s (globalized economy and transformation of economies and industrial communities into service economy based on knowledge and information) has increased the importance of paying attention to information systems. So, the issue of automation systems which is a kind of information system is gaining greater importance to a point that among organizations, only those that feature a high level of automation can often demonstrate the highest level of preparation against environmental and internal changes. Implementation of such communication will serve as a very effective factor in reducing costs and increasing efficiency. But, due to problems such as distances among cities, communication problems and high cost of machinery deployment, this project requires a careful scientific treatment and also a simulation to test and identify problems. In this research, by the aid of careful study of the infrastructures of the country and its cities and pre-deployment simulation, problems concerning this deployment are to be identified. Due to short history of research and projects in the world and a sudden interest in using possibilities of WAN system by companies, organizations and state and private sectors in recent years and obscurity of issues in this area and rise of problems and abandonment of many of these projects unfinished, this research will help throw light on some dark points and problems in deployment of such projects. Infrastructural problems, namely the speed and safety will be investigated and lab simulation will be tested in practice[1].

Most of the research into the issue has been sparse and limited. Research concerning WAN and Operational systems has been done occasionally. Although the research works mentioned possess their own significance, many questions concerning operational issues and level of efficiency and feasibility of such projects have been left unanswered. Conducting a comprehensive investigation in domestic and foreign research and studies, only a few have qualified as focusing on operational problems of such projects. In addition to lab studies, this research is aiming at investigating scientific aspects and deployment-related problems. Office automation is combinations of different equipment and devices used to facilitate office-related activities. Office automation facilitates different types of communication inside an organization. There is no doubt as to the importance of creating wide communication via WAN and values it brings. What will happen, and this is very important, if the communication fails? Absence of a proper answer to this very crucial question could lead to loss of information and investment beyond imagination. If an institute provides all the required investment but fails to set up proper communication for users, the loss of investment will be the result. Even if the investor sets up the proper communication but the users could not connect to use the systems or they could but the communication is slow or temporary, the efficiency of the system will practically collapse. So, not only communication is required, but it also should survive optimally so that the system successfully operates[2].

To deploy WAN, "rented lines" are used. Rented lines could be very expensive[3]. "Local Area Network" is a "Computer Network" which operates over a limited geographical boundary such as a house, an office or a block of buildings. Due to its importance, in this essay, we also pay attention to LAN, and could be said to be the key point in making the aim of this research operational. On one end of WANs there are always LAN users and in this essay, different parts of WAN are related to each other effectively, so the LANs connected to them must be efficient and problem-free to enable us use our facilities fully. Consequently, a well-managed LAN connected to our WAN could possess the efficiency we intend[3, 4]. Simulation is an imitation of function of a real process or a system over time. Regardless of the method of conduct (manual or computer-based), simulation is fabrication of system history and an analysis carried out to achieve results concerning specifications of real system function. Simulations are realistic and do not depend hypotheses, while analytic models depend on many simple hypotheses. Function criteria to implement system behavior are easily gained and illustrated output will help the end user[5]. OPNET software is able to create different layers modeling based on needs and necessities of simulation. OPNET simulation is a 3-layer simulator which includes network model, node model and process[6]. Part 3 in this essay recounts history of research based on simulation. Part 4 is about research history. In Part 5 the results of the research are stated and final part includes concluding and practical suggestions.

Research History: Today with the increasing growth of computer networks, methods that help analyze and investigate network behavior are of great importance. Simulation software are suitable devices to analyze networks, especially modern networks with complex structures on which application of analytic math methods in exact behavior investigation is literally impossible. Sajad Farhangi, "A Comparative Study of IS-IS and IGRP Protocols for Real-Time Application Based on OPNET" is aimed at investigating aforementioned protocols in improving function of IP-based networks in delay, traffic and etc. author in the beginning defines Intermediate System to Intermediate System protocols and Interior Gateway Routing Protocol and explains the importance of each[7]. Kuldeep Vats, "Simulation and Performance Analysis of OLSR Routing Protocol Using OPNET". Author, in the beginning, provides basic definitions and applications. He continues defining Optimized Link State Routing Protocol and applications in mobile networks. Optimized Link State Routing Protocol is based on dynamic linear stage routing algorithm. This algorithm chooses factors such as link burden, delay, bandwidth and etc. the author uses OPNET to simulate in small 30, 40, 50-nods networks and concludes that Optimized Link State Routing Protocol has been successful in sending packets and messages with optimal function[8]. Lio Guo, "Performance evaluation for on-demand routing protocol based on OPNET modules in wireless mesh networks" points at speed and development of wireless networks and wireless networks technology which have led to the emergence of wireless mesh networks. Regarding simulation and analysis of aforementioned protocols, this essay investigates the internal performance of the network based on following criteria: routing time, average function each hub in route, network delay and network operational potency. The results from this simulation shows that the base function of on-demand routing protocol which is source dynamicity is not suitable for wireless transmission, While mono-functional routing protocol based on vector-distance request works on purposeful routing and very suitable to transmit in wireless network along with rapidity and application of changes. Weiyi Zhao, "computer networks, OPNET-based modeling and simulation study on handoffs in Internet-based infrastructure wireless mesh networks" points at utilizing wireless internet on a larger scale. The role of managers using Wireless Mesh Network is crucial and necessary in offering higher quality service in mobile for users. Therefore, Hand-off performance analysis in wireless mesh networks is a vital need for network researchers and engineers. Recently, OPNET simulator, pioneer in offering solution for network analysis, has also been used[6]. Dong (Don) Xu (2011), "EIGRP, RIP and OSPF performance analysis based on Opnet, points at routing protocol performance as one of the keys in quality in modern communication networks. Dynamic routing protocols are used in operational networks for information communication in network typology. A host of static and dynamic protocols are available but choosing the right protocol depends strongly on vital parameters such as network convergence time, reliability, memory and processor needs, security and bandwidth. In this essay, OPNET devices which are widely used in IP-based networks are utilized to analyze the performance of aforementioned protocols[6]. Mohd Nazri Ismail, "Network traffic and utilization: Reliability of network analyzer development with independent data, OPNET simulation tool and real network" is written to calculate network analysis development with congruent service. This essay also focuses on analyzer software which are used in incongruent service. Investigating factors such as delay, bandwidth capacity, reliability within the framework of user needs, the author has been able to analyze the specified network. It follows dividing a network lifetime to preparation parts, planning, designing, implementing, operating and optimizing and has used Queue theory MM1 in analysis[9]. Aqun Zhao, "A Bandwidth Management strategy for DVB-RCS System", aims at allocation of bandwidth for Digital Video Broadcasting - Return Channel via Satellite. The base of the strategy is depicted by "Queue definition" with user and service priority. Combination of different support capacities through connection of reserve systems has been able to have the best utilization of systems bandwidth resources in increased efficiency and effectiveness of bandwidth. The results have been shown in OPNET simulator. The essay points out that transmission services are growing along with rapid satellite network development. Although the bandwidth resources are limited, but of great importance is the manner in which they are used and allocated to improve efficiency[10]. Another work in the area is "Co-simulation of wireless networked control systems over mobile ad hoc network using SIMULINK and OPNET". Mesh wireless network control system on "MANET" mobile networks is a new area of research and is used in many practical programs such as military and rescue missions and identifying environmental threats and etc. it was shown in this study that the main challenge in the systems is delay in sending acceptable packets. Data rate increase in the network in a narrower bracket is transferable on potential.[11,12]

Methodology

This study, based on its objectives, is practical. And also based on the study approach, lies within experimental and causal research because the researcher does not manipulate variants but attempts to find the reasons behind problems and offer solutions. Of course, current research could also be classified as case-based research. In addition, part of this research which will be chosen to properly underlie deployment of WAN, is of descriptive nature. In order to gather data, in current research, field study has been adopted. To answer the research question, "How to set up an unfailing communication?", researcher appears as one of the users of the system, and in so doing, directly relates to test-cases or research samples. This is to say that, in this method, researcher walks on to the research field using different qualitative and quantitative methods and directly relates with statistic body and sample (in other words evaluation units).After finding the cause problems and simulation in lab environment, attempt will be made to identify roots of problems. Data gathering in this research is in the form of field study. The main objective of this research is to eliminate reasons involved with failure of the system and the scope of the effectiveness of this elimination. Therefore, in addition to investigation of typology and structure of existing primary and secondary networks, there is a need for data gathering in order to compare results after the application of changes. Finally, to achieve specified objectives of this research, following model was developed to investigate elements[13].

System deployment: The system structure investigated in this research is the network and automation system in National Iranian Copper Industries Co. the core of the system is located in Rafsanjan, and depending on the work season, supports for 500 to 1000 users. Via Internet, this system offers service to partners from around the world. The internal structure of the group is shaped like a star and consists of several inter-related stars. Automation and data communication servers in National Iranian Copper Industries Co. are composed of database servers and software and following illustrations show their communication structure (figure-1, 2).

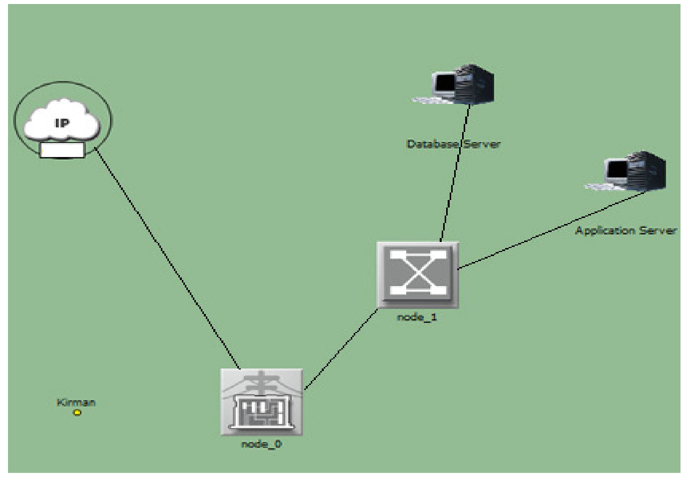


Figure-1
External model of partners

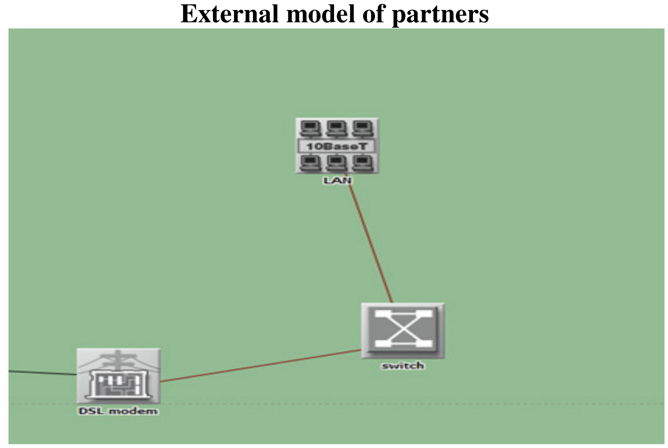


Figure-2
state of Iranian Copper servers

The main scenario in simulation model: In evaluating scenarios concerning user's increase, the estimation in increase per hour is 100 people. As the number of users increase over time, the bandwidth will be the same as in the beginning. On the whole, following program scenarios were simulated in servers and all performance was investigated based on following parameters (table-1).

Table-1
Simulation parameters

Program	Information input distribution
Database Access	Poisson
Web Browsing	Smooth
FTP	Poisson

In the main scenario inputs in specified parameters is arranged as follows (table-2)

Table-2
State of research input parameters

Program	Information input distribution	Center	Bandwidth (megabyte)
Database Access	P(1100)	Rafsanjan	10
Web Browsing	(5و25)U	partners	1
FTP	P(1100)		

Evaluation of state of Ethernet load tolerance: Ethernet in National Iranian Copper Industries Co. composed of a group of connected nodes, each consisting 30 PCs. In simulation, first the tolerance state of these nodes and the state of simulated server and then with the involvement of the second node, tolerance of extra load is calculated (figure-3, 4).

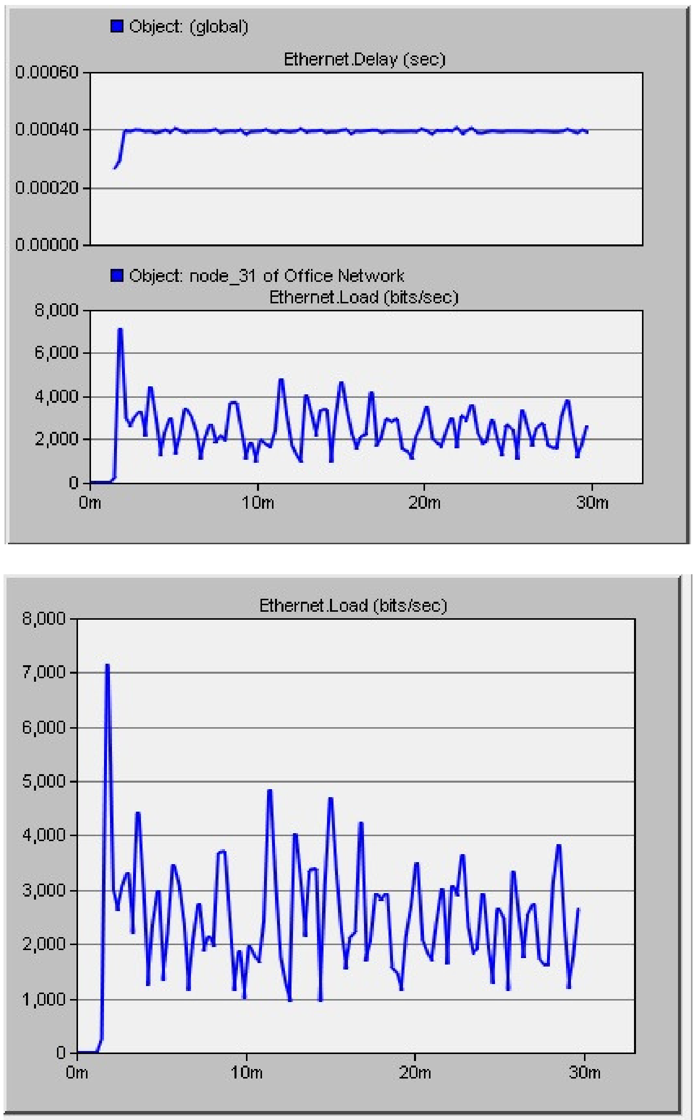


Figure-3
System delay state in one-node state with increased load

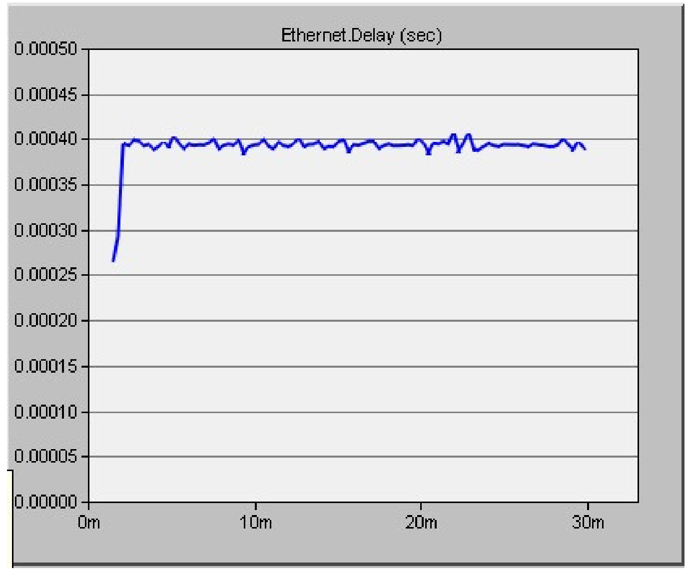


Figure-4
Level of Ethernet delay with increased load

Now we add the second node to the system and observe system reaction (figure-5).

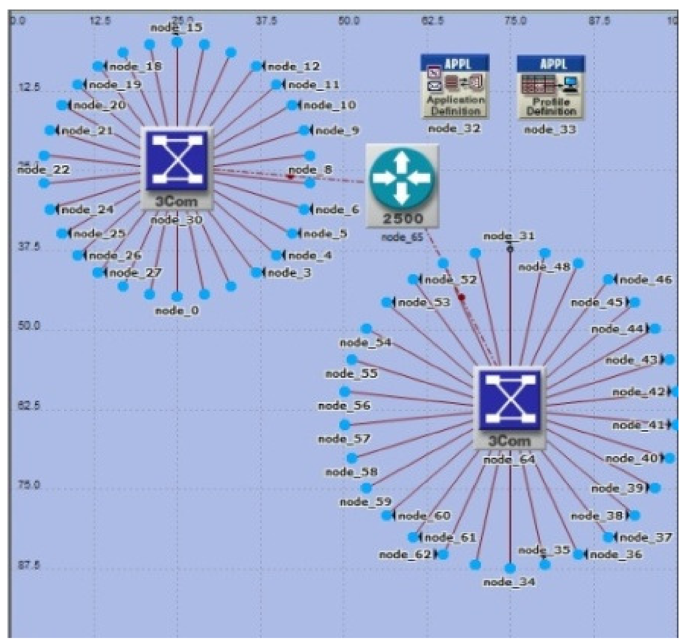


Figure-5
Extra network view at the time of adding load

The picture shows average load level between regular time and load addition to system (figure-6).

In the picture below the level of delay change in proportion to one-node state is simulated. As it is clear, 2 times increase in load does not create great change and delay does not exceed 0.00042. Table-3 and figure 7.

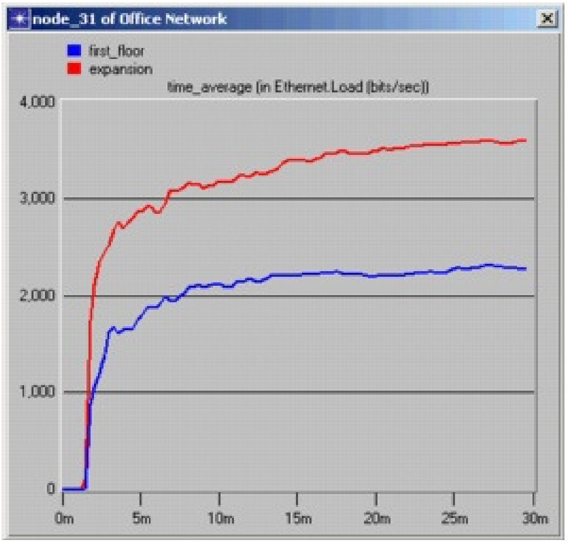


Figure-6
Average load level between regular time and load addition to system

Table-3
Delay state in proportion to Ethernet load

Number of users	Maximum load in seconds	Load
One-node 30 users	0.00025	2000-0 packets

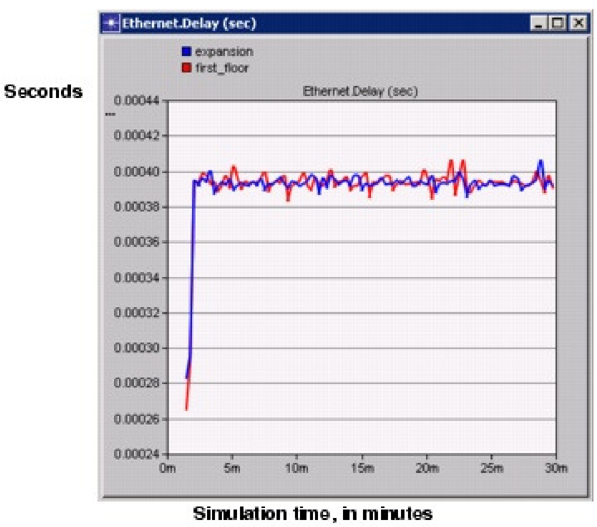


Figure-7
Comparison of delay in back load and no back load states

Evaluation of load tolerance in WAN: As mentioned before, Ethernet state for partners are stimulated in which transmission state of FTP input with heavy load is modeled. In this stimulation increase in traffic as a result of load change in different hours is investigated. Method of load increase is as follows: in the first 300 seconds of simulation extra load is 19.200 bits per second, for the next 200 seconds extra load is 25.600 bits per second and in the last part 32.000 is considered (table 4, 5; figure 8, 9, 10).

Table-4
Simulation method of extra load

Load (bit per second)	Time (second)
19،200	0
25،600	300
32،000	500

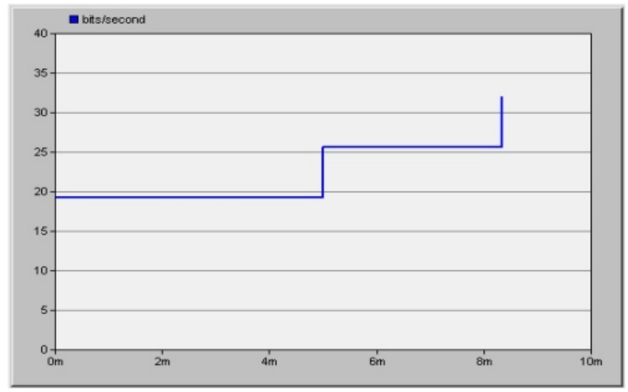


Figure-8
Stimulation of extra load in proportion to time

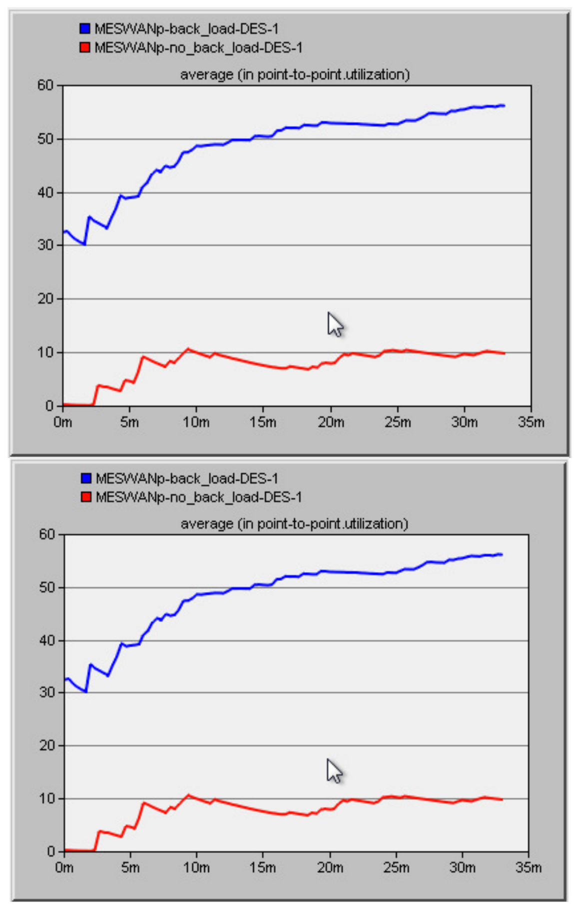


Figure-9
Comparison of FTP in the presence of back load and no back load

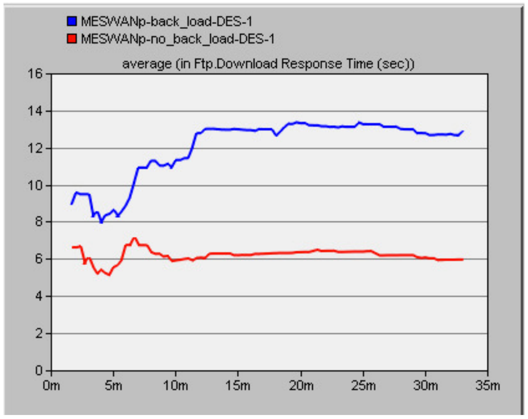


Figure-10
Point-to-point results of use in back load and no back load states

Table-5
Comparison of FTP back load and no back load states

Maximum average use	Minimum average use	Maximum delay	Minimum delay	Load state
10	0	5.5 seconds	4.5second s	No back load
55	30	12.5 seconds	8seconds	Back load

Since the automation uses HTTP protocol in communication, load state in this protocol is simulated. Picture below shows average load in back load and no back load states (figure 11).

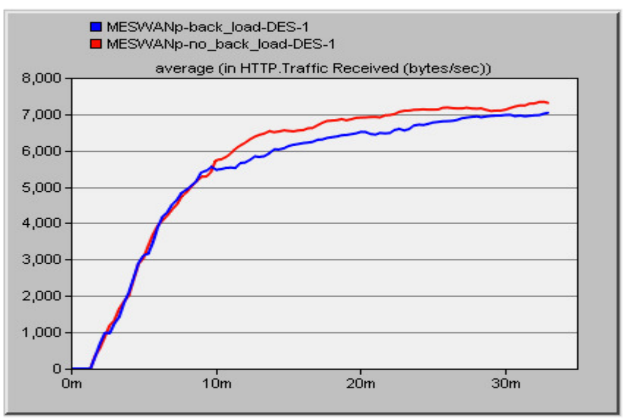


Figure-11
Load state in HTTP protocol

Simulated scenarios and investigation of outputs: In this section we investigate partners' state and links tolerance to destination. In the beginning, in scenarios, we study number of users considering five-unit increase and we continue until we have 100 users which is the maximum communication with the outside at a given moment. And it should be mentioned again that internal tolerance state in the previous part and this links tolerance is from partner to center (table 6; figure 12, 13).

Table-6
FTP respond time in proportion to number of users

Maximum respond time second	Minimum respond time Second	Number of external users (each partner)
5	0	No back load
10	0	5
12	5	10
14	8	15
15	10	20
22	12	25

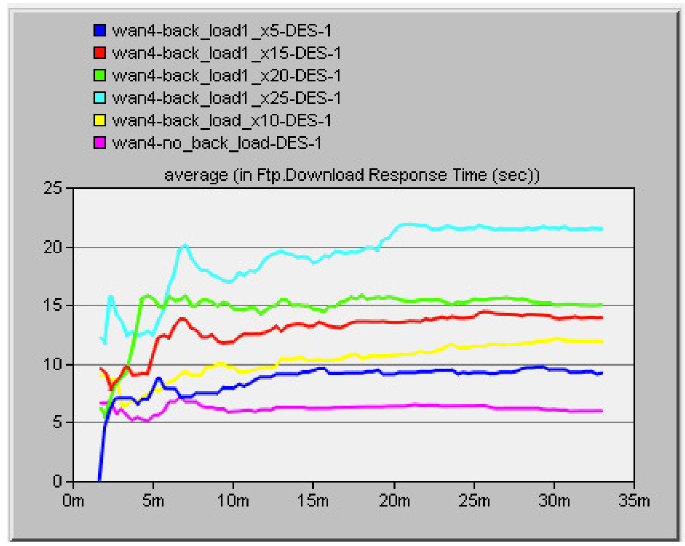


Figure-12
FTP respond time in proportion to number of users

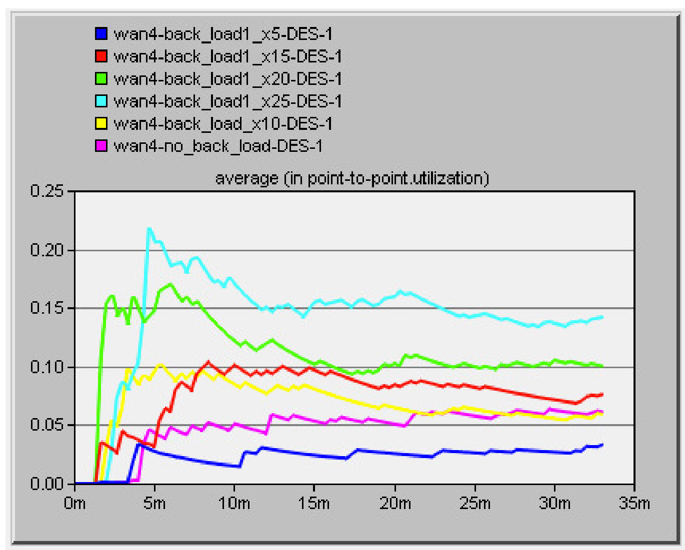


Figure-13
network use state in Rafsanjan center

It should be mentioned that stimulation was done for all centers and only table for Rafsanjan center is illustrated (table-7).

Table-7
Comparison of partners' network level of bandwidth use

	25	20	15	10	5	No back load
Isfahan	0.17-0	0.14-0	0.12-0	0.07-0	0.3-0	0.7-0
Kerman	0.18-0	0.17-0	0.12-0	0.06-0	0.3-0	0.7-0
Shiraz	0.15-0	0.15-0	0.14-0	0.15-0	0.3-0	0.7-0
Tehran	0.23-0	0.15-0	0.12-0	0.8-0	0.3-0	0.1-0
Rafsanjan	0.23-0	0.17-0	0.11-0	0.11-0	0.3-0	0.7-0

Evaluating HTTP response time state in Rafsanjan center (table 8, 9, 10, 11; figure 14, 15, 16, 17)

Table-8
Comparison of HTTP respond time Rafsanjan center

Maximum respond time second	Minimum respond time second	Number of external users (each partner)
0.4	0.4	No back load
0.6	0.4	5
0.65	0.4	10
0.7	0.4	15
0.9	0.4	20
1.3	0.6	25

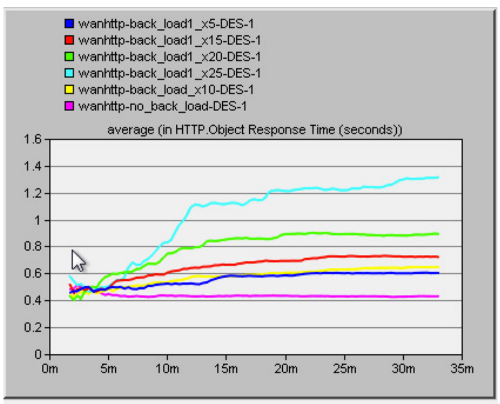


Figure-14
HTTP respond time state in Rafsanjan center

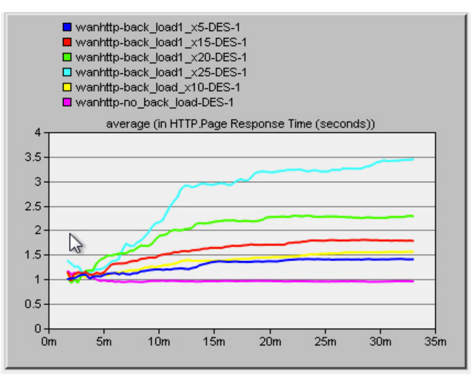


Figure-15
web pages respond time state in Rafsanjan center

Table-9
web pages respond time state in Rafsanjan center

Maximum respond time second	Minimum respond time second	Number of external users (each partner)
1	1	Without load
1.5	1	5
1.6	1	10
1.8	1	15
2.3	1	20
3.5	1.4	25

Table-10
received traffic state in Rafsanjan state

Maximum kilobyte per second	Minimum kilobyte per second	Number of external users (each partner)
7	0	No back load
3	0	5
7	0	10
11	0	15
14	0	20
15	0	25

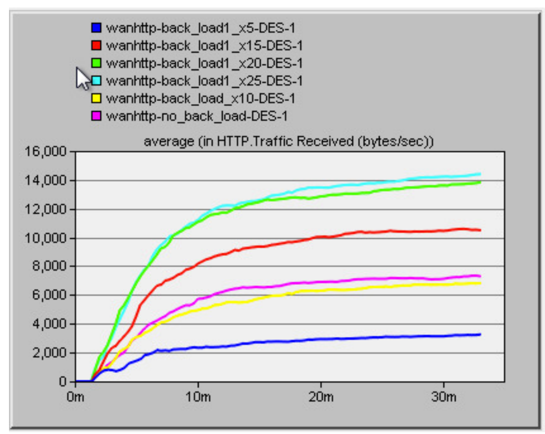


Figure-16
received traffic state in Rafsanjan state

Table-11
sent traffic state in Rafsanjan center

Maximum kilobyte per second	Minimum kilobyte per second	Number of external users (each partner)
7	0	No back load
3	0	5
7	0	10
11	0	15
14	0	20
15	0	25

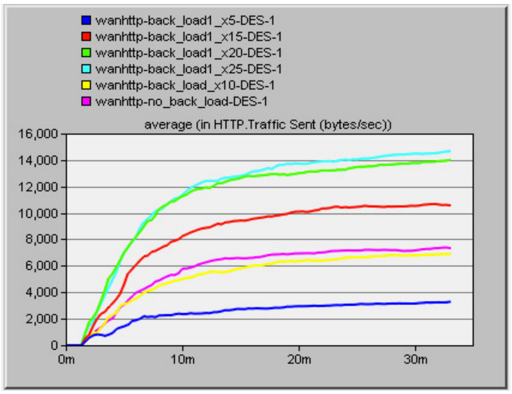


Figure-17
sent traffic state in Rafsanjan center

Output in simulation: There are 2 certainties in the exactness of calculations in an endless simulation models: i. Primary variance elimination. ii. Certainty that enough output is derived from stimulation for the purpose of exact estimation of performance. iii. Primary variance elimination: in the situation of unfailing output simulation, we should calculate- primary variance and eliminate it. There are 2 approaches to deal with primary variance. The First approach is to operate the model for a limited time. This basically means to operate the model until it reaches a real state (unfailing state for unending models) and only gather the results from this point on. The second approach is to create primary conditions in the model. Instead of operating the model until it reaches a real state, model in real conditions is put in operation in the beginning. This means make it operational and in model the first step is operation.

ii. Gaining output data enough to long-term start-up and numerous repetitions: in unending simulation, model can once have a long-term performance. In this type of simulation, input remains constant during simulation and there appears to be a primary variance, so it must be eliminated in the first step. Here, to calculate primary variance, graphic approach is used (figure-18).

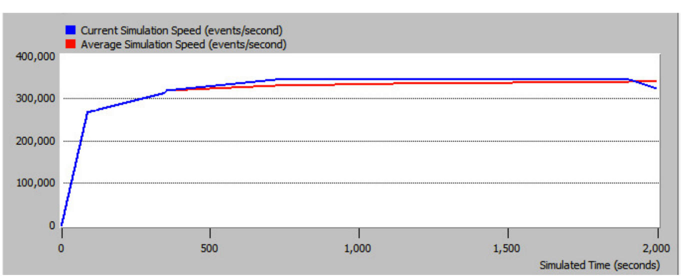


Figure-18
To calculate primary variance using graphic approach

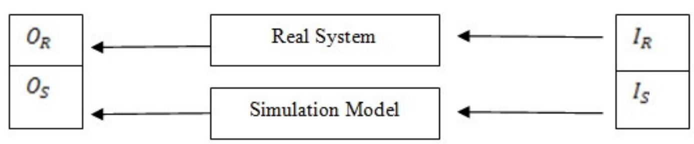
In current situation, primary variance network is 120 seconds of the whole simulation time and it means that in 120 seconds the system reaches stability, so a start-up time of 120 seconds is required. Since the model in this research is an unending simulation, there is no natural ending point for a repetition and functioning time must be "much" longer than start-up time, otherwise it's possible that there would be some variance in output. As the reliability distance becomes narrower, estimation exactness increases. The table below illustrates reliability distance of .95 for 6 optional repetitions of network performance simulation. Start-up periods are also eliminated from the calculations (table-12).

Table-12
Reliability distance of .95 for 6 optional repetitions of network performance simulation

Repetition of simulation	Response time average	Incremental average
No back load	0.41	0.41
5users	0.49	0.45
10usres	0.505	0.4775
15 users	0.585	0.53125
20 users	0.645	0.588125
25users	0.93	0.7590625
	Total average	0.594166667

$$CI = \bar{x} \pm t_{n,\alpha/2}\frac{s}{\sqrt{n}} = \quad 0.1511 \pm 0.5941 = [\ 0.4430\ ,\ 0.7452\ ]$$

Confirmation is a process that verifies the validity of model design (conceptual model) transformation to computer model and on the other hand verification is a process that guarantees model exactness for specified objectives. The purpose of Confirmation and verification is to make sure that the model is exact enough. In addition, the exactness of the model is evaluated according to the aim of the model. If the level of reliability of the model is to be increased, when the model is put operation in reality, outputs must be almost similar. The main problem with this verification process is the possibility of unavailability of real world exact data. If so, the comparison can be made by the aid of expectations and understanding of knowledgeable people who know the real system. Comparison using approximate data from the real world might not give us the highest level of certainty about the model, but certainly helps increase the level of reliability of the model.



IR: input to the real world, OR: output from the real world, IS: input to the simulation model, OS: output from simulation model.

AssumptionH1: if IS=IR then OS=OR

Universals' verification: comparison with the real system
Historical (or expected) data which are gathered from real system can be compared with results from simulation, when operated under similar circumstances. The assumption is that the amount of output data from simulation model equal existing

real world data and therefore reliability coefficient of averages' difference can be calculated using the following formula.

$$\overline{X}_S - \overline{X}_R \pm t_{2n-2,\alpha/2}\sqrt{\frac{S_S^2 + S_R^2}{n}}$$

In verification stage, the validity of the primary model was intuitively confirmed by experts in National Iranian Copper Industries Co. in this state, after calculating 6 previous simulations, reliability distance was calculated as follows:

Reliability distance= [-0.2311 و 0.2393]
So with reliability level of %95, the results of the operated scenario are correct (table 13).

Table-13
Gathering amount of consumption of real partners' users and management method of bandwidth

Average speed	Amount of consumption	Partner name
100Kbyte/ps	2.5gigabyte	Tehran
90Kbyte/ps	1.9 gigabyte	Shiraz
100Kbyte/ps	2.3 gigabyte	Isfahan
40Kbyte/ps	0/86 gigabyte	Yazd

Conclusion

In this research, according to its aim, first we put together the main model of research. Main model consists of National Iranian Copper Industries Co. headquarters in Rafsanjan and system users in four companies in Tehran, Isfahan, Kerman, Shiraz. It was necessary to evaluate the state of internal servers in National Iranian Copper Industries Co. The reason to this evaluation was that all data are put on servers and Ethernet and all users use this system. The specifications of the servers and network was extracted and after Copper industries 'experts' confirmation where used in the model. The load state of these servers were stimulated and after reporting was again confirmed by Copper Industries' experts. Then the communication state with these servers from different centers was evaluated and confirmed by centers' experts and the connections were stimulated. Then the number of users was increased from the least to the most and the effects on the output were evaluated. In these outputs, what is of great worth for evaluation is the access time to web pages, delay and the load put on links. It can be said about the ways to set up communication that the most economical way to set up communication is via Internet. Of course the rented lines are much more reliable and of greater quality and yet so expensive that most of business partners afford their monthly costs. Other ways, similarly, do not offer enough bandwidth. The security of communication with the center is guaranteed trough both virtual networks with coding and HTTPS. National Iranian Copper Industries Co. has gained its HTTPS certification and uses it to provide for the security of the data. Evaluating Copper Industries' Ethernet state and with increase load, maximum delay was .00045 which is a very acceptable number and shows that Copper Industries' Ethernet is of great tolerance and load increase does not create any noticeable slow-down. So it should be concluded that Copper Industries' Ethernet cannot cause slow-down or partners 'disconnection (figure-19).

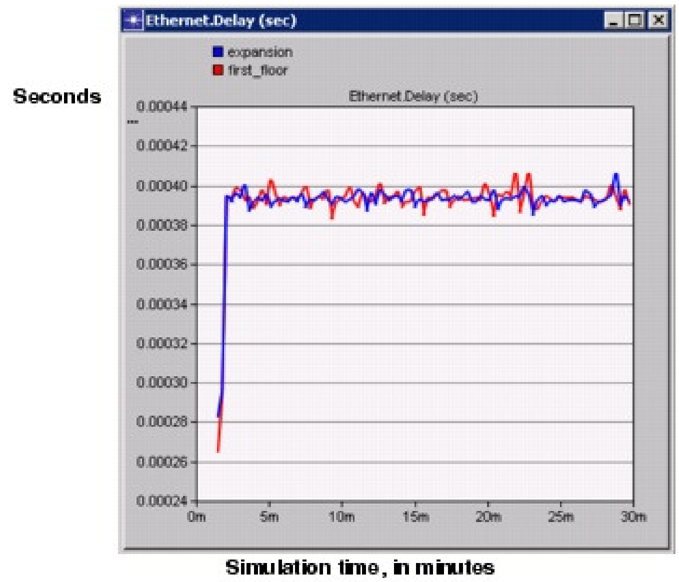


Figure-19
Evaluating Copper Industries' Ethernet state

So, now that it is clear that Ethernet is excluded from the list of disturbers, attention must be directed at partners' link to Coppers Industries. Links' evaluation was done with the knowledge that users change during the day and load input is not constant. So this factor is included in simulation model. After simulations in file sharing protocol, two times delay was noticed in the system (table 14).

Table-14
Load state, average use, and delay

Maximum average use	Minimum average use	Maximum delay	Minimum delay	Load state
10	0	5.5 seconds	4.5 seconds	No back load
55	30	12.5 seconds	8 seconds	Back load

As you see in the table, according to bandwidth, this is not a notable delay and cannot be the reason for dramatic slow-down and disconnection in systems. Not much delay was noticed in HTTP protocol and there is no problem in it. Then, scenarios of users' access with 5-unit increase in each partner company were stimulated to evaluate links' tolerance state. In the state of level of use of the network resources, following results were yielded (table 15).

Table-15
Results of the state of level of use of the network resources

	25	20	15	10	5	**No back load**
Isfahan	-0 0.17	-0 0.14	-0 0.12	-0 0.07	-0 0.3	0.7-0
Kerman	-0 0.18	-0 0.17	-0 0.12	-0 0.06	-0 0.3	0.7-0
Shiraz	-0 0.15	-0 0.15	-0 0.14	-0 0.15	-0 0.3	0.7-0
Tehran	-0 0.23	-0 0.15	-0 0.12	0.8-0	-0 0.3	0.1-0
Rafsanjan	-0 0.23	-0 0.17	-0 0.11	-0 0.11	-0 0.3	0.7-0

This table shows that all of the partner companies could use the network without any connection. What is clear so far is that allocated resources to partners and links include enough facilities and these resources do not cause instability in communication and having this state, normally no changes should happen in starting connection and possesses inexpensive communication and enough bandwidth. What remains is bandwidth dividing method in user companies. It was made clear that the user companies, on the average, used the bandwidth for straight 5 out of 8 work hours and the full bandwidth was used. So the user companies are having a major problem managing bandwidth which causes dramatic increase in slow-down. What is known as disconnection for companies is Ethernet failure in companies themselves or Copper Industries. The research demonstrated that none of companies' slow-down problem was not due to under-supply of equipment but misallocation of bandwidth. Suggestions are as follows:

i. Using proper typology in network design: based on gained output, using the proper typology in network design will lead to increase in information sharing speed and decrease in delay. ii. Using powerful hardware: as the servers and network equipment get more powerful, system efficiency will certainly increase. iii. The researcher's main suggestion is that using network management network in Internet line input and bandwidth management will prevent from non-business use. Special accesses should be allowed to users and with prioritization and creation of queue, the information related to Copper Industries transmitted first. Users should not be allowed exceeding consumption limit and bandwidth should not be occupied. iv. Using 2 Internet lines: National Iranian Copper Industries Co. should use at least 2 Internet lines and utilize network equipment to manage these lines in a way that once disconnection has occurred in one of the lines, the other line is replaced and at the time of reconnection, Internet use is divided between these two lines. So except for nation-wide disconnections, communication will go unfailingly.

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