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A Novel Expert System for PC Network Troubleshooting and Maintenance

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***Abstract*:** In today's world where information is knowledge and time is money, faster flow of information is the basic need of every organization. Hence, downtime of network can be a serious threat to win crucial competitions. Apparently most of the computer users are "layman" when it comes to troubleshooting and diagnosing network related problems. This situation requires the need of an expert system or network engineer to solve the respected issue and get the work back on track. However a faster and cost-effective solution can be deployment of an expert system for the same. This will not only omit the need of professional individual but will also enable PC users to handle these small yet significant issues on their own. Implementation of this expert system will reduce the downtime of a person and improve his/ her efficiency resulting in better production and increased turnover of the organization. On the other hand, this expert system may also be used by PC users and home or small and medium scale enterprises. An expert system named "Network Expert System (NES)" is proposed in this paper to assist and advice new technician and novice users to diagnose and troubleshoot computer network issues in MS-Window based Personal Computers.

Keywords: NES, Expert System, Artificial Intelligence, Knowledge Base, Rule-based reasoning.

I. INTRODUCTION

The modern world is the era of changing technologies, shorter product life cycles and increased system complexity and it demands the need of intelligent tools to be integrated as part of software product life cycles[3]. This change also requires the automated fault diagnosis tools for handling crucial predicament for increasing competence. Over the last two decades, automated fault diagnosis has been a major research topic but not much progress has been done in cost-sensitive areas. Fault diagnosing involves localizing the source of problem, finding the exact case when it happens and then resolving

It by using a rule-based approach[4][8]. At a time, when companies are downsizing, cutting support services, limiting budgets and resources, and expecting more with less, small PC based expert systems have become popular. These tools result in more cost saving, increasing productivity and building a knowledge base to help the trainees for future needs.

An expert system is a special field of Artificial Intelligence which will fill the shoes of a human expert without his presence. An expert system is software that attempts to provide an answer to a problem, or clarify uncertainties where normally one or more human experts would need to be consulted[1]. To do so, it simulates the human reasoning process by applying specific knowledge and interfaces. Expert systems also use human knowledge to solve problems that normally would require human intelligence. Usually, Expert systems are used as intelligent assistants or advisors helping the user to increase productivity by taking over the routine procedures and making confident assertions, thus liberating the user to work on more strategic tasks[9]. This basic functionality of expert system can be extended to real-time applications like network management. In network diagnosis and troubleshooting, the diagnostic task is approached by qualitative consideration and compiled form of knowledge. In this paper we have proposed a new Expert System for troubleshooting and maintaining computer network issues named: Network Expert System (NES).

II. DEVELOPMENT OF EXPERT SYSTEM

Designing and development of expert system proposed here is based on the basic idea of identifying the commonly occurring problems in computer networks, finding the real cause and then cure of that problem. This expert system will also try to discover the unusual happening tribulations which may cause chaotic situation. The Network Expert System will also build a log table for such rarely and critical setbacks. The several footsteps involved in designing and developing cycle of NES are listed as the following:

A. Localizing the issue.
B. Knowledge acquisition and documentation.
C. NES development & Refinement.
D. Maintenance and updation.

A. Localizing the Issue

The basic necessitate for development of such system is that a knowledge engineer should think like a network engineer[7]. He should be able to understand basic functionality of computer network hardware like Network Interface Card (NIC), wireless adapter, network cables, etc. He should be familiar be with the industry wide standards such as color coding schemes of twisted-pair cable. With this basic awareness of network devices, the knowledge engineer will be able to get familiar with the kind of issues that can be aroused in a computer network. Another important consideration to be taken care of is the type of connection between devices- it can be either wired or wireless network. Both need to be treated differently as each connection uses different sort of central server and connectors. Better acquaintance with networking hardware will better help to what is known as "localizing the issue". It means that the expert system will be able to find where exactly is the quandary which needs to be resolved. Thus the expert system can concentrate only on problematic part, and the effort and time to examine whole network can be saved. This is the foremost and primary need for the Network Expert System.

B. Knowledge acquisition and documentation

Expert system development engages obtaining, evaluating and interpreting the knowledge that human experts use when dealing with troubles. This is the principal step in expert system making and also the most intricate one, which may even cause bottleneck in its development cycle. Knowledge acquisition can be done broadly in two ways: Manual and Automatic (further divided into half and full)[1][5]. In NES, the manual mode is selected for knowledge gain and this is done primarily by subject-matter experts, journals, books and databases. Because experience and expert knowledge is the most vital thing, hence three subject-matter experts are chosen for the NES and the knowledge extraction modes used are interview, case-studies and video recordings[10]. Apart from network devices related data, another noteworthy data needs to be stored i.e. Non-device-data which includes the reliability failure report history, component maintenance manual troubleshooting sections, lab technician notebooks, historical data, pilot reports, and experience. The chief contemplation in knowledge gathering is the correct interpretation of knowledge experts as different subject matter experts may express same thing in dissimilar manner, hence every piece of information accumulated should be in same format[6]. A wrong interpretation may seem too hazardous earlier but may prove fatal at the end of development cycle.

When the required facts and figures are collected from all knowledge sources, there is the need of documentation and knowledge storage. The biggest benefit of knowledge documentation is that divide-and-conquer strategy can be used to partition domain information into small manageable pieces. Complex problems are easier to solve if partitioned into decomposable parts and strategically spaced in time[4][9].

The job does not finish after knowledge acquisition and documentation. Defining which device data to use, when to use it, and how to isolate problems based on this data was the first effort toward defining what the networking expert system must look like. Using the data must include reasoning about which data would be used, when the data should be used, whether the data could be trusted as good data, and how many times to read a particular type of data before going on to another approach.

C. NES development & Refinement

Network Expert System (NES) development actually takes place in three phases: Rules formation, Organization of Heuristics and Rapid Prototype Development.

NES is a rules-based diagnostic system which represents the experience of skilled diagnosticians in the form of rules which generally take the form "IF symptom(s) THEN fault(s)." Representing the knowledge for a particular problem domain, may require hundreds, or even thousands of rules. Rule-based inference involves taking information about the problem domain, and invoking rules which match this information. This generates new data which is added to the problem information. This process is repeated iteratively until a solution to the problem is found[11]. Thus NES includes rule-based approach that generates a list of symptoms for each malfunction parts in a computer network.

IF:	**NETWORK CABLE STATUS # CONNECTED AND CONNECTOR LED STATUS# NO LIGHT**
THEN:	**NETWORK PROBLEM = IP ADDRESS NOT SET OR IP ADDRESS CONFLICT**

Figure 1: An example of rules in NES

After the rules are defined and stored in Knowledge Base, there is a need of Inference Engine (IE), which acts as the rule interpreter. IE is definitely the brain of NES which provides a methodology for searching the rule base and finding an appropriate solution for the specific problem. Inference Engine endows with instructions on how to use the system's knowledge by developing the program that organizes and controls the steps taken to solve problem whenever consultation is executed. Here forward chaining with depthfirst modus operandi is used because of its competency with data orientation and diagnostic nature. A depthfirst search starts from the root node (broader picture of problem) and digs deep to successively deeper levels until it reaches the exact network problem[2].

After the Knowledge Base creation and deployment of Inference Engine, a rapid prototype needs to be developed. A prototype is a small working model of the full software that is developed in phases, where every phase adds value to the system. This incremental model is better because its pros and cons will be known well in advance, and shortcomings can be eliminated as soon as possible[3]. The knowledge elicited from the source is immediately implemented in the prototype expert system. The system is then evaluated. After the evaluation the elicitation process starts again, completing the circle. Thus missing knowledge and misinterpreted rules can be known and gives more chance of subject-matter experts to get more involved in the project. Prototype model can be extended to the end users of the expert system letting potential users work through problems with the prototype software, critique it, and help to refine it[7]. This sequence led to several major redesigns in our concept of the

prototype's capability; these changes reflected actual field needs rather than engineering perceptions of the field. The final prototype allowed us to realistically simulate failed device data and emulate the troubleshooting process.

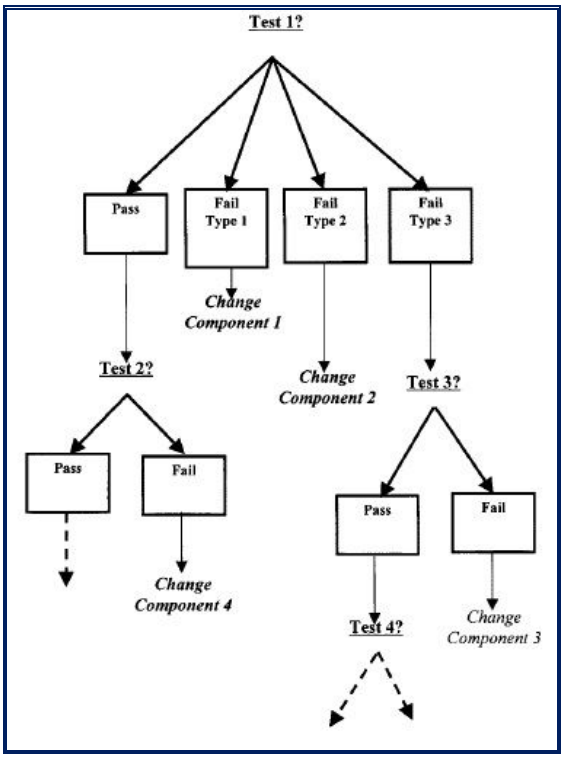

Figure 2: An example of Depthfirst Diagnosis

D. Maintenance and updation

This is the last step in Expert system development is the maintenance and updation. Maintaining and updating it at regular intervals is very imperative for the potential success of the system. This step also adds value to the NES by updating the expert system's knowledge base. This phase also entails making a note of end user suggestions and complaints, and then eradicating them off the expert system. Feedback of end user is most important for this stage.

III. IMPLEMENTATION OF EXPERT SYSTEM

Network Expert System (NES) developed is successfully tested on IBM PC 1.66 GHz processor on Windows 7 (32-bit Operating System). The following diagrams show the performance of NES in real-time operation:

IV. LANGUAGES SUITABLE FOR SES

This expert system has been implemented in .Net Framework with C sharp programming language. It can be deployed in any language that supports Unicode system.

V. CONCLUSION

In this paper a new Network Expert System (NES) has been proposed which deals with computer network troubleshooting. Experiments have shown that NES is fully capable of handling all network related problems whether wired or wireless accurately. It has been observed that NES is a proficient expert system which uses systematic methodology to dig out broad spectrum of network predicament into a narrow domain which actually identifies the real issue. The NES is not only bright for handling network hardware matters but also the network software quandaries. Another plus point of NES is that it can also be utilized to train new technicians and computer users to diagnose and troubleshoot PCs without any expert help. NES is reliable, portable and adaptable for future needs. It also provides prospect of modifying the knowledge base from time to time for future hardware and software variations. Finally can be concluded that Network Expert System(NES) is build with keeping in mind the future requisites and provides an excellent solution for Computer Network troubleshooting and maintenance.

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