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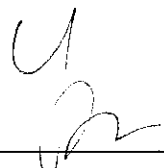
Computer Hardware Troubleshooting System
Using Expert System Shell

By

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(Yong Suet Peng)

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1) Expert systems Compute science

2) System design

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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SARAH HARYATI ZULKIFLI

ABSTRACT

The primary objective of this project is to develop a computer troubleshooting system that focuses on hardware problems. This system will be implemented using an expert system shell that is freely available on the Internet. E2gLite Expert System Shell was chosen to be used for this project because of the advantages it gives in terms of ease of use and time saved. It is also flexible and is easily integrated for use on the Internet.

The main objective is to make the system easy to use and understandable by the users. Diagnosing hardware problems can be made easier if done in a systematic manner. This project hopes to give users the ability to gain knowledge and insight on how to diagnose and troubleshoot possible problems in the future.

ACKNOWLEDGEMENTS

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Thanks also to all lecturers who has taught and tutored me over the years here in UTP. Thanks also friends for support through all of it. Last of all, thanks should be given to my parents for believing and having faith in me.

Thank you all.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background of study

Along with the rising birth of technology, the appearance of expert systems also made an impact in the way how humans communicate and work. Expert systems are used to imitate an expert's knowledge in a certain domain. The goal is for the system to be able to make a decision and rationalize it as a person would. These expert systems represent the expertise knowledge as data or rules within the computer. *Expert systems have been used to solve a wide range of problems in domains such as medicine, mathematics, engineering, geology, computer science, business, law, defense and education.* [6]

1.2 Problem Statement

Technology and advancements on the way people work and conduct business and pleasure has lead to the daily use of computers in a normal person's life. This makes computers an indispensable gadget. If and when a computer malfunctions, it can be the source of quite a headache for the owner. Some problems can easily be fixed by beginners with basic knowledge of computers. This can save a lot of money and time for owners of computers. Experience and knowledge is important when diagnosing or troubleshooting a computers' hardware device.

1.3 Objectives

1. To capture the experience and knowledge from experts in this tasks' domain.
2. To represent the knowledge in the form of an expert system that will include explanation facilities and is easily understood by beginning users.

1.4 Scope of study

The scope of the project is the troubleshooting of a computer's faulty hardware components. This project deals and refers to desktop computers in which the hardware is mostly plug-and-play devices and easier for beginners to work with. *Troubleshooting computer hardware is the easiest, but most frustrating, part of the troubleshooting process. It's easy because either the hardware works or doesn't work.* [4]   In dealing with hardware problems, it is difficult to diagnose them since failing computer parts effects may manifest themselves in many ways. *The real trick is to go about it in a systematic matter, eliminating possibilities whenever possible before you start purchasing replacement parts.* [5]

This system diagnoses a computer's faulty hardware components based on the symptoms and effects on the computer. The system will be created using an expert shell in order to reduce time and cost of development.

CHAPTER 2

LITERATURE REVIEW AND THEORY

2.1 History of study

Expert systems are used to solve problems. *Types of problems sometimes involve* diagnosis *(e.g., of a system fault, disease or student error)*[6]. They do this by asking questions and obtaining facts and based on the answers, search through all possible rules and facts to find a solution. Ideally, an expert system should be included with good explanation facilities.

Expert systems have more use nowadays. This has lead to the emergence of various expert shells programs. *Expert shells range in price from hundreds to tens of thousands of dollars, and range in complexity from simple, forward-chained, rule-based systems requiring two days of training to those so complex that only highly trained knowledge engineers can use them to advantage. They range from general-purpose shells to shells custom-tailored to a class of tasks, such as financial planning or real-time process control.*[7]

Expert shells in the public domain are also popular. These programs are designed to be used by users with little programming backgrounds or by the experts themselves. *Using shells generally greatly reduces the cost and time of development (compared with writing the expert system from scratch).* [1]

A frequently used technique for developing an expert system is rule-based programming. *Rules are used to represent "rules of thumb" which specify a set of actions to be performed for a given situation. A rule is composed of an if portion and a*

3

then portion. The if portion of a rule is a series of patterns which specify the facts (or data) which cause the rule to be applicable.

The process of matching facts to patterns is called pattern matching. The expert system tool provides a mechanism, called the inference engine, which automatically matches facts against patterns and determines which rules are applicable. [3]

An important part in the implementation of an expert system is acquiring and representing the knowledge in a systematic way. Knowledge engineers make use of a number of ways of representing knowledge when acquiring knowledge from experts. These are usually referred to as knowledge models. These can consists of diagnostic trees, flowcharts, diagrams, ladders, tables and charts and much more.

2.2 Previous Works

There are several troubleshooting programs or simple expert systems on the market and Internet. Microsoft Windows comes with a troubleshooting guide for its operating system and applications that are bundled up in Windows. The system provides step-by-step instructions in handling these problems by eliminating possibilities whenever possible. The system takes into account answers obtained by the users and also from the use of the Device Manager.

Other sites also offer a troubleshooting guide. However, these forum sites expect the user to have a basic idea of what is the faulty component and troubleshoot it from there. This may be difficult for users without basic experience in detecting what is wrong with a computer. Most of these sites also cater mostly to software problems and are very disorganized and difficult to navigate through.

2.3 E2gLite Expert System Shell

For this project **E2gLite Expert System Shell** [10] is chosen as the software of choice. E2gLite is a Java applet that is embedded in a Web page and downloaded from the Web server by the user's browser. The applet loads a knowledge base from the server and then runs entirely on the browser.

The advantages of this software are:

- **Accessibility.** E2gLite's applet and knowledge bases are files downloaded to the user's browser; therefore expert systems can be delivered from virtually any Web host including the free/very inexpensive hosts often provided to Internet Service Provider (ISP) customers or to students by their educational institutions. These sites often do not allow the use of server-side program execution environments.

- **Ease of use and flexibility.** A Java applet is almost as easy to embed in a Web page as a graphical image, and may be inserted in a cell in an HTML table for integration of expert system capabilities with other content.

There are disadvantages of this software and those include:

- **Startup time.** The e2gLite applet will be downloaded to the browser and download time for the knowledge base takes additional time depending on the size of the file. Once downloaded, the applet will not be reloaded until the browser is reloaded. Because of the startup time issue, e2gLite is mostly appropriate for small-scale expert systems not exceeding 100 rules.

- **Knowledge base design visibility.** An e2gLite knowledge base is a text file read from the Web server by the Java applet and therefore a public document. The design of the knowledge base cannot be kept confidential.

- **Browser compatibility considerations.** When an applet runs in a browser, it uses the Java Virtual Machine (JVM) installed with the browser. All Web pages

5

using applets will fail when accessed with the browser unless the user downloads and installs a JVM. If the potential user's browser is not configured to allow the use of Java applets, e2gLite will not run.

However, this software was chosen for this project because of the time constraint on the project and also because of the ease of use. The database of the system is also visible to users which can be shared as common knowledge and can be improved on by others. E2gLite also gives the flexibility and choice of displaying the system either in "end-user" mode or in "developer" (debug) mode for better comprehension.

Forward chaining or data driven technique will be used here by applying a set of previously determined facts to the rules in a knowledge base to see if any of them are relevant and will fire. The facts are obtained by asking questions to the user.

2.4 Knowledge Models

There are many forms of knowledge models and representations that can be used when designing an expert system. Here, the information gained was simplified by using matrices. **Matrix (aka grid)** or *decision table* is a type of tabular representation that comprises a 2-dimensional grid with filled-in grid cells. One example is a problem-solution matrix that shows the problems that can arise in a particular part of a domain as the rows in the matrix and possible solutions as the columns. Ticks, crosses or comments in the matrix cells indicate which solution is applicable to which problem.[11]

Rule	1	2	3	...
Starter runs?	Y	Y	N	
Smell gas?	Y	N	.	
Dead battery	.	.	X	
Out of gas	.	X	.	
Flooded	X	.	.	

Figure 1: Example of a decision table

6

CHAPTER 3

METHODOLOGY / PROJECT WORK

3.1 Project Development Phases

The development of this system is based on methodology that is adopted from several existing methodologies for different applications as this expert system will be an integration of these technologies.
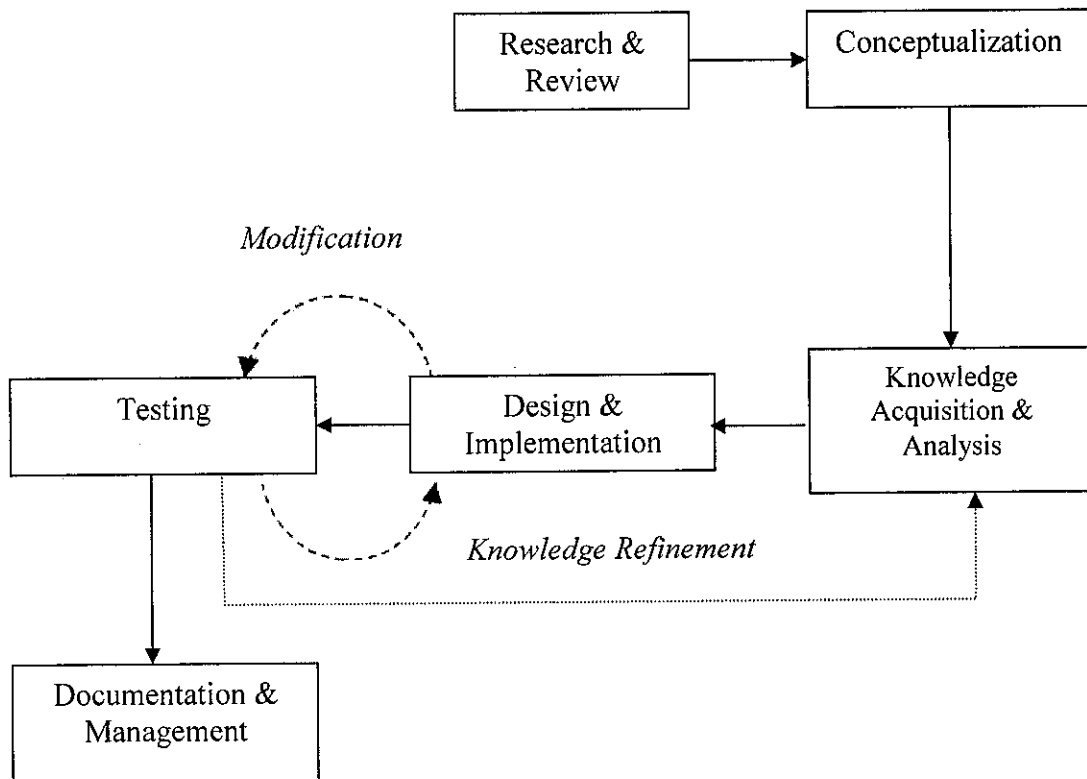
Figure 2: System's Development Methodology

-Research and Review

Research has been done regarding the use of *troubleshooting applications* that are built with expert system shells. Applications available on the internet consist of many different subjects such as medical diagnosis and animal identification systems. Results of researches and reviews conducted help in giving an idea and insight on how to implement an expert system.

-Conceptualization

The idea of building this expert system and the problem domain is determined for this system. Once the problem domain is determined, the title for the system development was set. The technologies that are needed, which includes the hardware and software are then selected for this system.

-Knowledge Acquisition and Analysis

The process of acquiring knowledge in the development of an expert system is very important. That knowledge acquired has to then be analyzed in order to find the connections and meaning between them. That knowledge then can be modeled either by using checklists, flowcharts or decision tables to simplify implementation of the system. For this system, the knowledge was acquired from the Internet, from books regarding the problem domain and also by interviewing and observing the experts and people with working experience related to the problem domain.

-Design and Implementation

After analyzing the information gathered, the structure and design of the system is to be implemented. The selected method for this system is as a forward-chaining rule-based expert system. The product in this phase will be a prototype system which will be refined in later phases.

-Testing

The prototype system is then tested to ensure that it functions accordingly. Testing is also done by target users to ensure the usability of the system. This means the system has to be user-friendly and understood by the users. The main objective of an expert system is to give knowledge that was recently unavailable to the users. Errors are also identified in this phase and corrected.

-Documentation & Management

At the end of the development of any system, it is wise to document aspects of the development process which may come become handy later on in the future as reference for future development.

3.2 System Analysis & Design

For this problem statement, the scope of the project is focused on *hardware problems* and parts for the *desktop PC*. The parts and devices that are included in this troubleshooting system are the motherboard, RAM, hard disk, power supply unit, monitor, video card, and other removable parts. Hardware was the chosen problem scope since hardware parts are easily replaceable and are possible to diagnose in a systematic matter

The development of this troubleshooting system is based on the current popular choice for building an expert system which is a *rule-based expert system*. The popularity of this kind of system's development is due to the large numbers of successful rule-based system built and also the abundance of rule-based expert system software that is available easily.

Knowledge processing in expert system is based on the insight gained from the way how humans reason, how they work with information on a given problem together with their general knowledge of the problem domain. Expert systems model the human reasoning process by using a technique called inference. The *forward-chaining* inference technique is used to build this Computer Hardware Troubleshooting system.

```
                    ┌─────────────────────┐
                    │ Insert information in│
                    │ the working memory   │
                    └─────────────────────┘
                              │
                              ▼
┌──────────────┐    ┌──────────────┐         ┌──────────────┐
│              │    │  Check rule  │◄────────│Check next rule│
│              │    └──────────────┘         └──────────────┘
│              │           │                        ▲
│              │           │                        │ Yes
│              │           ▼                        │
┌──────────────┐   ◇                        ◇
│Add conclusion│Yes│Premises match the│  No  │ Rules remain │
│to working    │◄──│working memory    │─────►│              │
│memory        │   ◇                        ◇
└──────────────┘                                    │
       │                                            │ No
       │          ┌──────────────┐                  ▼
       └─────────►│Display conclusion│         ┌──────────┐
                  │to user         │─────────►│   Stop   │
                  └──────────────┘            └──────────┘
```
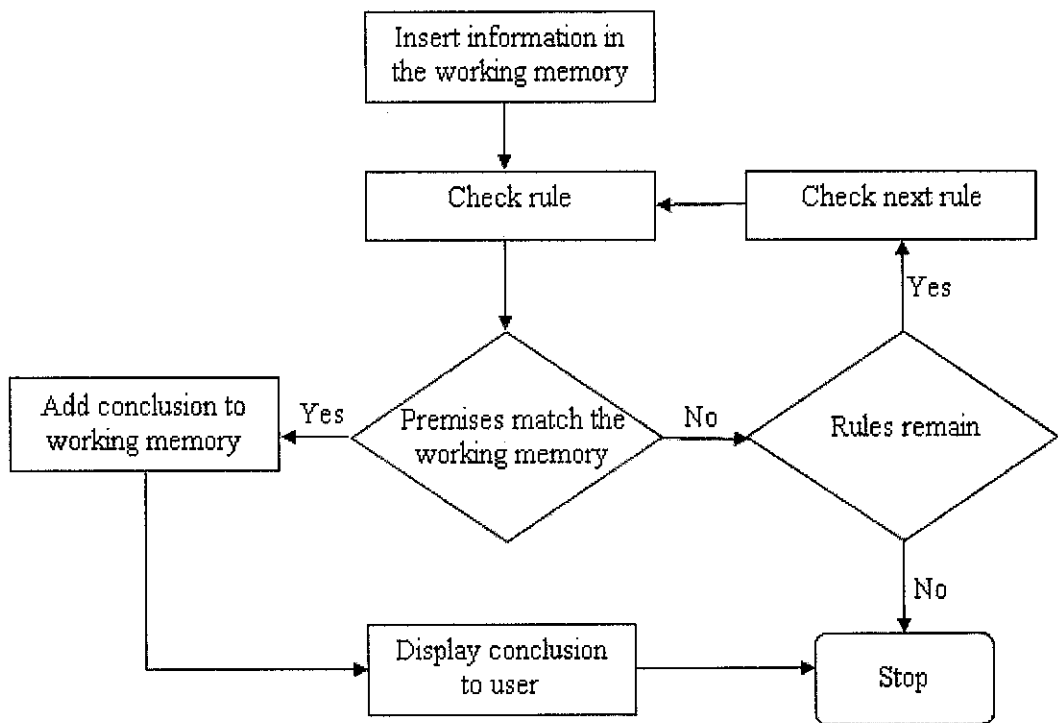
Figure 3: Forward chaining inference process [9]

In researching the appropriate expert system shell to use, e2gLite Free Expert System Shell was chosen. Criteria such as ease of usage (chosen because of the time factor), interesting interface and user-friendliness were taken into account. E2gLite Free Expert System Shell is also a free software system that is widely used on the Internet. It uses Java applets for its interface and Notepad as its knowledge base editor. This makes it easier to update and check the knowledge base. E2gLite Free Expert System Shell also offers a user-friendly system which has an explanation facility that is easy to understand. It also has a debug window that can trace the knowledge base as it being processed which is very useful for the programmer of the system. However, users are needed to download JVM or the Java Virtual Machine Environment first.

An expert system is build based on knowledge acquired from experts in the field. Knowledge acquisition refers to the task of endowing expert systems with knowledge. [7] Based on the devices that is a part of the desktop computer, common and possible problems are listed out. Then, based on information from reading materials such as books and from information on the internet and from experts, symptoms of the problems are then figured out. Some of this information comes in the form of *diagrams and flowcharts* for easy understanding. The information is then drawn into a matrix or decision table for a more structured and organized way of keeping information.

In analyzing flowcharts, certain symptoms and solutions to problems can be identified. These are then simplified into a decision table. One single flow on the flowchart can also be considered one rule.

Decision tables are useful for documenting rules. A decision table consists of a condition stub listing the attributes that may affect a decision and an action stub that lists possible decisions. Rules are written vertically and indicate the values of the condition attributes that will result in a specific decision. A dot in a condition cell means the attribute in that row is not relevant to the rule defined by that column.

Rule	1	2	3	...
boot?	Y	Y	Y	
text?	Y	N	.	
PSU	.	.	X	
monitor	.	X	X	

In implementing the system, the knowledge base is edited using Notepad. The knowledge base is a file that has to be downloaded by the browser. While testing the system, E2gLite gives the flexibility and choice of displaying the system either in "end-user" mode or in "developer" (debug) mode for better comprehension.
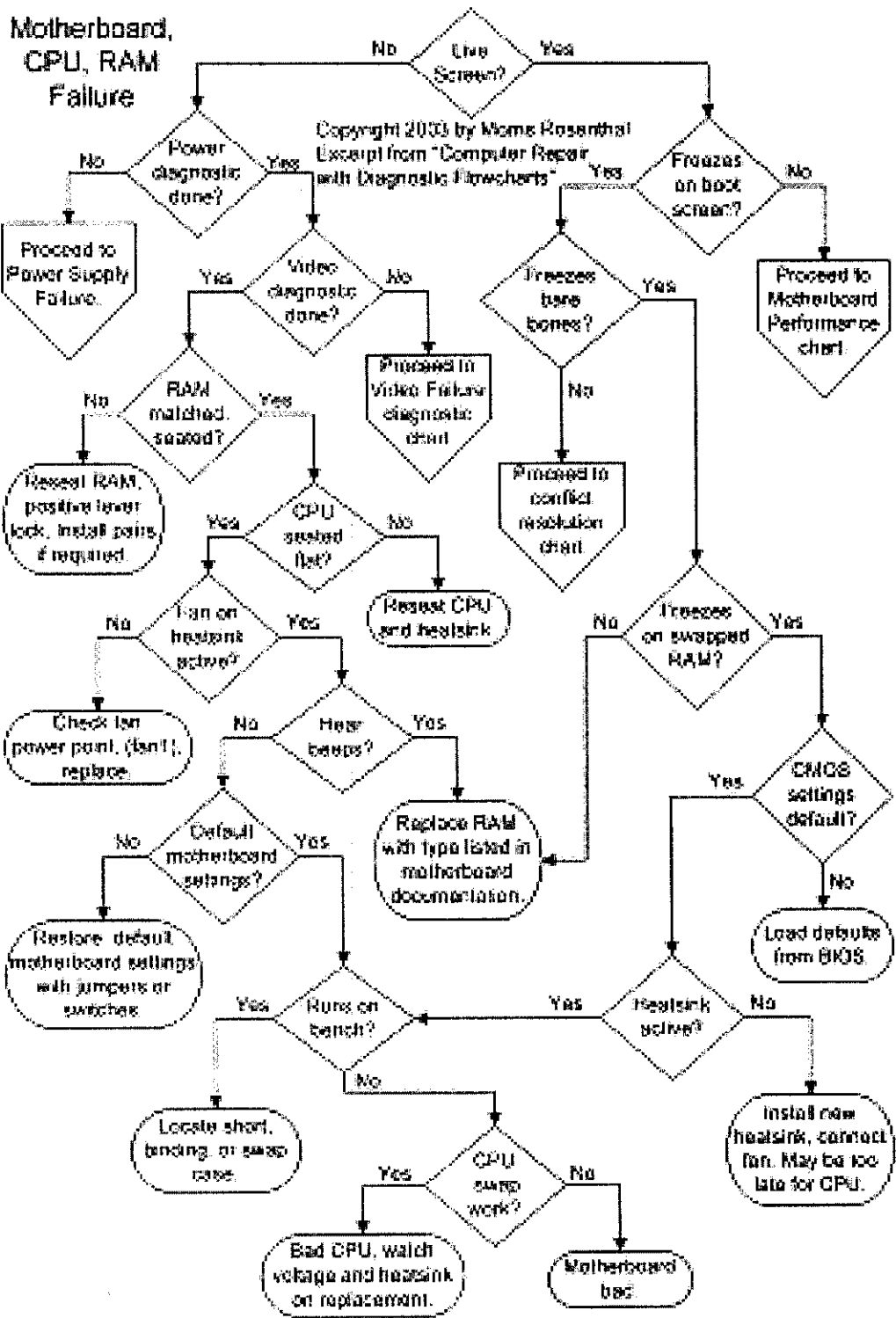
11

Motherboard, CPU, RAM Failure

Copyright 2003 by Morris Rosenthal
Excerpt from "Computer Repair with Diagnostic Flowcharts"

Live Screen? — No / Yes

Power diagnostic done? — No → Proceed to Power Supply Failure. / Yes

Video diagnostic done? — Yes / No → Proceed to Video Failure diagnostic chart

RAM matched, seated? — No → Reseat RAM, positive lever lock, install pairs if required / Yes

CPU seated flat? — Yes / No → Reseat CPU and heatsink

Fan on heatsink active? — No → Check fan power point, fan?, replace. / Yes

Hear beeps? — No / Yes → Replace RAM with type listed in motherboard documentation.

Default motherboard settings? — No → Restore default motherboard settings with jumpers or switches / Yes

Runs on bench? — Yes → Locate short, bending, or swap case. / No

CPU swap work? — Yes → Bad CPU, watch voltage and heatsink on replacement. / No → Motherboard bad

Freezes on boot screen? — Yes / No → Proceed to Motherboard Performance chart

Freezes bare bones? — Yes / No → Proceed to conflict resolution chart

Freezes on swapped RAM? — No / Yes

CMOS settings default? — Yes / No → Load defaults from BIOS

Heatsink active? — Yes / No → Install new heatsink, correct fan. May be too late for CPU.

Figure 4: Example of Computer Diagnostic Flowchart [5]

3.3 Tools Required

Hardware

- Desktop PC

Software

- E2gLite Free Expert System Shell
- Windows or any Operating System
- Internet Explorer or related browsers
- Java Runtime Environment -JVM

   (available at http://www.java.com/en/download/manual.jsp)

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Computer Hardware Troubleshooting System

The true measure of the effectiveness of an expert system is the extent of the knowledge base. For this system, there are 26 rules based on the possible hardware problems that commonly strike the desktop computer.

The system gathers facts from users by asking questions. Then pattern matching is done to figure out a premise or conclusion that can be used. For this system, there is a primary goal which pinpoints the source of the problem to a specific hardware. In some cases, there is an extra solution or step that can be tried to that may solve the problem. There is also an explanation facility that may help the user understand how a conclusion is reached in order to better understand about computers.
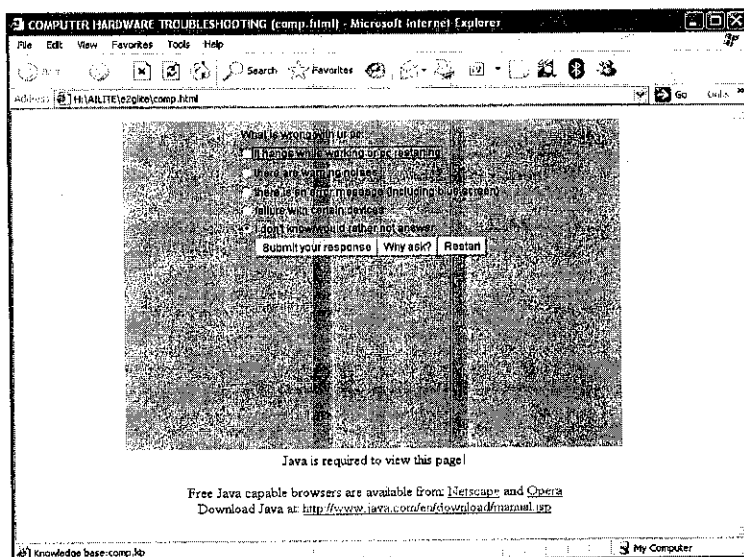
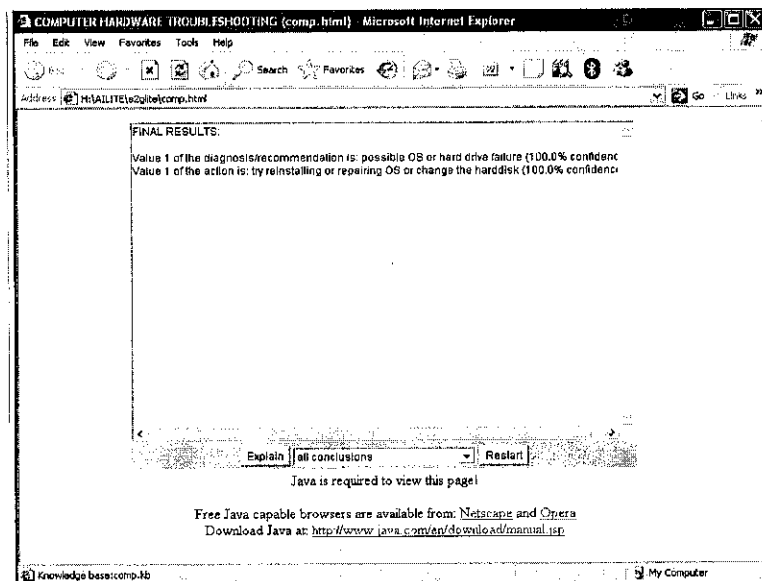Figure 5: Answering questions in order to obtain facts.

Figure 6: Reaching a conclusion or goal.

While implementing the knowledge base, the use of the debug window came in very handy in pinpointing the coding errors. Since the knowledge base is a file downloaded on the browser, it can be accessed and improved on by others.
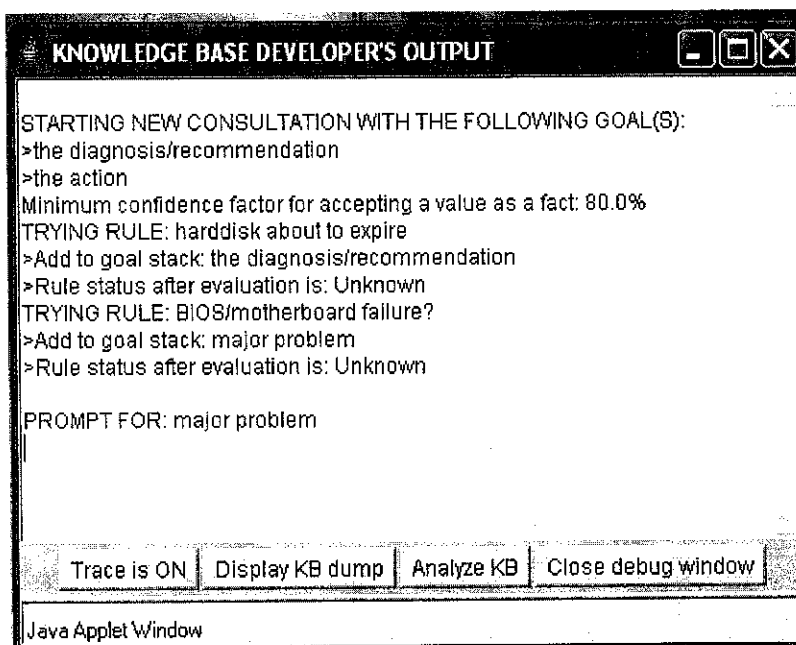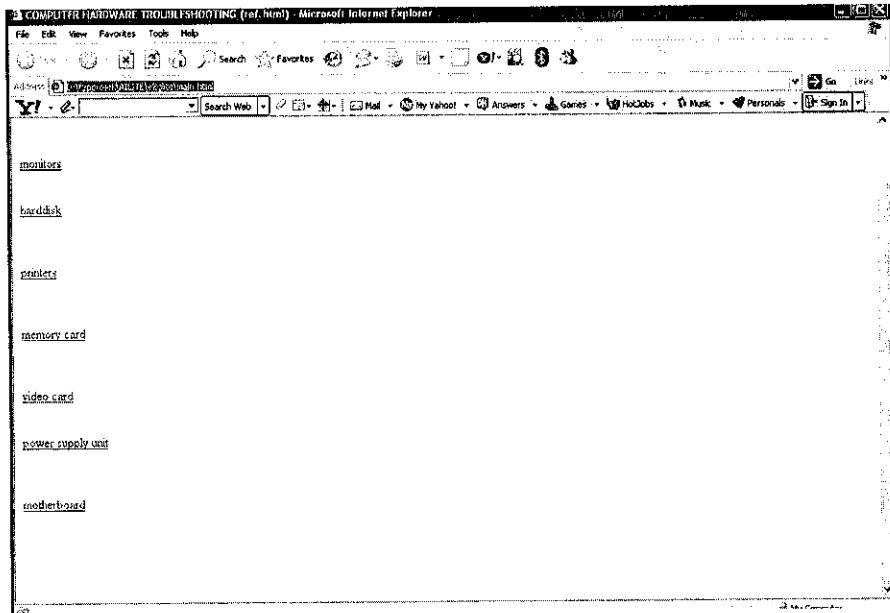

Figure 7: Debug window.

Figure 8: Links and references of problem domain.

To assist users in using the system, links and references are added. These give extra information if the user needs them.

4.2 Future Recommendations

This current system is far from perfect. Here are several recommendations for future work for this system.

- Improve and expand the knowledge base.
- Integrate the system with an archive of computer knowledge such as a computer website or forum.
- Be able to give more detailed explanation on how a conclusion is reached and integrate the solution into a comprehensive answer complete with pictures and step-by step instructions
- Reduce time to reach a conclusion by reducing the size of knowledge base.

CHAPTER 5

CONCLUSION

Troubleshooting computer hardware is the easiest, but most frustrating, part of the troubleshooting process. It's easy because either the hardware works or doesn't work. [4] In dealing with hardware problems, it is difficult to diagnose them since failing computer parts effects may manifest themselves in many ways. The real trick is to go about it in a systematic matter, eliminating possibilities whenever possible before you start purchasing replacement parts. [5]

Experience is a very important thing to have when diagnosing or troubleshooting a computers' hardware device. By implementing this troubleshooting system, it is hoped that this knowledge will benefit beginners who experience hardware problems with their computers. This knowledge can save them time and money.

By improving on this system, mainly by improving the accuracy and user-friendliness of the system and by integrating it with a site full of information about the problem domain, it is hoped to create an efficient system that is fast and is a one-stop site for fixing computer hardware problems in the future.

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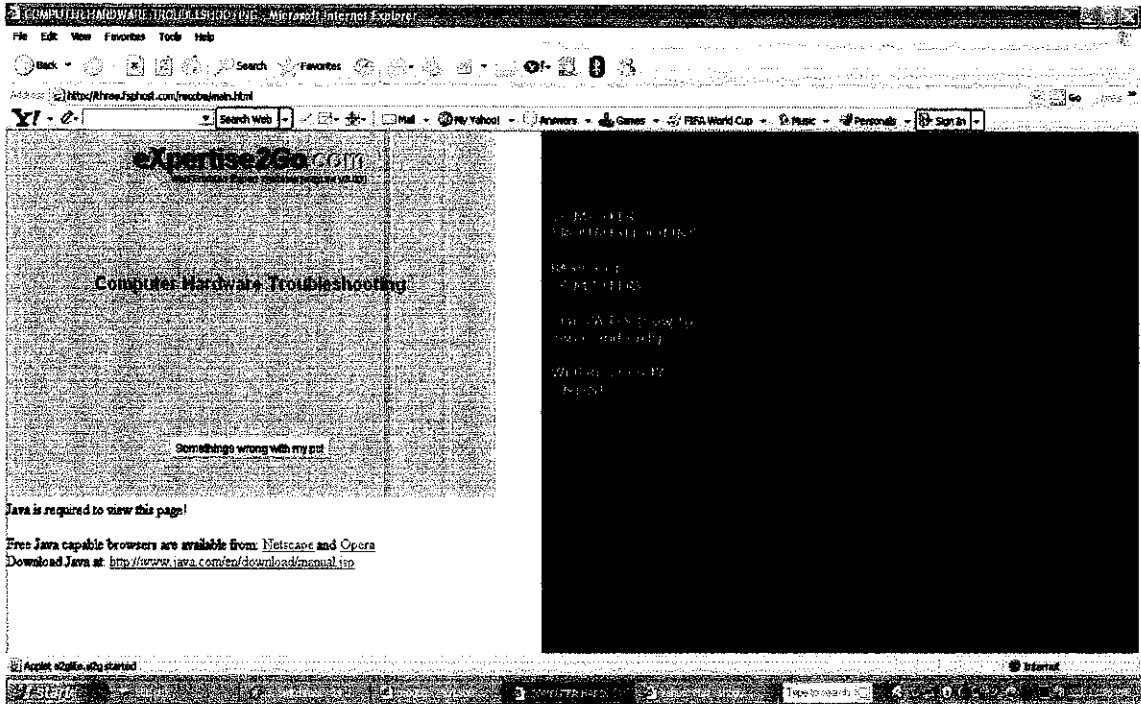   http://www.wtec.org/loyola/kb/c1_s1.htm, [25 Jan 2006]

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APPENDIX

Screen shot of system on the FSP server
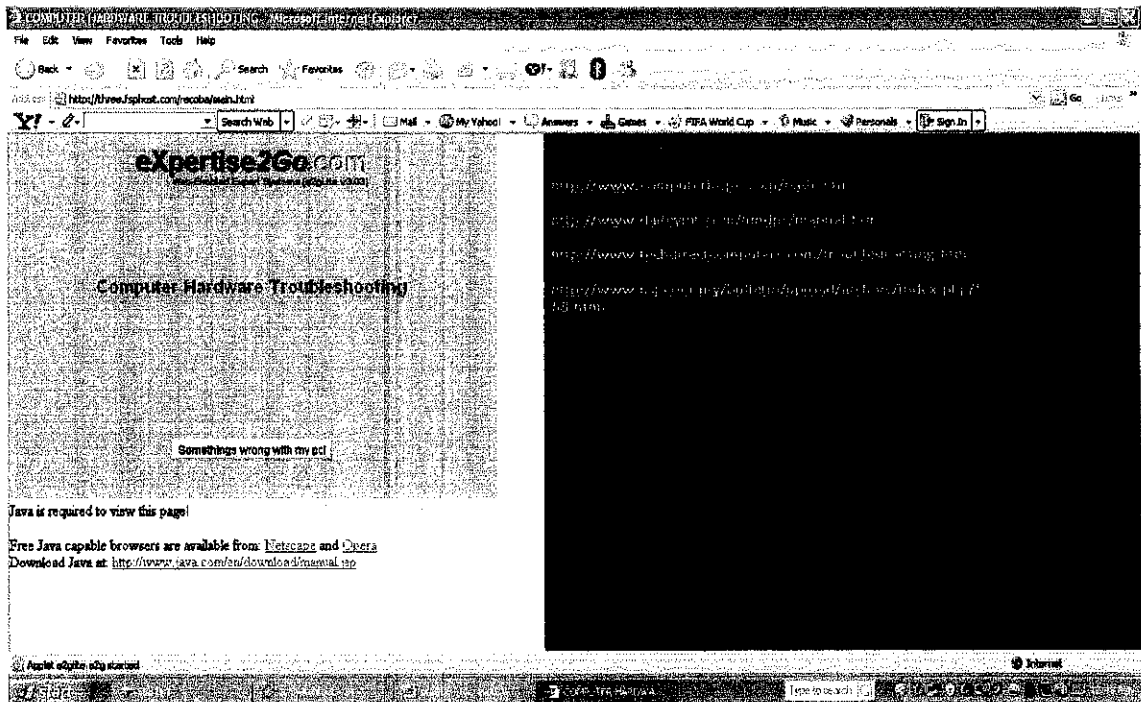
Examples of rules

REM Test Knowledge Base (comp.kb)

REM 1st Question

RULE [BIOS/motherboard failure?]

If [major problem] = "it hangs while working or pc restarting" and

[autoscandisk] = "Yes"

Then [the diagnosis/recommendation] = "possible OS or hard drive failure"

RULE [BIOS/motherboard failure?]

If [major problem] = "it hangs while working or pc restarting" and

[boot] = "Yes" and

[videoquality] = "Yes"

Then [the diagnosis/recommendation] = "possible BIOS/motherboard failure"

RULE [PSU failure?]

If [major problem] = "it hangs while working or pc restarting" and

[boot] = "No"

Then [the diagnosis/recommendation] = "possible power supply failure "

RULE [go to video chart?]

If [major problem] = "it hangs while working or pc restarting" and

[boot] = "Yes" and

[videoquality] = "No"

Then [problematic devices] = "monitor"

21