Expert System for PC Overclocking

by

Mohammad Radzi Zohri

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Technology (Hons)
(Information System)

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CERTIFICATION OF APPROVAL

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Information Technology Programme
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Approved by,

(Mr. Khairul Shafee Bin Kalid)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
July 2003

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 reference and acknowledgements, and that the original work contained herein has not been undertaken or done by unspecified sources or persons.

MOHAMMAD RADZI ZOHRI

ABSTRACT

This report is prepared for Final Year Project on Expert System for PC Overclocking. This report will explain in brief about the proposed expert system and its functionalities. This topic was proposed because of the increasing number of IT literate people in our community. The pace of technology today is very fast, so we cannot keep up with it. With the introduction of new microprocessors in an average duration of 1 to 2 years, consumers find it's hard to cope with and the requirements of software are getting higher and higher as well. People nowadays are resorting to overclock their microprocessors and graphic processing units (GPU). For example, a consumer can overclock their RM400 processor to reach the speed of a RM800 processor. The benefit can be seen there.

Currently, there are only small communities around the world that are involved in overclocking. The consumer knows about overclocking, but they lack the information and knowledge to do so. That is the aim of this expert system whereby it will assist the user all the way in the overclocking process. The expert system will cater for Intel Pentium3 (Socket370) and Intel Pentium4 (Northwood Core).

Overclocking PC is not as simple as it sounds, but along the way the users will be guided through every aspect they need to know before they start. Overclocking is an on going research of the microprocessor and its true potential. It is also hoped that this system will inspire the user to explore the possibilities of PC overclocking.

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ABBREVIATIONS AND NOMENCLATURES

FYP	-	Final Year Project
FSB	-	Front Side Bus
DDR	-	Double Data Rate
RAM	-	Random Access Memory
BIOS	-	Basic Input Output System
GHz	-	Gigahertz
MHz	-	Megahertz
AGP	-	Accelerated Graphics Port
PCI	-	Peripheral Component Interconnect
AMD	-	Advance Micro Devices

CHAPTER ONE

INTRODUCTION

Processors are an essential component of a computer. It acts like a "brain", processing every instruction that is handed to it. From the first commercial processor to the latest processor that we know today, users have been trying to push the limits of these processors. This community of users is better known as "overclockers". However the process of overclocking is complex and needs a lot of time. The aim of this expert system is to aid in the overclocking process for overclockers, especially beginners. The system will cater Intel Pentium4 socket478 and Intel Pentium3 socket370 processor overclocking. Besides aiding users to overclock their system, this expert system also gives advice to the user based on the hardware they have.

The overclocking expert system will be implemented in a rule-based expert system, where a set of rules will be specified for each combination of hardware given by the user. Once all the related information are gathered, the system will decide whether to continue with the overclocking process or not. The definition of expert system is a computer system that facilitates solving problems in a given field or application by drawing inference from a knowledge base developed from human expertise (Nivit Charoenchai, 2002). Expert system is widely used today as it focuses on a specific field, maximizing its efficiency. Some of the examples that can be found about an expert system are Expert System for Autonomous Satellite Monitoring developed for NASA (L. Wong, F. Kronberg, A. Hopkins, F. Machi, P. Eastham, 1998). Expert system can "imitate" the thinking of a human. The rules are gathered from overclocking expert, thus it can imitate the thinking of an overclocking expert. At the end of the project, a test phase will be conducted to see how successful this system has imitated human overclockers.

1.1 Background of Study

Many factors (mainly hardware) have to be considered before overclocking a processor. These factors and all the possible combinations will be included inside the expert system. Once the processor have been overclocked, it is crucial to ensure the stability of the system, because an unstable system can cause unwanted results. This requires research from various resources, to search for the optimum combination of hardware. Information regarding methods of overclocking is also being researched. It is also to make use of the rule-based expert system and to integrate it with the overclocking knowledge. The rules collected are then entered inside the expert system as part of it reasoning engine. Once the system has been completed, it will be tested by overclockers, beginner and expert, to gather data about the efficiency of the system and how it aids in the overclocking process.

1.2 Problem Statement

1.2.1 Problem Identification

Lots of people today know the term "overclocking" without even knowing how to actually overclock. What is the best combination of hardware and how to overclock a processor? Currently, a user will have to perform tedious tasks of finding and gathering information from various sources, especially the internet. A book about overclocking is very rare. The main source on the internet is normally review web sites and forums. Once the information is gathered, the user will have to verify that the information is correct by testing it practically. This method is better known as "trial and error". Why not build a system that combines the necessary information and at the same time eliminate this tedious process? Users can also learn and get inspired to experiment once they use this system.

1.2.2 Significance of the Project

This project aim is to aid the process of overclocking a processor in a way that benefits the user. This system will offer all the necessary information needed for a user to get started with overclocking their processor. This system will benefit users that often upgrade their system (more than once every two years). Users can also make out the most out of their spent money as overclocking will get the most out of the computer by optimizing the computer settings, and at the same time save their money by eliminating the need to buy a newer processor that are available in the market.

1.3 Objectives and Scope of Study

1.3.1 Objectives

The main objectives of this project are as follows:

(a) To find the optimum combination of hardware that yields the maximum overclocking results.

(b) To develop a prototype system that can aid user in overclocking their processor.

(c) To adapt the concept of rule-based system in the implementation of the system.

(d) To gather and compile the knowledge of overclocking from human overclocking experts.

1.3.2 Scope of Study

This system focuses on the process of overclocking a processor and finding the best combination of hardware for the user. Because of the time constraint in developing the system, the scope of processor covered is narrowed to Intel Pentium3 and Intel Pentium4 only (although there are many processors that can be overclocked out there). All the gathered data and findings will be presented in the form of flowcharts and explanation.

Based on this information, an expert system prototype will be developed. This system will take full advantage that EXSYS CORVID has to be offered, which is rule-based system. It is easy to learn and use, making it suitable to solve simple yet complicated problem of overclocking.

CHAPTER 2

LITERATURE REVIEW AND THEORY

2.1 Overclocking Basics

Overclocking simply means running something at a higher speed than it is rated for. So for example, take a Pentium 4 2.4GHz (2400MHz). It is designed to run at 2400MHz, but with the knowledge on how to do it, it can run at a higher speed, for example 2600MHz, which would make it perform like a proper Pentium 4 2.6GHz. All current processors are much the same; they have a multiplier, and a front side bus (FSB). In the case of the Pentium 4, the FSB or bus speed is 100MHz, 133MHz or 200MHz depending on what model of Pentium 4 the user own (Andy Brown and Scott Wasson, 2001). For example, take a Pentium 4 2.4c processor. It uses the fastest 200MHz FSB, which Intel quote as 800MHz due to their marketing of the 'Quad Pumped' bus, but for the time being it can be ignored. So, to achieve 2400MHz from a 200MHz bus, multiply 200MHz bus by its multiplier x12, this gives the final clock speed. Figure 2.1 shows how to calculate the speed of a processor.

Multiplier x FSB = Clock Speed

Figure 2.1: How to Calculate Processor Speed

2.2 Overclocking Methods

There are many methods used to overclock a processor (Charles M. Kozierok, 2000). Although the basic methods are the same, how the methods are performed and the sequence of the methods performed can vary widely depending on the experts that are performing the overclock. This is caused by the hardware configuration in the particular system. There will never be identical hardware configuration although roughly the hardware used is the same. This is caused by the silicon fabrication process during the manufacturing process of each of the hardware.

There are two types of processors. The processors are engineering sample processors and end-consumer processors. Engineering sample processors are given from Intel themselves to other organizations for the purpose of reviews while end-consumer processors can be found on the shelf. These two processors overclocking methods are obviously different, since engineering sample processors have its multiplier unlocked while end-consumer processors have its multiplier locked. To put it simple, overclocking an engineering sample processor is much easier than overclocking an end-consumer processor (Tarinder Sandhu, 2002). Since most users can only get their hands on end-consumer processor, the process of overclocking it might be difficult.

In some cases, there are methods involving dangerous procedures such as soldering the motherboard to get more voltage out of the motherboard (Terrence Miao, 2002). This method is considered to be vary harmful since it tampers directly with the hardware, and will void any form of warranty issued on it.

2.3 Different Approaches in Problem Solving

James P. Ignizio, (1991) points out that to be useful, collected data must be transformed into a useful format form, called information, such as trends, measures of tendency and measures of dispersion or variability (p.22).

The author gave various methods to make data into useful information. The simplest method is data processing (DP) (p.22). Management Information Systems (MIS) is the next level of sophistication. It provides Management Information, which is "relevant knowledge produced by the output of data processing operations, and acquired to achieve specific purposes." for managers to pursue their duties. However, MIS is passive because it only processes and channels information to the right person timely but does not support decision making. Therefore, Decision Support Systems (DSS) are developed. DSS is a computerized system for accessing and processing data, developing managerial displays, and providing recommended courses of action. One may think of DSS as a combination of MIS and the analytical tools. Analytical tools are methods to resolve problems represented by mathematical models, such as mathematical programming, marginal analysis, and input-output analysis (p.26).

2.4 Definition of the expert system

According to Whitten (2001), an expert system is a programmed decision-making information system that captures and reproduces the knowledge and expertise of an expert problem solver or decision maker and then simulates the "thinking" or "actions" of that expert (p48).

George F Luger (2002) describes expert systems as a construction of knowledge obtained from a human expert and coding it into a form that a computer may apply to similar problems. The knowledge is a combination of a theoretical understanding of the problem and a collection of heuristic problem-solving rules that experience has shown to be effective in the domain (p.20).

The author gave an example of expert system, DENDRAL. Developed at Stanford in the late 1960s, DENDRAL is capable of matching an organic molecule to the correct structure out of millions of possibilities. This capability is derived from applying the heuristic knowledge of expert chemists to the structure elucidation.

2.5 Components of Knowledge in Expert Systems

The knowledge that is contained inside an expert system consists of a *priori knowledge;* the facts and rules that are known about a specific domain prior to any consultation session with the expert system, and an *inferred knowledge;* which is the facts and rules concerning a specific case that are derived during, and at the conclusion of, a consultation with the expert system. In an expert system, knowledge is contained within both the expert system's knowledge base and its working memory. The knowledge within the knowledge base is that of the first type, a priori facts and rules about the specific domain.

2.6 Drawbacks of an Expert System

One of the major bottlenecks in building expert systems is the knowledge engineering process. The coding of the expertise into the declarative rule format can be a difficult and tedious task. One major advantage of a customized shell is that the format of the knowledge base can be designed to facilitate the knowledge engineering process (John Sowa, 2000). Knowledge acquisition and knowledge representation are phases of expert systems development that progress virtually together. These are basic for the development of an integrated rule base of the expert system to be built. Many professionals on the field have exposed a common view of that knowledge acquisition is an extremely hard task to accomplish.

This is due to the endless problems encountered dealing with human beings. Knowledge Engineers have to meet and overcome problems such as domain expert's fears, incompetence, inability to communicate, and ultimately the open opposition from the domain expert. However this problem is not one that only affects expert systems, people involved in the development of heuristic programs and decision support-systems have faced very much the same problem as is now faced in expert systems. There is not a "best way to elicit knowledge" as in a cooking recipe format because this is more an art than a science. However there are ways to improve the manner in which the knowledge engineer approaches the domain, the domain expert or experts and their own organizational ways to accomplish the task (Ignizio, 1991).

2.7 Rule-based expert system

Ignizio (1991) quoted that rule-based systems are formed by production rules, which are statements "if-then" or "if-then-otherwise". The statement implies that if a particular situation exists, then take a certain action. The rules are developed through experience and judgment. Rule based systems are used as the foundation for the vast majority of existing expert systems (p.49).

(Ignizio, 1991, p.57) A successful example of rule-based expert system is HESS: an expert scheduler for the petrochemical industry. It was developed to support the product scheduling at a major petrochemical firm's refinery. The knowledge base was developed via the acquisition of heuristic rules from 2 refinery product schedulers. The function was to determine what products to produce at what time and through which processors. The performance was measure against the costs of production, production ruins and lost customer sales. HESS was developed using EXSYS expert system shell through a 12-month effort. HESS stands for hybrid expert system scheduler. It consists of approximately 400 production rules and runs on an IBM PC or compatible. The system was successful because it did not only accomplish the scheduling job previously done by human expert but it did so in a consistent basis. The company saved billions of dollars each year through implementation of such system.
Ignizio also wrote what he thought about the future of expert systems. Early expert systems were mostly standalone but future ones will be developed as embedded system. Early expert systems were huge because it requires many rules. The future shall witness the development of smaller expert systems with 200 or fewer rules.

The author also mentioned about cost feasibility of an expert system. It was true that expert system used to be costly and only feasible for projects worth millions of dollars return. However, with the advent of cheap but powerful expert system shells, coupled with faster personal system, development of expert systems with very minimal cost was possible.

An example was set at Du Pont (Press, 1988) showing that the 200 small systems of the company averaging 80 production rules developed at Du Pont's AI division had saved the company tens of millions annually (p.62).

Popovic (1994, p.8) mentioned that production rules were demonstrated by Newell and Simon (1972) to be the most adequate knowledge representation form for human problem solving.

The author therefore, described rule-based programming as the most appropriate programming paradigm to build expert systems. It is the best means because human experts prefer to define the knowledge in terms of IF-THEN or situation-action rules (p.64).

The author (p.410) further described the internal structure of a rule-based language includes

a. A set of production rules
b. Working memory or database to store current information about the state of reasoning or inference.
c. Control strategy specifying the order in which the patterns in work memory are to be matched against the productions to build the corresponding conflict set of successful matches.

According to Popovic, a rule based language uses the Rete Pattern Matching Algorithm to match the facts and the rule patterns. It is a very fast matcher and operates on the principle of avoiding the repetitive matching of rules that satisfy the conditions in every recognize-and-act cycle. This reduces the number of matches, thus faster computing (p.411).

The general structure of a rule-based system is as the following:

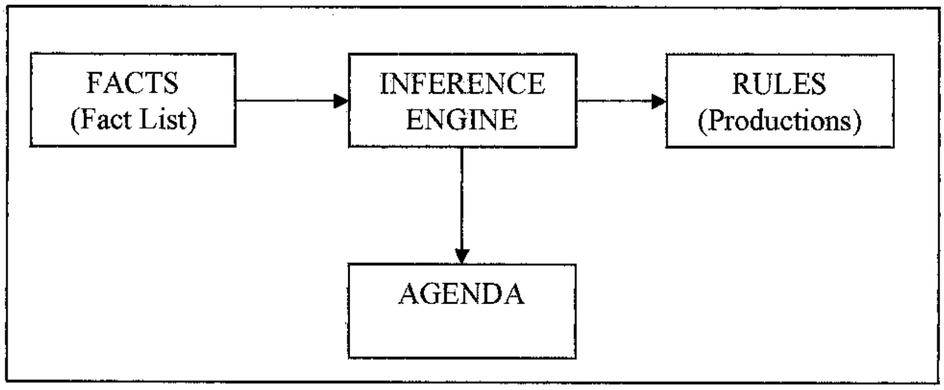


Figure 2.2: Structure of a Rule-Based System

Popozio, referring to the above diagram, explained about the inference cycle of the system:

Step 1: match RULES against the FACTS.

Step 2: set of rules satisfying the match are selected and put on the AGENDA to build the conflict set of rules.

Step 3: select one of the rules in AGENDA for execution.

Step 4: execute the selected rule and take the corresponding action.

The inference cycle is repeated under the control of Rete Algorithm, which minimizes the cycles by eliminating the need to check all rules (p.412).

Rule-base knowledge representation, according to Ignizio (1991, p.74) had the following advantages:

a. Majority expert systems use rule bases.
b. Rule-based expert systems development packages cost less.
c. It can run on inexpensive, general purpose personal computers.
d. Widespread availability of rule-based expert systems allows knowledge engineer to focus on the knowledge base.
e. It takes less time to learn how to use and implement rule-based expert system.
f. Rules are transparent mode of knowledge representation.

2.8 Knowledge Acquisition (KA) Method

Many of the various knowledge elicitation techniques which have become established in knowledge-based system development are relevant to our more specific task in natural language processing evaluation. This is particularly true when considering the presentation of material to end-users, when their natural categorizations of phenomena (rather than the categorizations of linguists or computer scientists) must be determined. It may also, however, be true for experts such as the linguists and computer scientists who build the kind of systems under test -- establishing their understanding of difficult areas where systems are weak for particular reasons of the techniques used and the phenomena. Such `inside' knowledge can support the development of `trick' tests which may serve to diagnose the kind of techniques being used in a system, which in turn may predict a whole aspect of its performance on user requirements. Organized knowledge acquisition methods assist in the standardization of the requirements they result in, in the sense that a specific method can make it easier to check or repeat the knowledge acquisition process. Methods range from informal techniques such as `user observation' through common social science methods such as interviews, questionnaires, and discourse analysis to more formal techniques used in KA for knowledge bases. The identification of relevant phenomena requires open-ended techniques, perhaps using some sort of scenario walkthrough technique with users.

The first step is to identify suitable information providers and a core idea of the tasks of interest. `Natural' observation may provide information about typical situations and tasks, but it may also be relevant to deliberately elicit information from informants about various common types of situation, as well as rare but important situations, and walk through these to gain further information, a sort of scenario-based requirements elicitation process. At the early stages, it is crucial not to have a ready-made list of categories into which users' views of the domain must be fitted; this can distort the information and prevent the uncovering of relevant phenomena (John Sowa, 2000). As relevant phenomena are identified, it is necessary to categorize them, although the two activities cannot be separated so cleanly. A number of relatively formal methods are in use (e.g., repertory grid analysis, laddering, card sorts, largely based around the ideas of Personal Construct Theory, providing constrained sorting or organizing operations to allow the development of categorization schemes based on the identification of contrastive discriminations whose labels are the constructs. In card sorts, for instance, some small and manageable set of elements are chosen, and the subject sorts like with like in as many ways as she can think of; each such distinction can be associated with a labeled construct. For instance, a set of spelling checkers might be sorted on the basis of whether they allow sharing of user-defined dictionaries; this would then become a construct. In the use of this sort of technique for product design or evaluation, it is common to include in the list of items to be sorted some `ideal' product, to facilitate the production of constructs which do not correspond to any discriminations between existing systems, but which guides to real user are needs or wishes. Constructs, as used, for example, in repertory grids, look very much like reportable attributes; a typical repertory grid based on elements which are spelling checkers might be represented as a matrix with one axis listing different spelling checkers and the other various attributes of the checkers, so that the values in the grid characterize the checkers. The main purpose of the grid, however, is not to evaluate the checkers but to elicit constructs/attributes that validly represent the important discriminations to be made among checkers. The use of an automated software system for representing repertory grids allows the values to be used in statistical analysis to identify clusters of constructs, and compare categorizations by a number of subjects.

The labels used with personal constructs are a matter of personal usefulness, and so the process of moving from a set of personal constructs to a sharable set of attributes suitable a wider audience may involve negotiation; there has been some work done on techniques for the identification of clashes in terminology and usage.

2.9 The Inner Workings of Production-Based Expert System

Production-based expert systems rely on formal RULES. Rules appear in IF-THEN-format. These rules are often called PRODUCTION RULES (i.e., IF-THEN). Each and every rule has an ANTECEDENT, or CONDITION part (which is always on the left-hand side), and a CONCLUSION part, (which is always on the right-hand side). To illustrate this, refer to the example:

IF the grain is mature THEN I harvest.

Rules can be simple or very complex. Below are examples of a simple rule and complex rule respectively:

IF the grain is mature
THEN I harvest.

IF the grain is mature
AND the ground is dry
AND the combine is maintained
AND the grain bin is clean
AND the hauling truck is working
THEN I harvest.

Each rule represents a small part of knowledge in the domain of expertise. The knowledge engineer then either constructs - or uses an Already developed inference engine to search through the rules to find those that match facts supplied by outside Sources. Facts are supplied to the inference engine through data bases, spread sheets, text files, or user.

Users supply facts when the inference engine asks them questions (QUERIES), which require them to answer (provide INPUT). The inference engine then searches through the rules and finds those that MATCH the facts. At this point, the inference engine is not involved with executing the rules; it just wants to find all the rules that pertain (even remotely) to solving the problem. Fact-matching can be done in one of two ways: matching facts with the conditions (left-hand side), or matching facts with the conclusion (right-hand side). Entered facts and selected rules are placed into working memory. Then, one rule is selected for EXECUTION. Selection is done in one of four ways:

(a) Select them arbitrarily

(b) Select different rules in the different stages of the solution process

(c) Select the first applicable rule identified

(d) Select the rule with the greatest value attached to it

The inference engine then attempts to execute the selected rule. It does that by either matching the conditions to the facts stored in working memory or by matching the conclusion with the facts that is stored in working memory. More on that later. If the needed facts are present, then that rule is executed. The inference engine then checks to see if the solution is at hand. If so, then it places that solution in working memory and then attempts to solve the problem with the same set of rules but by going through them in a different manner.

CHAPTER 3

METHODOLOGY AND PROJECT WORK

There are five main methods that have been used in order to complete the development of the system. Each method has their sub-methods that complement each other. The diagram below shows the overview of the methodology used.

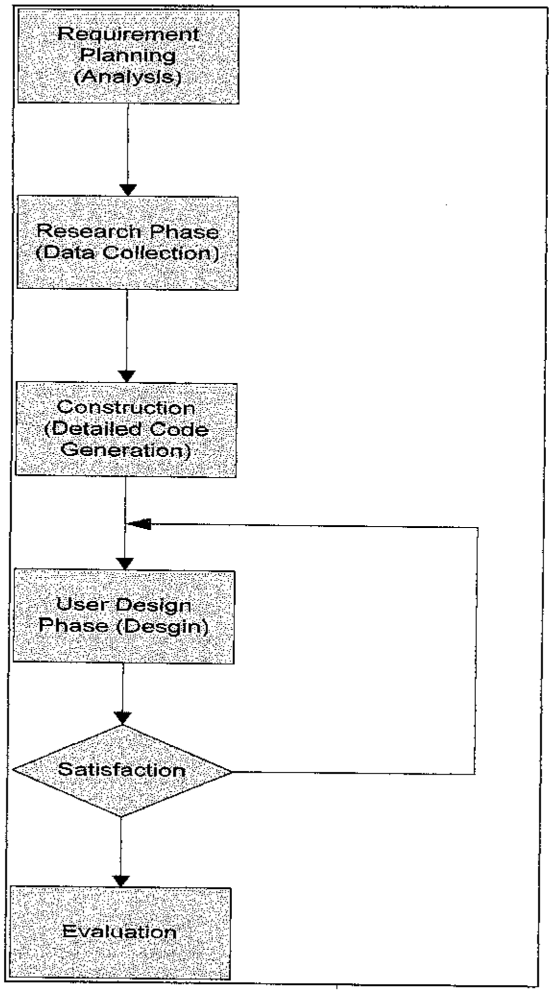


Figure 3.1: Methodology Framework

3.1 Requirement Planning Phase (Analysis)

The tools that are required to build the system are defined in this phase. There are several tools that can be used to build an expert system; among them are AMZI Prolog and EXSYS CORVID. In some cases, there are also some people that use PHP to build their expert system. EXSYS CORVID has been selected because it is more user-friendly and easy to use.

Some of the functions and features of EXSYS are:

- Easy to learn development interface
- Rules in English and algebra
- Trees and Logic Blocks organize and structure the logic
- Object-structured knowledge representation
- Backward and forward chaining Inference Engine
- Separates procedural control from logical control
- Probabilistic, "fuzzy" solutions
- Fast, efficient Inference Engine
- Special features for Product Selection
- Compatible with Exsys RuleBooks
- Web-enabled Runtimes
- Run via Applet or Servlet, or standalone
- Flexible system-user interface with HTML
- Multiple language support
- Integrates with databases and help desk systems
- Automatically generates emails and reports
- Power to handle real-world problems
- Beyond "business rules" - handles complex logic

Another requirement identified is rules about overclocking that are needed to build the expert system. This is the key component of the system.

3.2 Research Phase (Data Collection)

The rules that are required to be entered into the system are gathered and defined from this phase. This phase are divided into two sub categories, identify the hardware requirements for overclocking and gathering the necessary expertise from an overclocking expert.

3.2.1 Identifying the Requirements for Overclocking

Processors that are commonly overclocked by users are analyzed in detail to establish the overclockability of each of the processors. Detailed information about Intel Pentium4 and Intel Pentium3 are analyzed. Each and every processor is unique; therefore it will yield different overclocking results. Although there are two users with the same processor, the overclocking results will differ.
Sources of information are of course overclocking experts. Other sources include the internet (overclocking forums and websites).

3.2.2 Consulting An Overclocking Expert

An overclocking expert will function as the knowledge expert in this system. Once the rules are derived from researching overclocking factors, they will verify this information. If it is correct, it will be added into the system. The knowledge expert will (in some occasions) verify whether this information is correct or not. To develop this system, two knowledge experts for Intel Pentium4 processors are used. They have verified a lot of rules and tested many of them in order to make this system happen.

3.3 Construction (Rules Generation and Detailed Coding)

Once the rules for overclocking are derived, it will be simplified into tree diagrams to make it more understandable. Tree diagrams will also make the process of converting the rules into EXSYS easy.

3.4 User Design (Interface Design)

This phase is where the user interface is designed. Usually the construction is done first, but in this system the primary objective to complete the system is the rules. This is why user design comes after the construction phase. EXSYS offers a different approach to customize its interface. However, the author manages to learn the functions in customizing the interface. The interface is prepared to make the system more user-friendly, to give the system a professional look and to make the user understand what the system meant.

3.5 Evaluation (User Acceptance Test)

The objective of the evaluation is to verify how accurate did the system imitate a human expert. The test will be conducted by the domain expert and other expert overclockers. There are three main objectives of evaluation:

a) To assess the extent and accessibility of the system's functionality
b) To assess user's experience of the interaction
c) Identify any specific problems of the system

The system's functionality is important in that it must accord with the user's requirements. In other words, the design of the system should enable users to perform the intended task more easily. In addition to evaluating the system design in terms of its functional capabilities, it is important to assess the user's experience of the interaction and its impact upon them.

This includes considering aspects such as how easy the system is to learn, its usability and the user's satisfaction with it. The final objective of evaluation is to identify specific problems with the design. These maybe aspects of the design which, when used in their intended context, cause unexpected results, or confusion amongst users.
Basically there are two techniques in conducting evaluation. They are:

(a) Evaluation through expert analysis
(b) Evaluation through user participation

3.6 Requirements of the System

The list below shows the requirements in order to run the system (Note: The overclocking assistant must be executed on a separate machine). They are:

1. An Intel Pentium (3 or 4) class personal computer.
2. Microsoft Windows Operating System.
3. Internet browser (preferably Microsoft Internet Explorer).
4. JAVA 2 SDK.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Research Results

As stated before, the rules of overclocking are essential to the system. The findings of overclocking requirements are analyzed to generate the rules for the system.

4.1.1 Overclocking requirements

The requirements for overclocking are analyzed below. These requirements are captured form overclocking experts and information gathered from previous phase. The factors that affect a processor's overclockability are:

(a) Stepping

The first batch of processors usually don't overclock as well as later batches, although they are running on the same speed.

For example, during the initial release of the initial batch of Mendocino Celerons running at 300MHz, 333MHz and 366 MHz made overclockers had a rough time overclocking the 366MHz to 550 MHz.

When the 366MHz had moved to the 'low-end' portion of the Celeron line, a new stepping had improved chip quality enough that 366MHz were getting to 550MHz, or at least 495MHz. Every time a manufacturer introduces a new stepping, the overclocking capability will be increased (Jakub Wojnarowicz, 2000).

(b) Binning

Binning is essentially the process of dividing processor chips into different speed grades.

(c) Manufacturing process

With each die shrinking (i.e., switching from .35 to .25 microns, or .25 to .18), there are new possibilities. Chips run cooler, they need less power, and higher speeds are attainable. For example the Intel Pentium4 Northwood processors with .13micron manufacturing process require more power compared to Intel Pentium4 Prescott which are manufactured using .09micron.

This information is normally not included by Intel because end-users do not need to know about it. However, it is very useful if a user wants to overclock.

Next factor taken into consideration is the motherboard used in the system. Users that want to overclock their system will need to know their motherboard inside-out. These are the features that need to be identified on a motherboard before overclocking:

(a) Front Side Bus (FSB) Manipulation

This feature allows the user to increase or decrease the FSB (front-side bus) speed from the CPU default, since today's processor multiplier are locked (except for engineering sample processors). Some motherboards may not even allow any type of FSB tweaking, and even for those that do, the number of available FSB speeds can differ dramatically between models. The FSB speeds may be selectable through the system BIOS or physical jumpers may need to be changed to enable the higher speeds.

Some manufacturers, such as Gigabyte and ABIT, offer a software overclocking program that allows FSB manipulation through Windows.

Figure 4.1 shows a screen shot of a typical Pentium4 system to manipulate the BIOS.

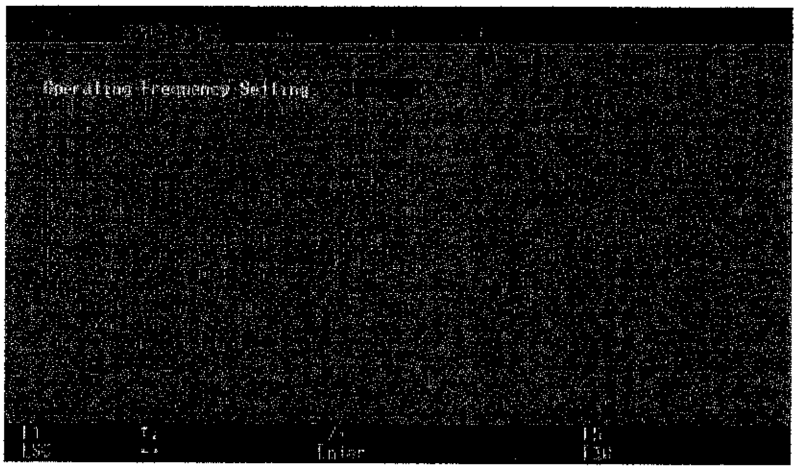


Figure 4.1: FSB Manipulation in BIOS

(b) PCI and AGP Ratio or Dividers

When using a 66 MHz CPU like the Celeron 500, the AGP and PCI dividers are quite different than with a 133 MHz CPU like the Pentium III 833. Also, the available FSB speeds may be limited only to those that apply to a specific AGP/PCI divider setting. Like the FSB speeds, these AGP/PCI divider settings may be present in the system BIOS or through a set of on-board jumpers. The following images represent the most common formats, from jumpered designs to a full BIOS setup. This option is very important to ensure that the system's hardware is running in specification when the system is overclocked.

Figure 4.2 is a screen shot of the BIOS to check for this feature.

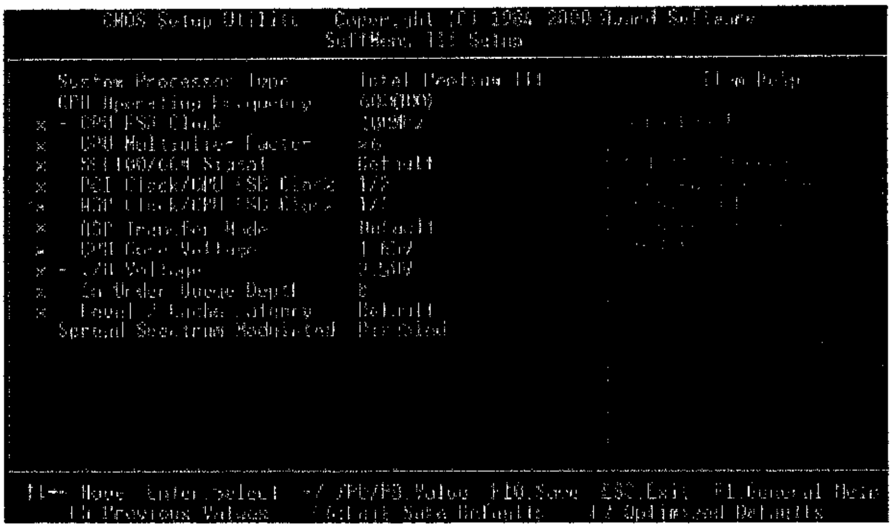


Figure 4.2: Common Method of Setting the PCI/AGP Ratio in BIOS

(c) CPU Voltage Selection

The ability to select a specific core voltage for the CPU could be the factor that determines overclocking success or failure. Many performance motherboards will offer a full selection of core voltages, most likely through the system BIOS, but also through on-board jumpers. Other motherboards do allow voltage increases, but only using a set percentage boost such as 5% or 10%. This is standard operating procedure on many VIA motherboards, but may also be found with other chipsets as well.

There are also motherboards that simply use a "CPU Detect" format that limits the core voltage to the default level of the CPU. Figure 4.3 illustrates this:

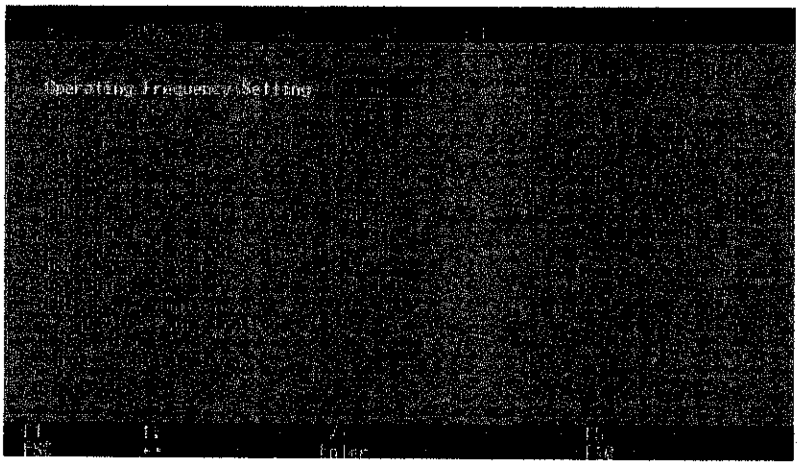


Figure 4.3: Setting the Voltage of the Processor When Overclocking

After the above information has been compiled, the overclocking success can be determined. The best scenario is having a motherboard that allows a full complement of voltage tweaks, along with a wide selection of FSB speeds. Even if the FSB options aren't too robust, the voltage control is the key element.

Motherboards that do not offer any form of voltage tweaking at all are likely to offer the lowest overclocking return. The above analysis is important both in terms of knowing the motherboard's capabilities as well as having realistic overclocking expectations. A motherboard offering full core voltage control and FSB increases in 1 MHz increments will have an excellent chance of reaching the CPU's maximum speed. On the other hand, a motherboard with little or no voltage control and a small set of FSB options will have less overclocking success, and the target should be lowered to a more realistic level.

Regardless of the overclocking potential of the CPU, the actual overclocked results will either be limited or enhanced by the motherboard itself.

The next contributing factor is the RAM used in the system. These RAM should vary from DDR266 (PC2100), DDR333 (PC2700), DDR400 (PC3200) and DDR500 and above. Timings for the RAMS are very essential in overclocking. The findings on RAM types that affect overclocking are as follows:

(a) For systems running on 2.6GHz or lower, using DDR400 (PC3200) and below are sufficient for overclocking.

(b) For systems running on processors higher than 2.6GHz, it is advised to use DDR400 (PC3200) and above to give maximum overclocking since these processors are near the maximum speed limit (currently 3.6GHz during publication).

Next factor that contributes to overclocking is the cooling used in the system.

An overclocked processor generates more heat than specified by the manufacturer, thus the stock heatsink that is provided by the manufacturer is not sufficient.

Complete rules are converted into tree diagrams. Figure 4.4 – Figure 4.7 shows these tree diagrams to illustrate overclocking requirements:

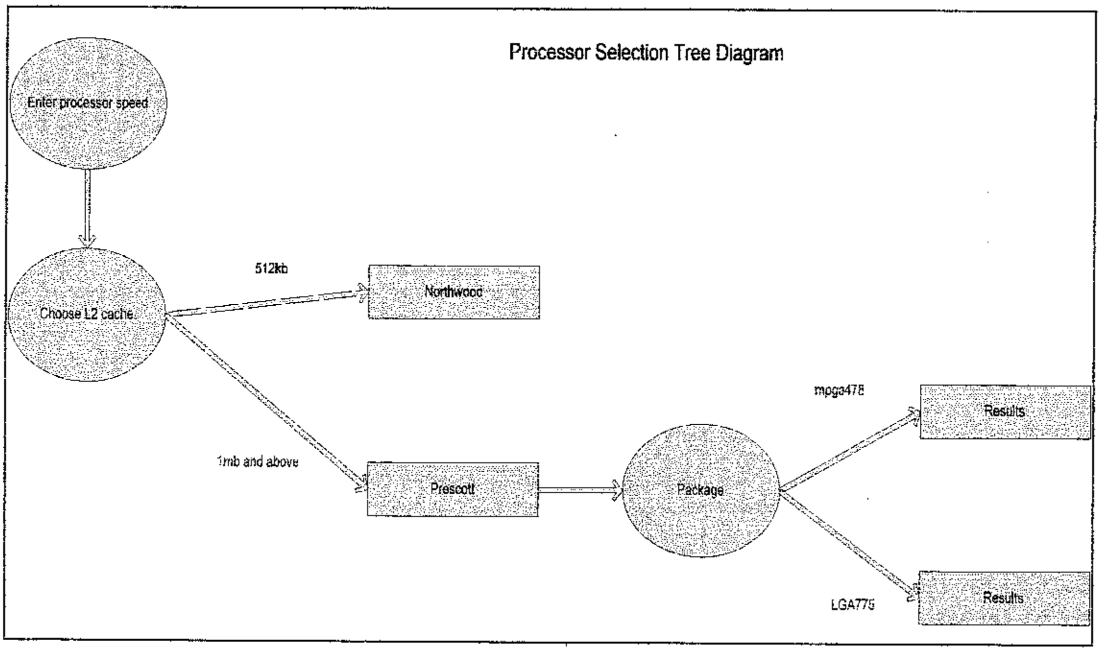


Figure 4.4: Processor Selection Tree Diagram

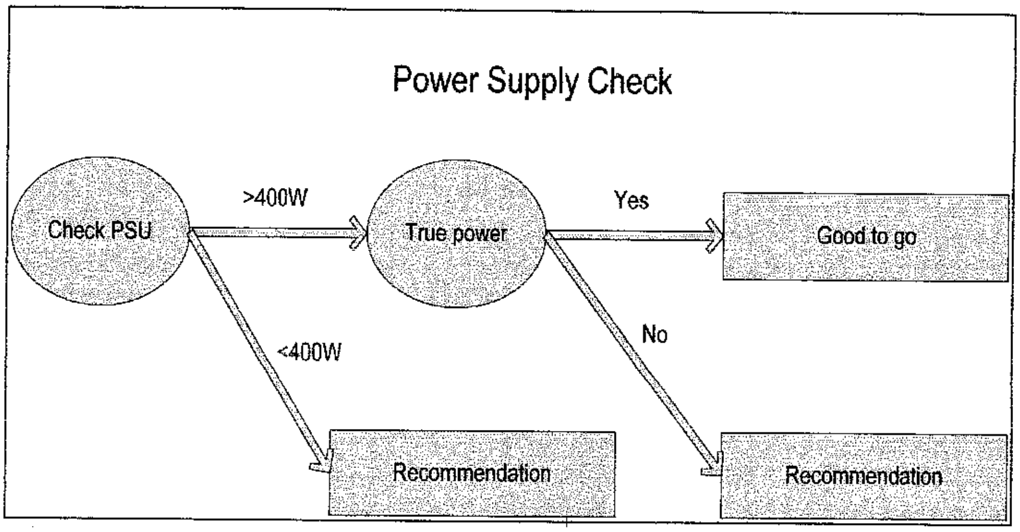


Figure 4.5: Power Supply Selection Tree

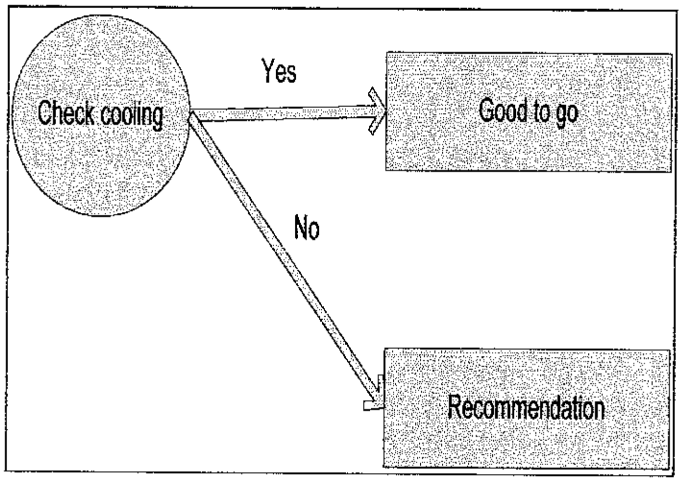


Figure 4.6: CPU Cooling Check

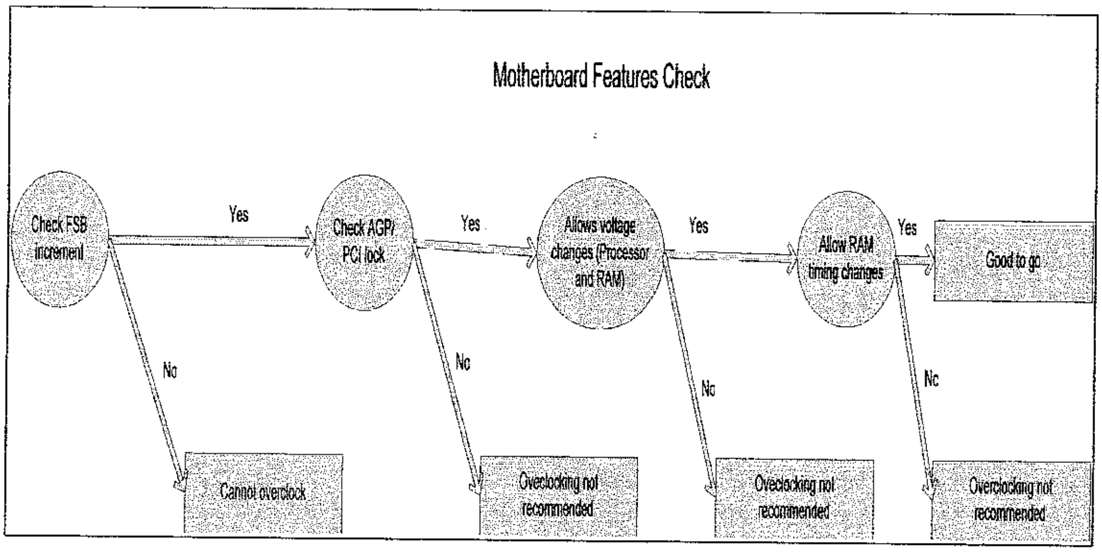


Figure 4.7: Motherboard Features Check Tree Diagram

The tree diagrams above shows only a partial of the system. Once the all the rules have been mapped in a tree diagram, it is converted into rules so that it can be entered into EXSYS CORVID. During the development process, there are several issues faced in EXSYS. First is how to use backward chaining function in EXSYS and how to customize the display.

Backward chaining functions are very hard to implement, while the interface customization are quite difficult because EXSYS has its own method to customize the display, although it is a web based system. The samples of the rules that have been converted into EXSYS are as shown in Figure 4.8:

IF:

What is your processor type ? Intel Pentium4

AND: Does your motherboard allows incrementing the FSB ? Yes

AND: Does your motherboard allows locking the PCI/AGP ratio ? Yes

AND: Does your motherboard allows changing the default voltage of components ? Yes

AND: What is your DDR type ? Below DDR400 (PC3200)

AND: Does your motherboard allows changing the default RAM timings ? Yes

AND: What are the heatsink are you using in your system ? Stock

AND: What is the wattage of your power supply (PSU) ? Less then 400W

AND: Is your PSU a "True Power" type ? Yes

AND: What is the speed of your processor ? Below 2.6GHz

THEN:

[Advise.ADD] Advice: Your processor has high overclocking capability. Your motherboard also have all the prerequisites to overclock. You have sufficient power supply for overclocking your system, because it is "true power" type. Your RAMS are also sufficient. Unfortunately your system's cooling are not, you can overclock but watch out for the temperature of the processor when it is overclocked.

Figure 4.8: Rules That Have Been Converted Into EXSYS

4.2 System Architecture

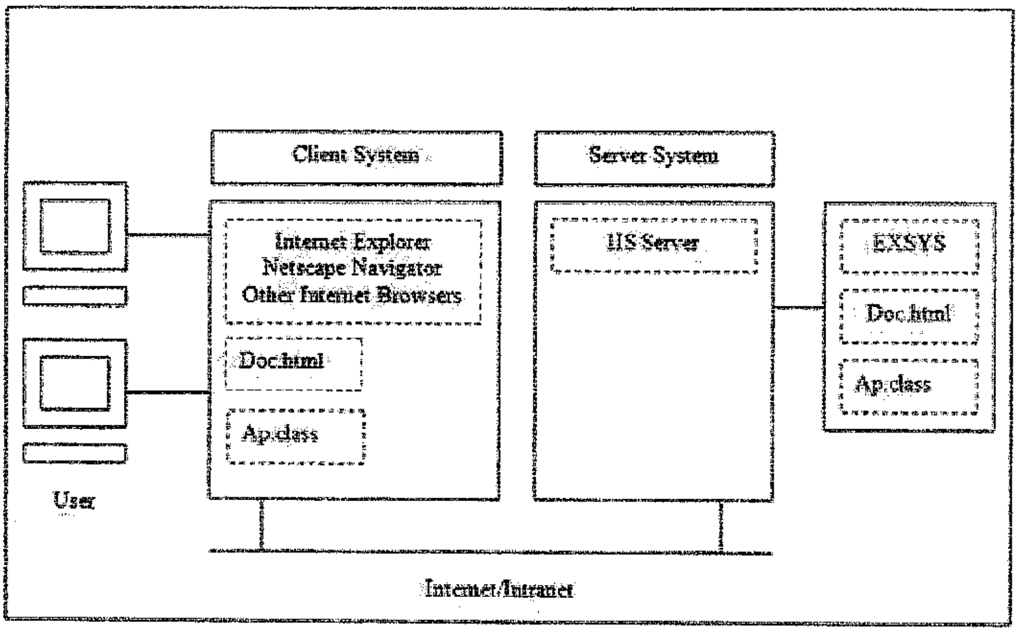


Figure 4.9: System Architecture for Overclocking Expert System

Figure 4.9 shows the system architecture for the overclocking expert system. It is divided into to sub components, client system and server system. Client system is the user-end where the user executes the expert system while the server system is where the expert system resides and can be accessed from virtually anywhere via internet or the local intranet.

4.2.1 Server System

The expert system is installed on the server. EXSYS will generate a default web page to view the expert system. The web page that has been generated will use JAVA applets to execute. Applets are small programs intended to be executed by another program, in this case a web browser such as Internet Explorer or Netscape Navigator. The server provides the JAVA applet that is required to run the expert system. The server also has internet information service (IIS) installed. IIS is the Windows component that makes it easy to publish information and bring business applications to the Web. This service also enables the creation of a strong platform for network applications and communications.

4.2.2 Client System

As depicted on Figure 4.9, the client system will require internet browsers such as Internet Explorer 5.0 or greater, Netscape Navigator or other internet browsers such as Opera that can handle JAVA applets. When the user executes the expert system, a compiled applet is downloaded by the browser and executed by the client system. The browser will then display the HTML document that is generated by EXSYS and will download and execute the applet. The expert system will continue to execute until the applet code terminates or the user stops viewing the expert system.

4.3 Final Prototype Product

The final prototype versions of this expert system are divided into two. The first part is the overclocking advisor and the second part is the overclocking assistant.

4.3.1 Overclocking Advisor

The overclocking advisor will gather the user's system hardware configuration to make sure what the overclocking capabilities of the target system are. When all the rules in the system have been fired, the system will come out with an advice to the user about overclocking recommendations and what to do next. If the user fulfills all the necessary overclocking requirements, then the system will be transferred to the overclocking assistant. If the user's hardware configuration does not meet the requirements, there will be some considerations that will be done by the system. In some cases, although the overclocking requirements are not met, the user can still overclock, causing the overclocking assistant to pop-up. The screen shot of the overclocking advisor are shown in Figure 4.10. The end result of the overclocking advisor is shown in Figure 4.11. The advice given to the user at the end are unique, each different combination of hardware yields a different advice. Figure 4.12 shows the sample execution rule for the overclocking advisor.

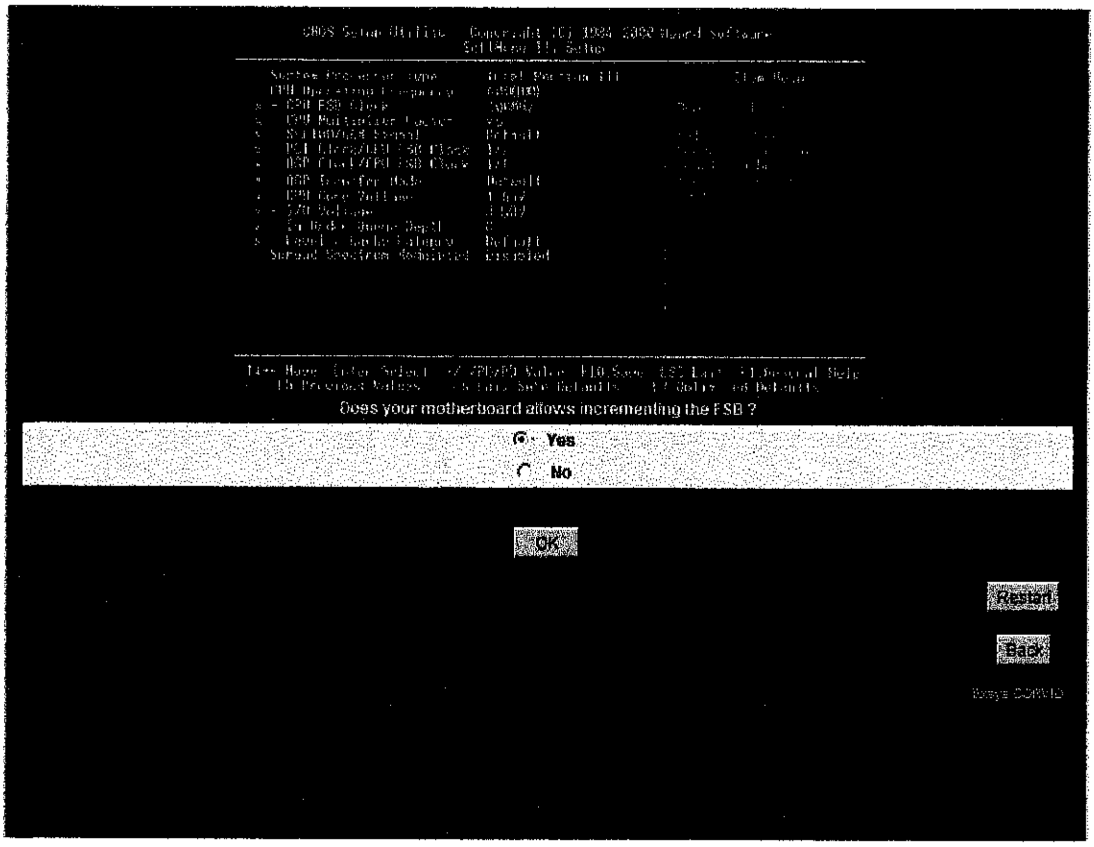


Figure 4.10: Screen Shot of the Overclocking Advisor

Figure 4.11: Results Driven from the Test Rule

IF:

What is your processor type? Intel Pentium4

AND: Does your motherboard allow incrementing the FSB? Yes

AND: Does your motherboard allow locking the PCI/AGP ratio? Yes

AND: Does your motherboard allow changing the default voltage of components? Yes

AND: What is your DDR type? Below DDR400 (PC3200)

AND: Does your motherboard allow changing the default RAM timings? Yes

AND: What are the heatsink are you using in your system? Stock

AND: What is the wattage of your power supply (PSU)? Less then 400W

AND: Is your PSU a "True Power" type? Yes

AND: What is the speed of your processor? Below 2.6GHz

THEN: [Advice will vary depending on the user input]

Figure 4.12: Sample Execution Rule for Overclocking Advisor

For the overclocking advisor, user will have to answer questions posed by the system and as a result they will receive an advice on the overclocking potential of their system. The overclocking assistant will guide the user in a walkthrough on steps to overclock their system to the satisfied level of overclock.

The advice illustrated in Figure 4.10 comments that the user does not have the adequate cooling to overclock, thus the system will recommend the user to change the stock heatsink. The system also recommends overclocking to the user but the user must keep an eye on the temperature generated by the processor once it is overclocked.

When the conditions to overclock are fulfilled, the system will transfer the user to the overclocking assistant. If the user hardware configuration does not meet any crucial factors in overclocking, the system will not transfer the user to the overclocking assistant.

4.3.2 Overclocking Assistant

The overclocking assistant will guide the user to overclock their system with the aid of screen shots from an actual overclocking process. All the steps required to perform overclocking are sorted to the optimized sequence. Figure 4.13 shows the screen shot of the overclocking assistant. Figure 4.14 shows the complete rule executed in the overclocking assistant.

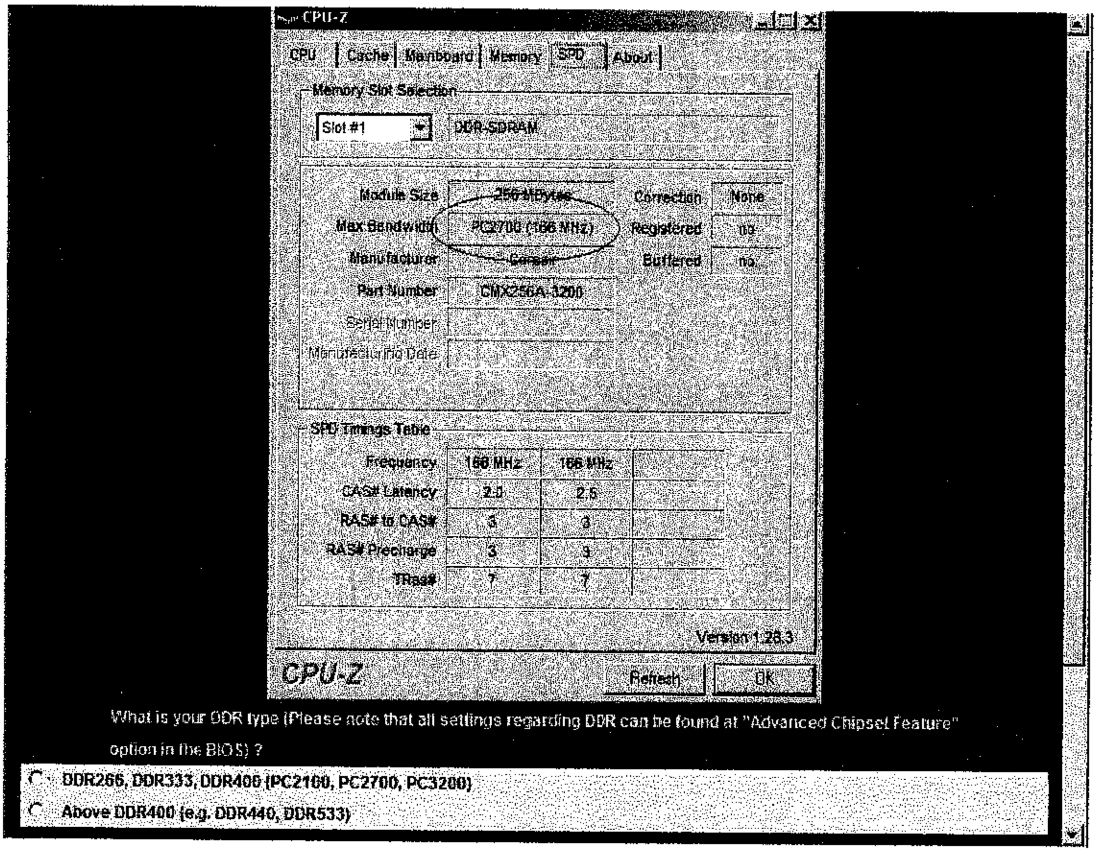


Figure 4.13: Screen Shot of Overclocking Assistant

IF:
What is your processor type? *Intel Pentium 4*
AND: Now we will check the "soft" requirement for overclocking. Have you installed prime95 (to stress testing your processor after overclocking) ? *Yes*
AND: Have you installed CPUz (any versions) in your system ? *Yes*
AND: What is your DDR type (Please note that all settings regarding DDR can be found at "Advanced Chipset Feature" option in the BIOS) ? DDR266, DDR333, DDR400 (PC2100, PC2700, PC3200). *Next*
AND: Boot the computer and enter the BIOS. Set the PCI/AGP ratio to "Fixed" or "33/66MHz". This is to ensure your hardware will run within specification. *Done*
AND: Set the FSB:DRAM ratio to 5:4 or DDR333 (80% of the current FSB). *Next*
AND: Set the CPU voltage to "User Defined" or equivalent. *Done*
AND: Set the DDR voltage to 2.7v. *Done*
AND: Increase the "ext. clock" or FSB by 10MHz. (e.g. 200MHz to 210MHz). *Done*
AND: Save settings to BIOS and boot your system normally. *Done*
AND: Run "prime95" stability test for 20-30 minutes. *Done*
AND: Repeat the process of incrementing the FSB by 10 and stress testing using prime95 until you encounter error in prime95 or your system cannot boot. *Next*
AND: Your final FSB value is the final FSB value that you have incremented by 10MHz (e.g. 250MHz). Now you have two options two choose from: *Reduce the FSB value*
AND: Decrease the final FSB value by 5MHz (e.g. 250MHz --> 245MHz). *Next*
AND: Run Prime95 torture test for a few hours (3 to 4 hours recommended) to make sure it is stable. *Next*
AND: Change the DRAM Ratio to 3:2 if your FSB exceeds around 250 MHz (Ignore to timings for now) to make sure your DDR is operating in specification. *Next*
THEN:
[P4 OC Process Complete Comment.ADD] [System completion comments]

Figure 4.14: Overclocking Process from the overclocking assistant

(Note: The Rule Selection are Underlined)

4.4 Evaluation (User Acceptance Test)

The user acceptance test was performed to verify the accuracy of the system in imitating a human expert. This test was conducted to measure the reliability of the system, no matter how accurate it is in imitating human experts.

The evaluation was conducted by five overclocking experts, four of them are an expert in overclocking Intel Pentium processor and the other is an experienced AMD Athlon processor overclocker. They are considered to be overclocking experts because they have been involved in the overclocking scene for at least 5 to 6 years. Three of the Intel overclocking experts are the moderator for a local overclocking forum. One of the experts also has a website about overclocking that has been referred to by many beginner overclockers. The AMD overclocking expert provides overclocking service for students in the campus. Judging from their experience in the field, they are the suitable candidates to test this overclocking expert system.

The test will require each of the evaluator runs the system on separate computers so that they can give their individual opinion. The evaluators are asked to give comments on the final results of the overclocking advisor and the overclocking assistant.

The evaluation is conducted in a controlled environment. All five experts are given the same problem or scenario. Each are given a similar system test bed for them to try overclock using the system. Table 4.1 shows the test bed system configuration:

Table 4.1: Hardware Configuration for the Test System

Processor:	Intel Pentium4 2.4GHz (Type "C")
DDR RAM:	Corsair CMX-256a PC3200 DDR
Motherboard:	Shuttle FB75
Graphics Card:	NVIDIA GeForce4 MX440 w AGP 8X

All evaluators are asked to run this system and fill up a form similar to Table 4.2 below:

Table 4.2: Sample Evaluation Form

Attributes	Rating				
	1	2	3	4	5
1. Realism of prototype					
2. Match between system and real world					
3. User control and freedom					
4. Visibility of system status					
5. Aesthetic and minimalist design					

The definition for scale is:

1 – Very Poor, 2 – Below Average, 3 – Average, 4 – Meet Expectation, 5 – Outstanding

Each of the evaluation characteristics are explained to the evaluators. They are;

(a) Realism of prototype: The overall performance of the prototype.

(b) Match between system and real world: The system should match the expert's language, with words, phrases and concepts similar to the experts.

(c) User control and freedom: The system supports undo and redo function.

(d) Visibility of the system status: Always keep users informed about what is going on.

(e) Aesthetic and minimalist design: The system content. Does not contain information and irrelevant information.

4.4.1 Evaluation Results

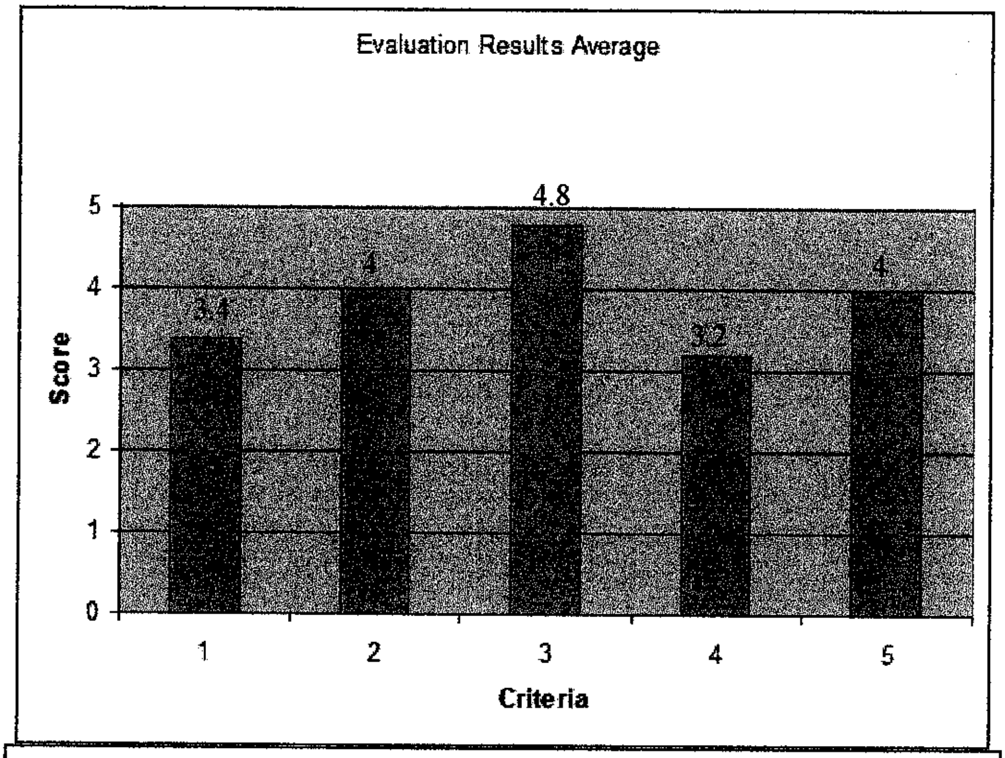
Table 4.3 summarizes the evaluation that has been made by all five evaluators. Please note that the score are on the scale of 5.

Table 4.3: Summary of Evaluation by Five Experts

Evaluator/Criteria	Realism of prototype	Match between system and real world	User control and freedom	Visibility of the system status	Aesthetic and minimalist design
Intel Overclocking Expert 1	4	5	5	3	4
Intel Overclocking Expert 2	3	4	5	3	4
Intel Overclocking Expert 3	3	4	5	5	4
Intel Overclocking Expert 4	3	4	4	3	4
AMD Overclocking Expert	4	3	5	2	4

4.4.2 Evaluation Results Analysis

Once evaluators have completed filling the evaluation form, they were asked some opinions on the evaluation they have made. The full score for each criterion is 5. Figure 4.15 summarizes the evaluation results.



Criteria Legend:

1: Realism of Prototype
2: Match between System and Real World
3: User Control and Freedom
4: Visibility of the System Status
5: Aesthetics and Minimalist Design

Figure 4.15: Average Score of the System

4.4.2.1 Realism of Prototype

The average score for this criterion is 3.4. Based on an informal interview session, Intel overclocking experts all agree that the system are presentable and is very similar to the real thing. The AMD overclocking expert however says that it is presentable but still needs some improvement, like including details for RAM chipsets.

4.4.2.2 Match Between System and Real World

The system's average score in this criterion is 4. All of the overclocking experts agree that it is similar but not close enough. They all agree that the system still requires much improvement in order to enhance its functionality and its dependability.

4.4.2.3 User Control and Freedom

The system's average score in this criterion is an astounding 4.8. All the overclocking experts agree that the system offers freedom to users. They are most impressed that the system allows user to go back to previous rule as simple as that.

4.4.2.4 Visibility of the System Status

The system's score in this criterion is 3.2. 3 of the experts think the system is average while the other two suggested that the system needs improvement in this criterion.

4.4.2.5 Aesthetics and Minimalist Design

All of the experts agree that the system does not contain any irrelevant information. All the information presented during both parts of the system is relevant to the context given. The images that accompany each question also simplify the system and are a value added feature.

Overall, the evaluators are satisfied with the performance of the system. Although there are some minor drawbacks, they have agreed that this system can be used for new and learning overclockers to further explore processor overclocking.

CHAPTER 5

RECOMMENDATION AND CONCLUSION

5.1 Summary of Project

By incorporating rule-based expert system, it is believed that the author had achieved the initial aims and objectives that are specified earlier. This project could imitate a human expert on an average 60%, which is quite high. This project can cater for the increasing number of beginner overclockers in the PC community for them to learn and further explore the limitless possibilities of overclocking. The author also had learned new lessons regarding overclocking during the development and research phase of the project, which can be useful in the future.

Towards the completion of the prototype, the methodology has provided the author as a powerful guideline of the project. The research and construction phase is very crucial completing the project according to the scope defined.
It is proven that the project able to meet all objectives outlined. The project is able to aid beginner overclockers in overclocking their system and it will benefit the PC Enthusiast community. In addition, will inspire overclockers to explore the unlimited possibilities of overclocking.

Overall, this system is very useful to overclockers, especially for beginners.

5.2 Suggested Future Work for Expansion and Continuation

There are several suggestions and recommendations that can be done to this project and the prototype, so that in the future the system will have increased functionality and flexibility.

5.2.1 Add a Website to Accompany the System

Currently, the system only runs on a JAVA applet in an internet browser. A website that comes with the system would complement the system nicely. Features such as walkthrough and explanation about how to use the system. Other useful feature to be added in the website is detailed information about overclocking to give the users of the system a better view of overclocking. This website will then be hosted in the internet, which will enable access to the system to all users in the world. Because overclocking is becoming a trend among PC owners, the system can guide all users that want to overclock. During the development of this system, the author has taken into consideration to build a website for the system, but because of the time constraint, the website development has been postponed.

5.2.2 Add More Rules Into the System

According to one of the evaluator, the system should use more set of rules to add more realism to the system. More rules can be added into the overclocking process to make it more comprehensive. The current system successfully aids the user in overclocking but it lacks the ability to troubleshoot any problems prior to overclocking a system. If a user cannot solve a problem caused by overclocking, it will be a problem because the user cannot move on to the next step in overclocking their system.

For the overclocking advisor part, more rules can also be added. More variables should be added such as the chipset information and their overclocking capabilities.

5.2.3 Cover More Processors

The current system only caters for Intel Pentium4 and Intel Pentium3 socket370 processors. All Intel processors (starting from Intel 550MHz) can be overclocked. There will be a user that owns an old system and the user will wish to overclock the system to boost the performance. The system should also incorporate AMD processors, such as Athlon XP and AMD Athlon 64-FX. The overclocking method of AMD processors is basically the same. When compared to Intel overclocking, the difference are only a number of factors during the overclocking process since there are a few AMD processor models that have its multiplier unlocked.

Apart from desktop entry processors, the system should include mobile processors in the future. The common types of mobile processors that can be overclocked are Intel Centrino Mobile and AMD Athlon Mobile. For mobile processors, the overclocking method is totally different than desktop processors. The factors affecting maximum overclock for mobile processors are slightly different, so adding mobile processor overclocking function to the system will be a breeze.

5.2.4 Add Graphic Card Overclocking Method

A graphic card has its own processor known as the Graphics Processing Unit (GPU). Therefore it can be overclock like a normal computer processors. The purpose remains the same, to gain more performance. The trend among PC users today is to overclock the graphic card to the maximum, no matter what type of graphic card it is. Overclocking a graphic card is a totally new scope compared to overclocking a processor.

5.2.5 Add Processor Advisor

There are many processors that are available in the market today, from both Intel and AMD. Today's user always looks for the cheapest processor since it is value for their money. But they do not know the capabilities and specification of the processor. A processor advisor will be a "nice to have" function to the system. This processor advisor can give the user detailed specification of a processor and do a head-to-head comparison of two processors and give the user advice on which processor is the best.

5.3 Conclusion

This project explores the potential of expert system in preserving the skills and knowledge of an experienced overclocking expert in providing advice about the hardware requirement and what is the best way to overclock a processor. The study concludes that overclocking is a heuristic decision-making and unique depending on the preferences of each expert. This warrants the research for the best method available to overclock a processor and the optimum hardware configuration needed. This information will then be stored for beginner overclockers to use or expert overclockers to use as a reference.

The study also discovers that the overclocking requirements and process can be effectively mapped into production rules, thus enabling them to be entered into a rule-based system. A prototype was developed using rule-based knowledge representation. The system was tested with a real overclocking to test its reliability. The result derived was satisfactory.

REFERENCES

[1] Vince Freeman, 2001, *CPU Overclocking Basics*, <http://www.sharkyextreme.com/hardware/guides/cpu_oc_guide>

[2] Jakub Wojnarowicz, 2000, *Overclocking Basics Guide*, <http://www.firingsquad.com/guides/overclockingbasicsver4/report.asp>

[3] Readings on AMZI website, creator of AMZI prolog, *Expert Systems in Prolog*, <http://www.amzi.com/01introduction.htm>

[4] James P. Ignizio, 1991, *Introduction to Expert Systems, the Development and Implementation of Rule-Based Expert Systems, New York*, McGraw-Hill.

[5] Tetsuo Tamai, Masayuki Fujita, 2000, *Development of an Expert System for Credit Card Application Assessment*, Mitsubishi Research Institute, Inc.

[6] Whitten, Bentley, Dittman.2001, *Systems Analysis and Design Methods*, 5th Ed, New York, Irwin/McGraw-Hill.

[7] Popovic, Bhatkar, 1994, *Methods and Tools for Applied Artificial Intelligence*, New York, Marcel Dekker, Inc.

[8] Yoon, Y., Guimaraes, T., Swales, G., *Integrating Artificial Neural Networks With Rule-Based Expert Systems*, Decision Support Systems, vol. 11, 1994, pp. 497-507.

[9] B. Lloyd, M. Krikorian, G. Hircshman, T. Rangongo, S. Zelingher, L. Bardsley, 2000, *Development and Implementation of HydroX an On-line Expert Diagnostic System for Hydro Generators*, Foster-Miller Technologies Inc.

[10] Nivit Charoenchai, 2002, *Tool Expert: A Knowledge-Based System for Non-Powered Hand Tools Design, Selection and Use,* Chiang Mai University.

[11] Ginsberg, Matt, Morgan Kaufmann, San Mateo, California, *Essentials of Artificial Intelligence* (1993).

[12] Stefano Ceril, Jennifer Widow, *Detecting and Correcting Errors in Rule-Based Expert Systems: An Integration of Empirical and Explanation Based Learning* (1991)

[13] L. Wong, F. Kronberg, A. Hopkins, F. Machi, P. Eastham, *Development and Deployment of a Rule-Based Expert System for Autonomous Satellite Monitoring,* http://iraf.noao.edu/iraf/web/ADASS/adass_proc/adass_95/wongl/wongl.html (1998)

[14] John Sowa, *Knowledge Representation: Logical, Philosophical, and Computational Foundations* (2000)

[15] Charles M. Kozierok, 2000 *How Do You Overclock?* , < *http://www.pcguide.com/ref/ram/timing.htm*>

[16] Andy Brown and Scott Wasson, 2001, *Overclocking Know-How,* <http://techreport.com/faq/athlon-2.x>

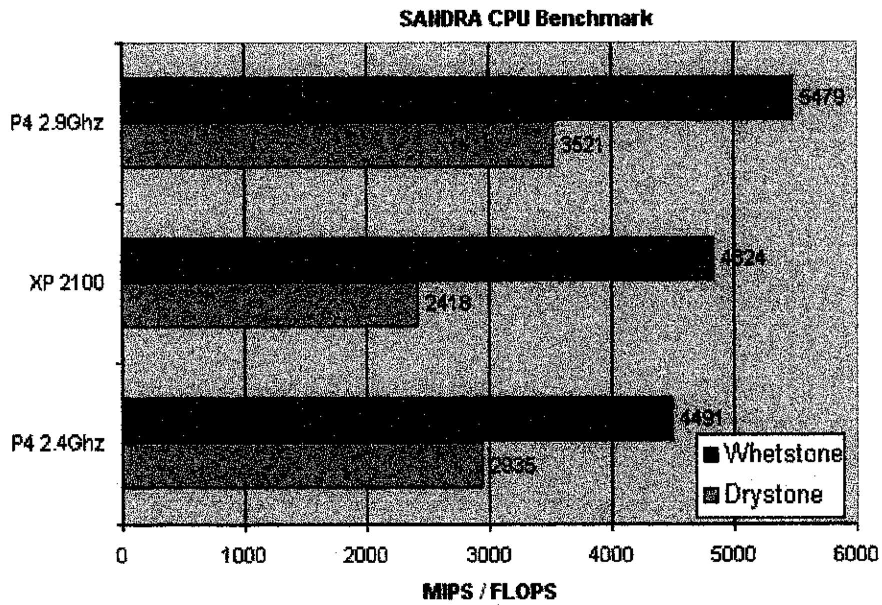
[17] Tarinder Sandhu, 2002, *Overclocking an Intel 2.4c,* <http://www.hexus.net/content/reviews/review.php?dXJsX3JldmlldI9JRD0zMjc mdXJsX2hpc3Rvcnk9LTI=>

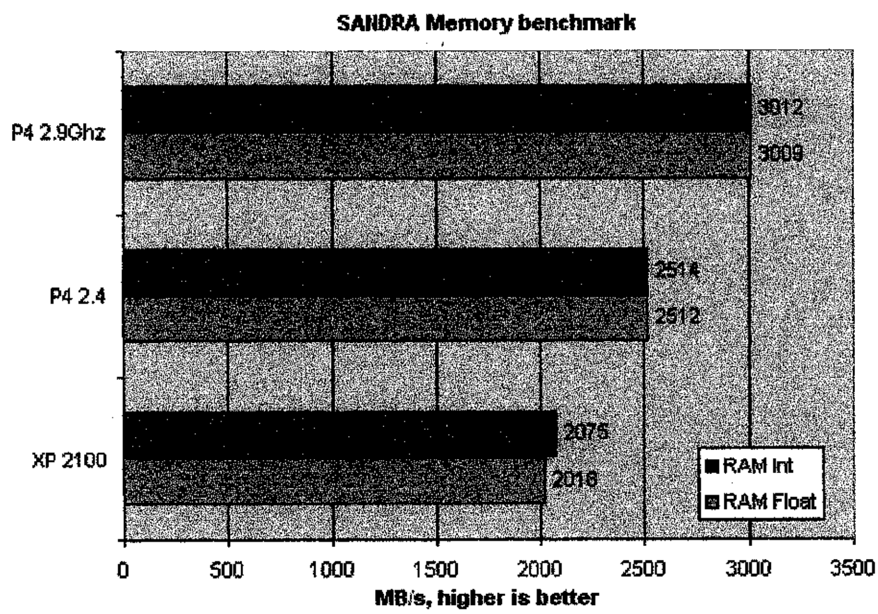
[18] Terrence Miao, 2002, *More Voltage for Overclocking,* <http://igloo.its.unimelb.edu.au/linux-online/overclock.html>

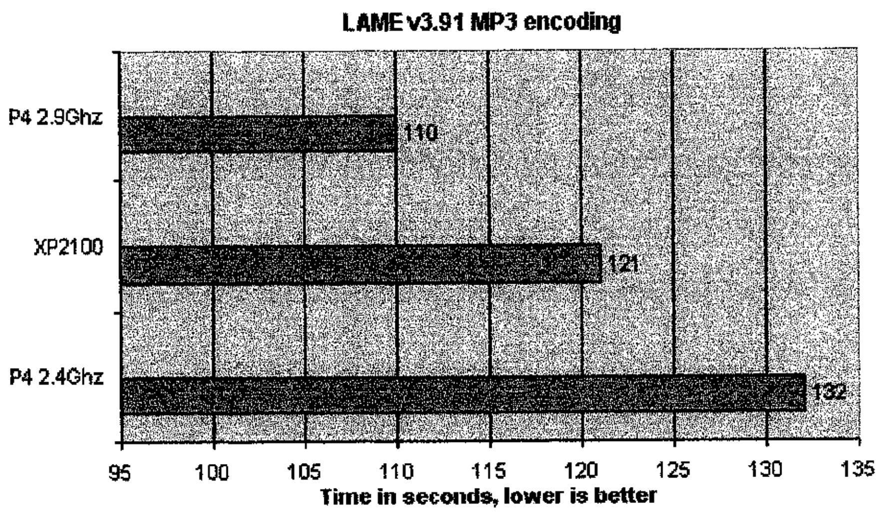
[19] Frank Volkel, 2001, *The Complete Overclockers Guide*, <http://forums.extremeoverclocking.com/forumdisplay.php?s=22baaa71e001cf1a189f7b8567d71ca1&f=84>

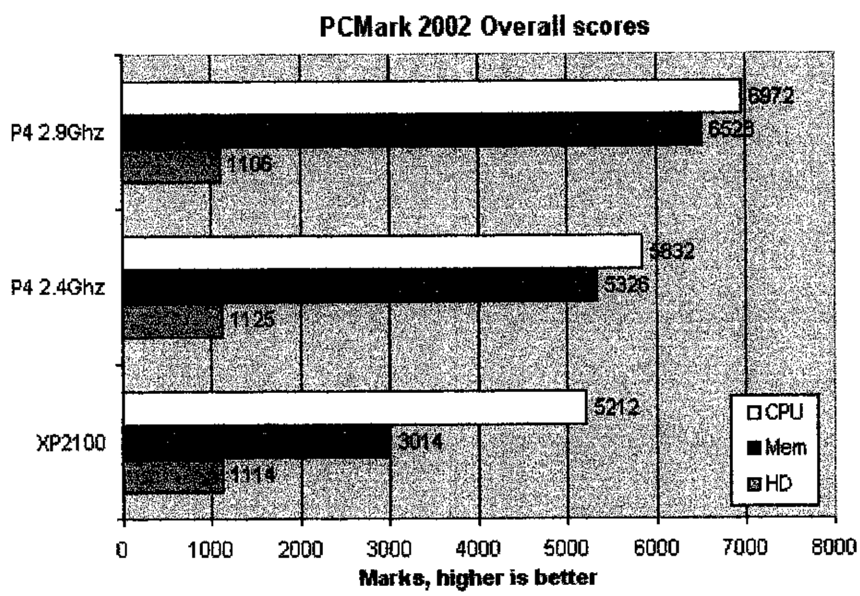
APPENDICES

APPENDIX I – Benchmark of Intel Pentium4 2.4GHz Overclocked to 2.9GHz






LAME v3.91 MP3 encoding
P4 2.9Ghz
110
XP2100
121
P4 2.4Ghz
132
95
100
105
110
115
120
125
130
135
Time in seconds, lower is better


PCMark 2002 Overall scores
P4 2.9Ghz
6972
6525
1106
P4 2.4Ghz
5832
5326
1125
XP2100
5212
3014
1114
CPU
Mem
HD
0
1000
2000
3000
4000
5000
6000
7000
8000
Marks, higher is better

APPENDIX II - Generic Architecture of an Expert System