An Intelligent Advisory System For Optimal Choice To Build Local Area Networks

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***Abstract*—This paper presents anadvisory system to assist in the optimum choice ofLAN networks suitable for University campus. The system is based on:**
The formulation of the optimal choice of LAN configuration problem.These problems are divided into linear optimization and non-linear optimization based in the linearity and nonlinearity constraints and objective cost function and system constraint.LinearPrograms (LP) is used for the solution of the linear optimization problem. Genetic Algorithm (GA)can be used for solvingthe non-linear optimization problem.Sensitivity analysis of the optimization solutions are saved in database. Machine Learning (ML) algorithm (decisiontree) is used to extract knowledge from the database.Finally the extracted knowledge a long side with human expert knowledge are used in developing the advisory system. The output of this system is divided into figures and table.

Keywords -LAN, advisory systems, genetic algorithm, linear programming, machine learning,decision tree and knowledge acquisition.

I. INTRODUCTION

Computer network is a collection of computers, which are in some way connected such that they can exchange data between themselves and other computers on the network [1].

Network design (ND) is one of the most important and most frequently encountered classes of optimization problem [2]. It is used extensively in practice in an ever expanding spectrum of applications. Network optimization problem needs careful attention for the objective and constraint formulation[3]. The choice of network optimization problem solution depends mainly on the linearity and non-linearity of the problem objective and constraints [4].

LP or GA has suitable role for the network optimization problem solution [5].GA are a particular class of Evolutionary Algorithms (EA) that use techniques inspired by evolutionary biology such as inheritance, mutation, selection, and crossover[6].

The solution is obtained by executing the program so formed [7]. Tree based representation of a program is a very common representation of individuals of genetic programming [8].

Expert systems, often referred to as knowledge based systems.They allow us to express design knowledge in terms that both humans and computers can do something with[9].

Advisory systems provide the advices and assist for solving problems that are normally solved by human experts. They can be classified as a type of expert systems [10,11].Advisory systems support decisions that can be classified as either intelligent or unstructured, and are characterized by novelty, complexity, and open-endedness [12].

Humans can read and improve the expert knowledge, while computers can aid in exercising and applying it, achieving (at least partially) the results that humanexperts do[13]. The decision-making process that occurs when users utilize advisory systems is similar to that which is used for the judge-advisor model developed in the organizational behavior[14].Knowledge engineer commonly carries out acquisitionof the relevant knowledge and expertise [15, 16]. Extracting knowledge from the expert and representing it in a knowledge base using a proper conceptualization, however cannot take place without first overcoming some obstacles [17]. In this paper, a generalized network design problems is focused in the form of a large scale backbone network which belongs to the family of network problem hard combinatorial optimization problem.The purpose of the backbone is to connect regional distribution networks and, in some instances, to provide connectivity to other peer networks [18].The primary objective of this research work is to develop a robust method based on linear programing or genetic algorithm to solve network design problem with minimum cost subject to a reliability constraint which meets the customer requirement. This paper used the concept of knowledge acquisition in the context of experts system by advisory system [19].

The advisory system is problem-solving packages that mimic a human expert in a special area [13, 20]. These systems are constructed by eliciting knowledge from human experts and coding it into a form that can be used by a computer in the evaluation of alternative solutions to problems within that domain of expertise [21]. Advisory systems do not make decisions but rather help guide the decision maker in the decision-making process, while leaving the final decision-making authority up to the human user [22].Information systems for networks of small and inexpensive sensors attached to computationalnodes in distributed networks will in

the future be required for applications where the focus is to assess information about different ground based targets in motion [23].

This paper presents an intelligent advisory system that helps network designers to get figures and tabulated decision about the desired network installation.

The paper is organized as follows.

Section 2 deals with LAN configuration.

Section 3 deals with knowledge acquisition.

Section 4 presents the advisory system.

II. CONFIGURATIONSOFLANS

Configuration for local networks depends on several factors, including:

- Strong performance.
- Stability for the largest possible time working hours.
- Component quality.
- Speed the flow of data.
- Provide data security.
- The possibility of expansion.
- Economy in price.

But this requires the amounts and financial possibilities must therefore choose the most appropriate to achieve the goal, where the network to provide the necessary requirements for the construction of the network and achieve their goal.

The next section presents the network optimization problem formulation.

A. Linear problemformulation

The objective of getting an optimum network components can be stated as follows.

$$\text{Minimize} Z = C_i X_i + b_j S_j + L_k MP_k \quad (1)$$

The network constraints can be written as follows.

$$X_i <= N_i \quad (2)$$

$$S_j = N_j \quad (3)$$

$$MP_k <= N_k \quad (4)$$

Where

X_I The $_i^{th}$ type of hardware (computers, routers, switches, cables, connectors and printers).

S_j The $_j^{th}$ type of software required.

MP_k The $_k^{th}$ Manpower required.

C_i The $_i^{th}$ per unit cost of hardware.

b_j The $_j^{th}$ per unit cost of software.

L_k The $_k^{th}$ cost of manpower.

N_i, N_j, N_k The hardware, software and manpower numbers respectively.

Since the objective function is linear then LP is used for the solution of the problem.

B. Non-linear problemformulation

The cost of network components can be non-linear consequently the objective cost function can be restated as follows.

$$\text{Minimize} \quad Z = C_i (X_i)^2 + b_j S_j + L_k MP_k \quad (5)$$

The imposed system constraints are the same. The final optimization problem is a non-linear one so GA is used for its solution.

III. SENSITIVITY ANALYSIS

As a result of the change in prices as well as the change in the specifications and techniques, it requires access to optimal design of the network. Once it had made some changes to the prices many items had to be done. Based on that edges over tables are obtained as a result of the introduction of prices.

IV. KNOWLEDGE ACQUISITION

In order to build the intelligent advisory system that can help decision maker to establish an optimum network configuration includes two types:

Type 1 Machine learning for knowledge acquisition (decision tree), this type pass through following steps:

1. Solution of optimum network configuration.
2. Getting dataset that contains different optimum solutions.
3. Determining the main goal (minimum cost).
4. Using decision tree to extract rules (according to the minimum goal).
5. Rule refining.

Type 2 Domain knowledge (human expertise in network configuration)

In this part the domain expert experience his/her knowledge is included in the knowledge base:

Sample of the domain knowledge is shown as follows:

If permissible budget = 25000.00$ then
Hardware Components:
Computers=20,
Routers=1,
Switches=2,
Cables=70m
Software Required:
Servers=1,
Clients=2,
Management Programs=2

Manpower Required:
Engineer=1,
Technician=1
End

If permissible budget = 100000.00$ then

Hardware Components:
Computers=50,
Routers=2,
Switches=5,
Cables=100m
Software Required:
Servers=1,
Clients=4,
Management Programs=2
Manpower Required:
Engineer=1,
Technician=2
End

If permissible budget = 500000.00$ then

Hardware Components:
Computers=215,
Routers=5,
Switches=10,
Cables=70m
Software Required:
Servers=2,
Clients=15,
Management Programs=18]
Manpower Required:
Engineer=2,
Technician=5
End

V. ADVISORY SYSTEM

The acquired knowledge is included in the proposed system. Part of GUI is shown in figure 1. It is divided into two parts the IF part and the THEN part.The if part gets the user input data. The THEN Part presents while the output decisions.

VI. APPLICATIONS AND RESULTS

The applications presented her is divided into 3 parts. The first application deals with optimum decisions of the network optimization. The second application is concerned with the proposed system advices. The configuration of the proposed LAN is the third application.

A. Optimum network configuration

The optimum configurations of network design is obtained via the solutions of the linear programming.According to the input data, and output results are shown in follow tables:

Table 1 shows the input costs.

TABLE 1 INPUTS FOR LINEAR PROGRAM (COSTS)

Input data									
Case	Per unit costs of hardware				Per unit costs of soft ware			Per unit costs of man power	
	C_1	C_2	C_3	C_4	b_1	b_2	b_3	L_1	L_2
1	1000	250	100	1	500	300	250	1000	500
2	1200	270	130	1	600	300	250	1000	500
3	1500	270	150	1.5	700	400	250	1000	700
4	1700	300	150	1.5	750	400	250	1000	700
5	1800	320	170	1.5	750	450	250	1000	700
6	2000	300	170	1.5	750	400	250	1000	800
7	2200	320	175	2	800	450	300	1000	850
8	2400	350	220	1	800	500	300	1000	850
9	2500	350	250	2	800	500	300	1000	900

Table 2 shows the system constraints.

TABLE 2 INPUTS FOR LINEAR PROGRAM (COUNT OF UNIT)

Input data										
Case	Bounds	Hardware limits				Software limits			Manpower limits	
		X_1	X_2	X_3	X_4	S_1	S_2	S_3	MP_1	MP_2
1	Lo	10	1	1	25	1	1	1	1	2
	UP	20	2	2	75	1	2	2	2	2
2	Lo	25	1	2	50	1	2	2	1	1
	UP	40	2	3	100	2	3	3	2	2
3	Lo	45	1	3	80	1	4	2	1	2
	UP	60	3	5	150	2	6	3	2	3
4	Lo	65	2	4	120	1	7	5	1	2
	UP	90	4	7	200	2	10	10	2	4
5	Lo	100	3	5	200	1	10	10	1	3
	UP	130	5	8	280	2	15	15	2	5
6	Lo	135	3	7	290	1	10	10	1	3
	UP	180	6	9	400	2	15	15	2	5
7	Lo	190	5	8	450	2	10	10	2	3
	UP	220	7	10	500	3	20	20	4	6
8	Lo	230	6	10	550	2	10	10	2	4
	UP	260	8	12	600	3	20	20	4	6
9	Lo	270	8	12	650	2	15	20	2	4
	UP	300	10	15	800	3	30	40	4	6

Where Lo is the lower value.

Up is the upper value.

Table 3 shows the optimum decisions.

TABLE 3 OUTPUTS BY LINEAR PROGRAM

Output decision values									Minimum Total Cost
Hardware				Software			manpower		
X_1	X_2	X_3	X_4	S_1	S_2	S_3	MP_1	MP_2	
18	1	1	57	1	2	2	1	1	22391.00
26	1	3	82	1	2	2	1	1	45930.00
49	2	5	89	1	4	2	1	2	83161.00
86	3	6	136	1	8	10	1	3	158358.00
120	3	6	250	1	10	10	1	3	232119.00
144	4	8	386	1	13	11	2	4	304071.00
197	5	9	499	2	14	17	2	5	458744.00
232	7	11	562	2	15	20	2	5	582783.00
272	9	15	731	3	23	30	3	5	717917.00

B. The proposed system advices

The system has been tested and judged by on more than one expert their recommendations wereadjustments.It appeared that the system was greatly beneficial, and the results were favorable by 90%.

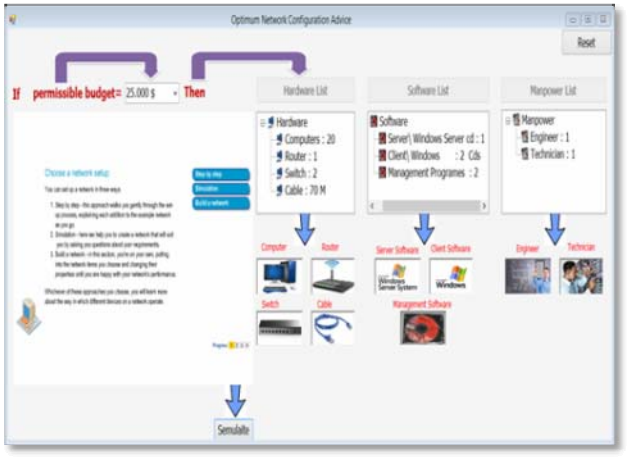

Figure 1. Optimum network configuration advices

Figure 1 shows the advice tree for hardware, software and the manpower required according to the proposed budget.

A tabulated report for the optimum decisions is show in table 4.

TABLE 4 SAMPLE OF OPTIMUM NETWORK CONFIGURATION ADVICE

Case	Permissible budget	Hardware				Software			Manpower	
		Computers	Routers	Switches	Cables (m)	Server	Clients	Manage	Engineer	Technician
1	25000	20	1	2	70	1	2	2	1	1
2	100000	50	2	5	100	1	4	2	1	2
3	250000	125	3	6	250	1	10	10	1	3
4	500000	215	5	10	495	2	15	18	2	5
5	700000	260	7	11	570	3	20	25	3	5
6	800000	280	9	18	750	3	23	30	3	5

C. Network configuration advices

The network topology may different according to the LAN size. This needs the human expert to change some of hardware. This topology can be depicted as shown in figure 2, 3 and 4.

In the case of a small (10 computers) configuration of LANs can be depicted as shown in figure 2.

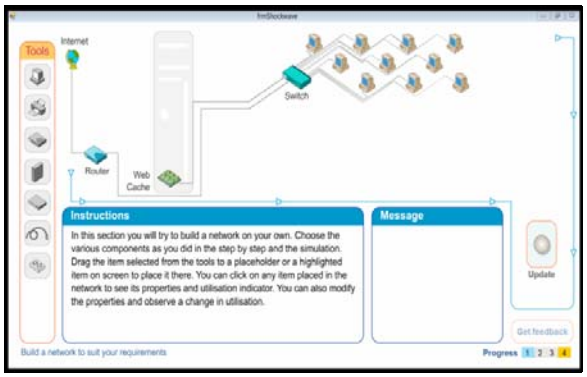

Figure 2. Small network(connect 10 computers)

In case of medium (20 to 30 computers) configuration of LANs can be depicted as shown in figure 3.

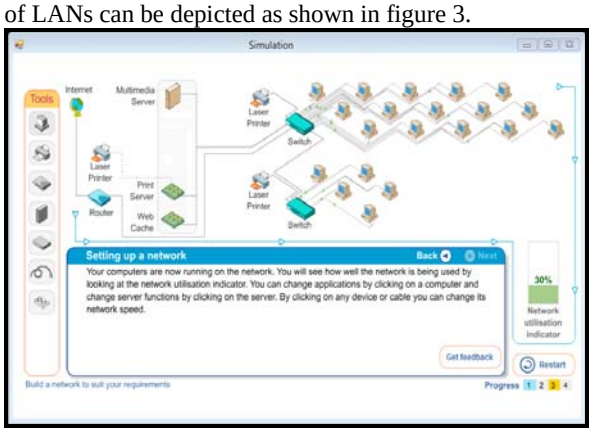

Figure 3. Medium network (connect 20 to 30 computers)

In case of large (up to 30 computer) configuration of LANs can be depicted as shown in figure 3.

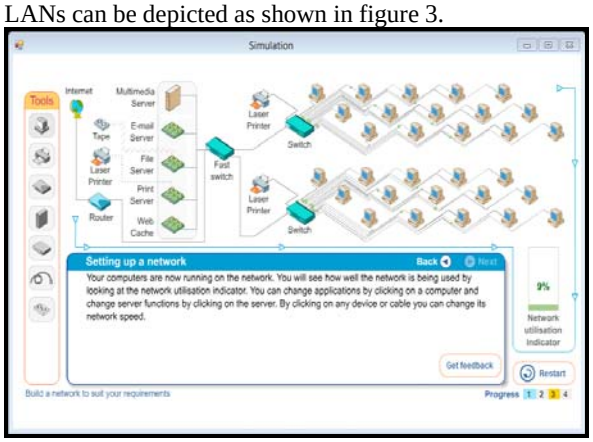

Figure 4. Large network (connect up to 30 computer)

VII. CONCLUSION

This paper presents:

- The problem formulation for optimum configuration of LAN.
- This formulation is either linear optimization problem or non-linear optimization one.
- Linear programming is used for the solution of linear one.
- A sensitivity analysis for the optimum solution is presented.
- Dataset is obtained for these optimum solutions.
- Decision tree is used to extract useful knowledge for optimum dataset.
- Both machine learning extracted knowledge and human expert are included in an advisory system.
- The advices are presented in GUI and in tables.
- These can facilitate the selection of the network components (hardware, software) and the manpower.

REFRENCES

[1] ANDREW S. TANENBAUM , DAVID J. WETHERALL.," Computer networks fifth edition" Vrije Universities Amsterdam The Netherlands, University of Washington,2011,PP.3-14.

[2] Kartik Pandya," Network Structure or Topology", International Journal of Advance Research in Computer Science and Management Studies,Vol 1, No.2,2013,PP. 2-5.

[3] Anand Kumar and N. N. Jani, " NETWORK DESIGN USING GENETIC ALGORITHM", For the award of the degree of Doctor of Philosophy in Computer Science, In Saurashtra University Rajkot , India , Registration,Vol 10, No. 3893, Date of Access 2010, PP. 77.

[4] Huynh Thi Thanh Binh and Ha Dinh Ly" Genetic Algorithm for Solving Multilayer Survivable Optical Network Design Problem", presented at International Network Optimization Conference (INOC), Spa, Belgium, April 2012,PP.22-25,.

[5] P. MARCOTTE ," NETWORK DESIGN ROBLEM WITH CONGESTION EFFECTS: A CASE OF BILEVEL PROGRAMMING", Mathematical Programming vol 34, 1986, PP.142-162.

[6]Xiang Zhang, David Rey, and S. Travis Waller," Bi-Level Program of Transportation Network Design Problem Accounting for Equity and Exact Solution Methodology ",*Journalof Traffic and Logistics Engineering Vol. 3, No. 2, December 2015*

[7]Srinivas Shakkottai and R. Srikant," Network optimization and Control",Texas A&M University, USA, Vol. 2, No. 3,2007, PP.271–379.

[8]Benjamin Doerr, Anton Eremeev, Frank Neumann, Madeleine Theile and Christian Thyssen,"Evolutionary algorithms and dynamic programming" , Theoretical Computer Science,vol 412 ,PP.6020–6035.

[9]Mauriaio Bielli,Massimoliano Caramia and Pasquale Carotenuto,"Genetic algorithm in bus network optimization", Transportation research part c 10, 2011 , PP.19-34.

[10]Rahul Kala," Multi-robot path planning using co-evolutionary genetic programming", School of Cybernetics, School of Systems Engineering, University of Reading, Whiteknights, Reading, Berkshire, UK ,Expert Systems with Applications 39 2012 ,PP.3817–3831.

[11] Ang Wang, Mahdi Mahfouf , Gary H. Mills, G. Panoutsos, D.A. Linkens,K. Goode, Hoi-Fei Kwok and Mouloud Denaï "Intelligent model-based advisory system for the management of ventilated intensive care patients.Part II: Advisory system design and evaluation",computer methods and programs in biomedicine 9 9, 2 0 1 0 ,PP. 208–217.

[12] Abdullah Al-Yami, Jerome Schubert and Vikrant Wagle," Development of an Advisory System

Based on Bayesian Network to Minimize Corrosion Problems in Underbalanced Drilling ",International Journal of Advancements in Research & Technology, Volume 3, Issue 7, July-2014 ,PP.23-27.

[13] A. E. E. ElAlfi and M. E. ElAlami," Intelligent Advisory System for Supporting University Managers in Law", (IJCSIS) International Journal of Computer Science and Information Security,Vol. 3, No. 1, 2009,PP.1-3.

[14] GUNNAR JOHANNSENt and JAMES L. ALTY," Knowledge Engineering for Industrial Expert", International Federation of Automatic Control, Vol. 27, No. 1,1991, PP. 97-114.

[15] Gia Sirbiladze, Irina Khutsishvili and Bezhan Ghvaberidze,"Multistage decision-making fuzzy methodology for optimal investmentsbased on experts' evaluations", European Journal of Operational Research 232, 2014 ,PP.169–177.

[16] Nattapong Kaewboonmaa, Kulthida Tuamsukb, and Wanida Kanarkardc," Knowledge Acquisition for the Design of Flood Management Information System: Chi River Basin, Thailand", Procedia - Social and Behavioral Sciences 73, 2013 ,PP.109 – 114.

[17]Rafal Bogacz," Optimaldecisionnetworkwithdistributedrepresentation", Neural Networks 20 ,2007 PP.564–576.

[18]Bernadia Irawati Tjandradewi and Peter J. Marcotullio ,"City-to-city networks: Asian perspectives on key elements and areas for success", Habitat International 33,(2009,PP. 165–172.

[19] Philip R.O. Payne a, Eneida A. Mendonc, Stephen B. Johnson b and Justin B. Starren ,"Conceptual knowledge acquisition in biomedicine: A methodological review", Journal of Biomedical Informatics 40,2007,PP. 582–602.

[20] Novruz Allahverdi,''Development a new mutation operator to solve the Traveling Salesman Problem by aid of genetic algorithms" , by Murat Albayrak and Novruz Allahverdi, Expert System with Applications, 38; vol 3,2015, PP. 1313–1320.

[21]Mandeep Kaur, Upasna Garg and Vinod Singla," An Implementation of Expert System For Registration of Events", Journal of Engineering, Computers & Applied Sciences (JEC&AS) ISSN No: 2319-5606 ,Vol 2, No.3 , March 2013.

[22] Brandon A. Beemer and Dawn G. Gregg, "Advisory Systems to Support Decision Making",Business School, University of Colorado, Denver, CO, USA,2007,PP. 1-17.

[23]Mathieu D'aquin,Jean Lieber and Amedeo Napoli, "Adaptaion knowledge acquisition : a case study for case – based decision support in oncology "",Computational Intelligence 22, 3/4 (2006) 161—176.

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