Experts Knowledge Sharing System
In Diagnosing Proton Car Engines

By
Mohamad Farid Bin Abdullah

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

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CERTIFICATE OF APPROVAL

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Approved by,

……………………………

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May 2012

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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MOHAMAD FARID BIN ABDULLAH

ABSTRACT

The proton car engine diagnosis system provides a broad range of technical expertise from top engines diagnosticians assembled in Proton cars to the mechanics or foremen at all Proton dealerships. The expertise provided by the system includes problem identification, analysis and solution. Current scenario that happened in service centre or at any dealership workshop is they still don't have a proper system to share and keep the knowledge of expertise so that the knowledge can be reused by others as well as can be retained in the company for future use. Experts' mechanics that have highly experienced skills and non-experts mechanics that are still new and less experienced working together in a certain location to do services and repair any problems happened to the cars. However, there is time when the experts are not available and the non –experts don't have referees (experts) to be referred to about certain issues and then the problems arise. When non experts do not know how to fix things correctly, thus the mechanical faults will not being properly rectified thus leading to the creation of another fault which will significantly cause Proton customers to spend unnecessarily in getting their vehicle fixed. After recognising this problem matters, study had been conducted in order to produce a proper system that can be used as the knowledge sharing centre for the users at every level. Findings based on the survey and interviews had gave the system developer more ideas to further understand on the system functionalities and system development processes. Right after the development phase, the system had been tested by the users and the feedback was very impressive and there were few recommendations given by the users for the system improvements.

ACKNOWLEDGEMENT

In the name of Allah, Most Gracious and Most Merciful,

Throughout the development this project named Experts Knowledge Sharing System In Diagnosing Proton Car Engines, the author would like to grab this opportunity to show his gratitude to a group of people who has directly and indirectly supported as well as assisting him in every phases throughout the system development in order to ensure that the system can be delivered in the given time.

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ABBREVIATIONS AND NOMENCLATURES

SDLC	System Development Life Cycle
UI	User Interface
AI	Artificial Intelligent
VB	Visual Basic

CHAPTER 1
INTRODUCTION

1.1 Background of Study

The advancements in the Information Technology have helped to improve our lives economically and socially. In the manufacturing industry, the use of computer systems has helped manufacturers to manufacture products or goods more quickly and substantially, perform quality control more efficiently and track sales more precisely. Thus the information technology greatly helps manufacturers and other business people to earn substantial profit and improve their business activities. Apart of that, the information technology enables people to communicatewith others far beyond their reach and also allows them to spread information about an event or etc more quickly. Through internet, information can be channeled and shared in every corner of the world and this therefore helps to significantly improve one’s knowledge in various fields.

The automobile industry is not exceptional. There are many vehicle manufacturers nowadays that use computer systems to assist them in monitoring the quality of the vehicles being manufactured and to manage the sales of the vehicles or automobile parts. In addition, some automobile manufacturers install computer chips in their automobile products to help diagnose the vehicle problems. The application of information technology in the automobile industry, both in manufacturing and servicing has benefited various parties and it will continue to enhance the quality and performance of the vehicles from time to time.

The national car manufacturer, Proton is also using integrated computer system to help them manufacture good and high-performing vehicles of various models from sedan cars to pick-up trucks and vans. Although not as sophisticated as their competitors like Bavarian Motor Works (BMW), Mercedes Benz and Honda, the integrated system enables Proton to design powerful and reliable vehicles both for exports and local sales. Besides manufacturing vehicles, Proton appoints a large number of workshops nationwide to provide necessary vehicle check-ups or diagnosis services to almost all Proton vehicles. Proton vehicle owners may purchase Proton spare parts from these authorized workshops too from engine to suspension or body kit parts on sale.

Despite of its advanced technology in manufacturing and managing its product sales, Proton’s dealerships nationwide are still relying on the old method to diagnose the vehicle mechanical problems. The traditional diagnosis method to jack the vehicle up and listen to the noises of the engine in an effort to identify a particular fault has proven to be quite inaccurate and dissatisfactory at certain times. Some unhappy customers who brought their vehicles to Proton service centers for certain repairs or check – ups complaint about inefficient and ineffective diagnosis service which is provided to them by the service centers. Hence, certain faults are not being properly rectified and this has caused the customers to spend more to rectify improperly fixed faults. As the number of Proton customer increases day by day, it is essential for the national automobile manufacturing company to improve its after sales services so that it can stay competitive in the automobile industry and establishes a firm base in the market.

1.2 Problem Statement

As Experts' mechanics that have highly experienced skills and non-experts mechanics that are still new and less experienced working together in a certain location to do services and repair any problems happened to the cars. However, there is time when the experts are not available and the non –experts don't have referees(experts) to be referred to about certain issues and then the problems arise. When non experts do not know how to fix things correctly, thus the mechanical faults will not being properly rectified thus leading to the creation of another fault which will significantly cause Proton customers to spend unnecessarily in getting their vehicle fixed.

Other than that, in most cases observed, the inexperienced mechanics who diagnose a vehicle tend to perform a try and error kind of check-up due to lack of sources on fixing the car problems as well as the absent of expertise in helping them or guiding them. Therefore, due to their inadequate experience in fixing faults, such mechanics will look and adjust other parts of the vehicle in their attempt to repair a particular fault. This somehow will worsen the situation and lead to damages of the other parts of the vehicles and eventually bring the vehicles to an endless series of faults if it is not rectified properly.

Therefore, a diagnosis system is needed to help experts'mechanics to share whatever expertise and skills or the valuable data and information that they have so that the non-experts can refer to and then they canidentify car faults more precisely and rectify them efficiently. The scenario above has inspired me to develop an AI-driven car engine diagnosis system as my final year project to help further improve the technical services of all Protons' dealership nationwide.

As the automobile gets more competitive day by day, automobile companies such as Proton bhd. must formulate a more solid business strategy by considering the application of technology to boost its production line and customer service quality so that enable to sustain its competitive advantages and retain its customer loyalty while dominating the domestic market at the same time.

1.3 Objectives

The sole purpose or objective of this project is to develop an experts knowledge sharing diagnosis systemwhich allows the experts and non-experts to share the valuable tacit knowledge assets that they have and to simplify the task of the mechanics in diagnosis a particular car's fault and provide a reliable and accurate solution in rectifying a car problem. Through detailed graphical illustration of the problematic area or component of the vehicle on the computer screen, mechanics will find it easier to locate the fault of the vehicle and fix the problem immediately based on the most probable solution provided by the system.

1.4 Scope of study

Since there are many divisions which a mechanic can diagnose in a vehicle like the vehicle's suspension, engine, body kit, electrical system, wheels or tires and others, therefore the project will focus entirely on developing the car engine diagnosis system for Proton's present car models. Proton has manufactured numerous car models over 30 years since it was established in 1984. The models include:

No.	Proton Car
1	Proton Saga
3	Proton Wira
4	Proton Perdana
6	Proton Waja
8	Proton Gen-2
9	Proton Savvy
10	Proton Satria Neo
11	Proton Persona
12	Proton Saga
13	Proton Exora
14	Proton Inspira
15	Proton Preve

Table 1.1: List of Proton's Car Models

Like most car manufacturers, Proton also manufactures its cars with either the manual or automatic transmission. Furthermore, most of the models described above are being manufactured with different type of engines and horse powers. Such engines which are being installed in Proton's cars include Mitsubishi 4G93 1.8CC, 4G13P 1.3CC, 4G15 1.5CC and Campro. Certain models of the car like Proton Putra, Proton Satria and Proton Perdana are modified to cater to the demand and interest of some of Proton's customers who fancy high performance fast cars or luxury driving.

With the engine as its primary diagnosis component, this system development will focus and assess the core areas and components of the engine such as:

- Ignition system [12] – spark plugs, injection, coil and distributor.
- Intake system – crankshaft, cylinders, pistons, rocker arm intake valves.
- Exhaust system – flywheel, timing belt, exhaust valve.
- Cooling system [13] – radiator, water pump, coolant hoses, fan and motor.

In identifying the right fault and ultimately providing the appropriate solution, the system will analyze a particular problem by certain rules and split a fault into a more specific and detailed cause. A sample of the system analytical method is illustrated as follow [14].

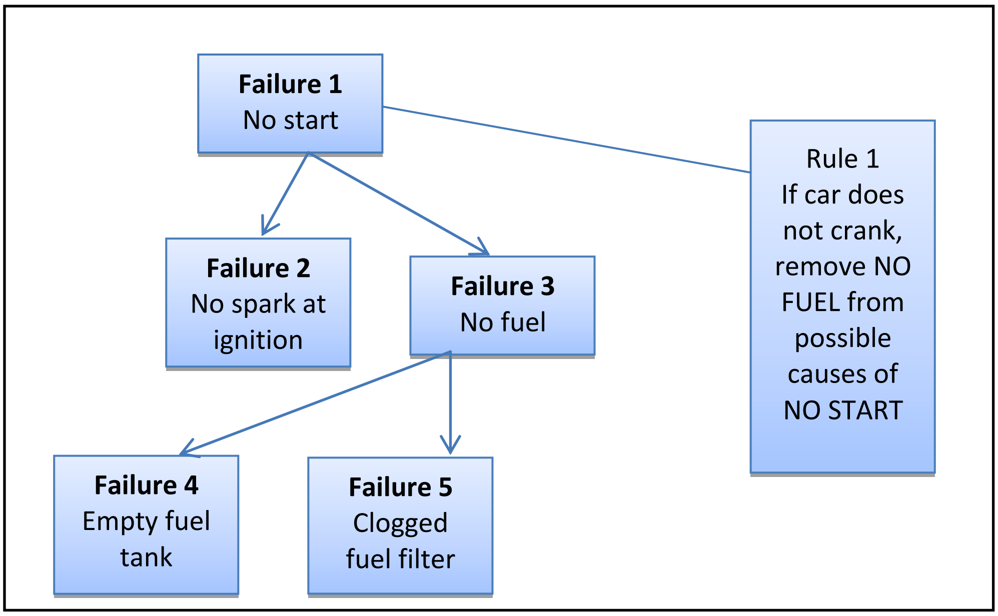


Figure 1.1: Problem analysis diagram

CHAPTER 2
LITERATURE REVIEW

2.1 What is Knowledge Sharing?

The study of knowledge sharing has its roots within the technology transfer and innovation literature. The research in this area has focused on explanations for different nations' successes or failures in fostering economic growth through technological development. While some theorists argue that high investment rates in physical and human capital drive national innovation and growth rates [1], 'assimilation theorists' instead argue that entrepreneurship, effective learning, and innovation are separate, but equally important variables affecting development [2][3]. Central to both approaches, nonetheless, is an understanding of the importance of the sharing of ideas.

Knowledge sharing has also become an important focus in the strategic management field, where knowledge is seen as "the most strategically-important resource which [organizations] possess," [4] and a principal source of value creation, [16]. Indeed, "in many industries, the importance of developing abilities to better utilize the knowledge contained in the firm's network has become apparent...Benchmarking has demonstrated the potentially great benefits of best practices transfer. Instances of failure in downsizing, on the other hand, have revealed the costs of losing knowledge. Empowerment and globalization have created local knowledge with 5potential for utilization elsewhere, and information technology has given individuals increasingly differentiated knowledge, unknown to [the] head office," [7]. Moreover, the very basis for some organizational activities is the sharing of knowledge both between units and with outside partners and clients.

2.2 Expert System (ES)

ES become so popular among the developers due to its easy understanding approach. ES direct application of expertise where the expert knowledge is transferred into computerized system to assist non-expertise user to conduct the similar task that conducted by the expert. However, ES do not replace the expert in the particular field but can make their knowledge and experience more widely available [6]. In addition, the computer based ES also view as a viable alternative from other model especially statistical model for decision making in the fields of finance, accounting and marketing [9].

Human experts are able to perform at high level because they know a lot about their area of expertise. An expert system, for example uses knowledge specific to a problem domain to provide 'expert quality' performance in that application area. Generally, expert system designers acquire this knowledge with the help of human domain experts, and the system emulates the human experts' methodology and performance.

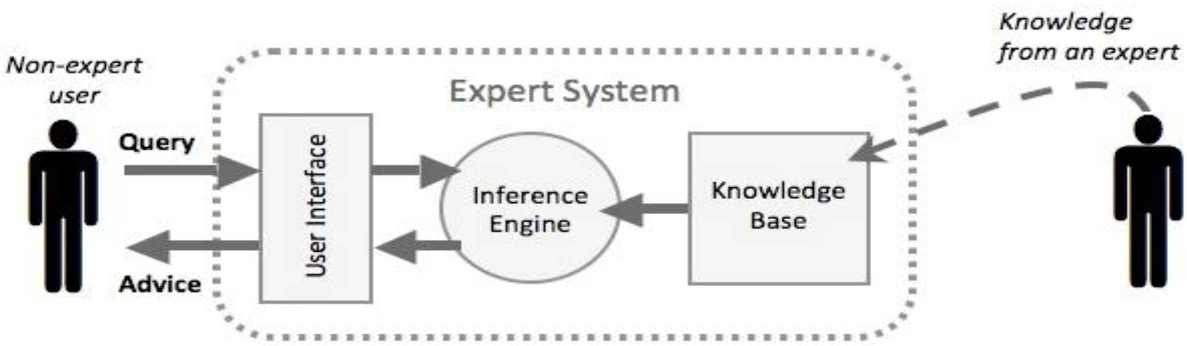


Figure 2.1 how an expert system works

As with human skilled, expert systems tend to be specialists, focusing on a narrow set of problems. Also like humans their knowledge is both theoretical and practical: the human experts who provided the system's knowledge have generally augmented their theoretical understanding of the problem domain with tricks, shortcuts, and heuristics for using the knowledge they have gained through problem solving experience.

2.3 Expert System Characteristics and Structures

Based on [7], Expert systems differ from the common conventional systems and have distinctive characteristics, which differentiate them from classical computer systems. It is designed to have the following general characteristics.

- High level Expertise – this is the most important characteristic of an expert system. This expertise can represent the best thinking of top experts in the field, which can lead to problem solutions that are imaginative, accurate and efficient.
- Adequate response time – system must also perform the solutions problem in a reasonable amount of time which is comparable to or even better than the time required by an expert to solve a problem.
- Flexibility – the system also need to have efficient mechanism for modifying the knowledge base as the system might have a large amount of knowledge that an expert may have.
- Symbolic reasoning to a problem – expert systems represent knowledge symbolically as sets of symbols that stand for problems concepts that an expert has. All these symbols can be combined together to express the relationship between them and when they are represented in a program, they are as symbol structures. For example, Assert: Farid has a headache Rule: IF person has headache THEN take medicine. Conclusion: Farid takes medicine.
- Reasons Heuristically - Experts in specific field are adapting at drawing on their experiences to help them efficiently solved some current problem. Example of typical heuristic knowledge used by experts:

- I always check the blood type first
- There is always traffic jam around 5pm
- If I suspect diabetes, then I always check the family history

- Mistakes – Expert system can also possible to make mistakes and since the knowledge of expert have to be captured as close as possible in expert system, like its human counterpart, it can make mistakes as well. [7]

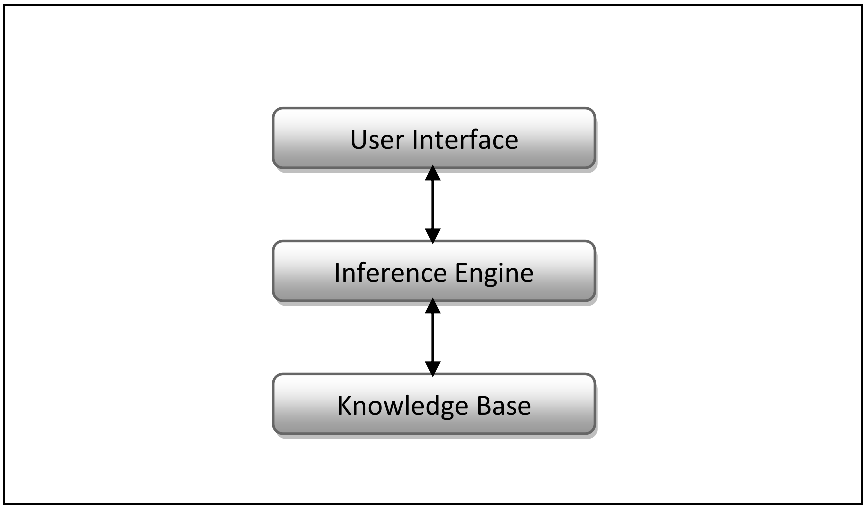


Figure 2.2 Basic Structure of Expert System

Figure 2.2 shows the typical structure of an expert system is developed based on three major components which include the user interface, inference engine and knowledge base [6]. The user interface is the interface between the systems with the users. The inference engine and knowledge are separated because the reasoning mechanism need to be as stable as possible and the knowledge must be able to grow and change as knowledge is added.

A user uses the user interface to communicate with the system by inserting input or viewing the output. The inference engine is where all the reasoning is done during processing the request by the users. The inference engine will retrieve the knowledge or the rules that store in the knowledge base. The figure below however shows a more detail and richer description of the typical expert system.

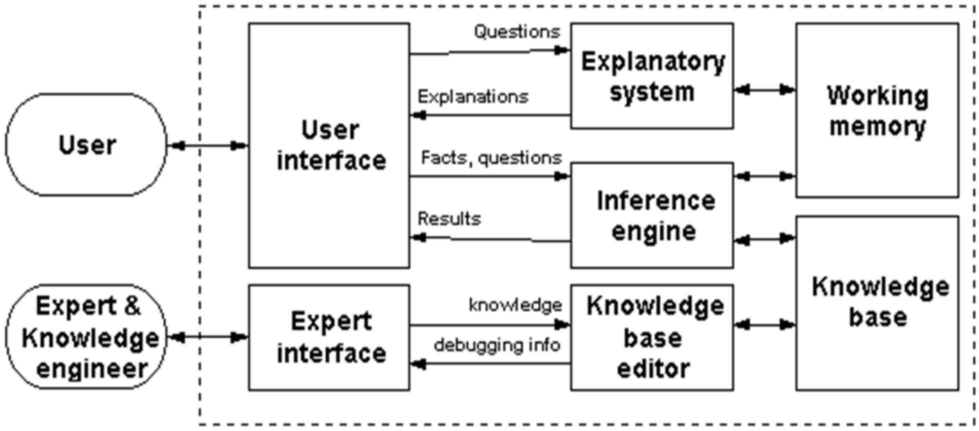


Figure 2.3 Details of Expert System Architecture

Based on the figure above, knowledge based also called as the heart of expert system contains the entire relevant, domain specific, problem solving knowledge gathered by knowledge experts through expert interface and knowledge based editor. To represent this knowledge depends on its nature. In this case, the knowledge is heuristic which is most naturally expressed as rules [5].

Inference Engine works as interpreter of knowledge in knowledge based. It examines the contents of knowledge based and accumulated input data about the current problem and infer (derived by reasoning) the conclusion.

3.4 Closely related work

A project paper entitled “An expert system for engine fault diagnosis:development and application” discussed on a project that is related to Expert Knowledge Sharing System in Diagnosing Proton car engines. This project was an expert system application for automotive engines. A new prototype named EXEDS (expert engine diagnosis system) has been developed using KnowledgePro, an expert system development tool, and run on a PC. The purpose of the prototype is to assist auto mechanics in fault diagnosis of engines by providing systematic and step-by-step analysis of failure symptoms and offering maintenance or service advice. The result of this development is expected to introduce a systematic and intelligent method in engine diagnosis and maintenance environments.

EXEDS is concerned with the general and most common gasoline engine failures that can be diagnosed offline. Given a concrete problem for a specific engine, the system is quite flexible to modify, so the database can contain specific design information such as valve clearance, thermostat opening temperature range, or pollutant content of the exhaust gas. Such engine specifications can be used in the diagnosis knowledge base and the system can refer to them under execution. Primarily, the system is equipped with user interface facilities, where the user interacts with the system through windows and menus. The user is provided with various types of window that fulfill a variety of functions:

- Show the list of possible symptoms;
- Serve as information inputs in response to the system queries;
- Provide on-line explanations;
- Provide diagnosis result(s);
- Provide recommended actions to cure the problem;
- Provide graphical illustrations of engine systems.

The knowledge base module, formulated using IF-THEN rules, is mainly founded on experience basedknowledge in the maintenance environment. It containssymptom-hypothesis relations corresponding to the levelof search in the search tree. The search for a fact is pre-dominantly performed using a depth strategy assisted by heuristics that systematically guide the search path considering the most likely conditions. Different types of rules were used to make the diagnosis. These rules were structured in such a way that the system could consider four aspects:

- How to search for new symptoms;
- How to access a node in a decision tree;
- How to establish a diagnosis;
- How to make recommendations about the repair action needed.

The sample rules given elaborate the rule base was constructed to accomplish the four tasks.

RULE 1 IF *`Fuel flow at filter inlet' is YES and `Fuel flow at Carburetor jet' is NO, THEN search is Filter upstream.*

RULE 2 IF *`Several cylinders show low pressure under compression test' and `two consecutive cylinders show low pressure', THEN fault is `The cylinder head gasket is blown' and recommended action is `Remove cylinder head and re- place the gasket'.*

The system starts from a given or known failure symptom. Possible causes are then identified by generating different hypotheses that suggest the likely component failure or cause for the observed symptom. The triggered hypothesis is then proved through tests until the leaf node (failed component) is reached. This hierarchy from the root node(engine) can be listed as follows (see also Fig. 2.4):

- Engine type level
- Symptom level
- Hypothesis level
- Test level
- Cause and fault level
- Solution and action level

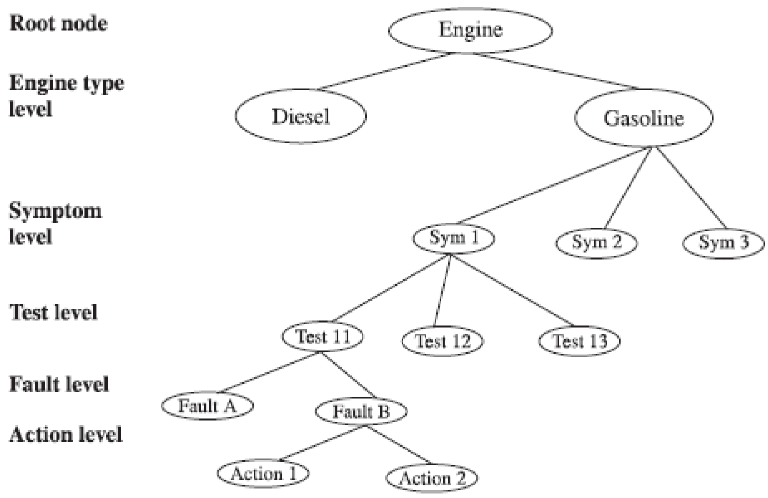


Figure 2.4: *General structure of decision tree in EXEDS: Sym1 could be engine does not rotate when attempting to start; Sym2 could be engine rotates but will not start.*

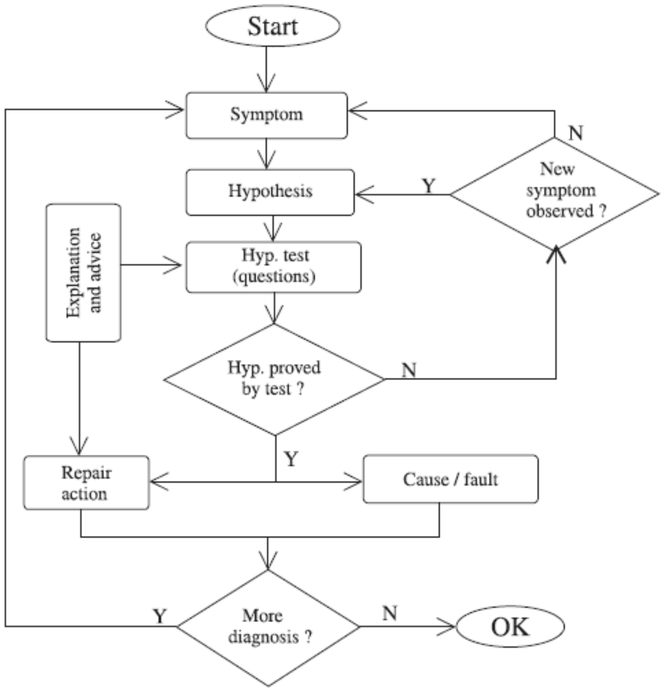


Figure 2.5: *Flow chart for knowledge representation process.*

The overall strategy and methodology for acquiring the necessary knowledge and encoding the knowledge base are progressive developments of a decision tree, hypothesis generation and testing through question sets. The question sets require direct answers from the user (based on his or her previous understanding of the problem) or interactive checking, measuring or testing of certain engine performance parameters. Depending on the responses, the system arrives at a justification of the hypothesis or selects a search branch where a new symptom or a new hypothesis is generated. The rule base development and the line of reasoning are shown by a flow chart in Fig. 2.5.

Figure 2.6 shows the EXEDS system application working prototype. As illustrated, this new prototype can assist engine diagnosticians and other users in following a systematic diagnostic strategy using the symptom lists, the necessary explanations, the advice and the illustrations included in the system.

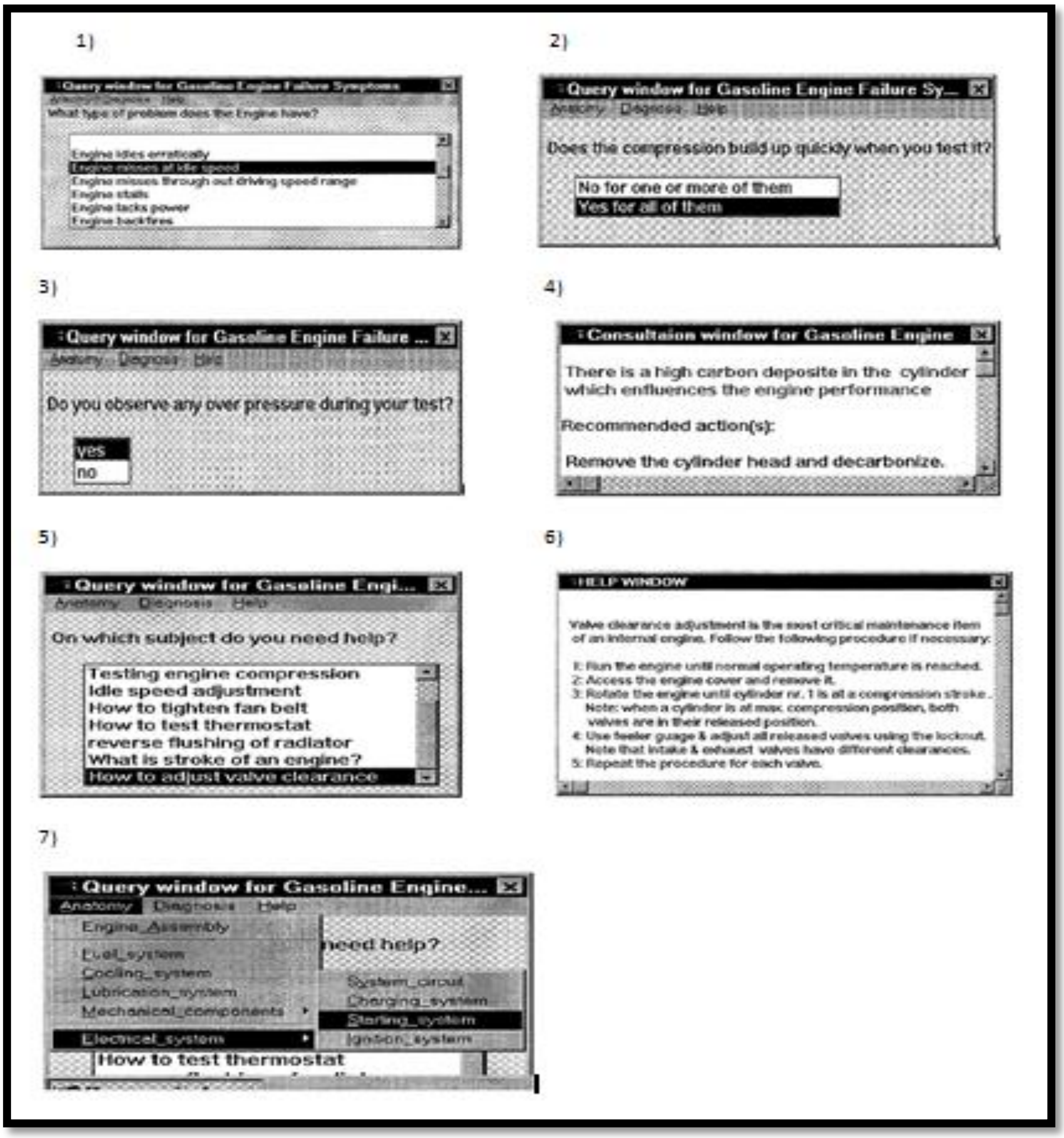


Figure 2.6: EXEDS system application

The system able to provide both low-level and expert assistance in fixing engine malfunctions; it is expected to change the traditional techniques of engine diagnosis and maintenance to something both systematic and intelligent.Apart from keeping and delivering a consistent diagnosis expertise of experienced mechanics, the system is also believed to contribute to safe operation and economy in maintenance work.

CHAPTER 3
METHODOLOGY

3.1 System Development Life Cycle (SDLC)

Ideally, a need of some kind starts the process and a complete system is its result. Moreover, the system development is regarded as a very delicate and orderly approach to making a system a reality. Therefore, a methodology is needed to provide a structure to system development.

Before proceeding with the system development, an appropriate System Development Life Cycle (SDLC) had been constructed for the system. The SDLC consists of four phases which are Planning, Analysis, Design and Implementation (PADI) that lead to a developed system [9].

The table 3.1 below indicates the phases of the system development as well as the corresponding activities:

Table 3.1: Development phases

Planning	• Feasibility study
Analysis	• Knowledge validation • Knowledge representation • Knowledge acquisition
Design	• System architecture construction • Decision tree formulation • Symptom programming
Implementation	• Interface development • Coding

3.2 Planning

Project milestone as well as Gann chart had been designed in order to make sure the project development follows the right timing limitation based on the duration allocated for the completion of the project. Project milestone shows the allocation of activities that need to be completed within 10 months duration starting from the project topic proposal until the submission of the final report. Project Gann chart however shows the task completion that need to be followed accordingly by the number of weeks allocated for each task for the development phases starting from planning phase until testing phase. Both project key milestone and project Gann chart can be referred in the Appendix of this report.

3.2.1 Feasibility Study

This phase involves identifying the possible opportunities through environmental scanning. Hence, feasibility study had been conducted toaddress and identify the problems that prompted the needs for the development of the diagnosis system. Initially, significant problem that Proton encounters is its inefficient traditional diagnosis of its manufactured engines as mentioned in the reports introduction. The growing numbers of complaints from its valuable customers regarding the inefficiency and inaccurate diagnosis have signified the need for a robust and accurate computerized diagnosis system.

The following charts indicate the survey result obtained from around 20 experts and non-experts mechanics of Proton Service Centre Seri Iskandar Tronoh as well as few other Proton dealership workshopsaround Seri Iskandar asking them regarding the current system that they have implemented for knowledge management as well as their responses to the new proposed knowledge sharing system that can be implemented in their workshops.

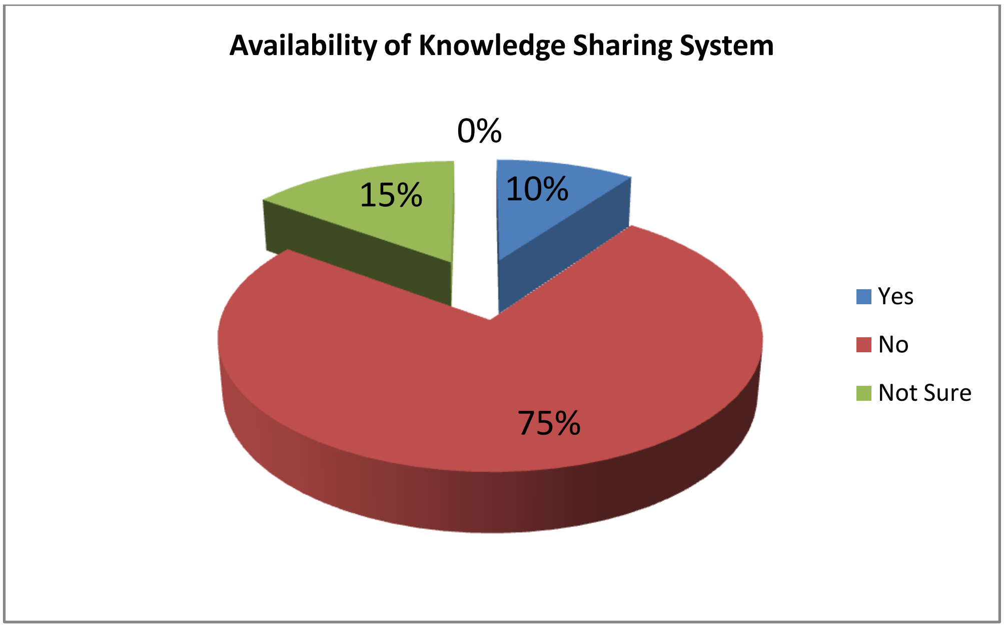


Figure 3.1: Knowledge sharing system availability

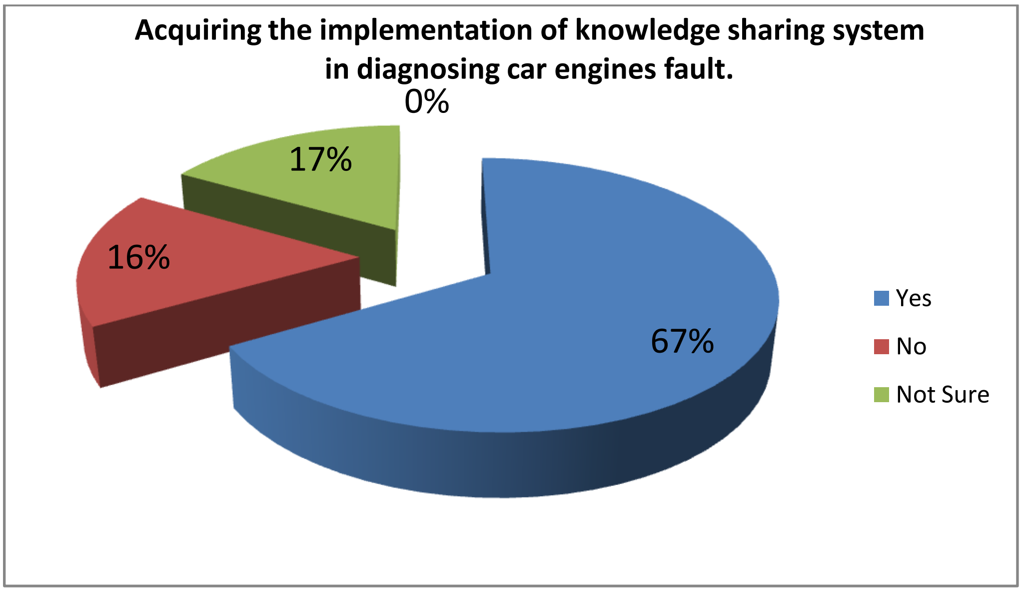


Figure 3.2: Employee responses on the new system proposed

Based on the two figures above, we can conclude that most of the numbers of respondent really interested on the implementation of the new system. They really want to have a proper system where they can share and obtain the knowledge on car diagnosis easily without asking the experts all the time. Figure 3.1 shows us most of the workshops haven’t implement knowledge sharing system into their workshop and they are just using traditional way to share the knowledge.

Figure 3.2 then shows that more than half of the respondents want the new knowledge sharing system being implemented into their workshop so that the expert mechanics can share their knowledge expertise on the fixing faults of the car engines through the system and the non-experts can easily assess the information and knowledge through the system.

3.3 Analysis

3.3.1 Knowledge Acquisition

Since the system needs some information or knowledge from the experts to be kept into the database for the testing processes, the system developer had done some research and interview session to acquire the right knowledge input. Knowledge acquisition is not an easy task. It includes identifying the knowledge, representing the knowledge in proper format, structuring the knowledge and transferring the knowledge to a machine [10]. Moreover, part of successful knowledge acquisition involves developing a positive relationship with the expert [11]. In this part, system developer responsible to create a right impression, positively communicating information about the project, understanding the expert's style and preparing session.

During the period of knowledge acquisition, several interviews or consultation sessionshad been setup or with the Proton's Chief of Technician at one of the Proton's authorized service centers in Perak. Face to face interview is very helpful as it enables direct interaction with the knowledge expert and get a thorough and elaborated explanation on some of the mechanical problems that occur in several Proton engines.

The following is an excerpt of one of the interviews I have previously conducted:

E: Expert

KE: Knowledge Engineer

E: I understand that you are somehow going to try to capture my knowledge about vehicle engine diagnosis for Proton's cars.

KE: Yes, indeed! Thanks a lot for spending time with me, Puan Siti Saniah. You are the service advisor of this workshop that has been the service center of Proton for quite sometimes. I am very certain that you know very well about the typical problems in Proton's engines. Can you briefly explain to me on some of the frequently occurred problems?

E: well, the most important thing you need to understand is that different engine models have relatively different kinds of problems and require different type of diagnosis. The most regular problems that occur in most Proton engine as far as I am concerned is the misfiring of engine.

KE: what actually distinguishes one model from the other? Is it the ignition system?

E: Indeed it is. Carburetor-powered engines operate differently than injection- powered engines and the problems are somewhat different in each type of engine. During its early years, Proton had mostly manufactured and engineered carburetor-powered engines. It only began to manufacture injection engines when it introduced the Proton Wira models.

KE: Can you tell me about the primary systems that drive the engine?

E: there are four precisely. One of them is the ignition system that burns and blows off gasoline, the compression system that produces the power needed to get the engine moving and remove excessive gasses from the combustion chamber, the cooling system that cools down the engine and lastly the fuel system that supply fuel constantly to the engine.

Besides conducting interviews with the engine experts, I also conducted some research on the existing diagnosis system. Doing so greatly helps me to gain some insight about the architecture of an intelligent system.

3.3.2 Knowledge Verification

After collecting and eliciting the knowledge from the experts, a knowledge engineer would need to verify the knowledge first before incorporating them in the knowledge base. The three significant processes used in validating knowledge are:

- Evaluation is performed purposefully to assess an expert system overall review [11].
- Validation is about building the right system which is substantiating that a system performs with an acceptable level of accuracy [11].
- Verification is related to ensuring the system is correctly implemented to its specifications [11].

In order to perfectly and thoroughly verify the knowledge that had been gathered, several measures of validation had been used as illustrated in the following table 3.2:

Table 3.2 Evaluation Criteria

Measure/Criterion	**Description**
Accuracy	How well the diagnosis expert system reflects reality and how correct the knowledge is in the knowledge base.
Adaptability	Possibilities for future development or changes.
Usefulness	Relevant or related to how adequate the knowledge is for solving correctly.
Face validity	Credibility of knowledge.
Depth	Degree of detailed knowledge.

3.4 Design

3.4.1 System Architecture

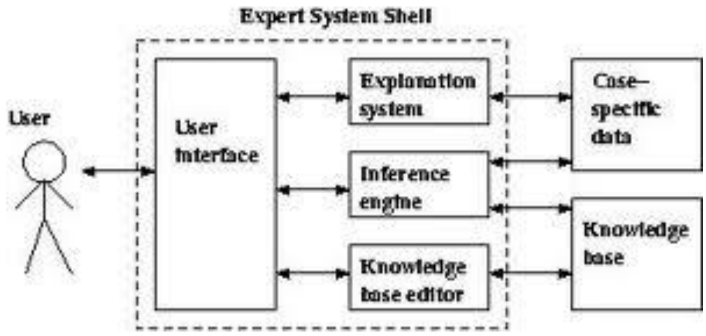


Figure 3.3: Proton Engine Diagnosis System Architecture

To easily understand the operation and process flow of a decision support system, one should analyze and observe the structure of such system. The system architecture illustrated above does that, providing the users and everyone else the general view of the system along with its primary functional components. As shown by the layout, the end user of the system will interact with the system through the User Interface (UI). Being the backbone of the system, the Knowledge Base (KB) stores and provides the essential data required by the system to process and presented to the user. In addition, the knowledge from the system is collected from mechanic experts, specialized books, from different car websites. As a rule-based shell, Visual Basic Studio 10, stores the knowledge in rules which are logic-based structures [6].

The inference engine on the other hand is the processing medium of the system in which the Inference Engine will make inferences by deciding which rules are satisfied by facts stored in the working memory and executes the rules with the highest priority and proposes proper correction solution. The rules whose patterns are satisfied by facts in the working memory are stored in the agenda part of the inference engine. To describe and further explain a particular solution or reasoning, another mechanism is developed known as Explanation System. This component illustrates to the user how and why the system gave a certain cause of failure for instance, it explains the reasoning of the system to the user. Apart of that, it also interacts with the Inference Engine for further processing.

After processing and reasoning of a particular problem, the Inference Engine will deliver the result to the user through the User Interface (UI). In addition, the User Interface is represented as a menu which displays the questions to the user and the user answers with the specific right answers or either using Yes or No. Besides that, the user Interface also receives input from end users and delivers them back to the Inference Engine for necessary analysis and processing.

3.4.2 Symptom Programming

In designing the system architecture of Proton Engine Diagnosis Expert System, I have identified two types of rules which are commonly found in Artificial Intelligence namely the knowledge and inference rules. Knowledge rules or declarative rules state all the facts or relationships about a problem [15]. Inference rules or procedural rules on the other hand advise on how to solve a problem given that certain facts are known.

3.4.3 Formulation of Decision Table and Trees.

A decision table is a convenient way to organize information in a systematic manner. The decision table is normally built up by the problem (also known as the decision variables), the uncontrollable variables as well as result variables [11]. Table 3.3 shows the decision table containing some knowledge on diagnosing Proton car engines. The knowledge had been obtained from the interview sessions with the expert mechanics from Proton Car Service Centre, Seri Iskandar.

Table 3.3: Decision table for Proton engine diagnosis system

Problems	**Diagnosis (Uncontrolled variable)**	**Results**
Engine does not crank, and car does not start but fuel delivery is normal.	▪ Check whether battery is operational or not.	▪ Jump starts the car.
	▪ Check for bad connection.	▪ Clean corroded connection.
	▪ Inspect the starter gear.	▪ The starter gear is jammed if it is not free, otherwise the starter circuit is faulty.
The starter cranks but car does not start.	▪ Check for worn internal engine parts.	▪ If they are already worn out, replace them accordingly.
	▪ Check for compression's stability.	▪ Unable engine compression indicates low compression.
	▪ Inspect whether the fuel injection is functional or not.	▪ If it doesn't, it indicates that the fuel injection is faulty and requires repair.
	▪ Check the ignition system.	▪ If the ignition timing is incorrect, set the timing to specification.

	▪ Inspect the electronic system.	▪ If the system ID dysfunctional, fix the system accordingly. Otherwise replace the faulty parts as required.
	▪ Check and see for spark at plugs	▪ If there is not spark, replace the spark plugs.
	▪ Examine the choke for any mispositioning	▪ If it stuck, close choke manually and clean linkage. Otherwise, reset the choke.
The car starts but the engine vibrates roughly.	▪ Check for the worn piston rings.	▪ If they are worn out, repair or rebuild engine.
	▪ Check gaskets.	▪ If gaskets are functional, replace valve stem seals or valve guides.
	▪ Inspect for leaking head gasket.	▪ If it leaks, replace gaskets.

After constructed the decision table as stated in table 3.3, the decision tree diagram had designed in order for system developer to have a clear understanding and clear views on the processes of diagnosing the car engines. Figure 3.4, 3.5 and 3.6 shows the decision tree diagram of the car engine diagnosis. Each figure relates to one another and it starts with the symptoms happened to the car engines until way to diagnose the car engine problems and the symptoms can be different for different cars.

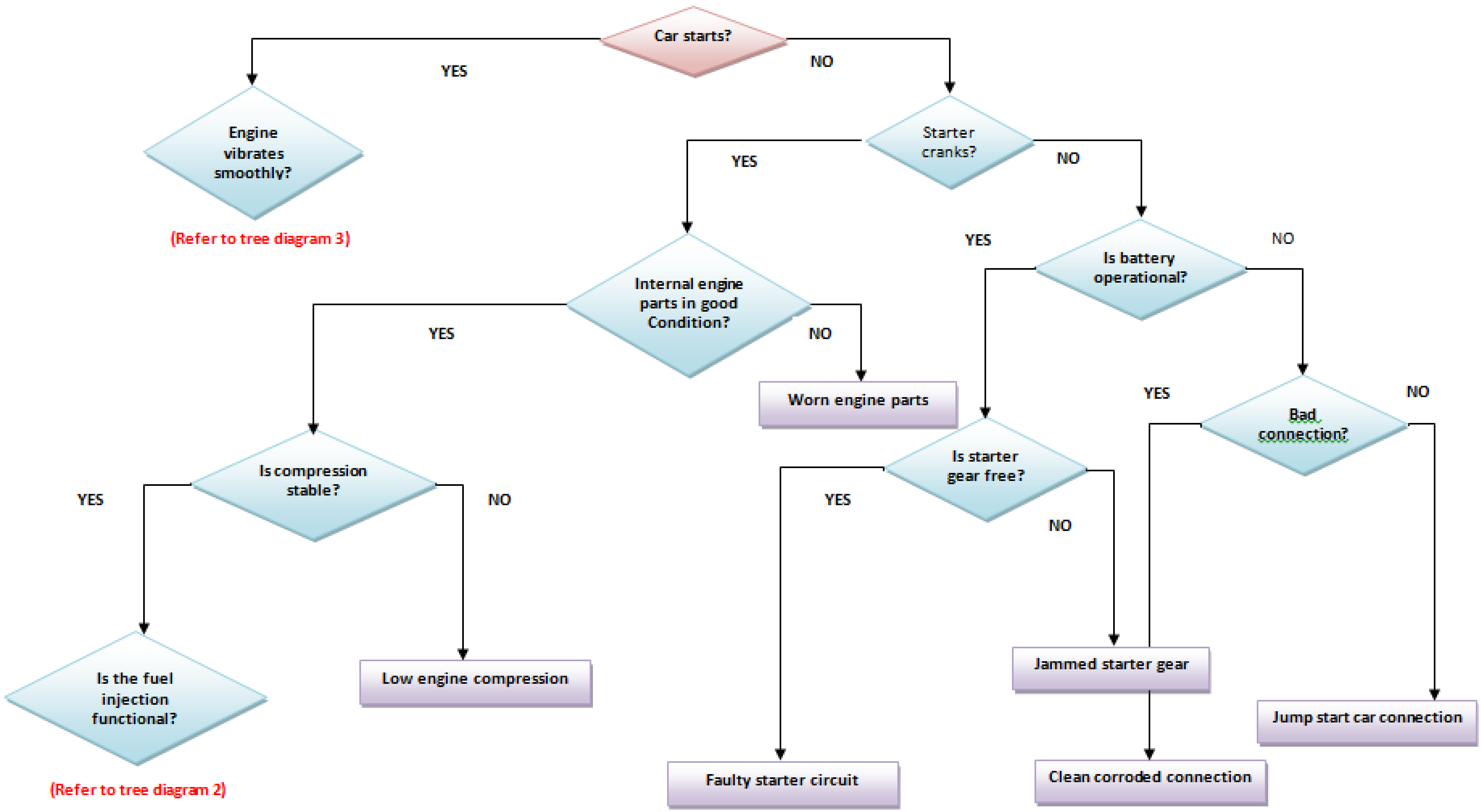


Figure 3.4: Tree Diagram on Car Engine Diagnosis part 1

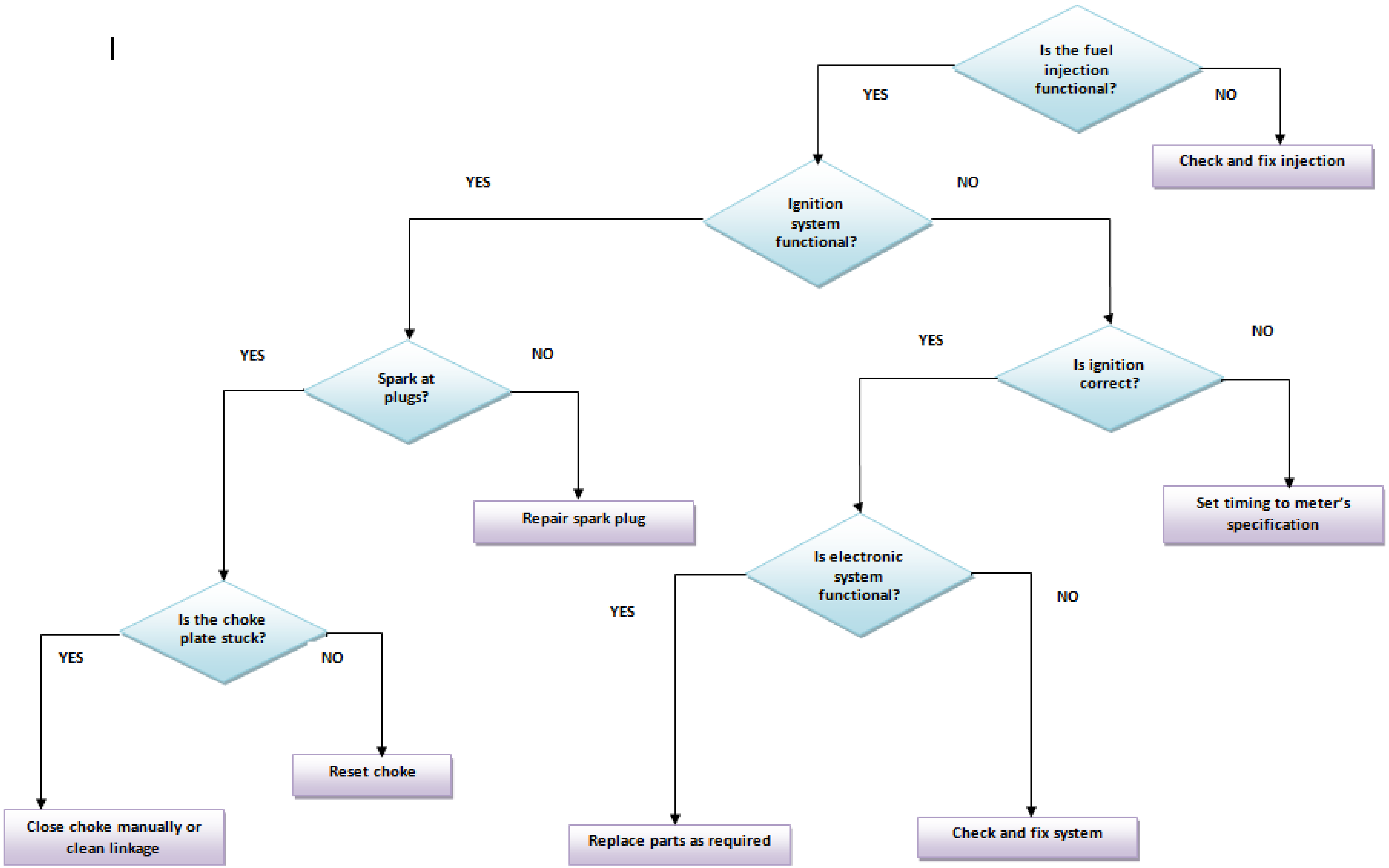


Figure 3.5: Tree Diagram on Car Engine Diagnosis part 2

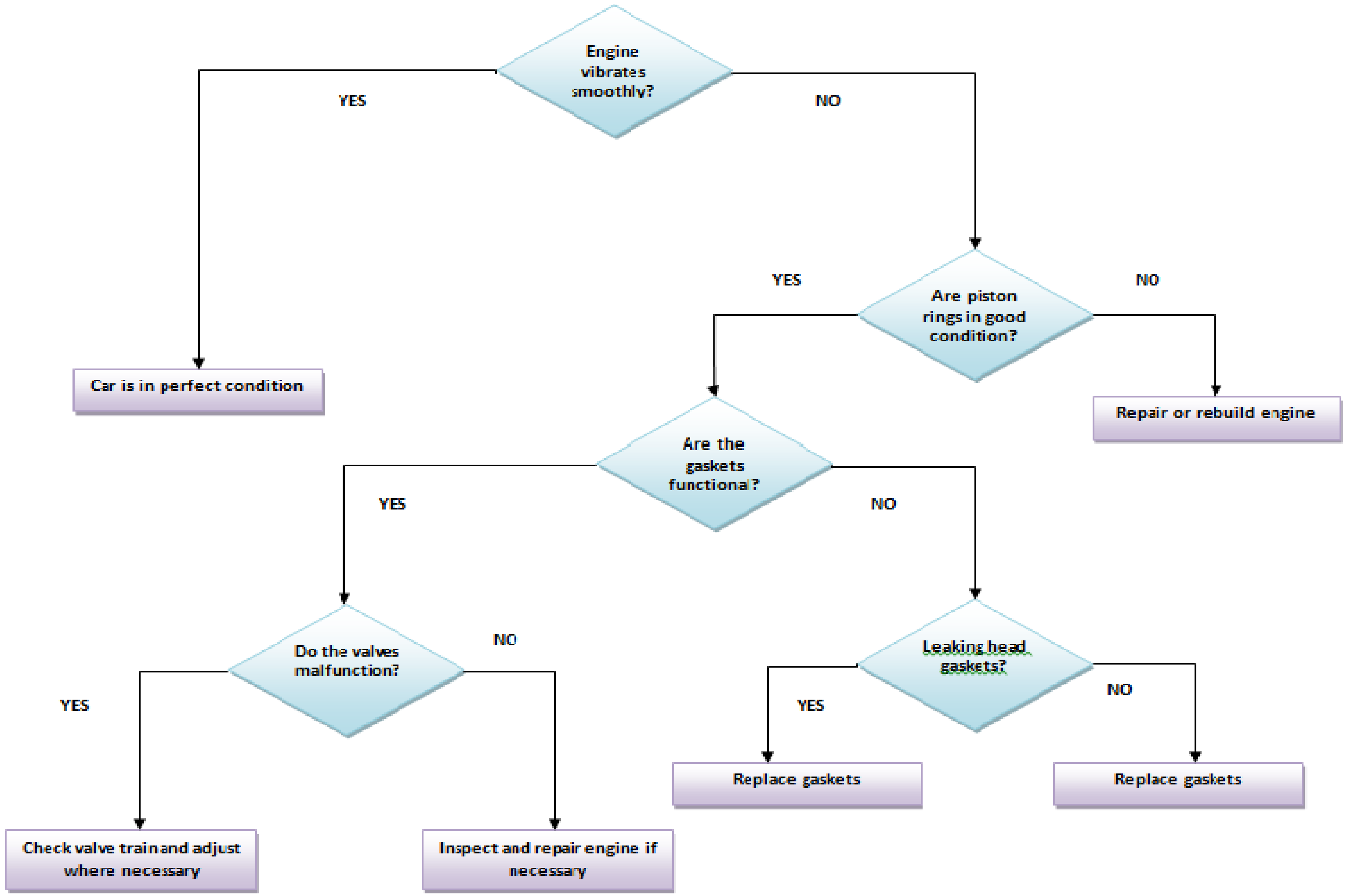


Figure 3.6: Tree Diagram on Car Engine Diagnosis part 3

3.5 Tools for system Implementation

3.5.1 System Interface Development tool

Figure 3.7 shows the system software that had been used to develop the Expert Knowledge Sharing System in diagnosing the Proton Car engines. It is called as Microsoft Visual Basic 2010.

Visual Studio 2010 is an evolution of the Visual Basic language that is engineered for productively building type-safe and object-oriented applications. Visual Basic enables developers to target Windows, Web, and mobile devices.

There are few factors that had led to the chosen of Visual Basic as the development tool. Among those includes:

- VB is a rapid application Tool to develop applications faster
- Flexibility in design time
- Debugging the source code
- .(dot) operator for objects to expose its properties and methods
- plug and play wizards to connect databases

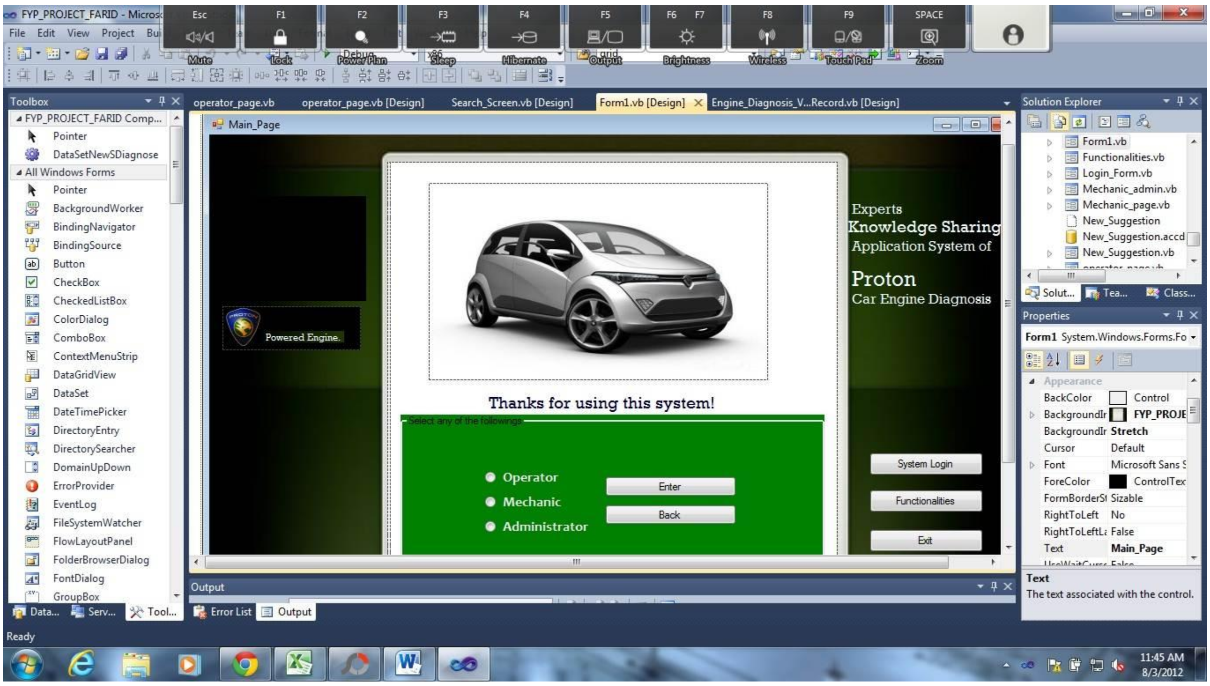


Figure 3.7: Microsoft Visual Studio 2010 as system development tool.

3.5.2 Database implementation

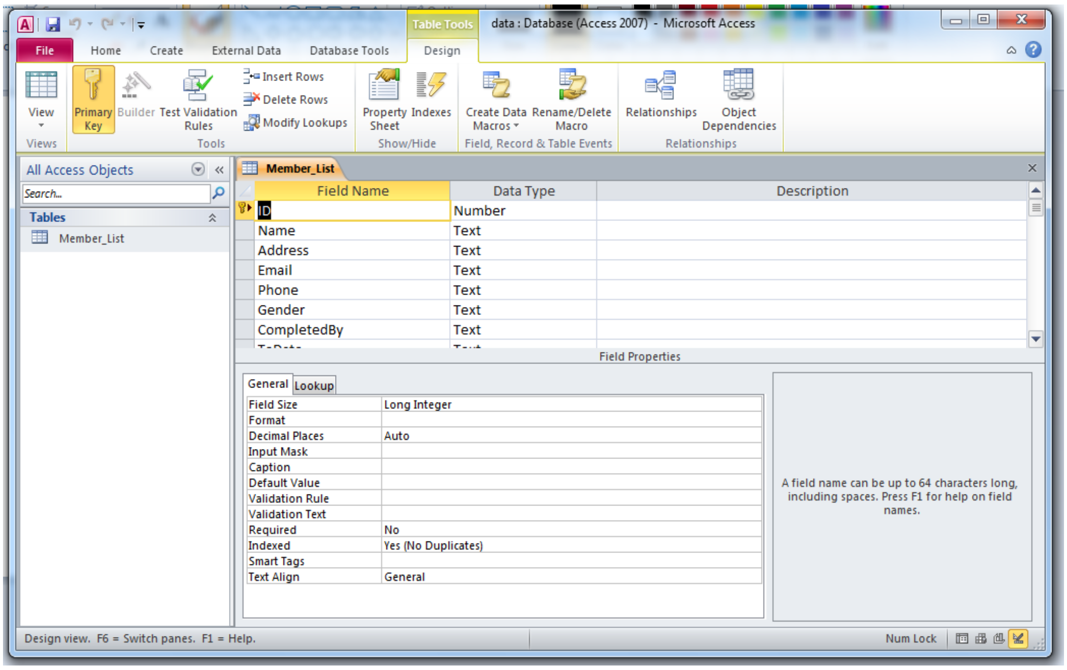


Figure 3.8: Microsoft Access 2007 as the database tool

Figure 3.8 shows the database software that had been used for the system data records. Microsoft Access, also known as Microsoft Office Access, is a database management system from Microsoft that combines the relational Microsoft Jet Database Engine with a graphical user interface and software-development tools. It is a member of the Microsoft Office suite of applications, included in the Professional and higher editions or sold separately. The current version of Microsoft Access 2010 was released by Microsoft in Office 2010; Microsoft Office Access 2007 was the prior version.

This project used Microsoft access as the database tool because of the less complexity to code the linking part of the system visual basic with it. Other than that, Microsoft access is easier to handle compared to other database tool like oracle and many more. As the capacity of access database might not be as huge as oracle database for example, maybe for future improvement, the system will change the database into oracle database.

CHAPTER 4

RESULTS AND DISCUSSION

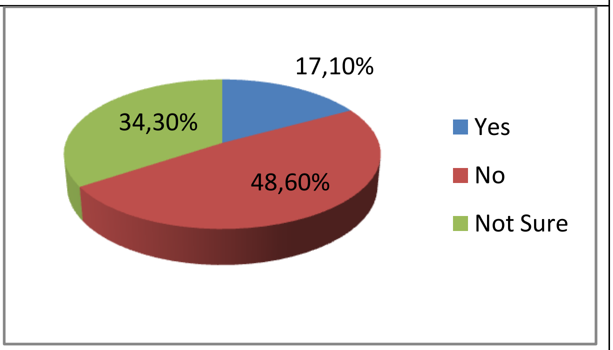
4.1 Findings and Analysis

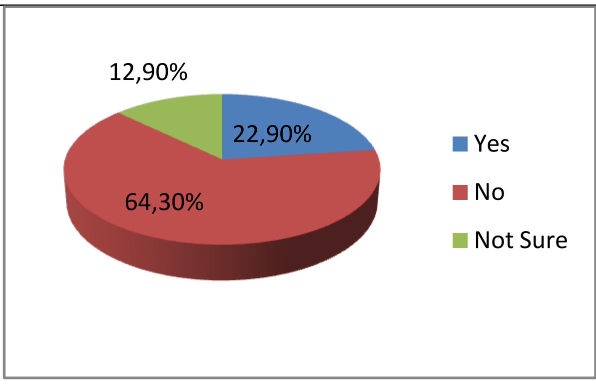
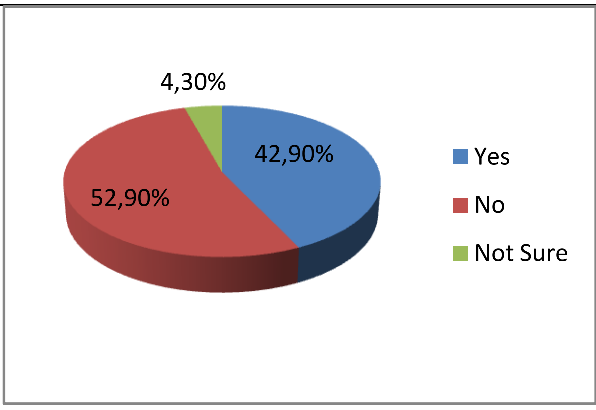
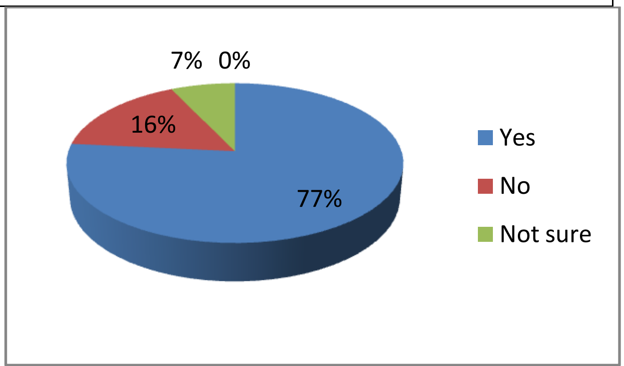
4.1.1 Result of the survey on Proton Car owners.

A survey has been conducted among the customers who came to the Proton Service Centre, Seri Iskandar, Tronoh Perak as well as few other Proton dealership workshops around Seri Iskandar areawith all kinds of car models. The selected workshops and service center haven't implemented any knowledge sharing system to their mechanics. The purpose of the survey was to study on the effectiveness and efficiency of the mechanics from the eyes of customers there as they were not using any knowledge sharing and knowledge management system while fixing the car. A sample from 15customer response has been captured.

4.1.2 View from customers toward the current traditional system used by the Proton Service centers in diagnosing the car faulty.

Table 4.1: Result for survey

Question	Result
1. Are you satisfied with the current service provided by the service center or the workshop in repairing your car?	

2. Some of new mechanics take long time to diagnose a car problem and they need to ask the expert to give them advice on certain part that they are not really sure. Do you like this situation to be happened?	
3. Are you okay to wait for a long hours for the mechanics to diagnose the car problem and then repair the car?	
4. Do you think Proton Service center or workshops need to have knowledge sharing system software which can be used tokeep diagnosis knowledge of the experts and the non-expert mechanics can just refer to the system when needed?	

Based on all the pie charts shown in table 4.1 above, it has already been verified that the most of the respondents who own a Proton car are not really satisfied with the current traditional system of diagnosing the car faulty. When there are no enough experienced mechanics in the department, the new mechanic with less experience will take over the job and they believed that the new mechanic who has no enough experience need to take long time to diagnose the car problem compared to the expert mechanics.

Apart from that, 77 percent of the respondents agree with the statement asking Proton to have an automated knowledge sharing system of diagnosing the car problems so that the new or less experienced mechanics can directly refer to the system whenever they have difficulties in fixing the engines. Thus, even though the experts are not around, the non-experts mechanics can still fix the problems easily. This can reduce much more work and at the same time can reduce lots of time.

4.2 Working Prototype of Experts Knowledge Sharing System

This part will discuss on the prototype functionalities and testing which consist of flow and processes throughout the system usage.

Figure 4.1: The Starting Page

The starting page is the first screen that appears when the system is being run. It prompts the user to login to the system or to know more about the system by clicking on the “Functionalities” button. User can also exit the system by clicking “Exit” button.

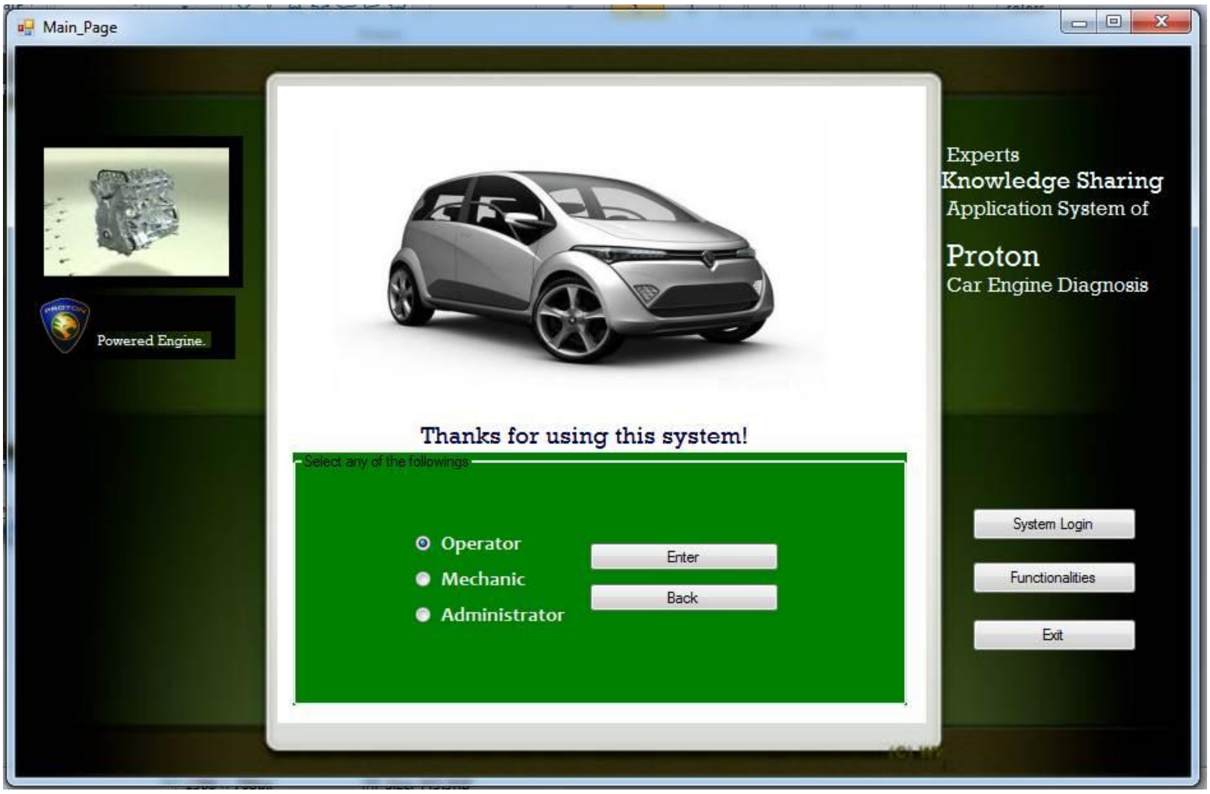


Figure 4.2: The Main Menu

In this section, the screen prompts the user to select any of the three roles namely "Operator", "Mechanic" or "Administrator". All of these three roles will have different access to the system. Mechanic here means the non-experts user or mechanics while administrator means the experts mechanics. "Back" button will terminate the page and go back to the main page. "Enter" button on the other hand will direct the user to the "Login" screen for the password input process.

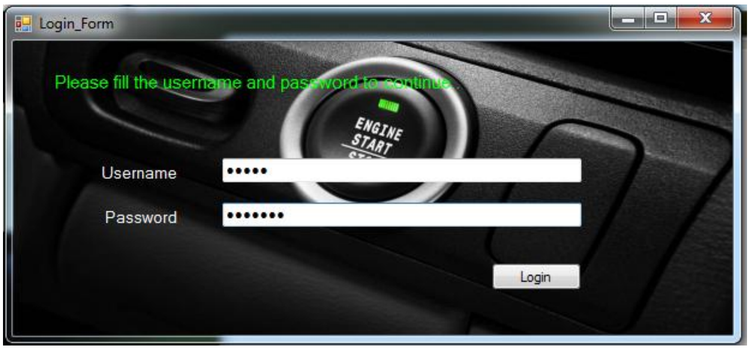


Figure 4.3: The Login Menu

The screen in figure 4.3 prompts the user to specify his or her username as well as his or her password. After user has completed all fields, the user will click on "Login" button and proceed to the next screen.

Figure 4.4: Operator Control Menu

The menu in the figure 4.4 shows the operator has the least access to the system. The user have the privilege of viewing the customer profile, adding new customer details or updating a particular customer profile. Since the operator is assigned to gather information from the vehicle owner pertaining to the vehicle engine problems, the operator therefore will deal with the customers most of the time as well managing the customer records in the system database.

The next figures which are figure 4.5 and figure 4.6 show how the system prompts the users in viewing the customers' details as well as to add new customers' details into the system database. User can update and delete the customers' details as well. The operator can also use the "search" button to search the information regarding the existing customers details captured into the database before.

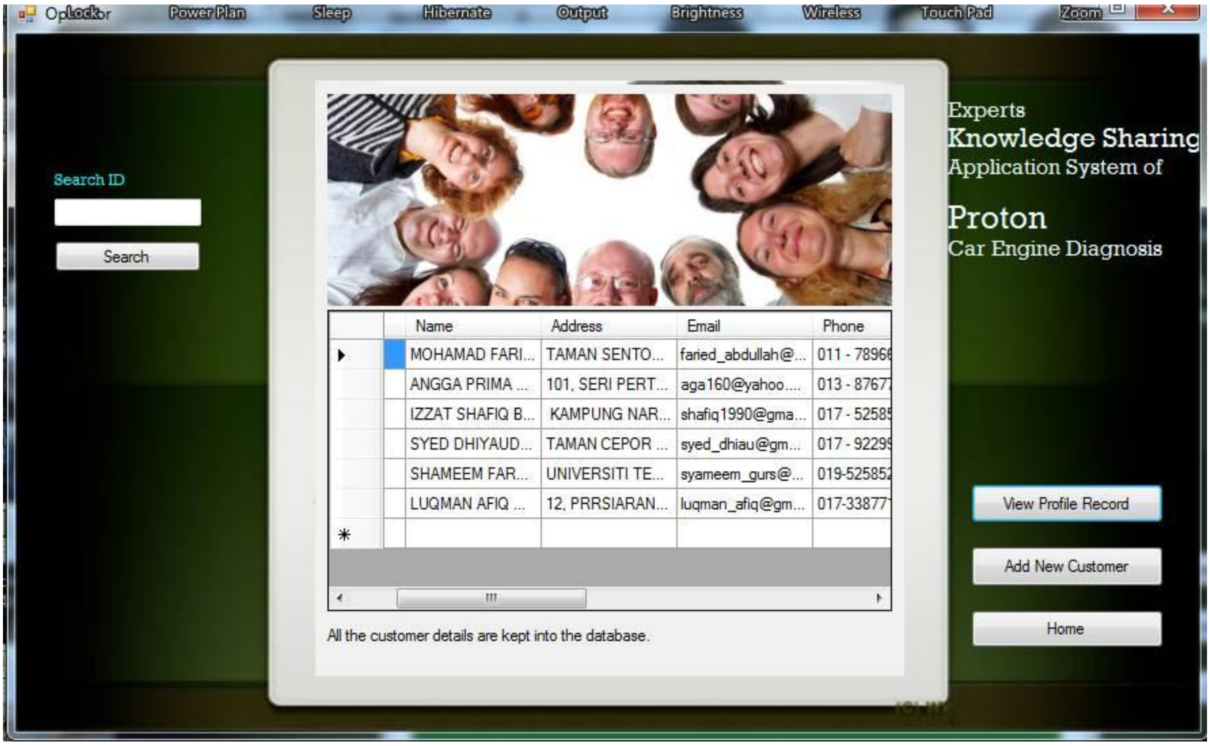


Figure 4.5: Viewing Customer's Profile Details

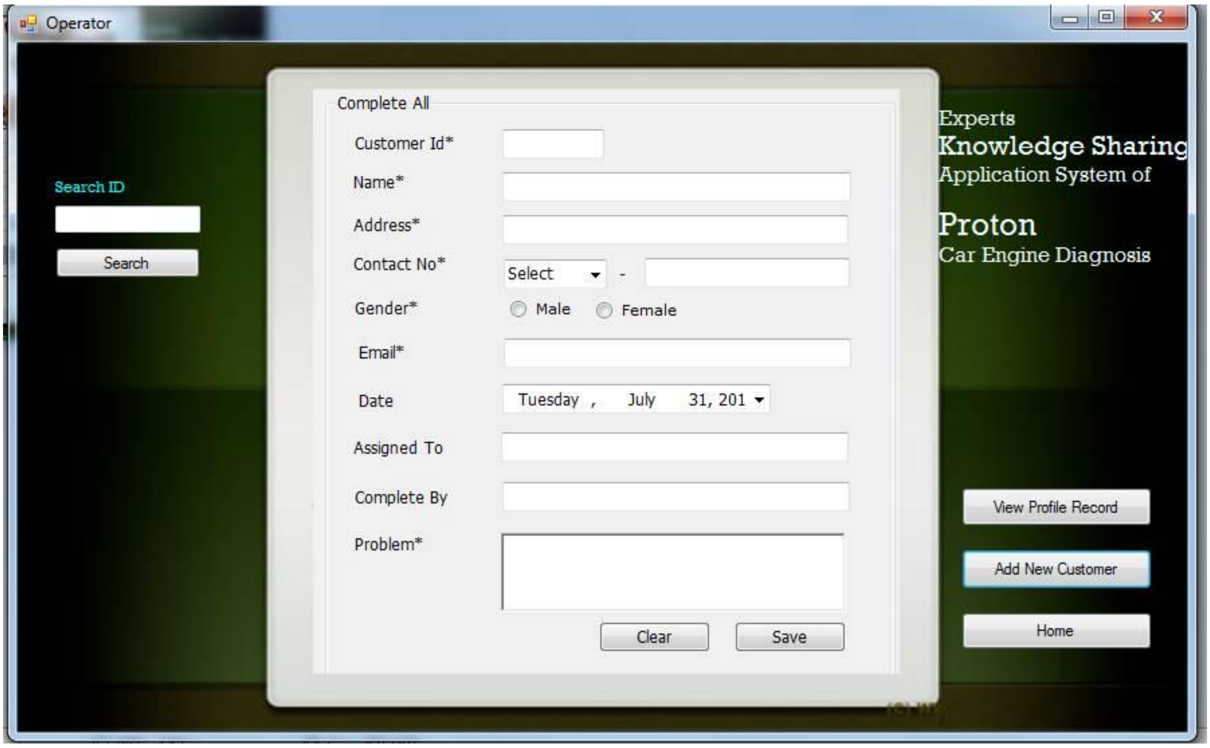


Figure 4.6: Add New Customer Profile Screen

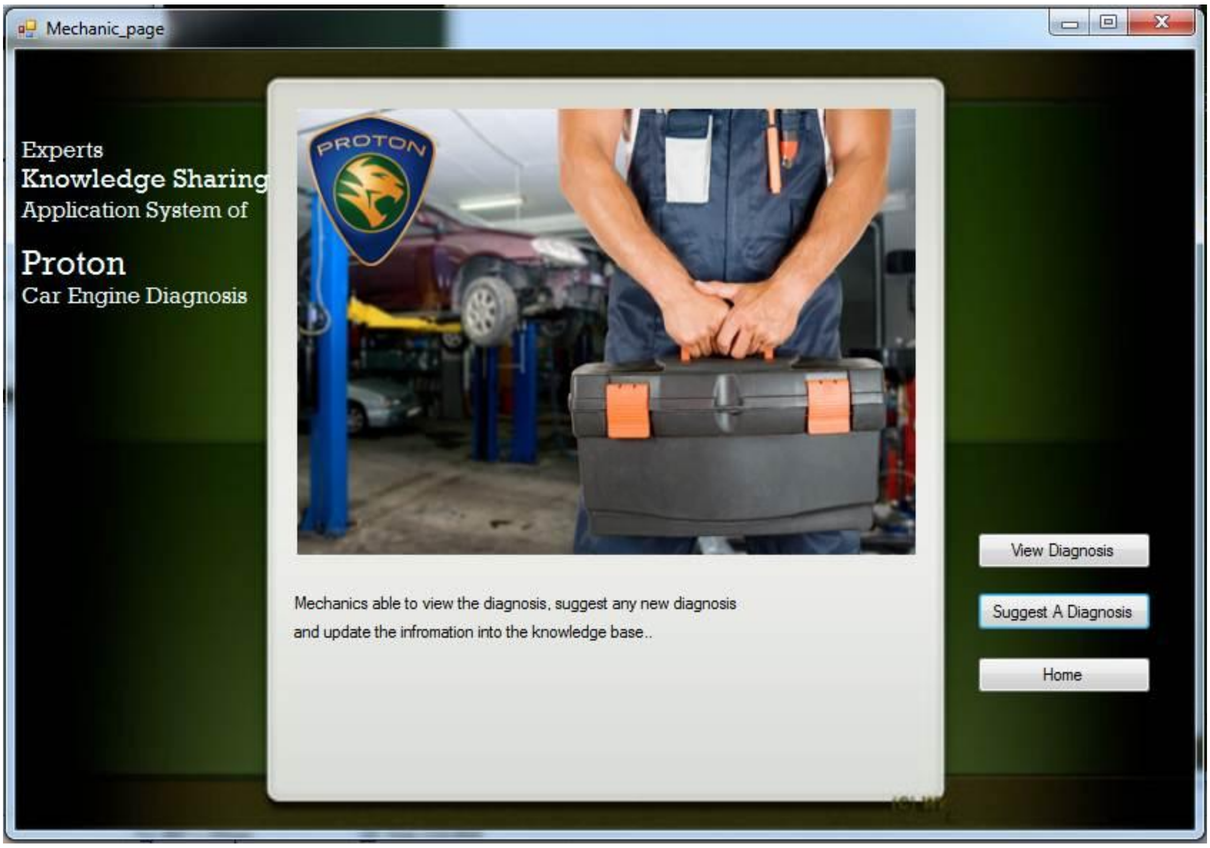


Figure 4.7: Mechanic Main Menu

The figure 4.7 above shows the main menu for mechanic with all of its privileges to add new suggestion to the system as well to view the existing diagnosis stored in the database shared by the experts' mechanics. Mechanics as the non-experts can add a suggestion of diagnosing certain car engines symptoms and all the new suggestion will be viewed by the administrator who also the experts mechanics.

Figure 4.8 shows the normal mechanic able to develop a new set of diagnosis or add an additional diagnosis to the existing diagnosis in the knowledge base. The new suggestions then will be stored in the temporary database before it is viewed and approved by the experts' mechanics.

Figure 4.9 shows the ability of normal mechanics to view the existing sets of diagnosis stored and shared by the experts in the knowledge based.

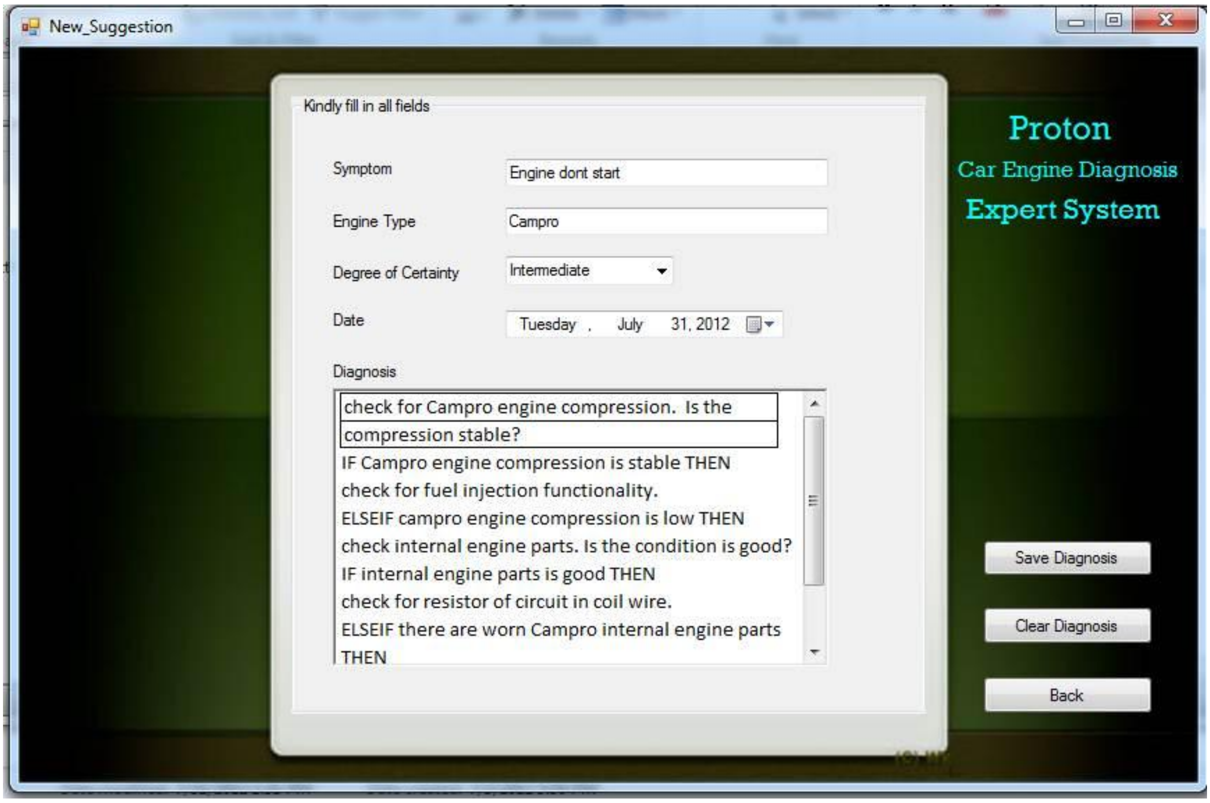


Figure 4.8: Mechanic Diagnosis Suggestion

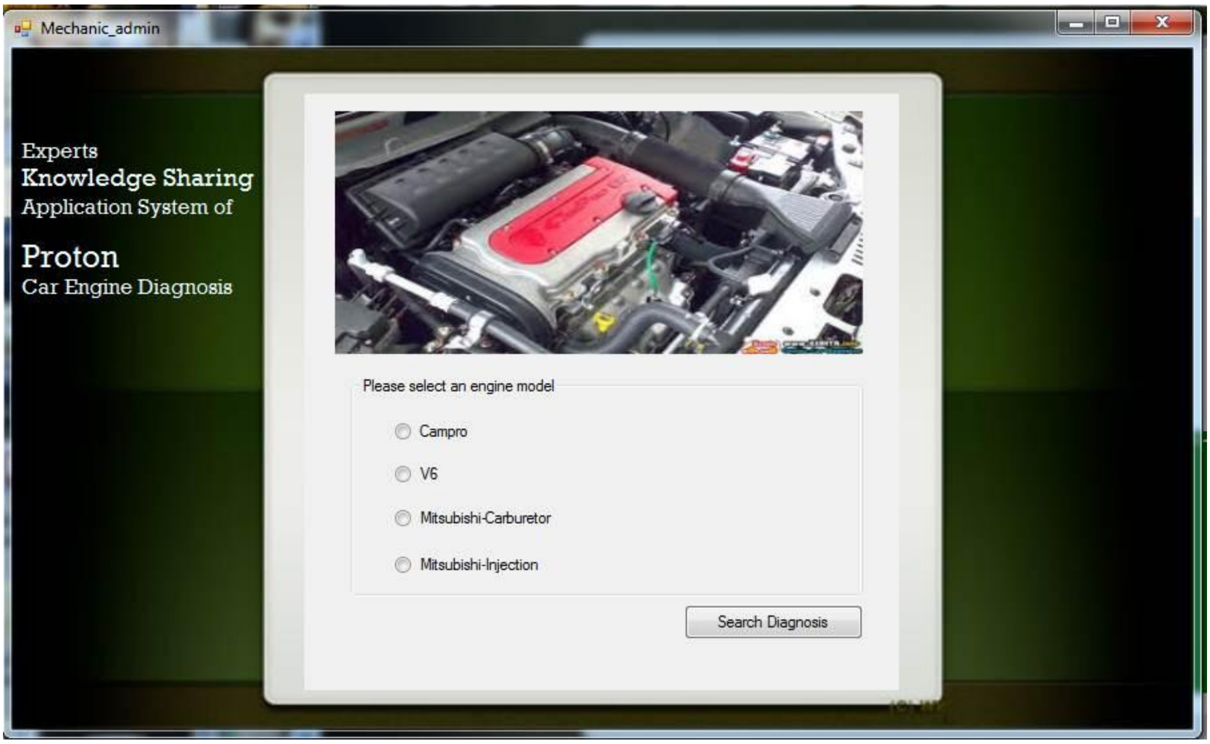


Figure 4.9: Search Existing Diagnosis Information

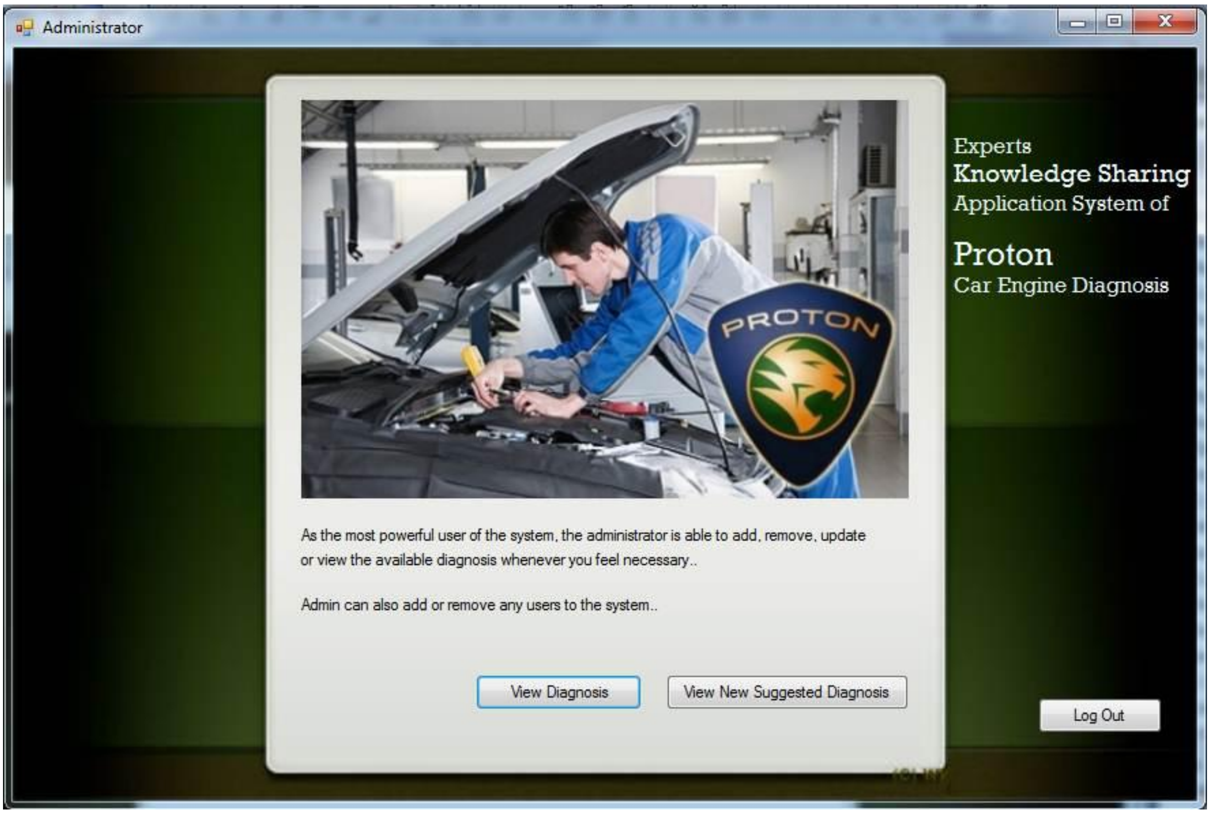


Figure 4.10: Administrator Main Menu

The screen above shows the control menu for the administrator or the 'experts' mechanics'. As the most powerful user of the system, the administrator is able to add, remove, or view the available diagnosis whenever he feels necessary. Besides that, he or she can remove any users to the system and have the accessibility to all functionalities in the system. In other words, admin is the one control all the systems functions and supervise whatever process conducted or happened to the system.

Figure 4.11 shows the admin ability to view all the new suggestion sets of diagnosis suggested by the normal mechanics. If the new suggestion is acceptable and reliable to be used and effectively tested, then the admin will add the new diagnosis into the system knowledge base as shown in the figure 4.12.

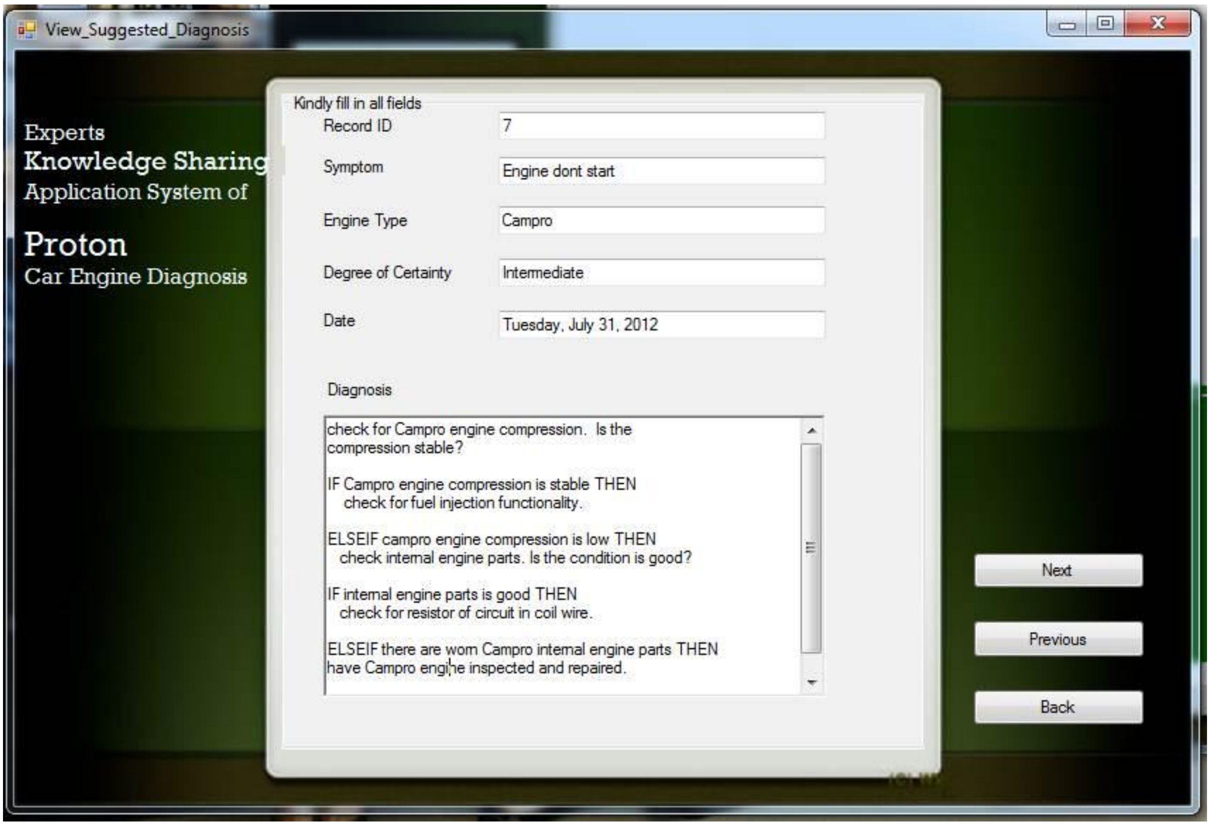


Figure 4.11: Viewing Suggested Diagnosis made by non-experts mechanics.

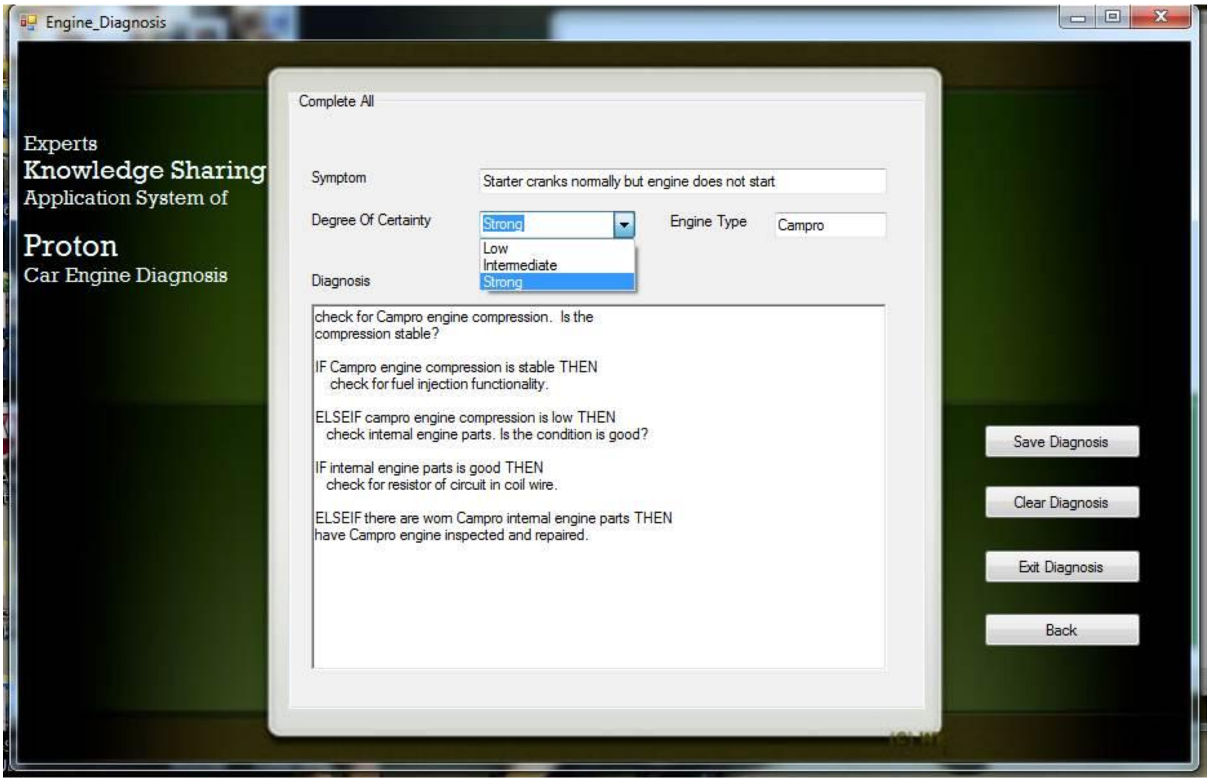


Figure 4.12: Adding New Record to the Database

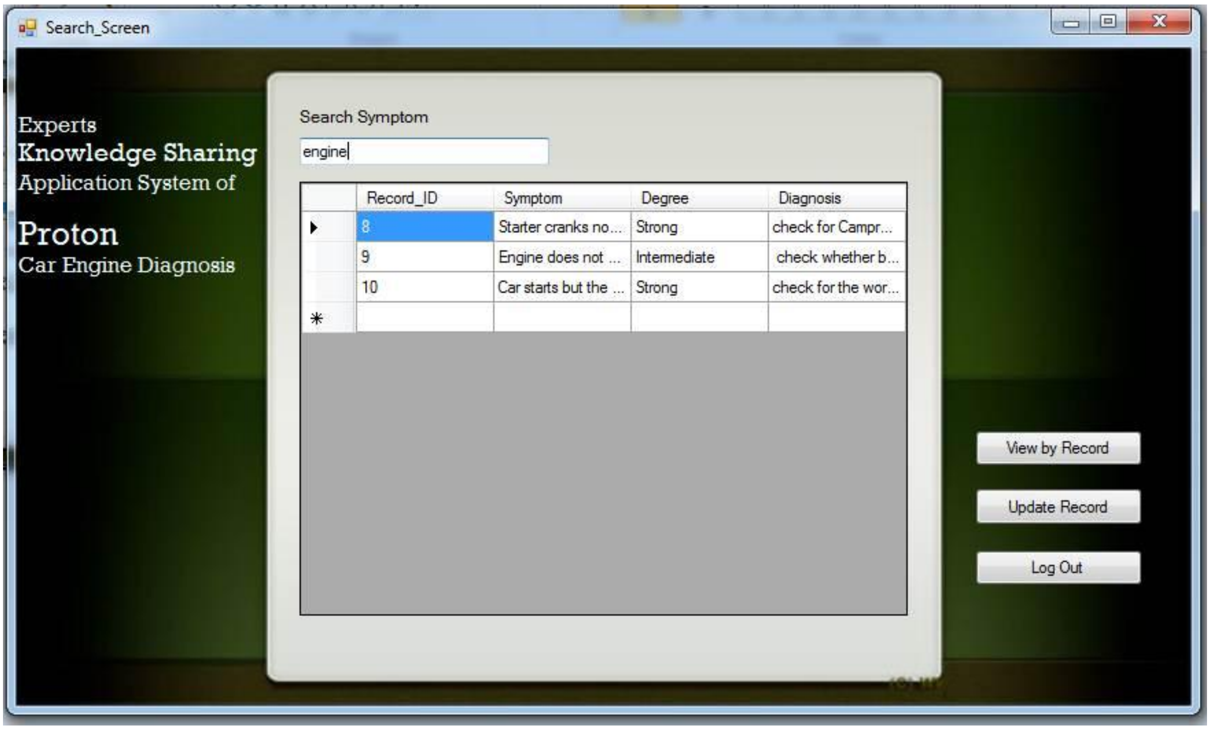


Figure 4.13: Search Screen.

Admin and normal mechanics have similar ability in viewing or searching for the existing diagnosis when needed. When the user click on the “Search Diagnosis” button in figure 4.9, the new screen will prompts as shown in the above figure 4.13.

To view the result of the search, the user namely the admin or the mechanic will need to type any description of diagnosis or symptom either full or partial description of a diagnosis and the system automatically generate the most-closely-related diagnosis results for the knowledge base. In order to view the record that the user wants, the user just need to click or position the cursor at the row of a particular diagnosis and the click the “View by Record” button.

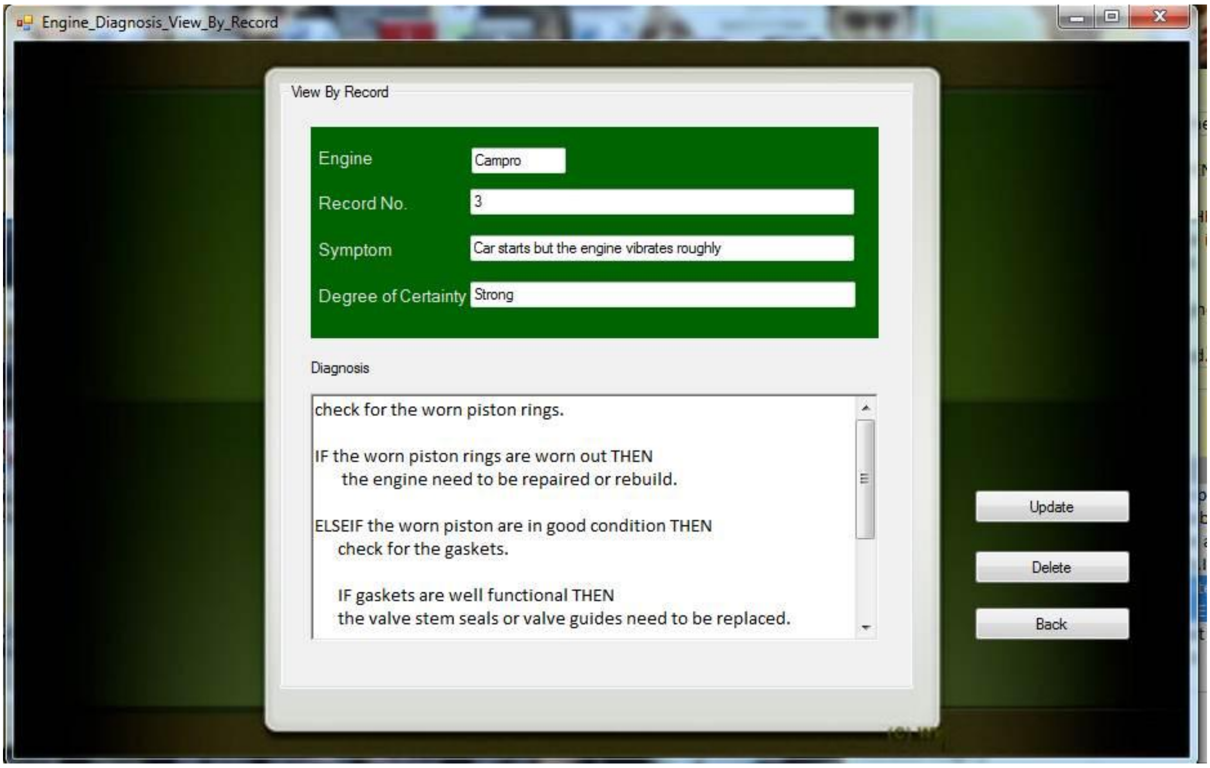


Figure 4.14: Detailed Diagnosis

The respective screen shown above illustrates the cause and effect of the diagnosis selected by the administrator or the mechanic. Apart of that, the screen indicates the level of certainty which signifies how accurate the diagnosis is in rectifying the symptom. While viewing the screen, the admin is able to remove or update the selected diagnosis by pressing the “Delete” or “Update” button.

4.3 System Testing

After completion of the system development, the developer started to do system testing. The first testing to be done is functional testing. The purpose of this testing is to check all the system functionalities whether they are usable and well-functioned or not. Some of the results from the functional testing can be seen in the table 4.2.

Table 4.2: System Functional Testing

Component	Expected test result	Testing result
Login button	Match the username and password to the existing users.	Able to match with the existing users' username and password.
Add new customer button	Prompt the new customer form to get the details of new customers.	Able to prompt the new customer form.
Add new diagnosis suggestions button	Transfer the information input to the database	Able to transfer the new input to the database.
Search diagnosis button	Search all the diagnosis information kept in the database.	Able to search the diagnosis in the database.
Exit button	Ensure the system is closed	The system successfully closed.

Other than functional testing, system developer also conducted user testing in order to make sure whether the system functionalities follow the right processes according to the users or not. For example, the system functionalities for non-expert mechanics really can be used by the non-experts mechanics and same with the experts' mechanics. The system logic also been tested in this user testing as different users have their own accessibility. The testing had been done to the right users which are operator, experts' mechanics and non-experts mechanics of Proton Service center, Seri Iskandar, Tronoh, Perak.

The results from the user testing can be seen in the table 4.3 below.

Table 4.3: User testing

User type	Test case provided	Testing result
Operator	Search for existing customer records and add new customer's details.	Success
Non-experts mechanics	Add new diagnosis suggestions and view / search for the existing diagnosis from the system	Success
Experts mechanics	View new suggestions made by the non-experts, add new accurate diagnosis and view / search for the existing diagnosis from the system	Success

4.4 User evaluation

After conducting all the user testing and functional testing of the system, all the feedbacks from the users had been interpreted as in figure 4.15. Based on the pie chart, more than 80 percent of the users strongly agree and agree on the implementation of the system. They really agree on the system helpfulness and the benefits of implementing it in their workshop.

They also recommend some improvements to the system as well as suggest little more additional functionality to the system. In overall, the system had successfully met all the requirements and can the problems faced by the non-experts. By using this system, the experts' mechanic can share their knowledge through the system and the non-experts can review it when needed. The system can reduce time and can increase the performance of the mechanics as well. At the end, the customers will then benefit from this system.

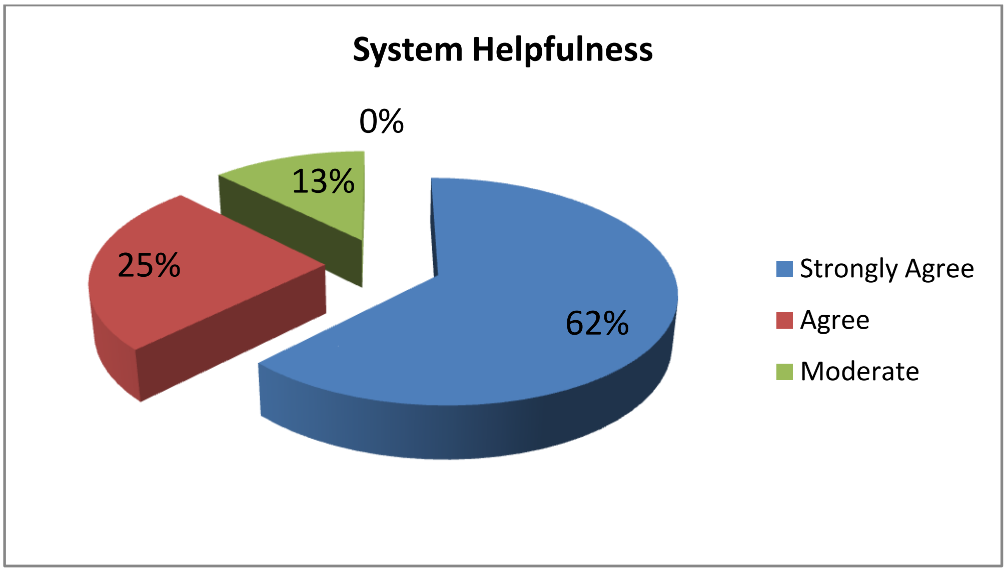


Figure 4.15 User Evaluation result

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The most significant discovery from the Experts Knowledge Sharing System in Diagnosing Proton Car Engines is the ability to retain all the experts' knowledge in the organization even though they experts are no longer available in the organization or they are not around when needed. The main purpose of the system development is to capture all the relevant information and facts from the experts regarding the car engines and at the same time able to accurately diagnose a particular mechanical problem of a car engine and provide systematic reasoning to rectify the problem. Once the system stores all the data and information from the experts' mechanics on how to diagnose certain engine symptoms then for each problem, the non-experts mechanics can used the system for their references. Apart from that, the system will keep store and retain the knowledge even though the experts leave the company.

As this system is intranet-based, top Proton automobile diagnosticians or expert's mechanics are able to share their knowledge and expertise with other Proton mechanics at Proton's dealership nationwide in an effort to provide a high-quality service to Proton customers. In relation to that, the Experts Knowledge Sharing System in Diagnosing Proton Car Engines enables mechanics to suggest a new technical diagnosis or solution and the system will adjust its diagnostic strategy to the new information.

5.2 Recommendation

Every computer systems or application are subject to upgrades. Similarly, the Experts Knowledge Sharing System in Diagnosing Proton Car Engines requires certain upgrades to provide a better and more reliable service to the end users. Hence, in the near future, system developer had plannedseveral features that are necessary and vital for the system in assisting its end users efficiently. One of the future upgrades is convert the system into online web based system. This will make the experts as well as non-experts easily can access the system even though they are not available at the service center or the workshops. Therefore, all the information can be retain, restore, reuse and reedit at anytime and anywhere.

Other than that, the system also can be upgraded into the touch-screen or voice recognition mechanism. By developing or assembling a touch-screen diagnosis system, mechanics do not have to use hardware such as the key board or mouse to navigate through the system. Instead they can just communicate with system through physical contact like touching the buttons on the screen to look for the solutions. Voice recognition-based system on the other hand enables mechanics to use the system by speaking to the system. In doing so, mechanics will be taught about the terms that are programmed in the system which can only be used with the system.

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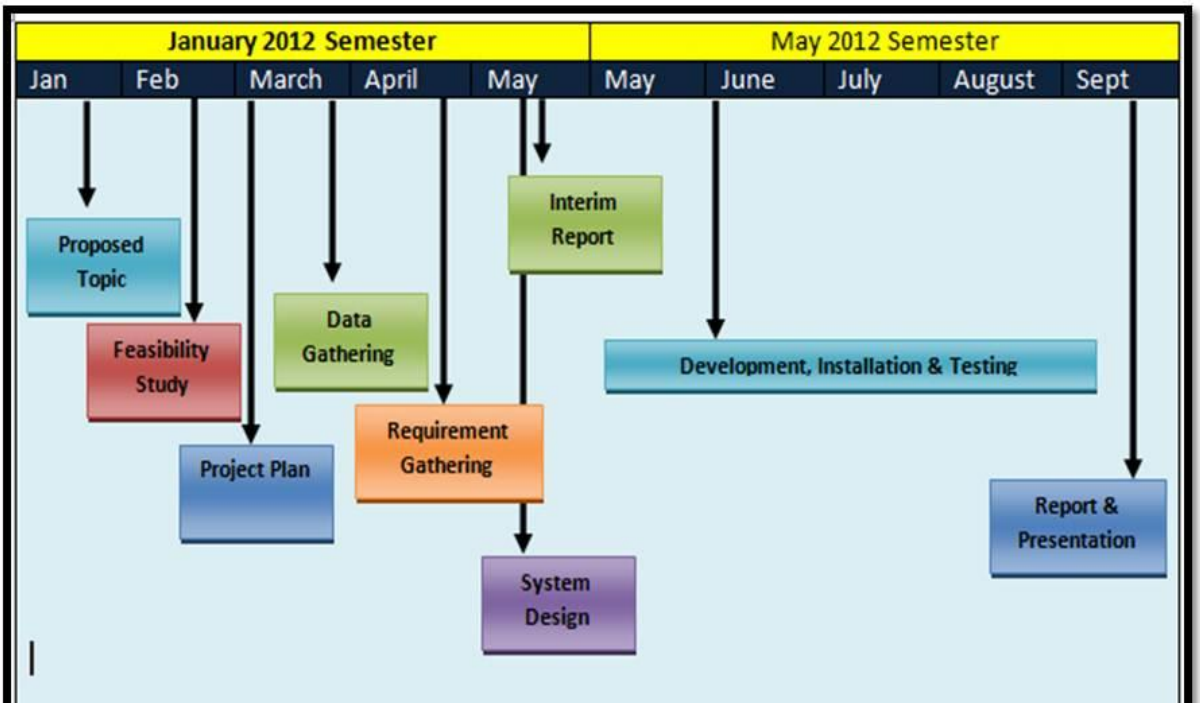
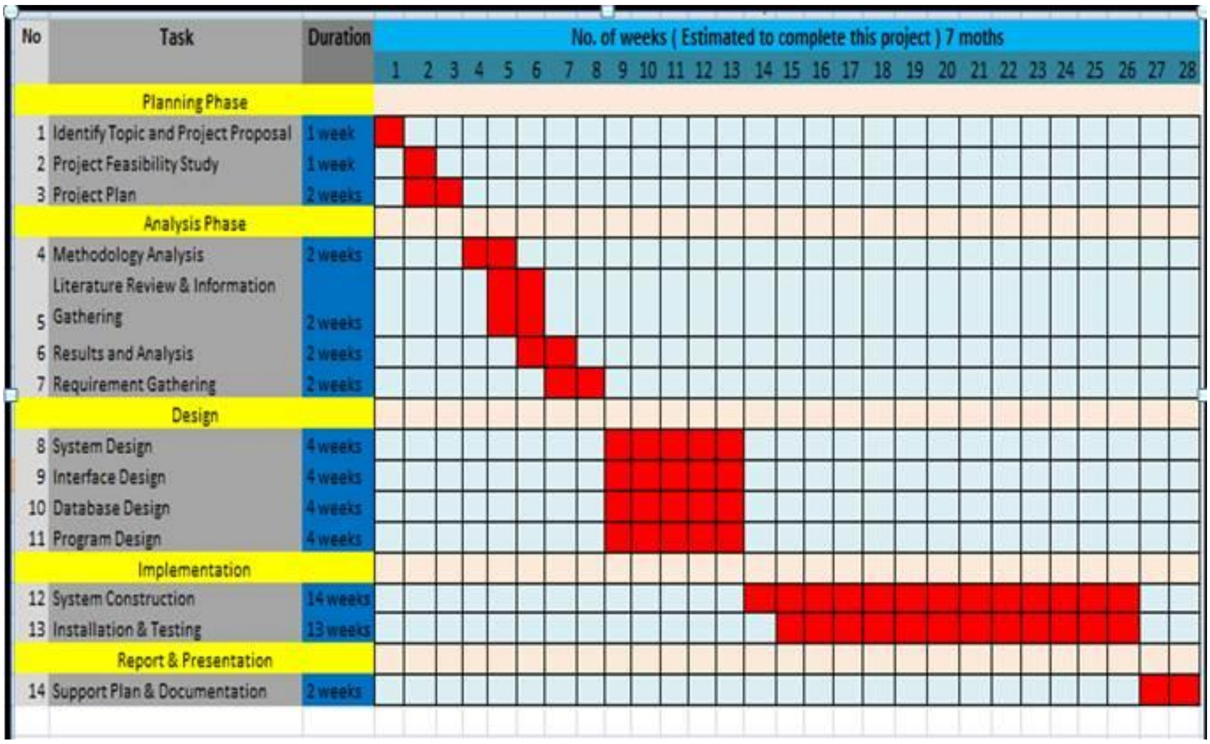
APPENDICES

Project milestone



Project Gann Chart



Project Activities

Task No	Task Name	Duration (in days)	Status
1	Identify a topic area and define title	5	Completed
2	Discuss with supervisor on the next step	3	Completed
3	Prepare for literature view, background studies, objectives, and methodology	7	Completed
4	Create workplan and Gantt Chart	2	Completed
5	Analyze as-is process and define to-be process	4	Completed
6	Gather requirements and data necessary for the analysis	7	Completed
7	Finalize the functions (system specification)	3	Completed
8	Create functional, structural and behavioral models	7	Completed
9	Develop Design Strategy	3	Completed
10	Architecture and Interface Design	5	Completed
11	Program Design	5	Completed
12	Development of the system	90	Open
13	Testing	5	Open
14	Provide Feedback to and fro Users and Modify requirement if any	5	Open
15	System Implementation and Documentation	14	Open