Optimizing Electric Vehicle Battery Management Systems for Enhanced Performance and Efficiency in the Automotive Sector

UNDER THE GUIDANCE OF MS. SHIWANI SINGH

Submitted By
AFJAL

School of Business, Galgotias University

ABSTRACT

Automotive means of transportation has become the major and cheapest means transportation in Nigeria. This fact has put more pressure on manufacturers to provide customers with high quality Automobiles with the aim of making profits. Nowadays, manufacturers are faced with a major problem in the management of information within amanufacturing plant and creation of effective relationship with customers. As an approachto solving these problems, a detailed analysis is carried out on the existing system to find out the strength and weaknesses of the existing system. And based on the requirements generated, the new system is designed. An Object Oriented design approach is used to describe the various units (modules) that make up the system in terms of classes and objects. The design and development of an Automotive Plant Management system for a manufacturing company is a project developed with PHP, MySQL, Ajax, HTML, JavaScript and Jquery Plugins, it provided better and more efficient management of information generated from Human Resource, Inventory, Company Finance and also Customer Relationship Management

In recent years, the surge in the adoption of electric vehicles has played a vital role in reducin fossil fuel consumption and greenhouse gas emissions. However, limited cross-national research has been conducted on the determinants of electric vehicle adoption in developing and developed countries. This study examines the factors influencing the intention to adopt electric vehicles in India (378 participants) and Spain (265 participants). This study develops an integrated model that combines the unified theory of acceptance and use of technology (UTAUT2) and the value-belief-norm (VBN) model while accounting for the impact of national culture. The model is tested using structural equation modeling. The results indicate the integrated UTAUT2-VBN model is a valuable tool for explaining the differences in adoption intention across cultures. Moreover, the national cultural system plays a significant moderating role in most relationships within the model. This study offers valuable insights intothe factors influencing electric vehicle adoption in different cultural contexts, which can inform policies and strategies to promote sustainable transportation.

1. INTRODUCTION

An automotive plant is a factory which carries out activities involved in the manufacture of motor vehicles, including most components, such as engines and bodies, but excluding tires, batteries, and fuel. The industry's principal products are passenger automobiles and light trucks, including pickups, vans, and sport utility vehicles. Commercial vehicles (i.e., delivery trucks and large transport trucks, often called semis), though important to the industry, are secondary.

Automotive industry businesses struggle to meet the needs of a demanding market. Increasingly complex requirements from customers make it difficult to concentrate on reducing inventory, eliminating scrap and waste, and dealing with volatile commodity costs, all with a workforce that's dramatically smaller than it was just a few years ago. [1]

An Automotive Plant Management System (APMS) is a software solution for automotive plantswhich captures and accesses all production and quality data at the "manufacturing moment" to gain the real-time intelligence required to make timely and effective manufacturing decisions [1] in the areas of accounting and financial management, customer relationship management, human capital (human resource) management, inventory management and maintenance management. This software solution makes use of the concept of cloud computing in order to integrate data making the same data available throughout the company.

The Automotive Industry in Nigeria dates back to early 1960s when private companies like UAC, Leventis, SCOA, BEWAC and R.T. Briscoe pioneered the establishment of Auto Assembly Plants using Completely Knocked Down (CKD) or Semi-Knocked Down (SKD)parts.

Government however, became involved in the industry between 1970-1980 when it concluded agreements with a number of Automobile Plants in Europe to set up 2 cars and 4 truck/light commercial vehicles assembly plants using Completely Knocked Down (CKD) Parts.

The 2 car plants are Peugeot Nigeria Ltd. (PAN), Kaduna, and Volkswagen of Nigeria Ltd.(VWON) Lagos. The 4 truck plants are Anambra Motor Manufacturing Company

(ANAMMCO), Enugu, Styer Nigeria Ltd., Bauchi, National Truck Manufacturers (NTM), Kano, and Leyland Nigeria Ltd., Ibadan. These car and truck/light commercial vehicle plants were all privatized by the end of 2007.

In 1982, the Federal Government completed agreements with five manufacturers for the establishment of the following five light commercial vehicle assembly plants: Mitsubishi in Ilorin, Nissan in Minna, Peugeot in Gusau, Isuzu in Maiduguri and Mazda in Umuahia.

However, they were not established, though GM subsequently entered into partnership with UAC to produce Isuzu by FMI of UAC, which later became GM Nigeria Ltd.

On October 15th 2012, Innoson Vehicle manufacturing (IVM) plant was opened, to produce sundry commercial automobiles, utility vehicles and passenger cars, in collaboration with a consortium of Chinese auto manufacturers. It produced the country's first Nigerian produce vehicle.

IVM introduces automotive products from china, Japan and Germany. Its product line includes heavy duty vehicles, middle and high level buses, special environment friendly vehicles. The company carries out optimization design and assembly according to West African road condition so as to produce suitable products at affordable prices.

The company also provides goods and services for repairs and parts supply. All these actions are engineered to meet the customers' special requests, attain the highest possible performance and safety standards and also make the vehicles suitable for the West African market.

The Nigerian automotive Industry has installed capacity to produce 108,000 cars, 56,000 commercial vehicles, 10,000 tractors, 1,000,000 motor cycles and 1,000,000 bicycles annually. Capacity utilization in vehicle manufacture is below 10% and about 40% in motorcycle, bicycleand components parts manufacturing. [2]

The current vehicle inflow into the economy is about 50,000 new and 150,000 used ones. This translates into about 100,000 units of new vehicles annually and is set to rise as the economy improves. The ECOWAS countries are current and potential customers for our auto products. [2]

The Nigerian automotive industry has performed poorly due to the following general reasons: Low Patronage by government and the general public, very low capacity utilization, poor perception of locally made goods, high cost operating environment, insufficient government protection policy, absence of low cost long term funds, weak and deteriorating infrastructure, lack of efficient management systems and inconsistency in tariff policy. In order to run a manufacturing plant efficiently, the plant must keep assets and equipment in good working order. If your equipment is down or operating inefficiently, it could slow down or halt production completely. The plant cannot afford to have equipment out of service unexpectedly

because it could impact the company's profitability and hurt their reputation. Maintenance management has also been one of the reasons for poor performance of automotive industries.
[4]

Automotive Plant Management System (APMS) is a single unified platform that helps automotive plants manage their manufacturing operations [1] by connecting the manufacturingfloor with the management floor for actionable information to understand costs, optimize schedules, eliminate waste and keep up with the pace of the business. [1]

1.1 Statement of Problem

After taking an in-depth look at Innoson Vehicle Manufacturing, I noticed some areas of weakness in the management of certain operations in the company, below listed are these problems:

i. Poor staff data management.
ii. Ineffective customer relationship management. **iii.** Inefficient inventory management tomaintain accurate real time data and reduce excess inventory.
iv. Inadequate documentation of finance and accounting information produced from companyactivities.

Apart from the above challenges, automotive plants that base all operations on the manual process of filling forms, carrying files from one table to another, storing files in cabinet etc., are faced with problems like;

i. Having inconsistent data.
ii. Files and document not being secure enough.
iii. The manual process is slow and cumbersome.

1.2 Objectives of the Study

The objective of this project is to develop a management information software that coversmodules which:

i. Provides management of all employee information.
ii. Provides customer relationship management. **iii.** Handles inventory of automotive production parts. **iv.** Provides management of financial information such asestimates, invoices, receivables, sales receipts and supplier invoices.

1.3 Significance of Study

This project will go a very long way in improving management of automotive plants. Listed below are the significances of this system if employed in an Automotive Plant:

i. Increased customer satisfaction as services and products consistently deliver what they promise providing faster customer response time.

ii. Easy access to staff information. **iii.** Improved risk management due toaccurate inventory data. **iv.** Better data management and security of data.

v. A computerized way of organizing transaction details between manufacturers and distributors.

1.4 Scope of the Study

The Automotive Plant Management System covers management of activities and operations which take place in an automotive plant in the view of improving customer satisfaction, higher profit and also making better management decisions. This system consist of five (4) modules which are accounting and financial management, customer relationship management, human capital (human resource) management, inventory management. This project covers user accessto various modules of the system based on user identity.

1.5 Limitation of the Study

a. An automotive plant having so much inventory processes involved in the activities whichare carried out daily will produce a lot data. These data will have to be stored securelyand is too large to be stored on local servers, therefore the introduction of cloud computing services will be required to provide efficient storage space to complement

already existing local servers, a private cloud will have to be deployed in order to storethe large amount of data and also to ensure safety of information.

1.6 Definitions of Terms

i. Assembly parts: These are individual parts which are used in an automotive assembly plant to assembly an automobile machine

ii. Assembled automobiles: These are already assembled automobiles which are ready for sale.

iii. Cloud computing: it is computing in which large groups of remote servers are networked to allow centralized data storage and online access to computer services or resources

iv. Private cloud: Private cloud is cloud infrastructure operated solely for a single organization,

whether managed internally or by a third-party, and hosted either internally or externally.

v. Servers: A computer that provides data to other computers. **vi.** Operation System: the software that supports a computer's basic functions, such scheduling tasks, executing applications, and controlling peripherals.

vii. API(Application Programming Interface) : a specific method prescribed by a computer operating system or application program by which a programmer writing an application program can make requests of the operating system or another application. **viii.** IDE (Integrated Development Environment): An IDE is a programming environment that has been packaged as anapplication program, typically consisting of a code editor. A compiler, a debugger, and a graphicaluser Interface (GUI) builder.

ix. GUI (Graphical User Interface): a visual way of interacting with a computer using items suchas windows, icons and menus used by most modern operating systems.

x. Ajax (Asynchronous Javascript and XML): Ajax is a group of interrelated web development techniques used on the client-side of to create interactive web applications. **xi.** Programming Language: A programming language is an artificial language designed to express computations that can be performed by a machine, particularly a computer.

2.

3. LITERATURE REVIEW.

A study conducted had revealed that in developing countries like India, Electric Vehicles would be a more natural alternative, than in developed countries. Given the lack of oil reserves and the driving habits of the people in India, EV technology appears to be appropriate and economically viable (Biswas & Biswas, Citation1999). However, the development of the market of electric vehicles is intrinsically bound to general awareness, prospective consumers' choice, and understanding of potential benefits of using electric vehicles. Although the electric vehicle market growth continues, its widespread uptake is prevented by various barriers. Rezvani et al. (Citation2015) have successfully carried out research in the past and have identified some factors that affect a consumer's choice on purchasing an EV. When it comes to Vehicle Restraint Systems (VRS), researchers have found that including elements like guardrails, terminals, transitions, and crash cushions in the planning stages of road and highway construction can boost VRS's overall performance (Tahmasseby et al., Citation2021). The future of electric vehicle viability has been researched and discussed extensively. It's commonly accepted that "net abatement benefits from EVs depend primarily on two key factors: 1) the marginal source of electricity generation, which depends on the composition of the electricity grid; and 2) the effect ambient temperatures have on the efficiency of charging and discharging batteries" (90, Archsmith, 2015). However, "for the sustainable implementation of electric vehicles, it is vital to increase the share of renewable sources of power generation in the energy grid mix worldwide" (Nimesh et al., 2021). The more we move forward to electrify transportation the more need there is to innovate and create better/more efficient energy generation.

Some of the critical factors/barriers have been discussed below.

Technological factors (vehicle performance)

While electricity as a vehicle fuel has many benefits, it has two disadvantages: it is bulkier to store and costlier, and slower to refill. The former means that the current electric vehicles would have a smaller range than diesel, and the latter means that they cannot be refuelled easily on the road (Pearre et al., Citation2011). This brings us to the major technological factors.

These include driving range anxiety, recharging time and EV model variety.

• *Range Anxiety*: According to studies conducted, range anxiety is found to be a predominant barrier in a customer's decision to buy an EV (Jensen et al., Citation2013). Research suggests that consumers prefer an ideal

driving range, which is expected to be between 300 km to 450 km
(Zhu, Citation2016). However, this at times is not practically possible thereby giving rise to range anxiety. This is mainly observed during battery charge depletion while driving for long hours when the driver fails to predict the approximate distance that could be covered with the remaining battery power. The limited and uncertain vehicle range aroused anxiety among drivers to use EVs for long journeys (Noel et al., Citation2020). This would decrease the reliability of these vehicles.

- *Recharging time*: Here, the time it would take to recharge the battery would depend on the driver's batteryrange choice. The more the battery is charged; greater range would be offered (Daziano & Chiew, Citation2012). But this leads to excess charging time since the refuelling capacity is slow (Egbue & Long, Citation2012). Although this factor is viewed as the least problematic, it still contributes to increasing the rejection factor for EV purchase (Carley et al., Citation2013). Most of the drivers consider charging an EV to be inconvenient as compared to refuelling an Internal Combustion Engine (ICE) vehicle (Brückmann et al., Citation2021). They believe that EV charging time may pose to be a constrain in their everyday routines as the inability to quickly refill fuel and go on-the-run causes inconvenience especially for on-road drivers (Graham-Rowe et al., Citation2012). Also, if a charging station is available at home, sudden unexpected trips cannot be made by the driverwhen the EV is being charged. This reduces flexibility.

In case of taxi drivers, unintelligently controlled charging of electric vehicles, may lead drivers to return back home and plug-in their vehicles for charging when the demand is at its peak (Christensen et al., Citation2012).

- *EV model variety*: Bessenbach and Wallrapp (Citation2013), also state that model variety of ElectricVehicles is also a significant barrier in EV adoption.
- Economical factors (financial barrier)

These include purchase price of the EV, fuel price and price of battery.

The high purchase price of an EV is found to be a large constraint in many consumer survey studies (Carley et al., Citation2013; She et al., Citation2017). The technology used in manufacturing EVs is expensive and this in turn raises the price value of the vehicle (Noel et al., Citation2020). As constant efforts are made and newer technologies are introduced to increase range of EVs, the complexity of battery material (Lithium-ion batteries) used increases (Biresselioglu et al., Citation2018). This causes a rise in the battery price (Noel et al., Citation2020). Thus, replacement of such batteries in the future would be expensive. Poor understanding of the costs of vehicle fuel and maintenance also add to this barrier. Basically, the poor economy of scale causes upcoming technologies to compare unsatisfactorily to existing dominant price designs.

This has also to do with the customer's perception about the money value of the EV. The service and maintenance costs of these are less when compared to ICE vehicles. But the initial high purchase price becomes a hindrance to consumers to buy EVs. This shows that the consumers aren't fully aware that an advantage of having lower operating costs of EVs is that it leads to potential savings (Krause et al., Citation2013).

Lack of infrastructure- charging networks

Another relevant risk is the lack of a charging station when travelling (Krupa et al., Citation2014). As a result, to consider the need of long-distance drives, consumers would often demand that public charging stations be made available at more locations (Habla et al., Citation2020). The cost of setting these networks is again very high (Brückmann et al., Citation2021). This has led to uncertainty regarding the future expansion of the infrastructure for charging stations. Investing in infrastructural facilities by the Government and manufacturers for EVs could facilitate the consumers' EV adoption rate (Bhalla et al., Citation2018).

The lack of a consistent charging system often discourages some drivers from depending on it. Still, there continues to be some debate as to how far public charging facilities may be needed to raise the willingness of consumers to adopt EVs. It is likely that setting up more charging points thus making them accessible would offer reassurance to

consumers to accept EVs as a viable transportation alternative (Noel et al., Citation2020). It will be important to monitor how public perceptions of EVs change in cities where charging points are introduced and thus the salience of EVs increased (Bunce et al., Citation2014

Personal characteristics

According to the Theory of Planned Behavior humans make decisions bases on logical evaluations of stimuli and the plausible outcomes of decisions (Ajzen, Citation1991). Customer knowledge and experience have an effect on attitude (Ajzen & Fishbein, Citation1980). Other factors that influence EV adoption are gender, age, income, educational level, tastes and environmental awareness.

Consumers who readily adopt EVs are usually highly educated and environmentally sensitive. Individuals respond to social expectations and social pressure reflected in statements, such as socially acceptable behaviour, being considerate of others, expressing shared values and social responsibility.

Kahn (Citation2007) further goes on to state that a consumer who strongly believes in environmental conservation purchases an EV for two incentives. First, driving a more fuel-efficient car would reduce one's carbon footprint for any given number of miles driven per year. The second incentive is that, everybody in the community sees the type of vehicle that a person drives. In an environmentalist community, driving a fuel inefficient vehicle may trigger some embarrassment and ostracism. This would lead to a person's purchase of an EV due to peer pressure.

In some cases, EVs' performance, style, size and safety were reported as barriers.
Lack of awareness regarding EVs and its benefits can also be a barrier in its adoption (Wang et al., Citation2017). A lack of knowledge about future market opportunities inhibits innovation in EVs with many manufacturers (Lieven et al., Citation2011). It is also important for product designers and marketers to develop and align electric vehicles to elicit positive emotional reactions (Moons & Pelsmacker, Citation2012).

Providing effective information would increase environmental knowledge. This will raise more doubt, decrease fatalism and increase consumer desire to change behaviour (as suggested by the Theory of Planned Behaviour), but it is often a necessary precursor (Lane & Potter, Citation2007).

In general, education and environmental consciousness are found to be mildly associated. Higher education could foster understanding of the climate-mitigation potential of a purchase of a single vehicle. Nevertheless, as higher education positively correlates with employment, higher-educated customers prefer to drive more costly vehicles with usually higher CO_2 emissions (Peters et al., Citation2015).

Environmental concern as a factor

Temperature increase in cities have been linked to increasing population, urban surface materials, forest removal, man-made heat, noise and air pollution, concrete buldings and building congested roads(Sampson et al., Citation2021). This further reinstates the thought that few people are heavily influenced by the depletion of natural resources and are thus concerned about environmental conservation (Heffner et al., Citation2007; Mohamed et al. Citation2018). It was found in a focus group analysis that most participants did not find any correlation between their choice of vehicle ownership and their environmental attitudes until the subject was addressed in structured conversations (Flamm & Agrawal, Citation2012). According to Asadi et al. (Citation2021), Electric vehicles are considered to be the future alternatives which will address most of the environmental concerns. People/consumers accept the idea that by adopting EVs, a lot of pollution would be reduced (Skippon & Garwood, Citation2011). This motivates them to buy the EV to reduce the ecological footprint and "living lighter", i.e. consuming fewer natural resources (Ozaki & Sevastyanova, Citation2011; Mohamed et al. Citation2018). An Environmental Index was employed to conduct this study in order to measure respondent environmental awareness. Currently, electric vehicles are mostly used by particular social groups, such as environmentalists, early adopters, people with above average income, young urban citizens and technology enthusiasts (Axsen et al., Citation2015; Talantsev, Citation2017).

Skerlos and Winebrake (Citation2010), in their study discuss the social benefits of using EVs which include reduction in GHGs emissions and other air pollutants. EVs have shown substantially lower emissions than traditional ICE vehicles, while considering the emissions from power plants used in charging such vehicles. The magnitude of this difference depends strongly on the source of generation of power for these EVs: natural gas, coal or renewable fuels.

Policies

The Non-acceptance of policies and consumers' perception towards them could also be a barrier in EV adoption (Brückmann et al., Citation2021). Regulations and incentives put forth by the government regarding fuel prices, fuel infrastructure development which are environment related would influence the adoption (David Diamond, Citation2009). Sometimes these policies aren't well understood by the consumers. This may be caused due to frequent changes in policies, thus creating uncertainties for consumers. This in turn may make them reluctant in adopting EVs (Kester et al., Citation2018).

In order to facilitate EV diffusion in the market, policymakers are suggested to allow companies to experiment with automobiles to promote the spread of EV on the market. This can also be done by providing EVs for monitoring or removing other possible obstacles, which do not result in consumers purchasing EVs (Sierzchula, Citation2014).

4. METHODOLOGY

This project is being developed to manage and computerize certain processes involved in the everyday running of an automotive industry like Innoson Vehicle Manufacturing Ltd., in the areas of manufacturing, human resource management, financial management and supplyprocesses.

3.1 System Analysis

Analysis involves a detailed study of the current system, leading to specifications of a new system. Analysis is a detailed study of various operations performed by a system and their relationships within and outside the system. During analysis, data are collected on the availablefiles, decision points and transactions handled by the present system.

3.1.1 Facts Gathering

In carrying out this research work, two major forms of data finding techniques were used and they include:

i. Primary source

ii. Secondary source

I. **Primary source:** This is a form of collecting original data directly from the user of the existing system, in which the researcher made use of empirical approach such as a personal interview and the use of questionnaires.

II. **Secondary source:** A secondary source refers to sources of collecting data in which the collected information are not as exact as the original sources. The secondary sources must have modified or

summarized the original information. The need for secondary sources in this project cannot be over emphasized. The secondary data were obtained from Journals, Library sources, and Websites.

3.1.2 Methods of Data Collection

Below is an outline that gives an overall idea about the search methods/fact gathering techniques I used while gathering the information:

a) Interview
b) Study of records/manuals
c) Evaluation of forms

A. Interview

A face-to-face interview was carried between the researcher (me), head of the Department (HOD) of the Spare Parts Department (SPD), and the Human resource manager (HRM). This enabled the researcher establish good rapport with the participants and therefore gained their cooperation.

B. Study of Records/manuals

An existing system can best be understood by studying the existing documents, such as;

i. Written policy manuals
ii. Rules and regulation
iii. Standard operating procedures.

C. Evaluation of Forms

I was able to gain access to some forms (paper documents) that are used by the company which are useful; these forms include Bill of materials, candidate form for applicants, invoice documents, sales receipts and purchase order documents, A bill of materials is a list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts and the quantities of each needed to manufacture an end product. A BOM may be used for communication between manufacturing partners, or confined to a single manufacturing plant.

3.2 Analysis of the Existing System

3.2.1 Current Customer Relationship Management and Inventory Process

Innoson Vehicle Manufacturing (IVM) current inventory process is an outdated, manual process that is time consuming and not financially responsible. The process relies on manual entry at the end of each business day by the warehouse department. Each of the locations within the company operates independently of each other with no inner company communications. Each warehouse department has its own inventory which could result in over purchasing of materials that another location could have overstocked. The receiving of materials process is slow and time consuming. A receiving department employee has to visually inspect the paper work and verify that all materials arriving are on the manifest. These processes are paper based that could result in lost time and money if papers are misplaced or lost.

3.2.2 Current Human Capital Management Process

The current Human Resource management process is based on storing employee information in Microsoft Access databases. This process does not provide easy identification of particular staff, for instance staff with the same surname and initials but in different department, management officials cannot easily identify the particular staff data needed because the image of the staff is not present thereby making the searching of employee data time wasting and inefficient. Also it does not provide sorting of employee information, for example, based on salary, position, qualifications etc.

3.2.3 Current Financial and Accounting Management Process

The current system in Innoson Vehicle Manufacturing is based on entry of financial data into Microsoft Excel spreadsheets. This process does not provide currency changing capacities, which indicate ineffectiveness looking at the fact that transactions are sometimes carried out in foreign currencies and also it cannot create reports and invoices automatically for transaction.

3.2.4 Feasibility Study

Feasibility studies aim to objectively and rationally uncover the strengths and weaknesses of the existing business or proposed venture, opportunities and threats as presented by the environment, the resources required to carry through, and ultimately the prospects for success.

a) **Economic Feasibility:** Economic analysis is the most frequently used method for evaluating the effectiveness of a new system. More commonly known as cost/benefit analysis, the procedure is to determine the benefits and savings that are expected from a candidate system and compare them with costs. As such the implementation of the new system will save a lot of money (money used in running the manual process and elimination of loss form overstocking).

b) **Operational Feasibility:** Operational feasibility is a measure of how well a proposed system solves the problems. To an extent the proposed system is going to solve the problem of high dependency on forms, files, and cabinet in carrying out the basic processes of the company. It eliminates double of entry of data, cuts down on excess personnel staff and helps in decision making of the management.

3.2.5 Problems and Weaknesses of the Existing System

The major problems the present system face are associated with the fact that it is not automated, these problems are outlined:

i. Creation and storage of Invoices: Invoices cannot be automatically generated and stored using the existing system.

ii. The shipping process: Products to be shipped or received are also registered using forms, this process faces the problem of sorting time, but also when products are distributed to various depots, it takes lots of time to confirm if the products arrived the depots safe and complete.

iii. Stocking process: The process of taking stock is tedious because it involved manual counting

the amount of goods left in the stock, as a result of the process the results areerror prone and not secured.

iv. Searching of Employee Data: The process of searching for employee information is tedious because double entry error of particular employee may occur due to human error and also due to the fact that employee images or visual verification are not ableto saved, identification of employees with the same names is very hard.

v. Stock Replenishment: Due to the manual process of taking inventory of stocks it is hard to know when a stock is low, and when to replenish stock, no stock alert is set inplace.

Also the right amount of stock needed cannot be identified and can lead to overstocking.

vi. Data Integration: Due to the different processes of taking data in different departments, there is no integration or availability of the same up-to-date data throughout all thedepartments.

vii. Difficulty in tracking and retrieving data from the related inventory.

viii. Constraints couldn't be applied to the existing system.

3.4 Analysis of the Proposed System

Just as the problems and weaknesses of the present system have been rightly outlined, the proposed system is being developed particularly to automate all manual processes, to save time, increase production efficiency and make profit which is the ultimate goal of all automotive industries.

3.4.1 Functional And non-functional Requirement

A. **Functional Requirement:** These are statement of services that the system provides, how the system should react to particular inputs and how the system behave in particular situation. The functional requirements are:

i. It requires 3(three) privileged users; the Plant Manager, administration officer (admin), and the user (staff).

ii. Each user must have unique passwords and username which are there auto-generatedstaff ids, which determines their interfaces and operations as well.

iii. The Admin officer should have privileges to create other admin users and manageapplication access of any employee.

It also provides the following functionalities below:

a. Creation of customer invoices including consolidated billing in real time

b. Creation and management of journal entries such as a Receivables, Sales Receipts, invoice, Estimates, Supplier Invoices.

c. Creation and maintenance of detailed customer records and related data such as financial, address, contacts and communication information

d. Entering, tracking and fulfilling of customer orders.

e. Storing of all customer order and release information, including order number, item numbers, due dates and quantities, for detailed analysis and reporting.

f. Creation and maintenance of a master-list of departments within the company.
g. Creation of a master employee list.
h. Creation and maintenance of employee records.
i. Creation and maintenance of a master list of inventory of production parts.
j. Selection of inventory and stage it for shipment
k. Saving and emailing of invoices to customers.

B. **Non-functional Requirement:** these are the constraints encountered in thedevelopment of the system. Some of these constrains includes:

a. The cost of setting up a local or cloud network to host the application.
b. Sufficient network bandwidth is required for the system to run effectively.

3.4.2 Benefits of the Proposed System

Due to the issues arising from the manual process of delivery of goods of the existing system,this research work is being carried out to automate the manual processes involved in the inventory of stock, the registration of incoming and outgoing shipments and every other process

carried out manually. And also the lack of a proper financial and HR management system; below are some of the benefits that would be derived from the new system:

i. Better management decisions are made based on financial reports.

ii. Provides the manufacturer with up-to-date information about current stock level, customers, employees and maintenance schedules.

iii. Provides better security of information from unauthorized users and hackers.

iv. Provides the manufacturer with up-to-date information about previous shipments made, and confirms the amount of goods sent or received from the manufacturer through the invoices generated.

v. Saves the time in searching for stock or employee data.

vi. Alerts the admin officer when a particular stock is low in the warehouse of the plant.

vii. Eliminates double entry of data, under-stocking and also overstocking.

viii. All the transactions made should results either success or failure to provide consistency.

3.5 System (Software) Development Methodology

A Software development Methodology also known as Software Development Life Cycle Modelis a set of activities together with an ordering relationship between activities which if performedin a manner that satisfies the ordering relationship that will produce desired product. Software Development Life Cycle Model is an abstract representation of a development process.

In a software development effort the goal is to produce high quality software. The development process is, therefore, the sequence of activities that will produce such software. A software development life cycle model is broken down into distinct activities. A software developmentlife cycle model specifies how these activities are organized in the entire software developmenteffort. We discuss each software development life cycle model in detail.

There are various types of software development methodologies such as

i. Waterfall Model
ii. V-Shaped Model
iii. Evolutionary Prototyping Model iv. Spiral Development Methodology (SDM)
v. Iterative and Incremental Method
vi. Agile development(Extreme Programming)

In this project the software development methodology used is

Agile Development Methodology.

3.5.1 Agile Development Methodology.

Agility is both a development philosophy and a collection of concepts embedded intodevelopment methodologies. An agile approach to development is essentially a resultsfocused method that iteratively manages changes and risks. It also actively engages customers in providing feedback on successive implementations, in effect making them part of the development team. Unlike process-driven documentation, it promotes outcome-driven documentation. The emphasis of agile practices is on traveling lightweight, producing only those artifacts (documentation) that are absolutely necessary. [15]

Agile Development Methodology combines a philosophy and a set of development guidelines. The philosophy encourages customer satisfaction and early incremental delivery of software; small, highly motivated project teams; informal methods; minimal software engineering workproducts; and overall development simplicity. The development guidelines stress delivery over analysis and design, and active and continuous communication between developers andcustomers.

3.5.1.1 Advantages of Agile model:

i. Customer satisfaction by rapid, continuous delivery of useful software.

ii. People and interactions are emphasized rather than process and tools. Customers,developers and testers constantly interact with each other.

iii. Working software is delivered frequently (weeks rather than months).

iv. Face-to-face conversation is the best form of communication.

v. Close daily cooperation between business people and developers.

vi. Continuous attention to technical excellence and good design.

vii. Regular adaptation to changing circumstances.

viii. Even late changes in requirements are welcomed

3.5.1.2 Disadvantages of Agile model:

i. In case of some software deliverables, especially the large ones, it is difficult to assessthe effort required at the beginning of the software development life cycle.

ii. There is lack of emphasis on necessary designing and documentation.

iii. The project can easily get taken off track if the customer representative is not clear what final outcome that they want.

iv. Only senior programmers are capable of taking the kind of decisions required during the development process. Hence it has no place for newbie programmers, unless combined with experienced resources.

3.5.1.3 When to use Agile model:

i. When new changes are needed to be implemented. The freedom agile gives to change is very important. New changes can be implemented at very little cost because of the frequency of new increments that are produced.

ii. To implement a new feature the developers need to lose only the work of a few days, or even only hours, to roll back and implement it.

iii. Unlike the waterfall model in agile model very limited planning is required to get started with the project. Agile assumes that the end users' needs are ever changing in a dynamic business and IT world. Changes can be discussed and features can be newly effected or removed based on feedback. This effectively gives the customer the finishedsystem they want or need.

iv. Both system developers and stakeholders alike, find they also get more freedom of time and options than if the software was developed in a more rigid sequential way. Having options gives them the ability to leave important decisions until more or better data or even entire hosting programs are available; meaning the project can continue to move forward without fear of reaching a sudden standstill.

3.5.1.4 Reason for employing Agile model:

Unclear Requirements from the user of the system has led to the use of Agile developmentmethodology in this project.

Under Agile Methodology, Extreme Programming is employed in this project.

3.5.2 Extreme Programming (XP)

XP uses an object-oriented approach as its preferred development paradigm. XP encompasses asset of rules and practices that occur within the context of four framework activities: planning, design, coding and testing. Figure 3.1 illustrates the XP process and notes some of the key ideas and tasks that are associated with each framework activity. [7]

Fig 3.1 XP programming model

a. Planning

The planning activity begins with the creation of a set of stories that describe required featuresand functionality for software to be built. Each story is written by the customer and is placed on an index card. The customer assigns a value (i.e. a priority) to the story based on the overall business value of the feature or function. As development work proceeds, the customer can add

stories, change the value of an existing story, split stories, or eliminate them. The XP team then reconsiders all remaining releases and modifies its plans accordingly. [7]

b. Design

XP design rigorously follows the KIS (Keep It Simple) principle. A simple design always preferred over a more complex representation. In addition, the design provides implementation guidance for a story as it is written – nothing less, nothing more. The design of extra functionality (because the developer assumes it will be required later) is discouraged. [7] **c. Coding**

XP recommends that after stories are developed and preliminary design work is done, the teamshould not move to code, but rather develop a series of unit tests that will exercise each of the stories that is to be included in the current release (software increment). Once the unit test has been created, the developer is better able to focus on what must be implemented to pass the unit test. Nothing extraneous is added (KIS). Once the code is complete it can be unit tested therefore providing instantaneous feedback to the developer. [7]

d. Testing

We have already noted that the creation of a unit test before coding commences is a key elementof the XP approach. The unit tests that are created should be implemented using a framework that enables them to be automated. This encourages regression testing strategy whenever codeis modified. XP acceptance tests also called customer tests are specified by the customer and focus on overall system features and functionality that are visible and reviewable by the customer. Acceptance tests are derived from user stories that have been implemented as part ofa software release.

5. SYSTEM DESIGN AND IMPLEMENTATION

4.1 System Design

During the Design Phase, the system is designed to satisfy the requirements identified in the previous phases. The requirements identified in the Requirements Analysis Phase are transformed into a System Design Document that accurately describes the design of the systemand that can be used as an input to system development in the next phase. In this project the design methodology employed is Object-Oriented Design Methodology.

4.1.1 Object-Oriented Design Methodology.

Object-oriented design is a design strategy where system designers think in terms of ‘things’ instead of operations or functions. Rather than a program being designed as a set of functions that interchange data through their parameters and through a shared memory (global variables),an object-oriented program is made up of interacting objects. Objects maintain their own local state and define operations on that state information. They hide information about the representation of the state and hence limit access to it.

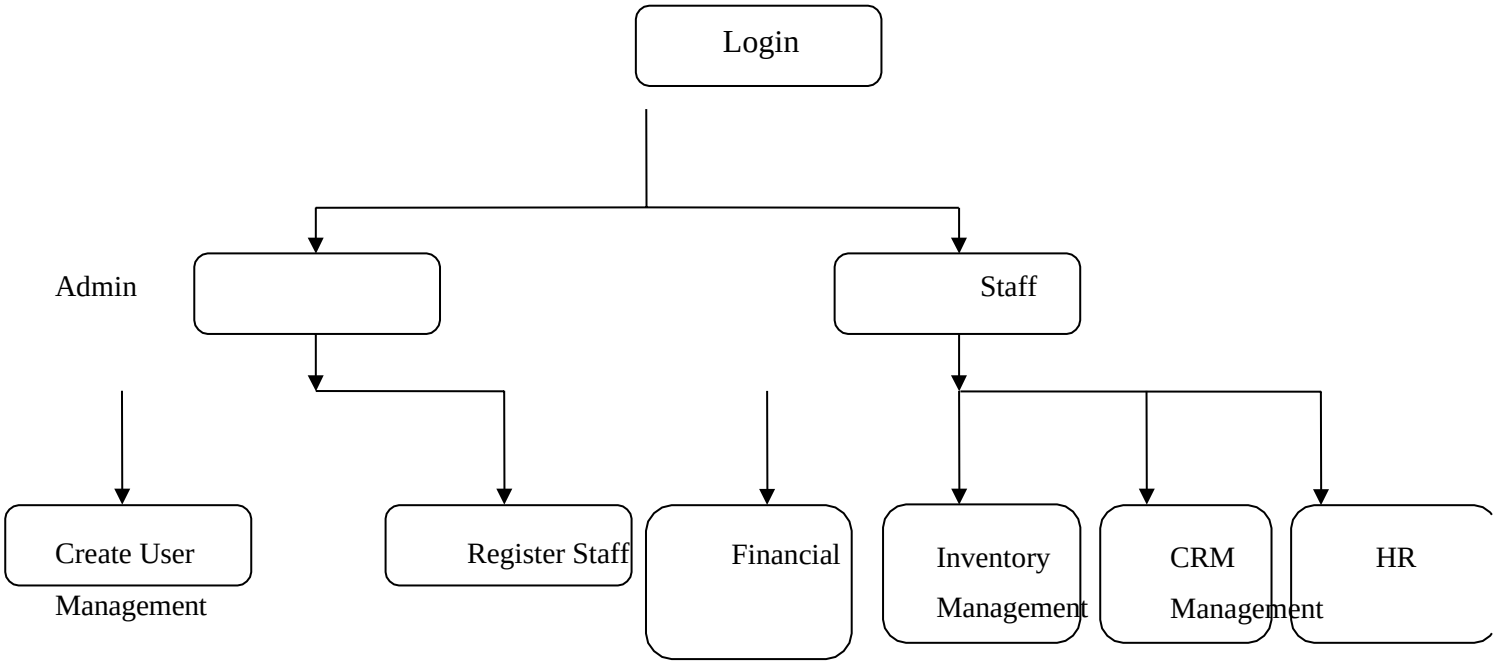


Fig 4.1 A hierarchical model of the proposed system 4.2. DataFlow Diagram of the Proposed System.

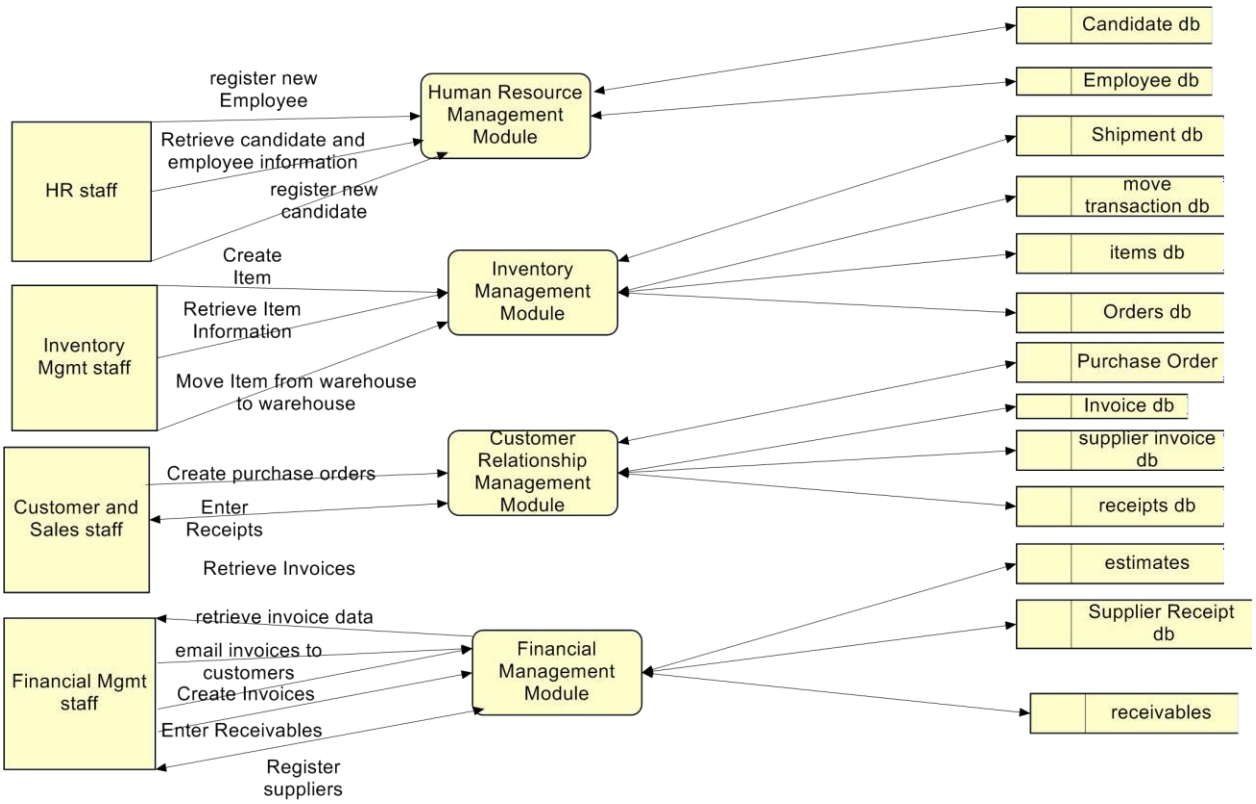


Fig 4.2 A Data Flow Diagram of the proposed System

4.2.1 A Data Flow Diagram of the Order Processing of the proposed System.

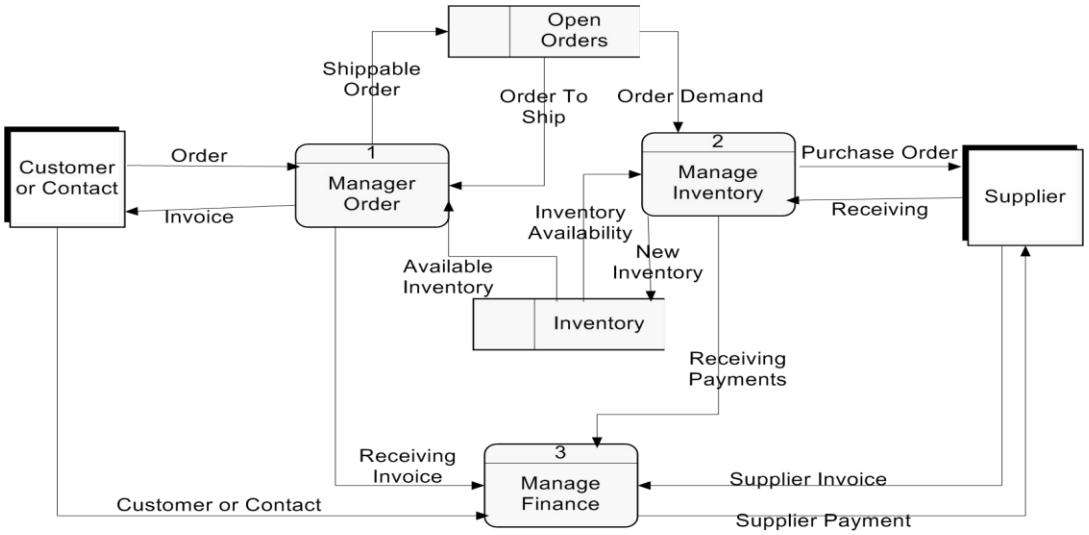


Fig 4.2.1 A Data Flow Diagram of the Order Processing of the proposed System

4.2.2 Description of System Modules

The system has 4 (four) modules namely: Financial Management, Customer Relationship Management, Inventory Management and Human Resource Management.

1. Financial Management: This is composed of creation, viewing, deleting, updating andsaving of Estimates, Invoices Receivables, Supplier Receipts and Supplier Invoices.
Estimates and Invoices can be saved or emailed to the customer in a pdf format.

2. Customer Relationship Management: This is composed of creation, viewing, deleting,updating and saving of Leads, Opportunities, Customers and Contacts. Leads can be converted to opportunities, opportunities to customers, and customers to contacts.

3. Inventory Management: This is composed of creation, viewing, deleting, updating andsaving of Items, Shipments, Move transactions, Purchase orders, receipts and orders.

4. Human Resource Management: This is composed of creation, viewing, deleting, updating and saving of Candidates and Employees. Here application access can be managed by the admin or HR manager.

4.3 Database Design

Database design is the process of producing a detailed data model of a database. A properlydesigned database provides you with access to up-to-date, accurate information.

4.3.1 Enhanced Entity Relationship Diagram

This shows the entities of the database and their relationships.

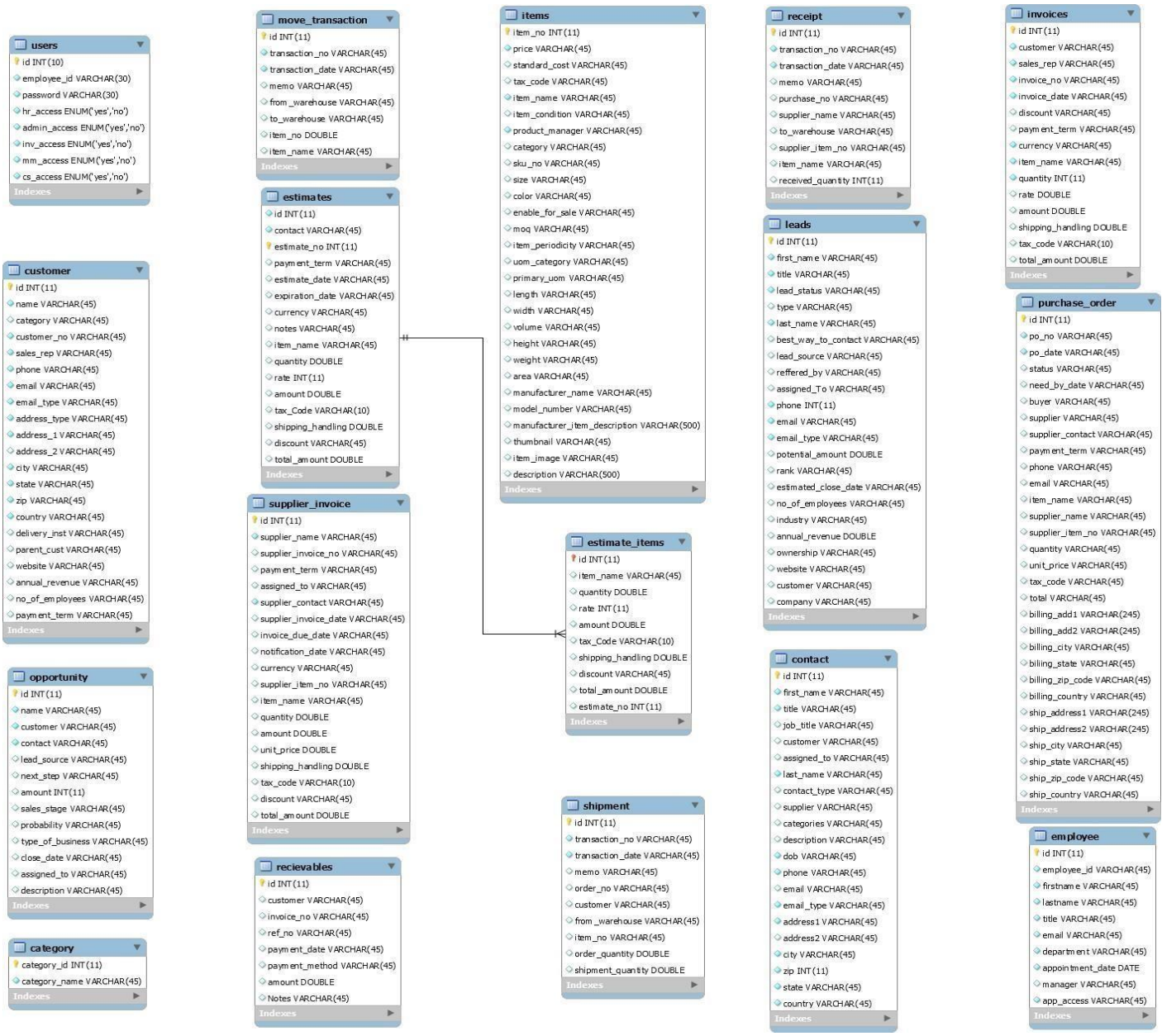
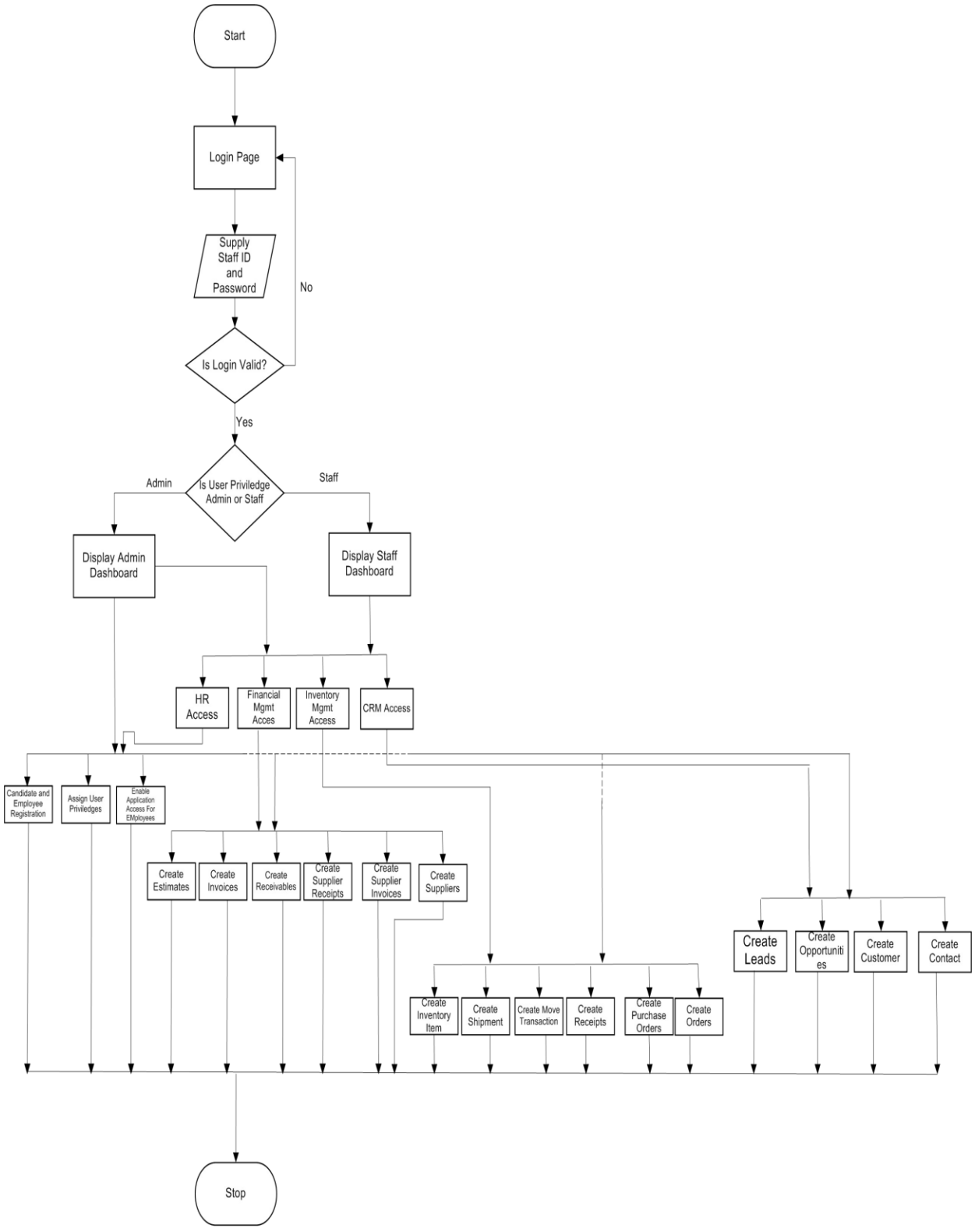
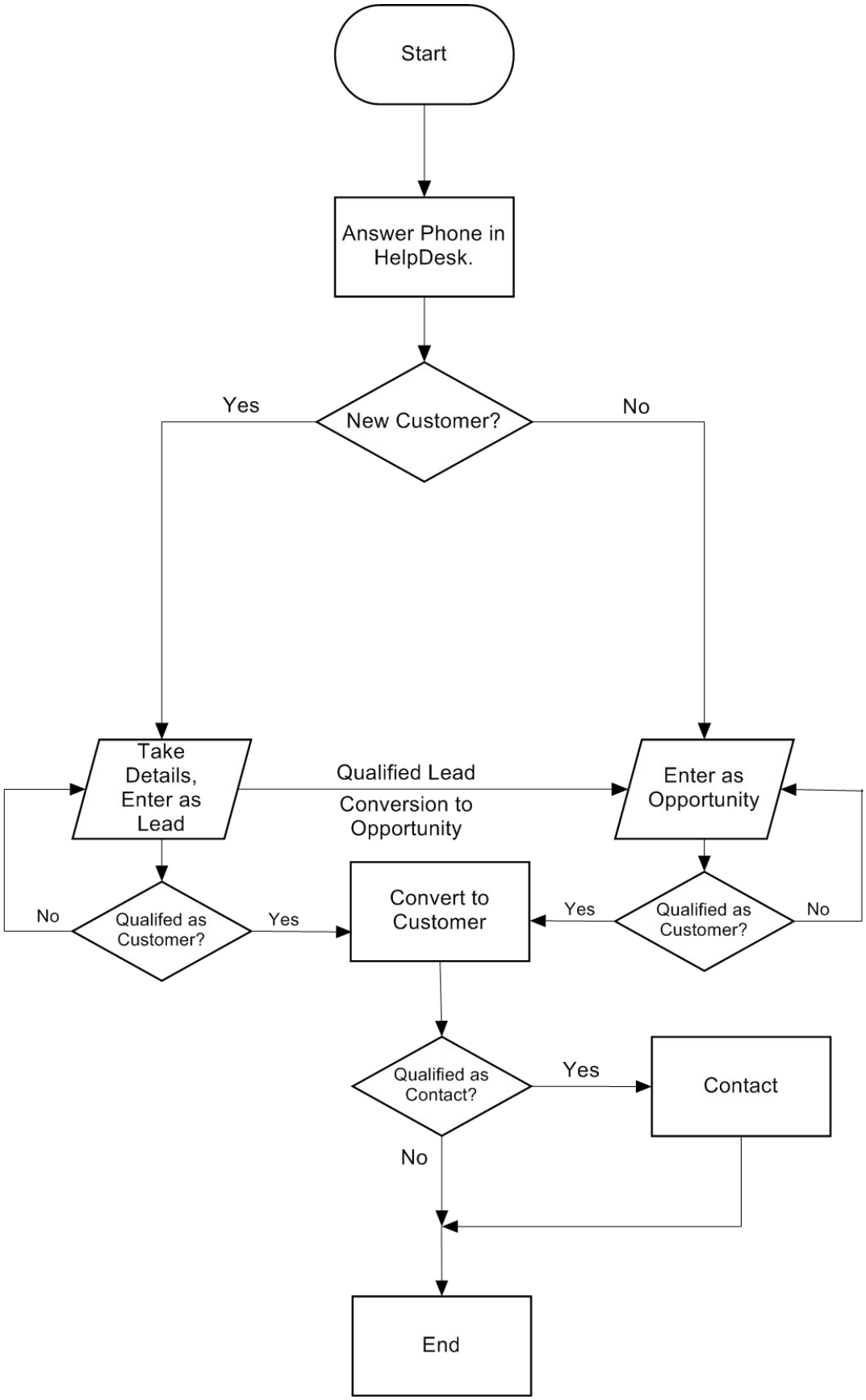


Fig 4.3 An EER diagram of the Database and its Tables



4.3.2 Program Flow Chart of the proposed system.Fig 4.4 A flow Chart of the proposed System

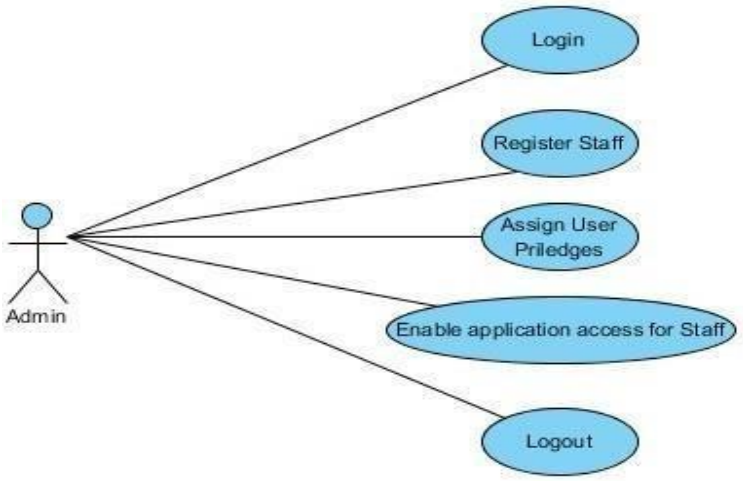
4.3.3 Customer Relationship Management Flow Chart of the proposed system.



A program Flow Chart of the Customer Relationship Module

4.3.4 Use Case Diagram

UML Use Case Diagrams (UCDs) can be used to describe the functionality of a system in a horizontal way. That is, rather than merely representing the details of individual features of your system, UCDs can be used to show all



of its available functionality. UCDs have only 4 major elements: The actors that the system you are describing interacts with, the system itself, the use cases, or services, that the system knows how to perform, and the lines that representrelationships between these elements.

Fig 4.6 UML showing Admin functionalities

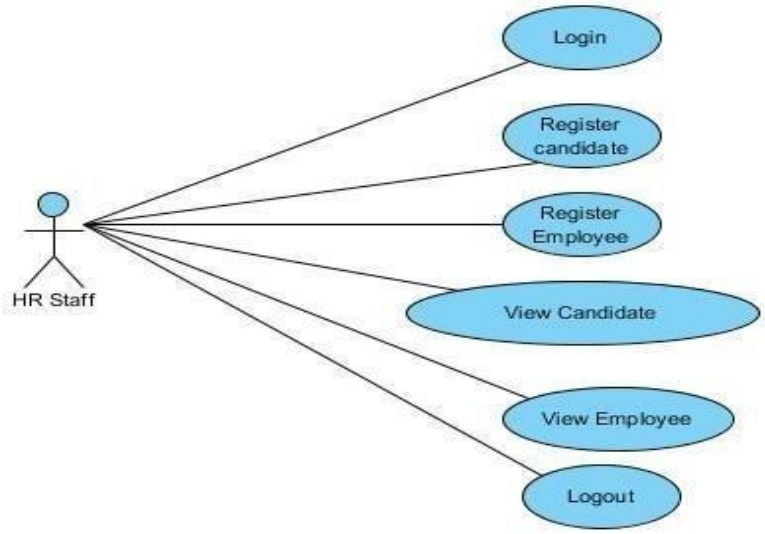


Fig 4.7 UML showing HR Staff functionalities

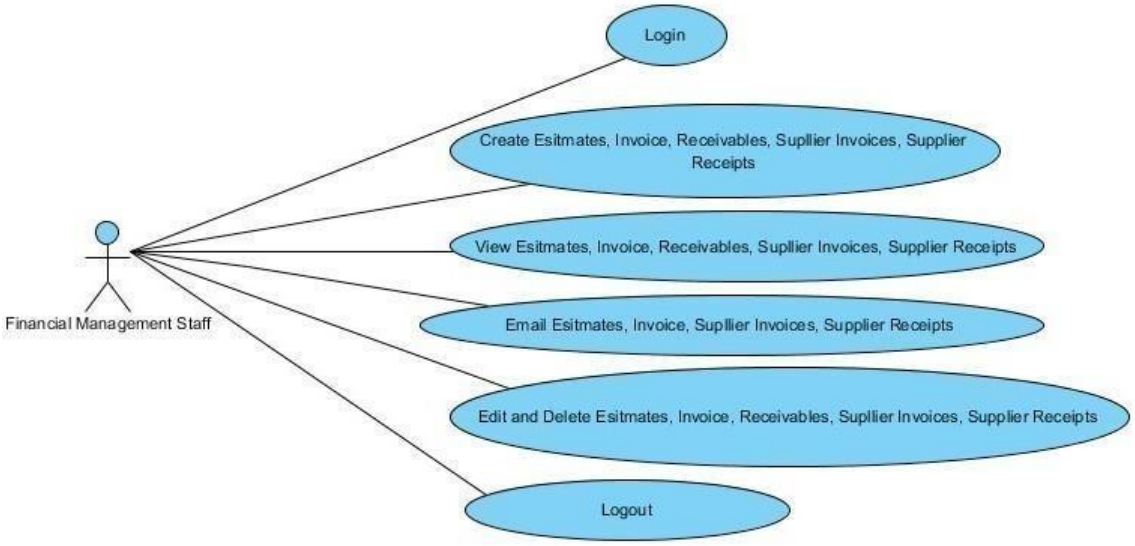


Fig 4.8 UML showing Financial Management Staff functionalities

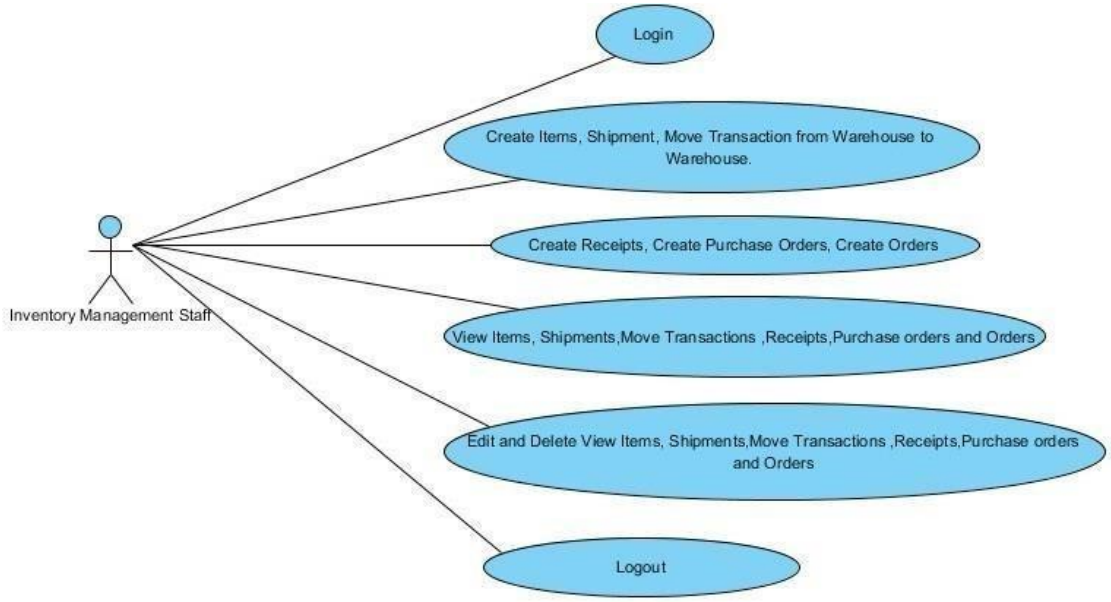


Fig 4.9 UML showing Inventory Management staff functionalities

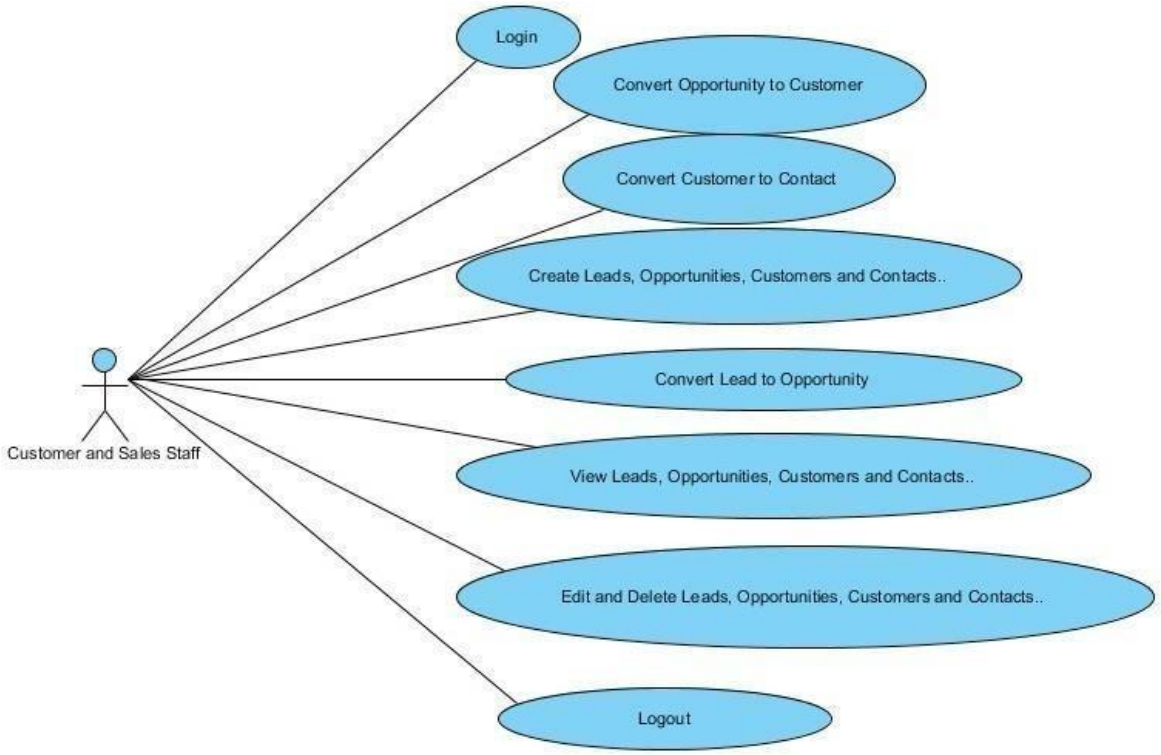


Fig 4.10 UML showing Customer and Sales Staff functionalities

4.4 System Implementation

This phase constitute one of the final steps to the full development of the software. The system implementation phase covers all the activities that take placed in converting from an old (already existing) system to a new system. The proposed system is implemented using PHP asthe scripting language, Javascript, Ajax and MySQL.

4.4.1 Development Environment

The suitable development environment has to be established to ensure that the implementation process runs smoothly. The following describes the software and the hardware requirement forthe development process.

4.4.1.1 Hardware Requirements.

Table 4.1 describes the hardware requirements for the Automotive Plant Management system.

Hardware	Description
Processor	Intel Celeron/Centrino 1.6 Ghz Processor orhigher or other equivalent processors
Memory	At least 1GB. Recommended: 2GB or more

Hard disk space	At least 1024MB
Others	Internet access

4.4.1.2 Software Requirements

Table 4.2 describes the software requirements for the Automotive Plant Management System

Software	**Description**
Operating System	Microsoft Windows Vista or higher
Web Server	Apache 2.2.12 or higher
Relational database management	MySQL 5.1.37 or highersystem
Internet Browser	Google chrome, internet explorer, MozillaFirefox.
Programming(Scripting) Languages	PHP 5.5.2 , JavaScript, HTML, Ajax
Web design and Development tool	NetBeans 8.0.2, MySQL Workbench 6.2 or anyother tool.

4.4.2 Development Tools

a. PHP

PHP (acronym for Hypertext Preprocessor).PHP is a simple, fast, portable scripting language well suited for development of database-enabled Web sites. It was developed in 1995 and is currently powering tens of millions of Web sites worldwide. The predecessor to PHP was

PHP/FI, Personal Home page/Forms Interpreter, developed by Rasmus Lerdorf in 1995 to help him track the number of visitors accessing his online résumé. It was basically a set of Perl/CGIscripts later rewritten by Lerdorf in the C language and opensourced; that is, made freely available. PHP was very Perl-like in sytnax, but whereas Perl is an all-purpose, jack-of-alltradesscripting language, PHP was designed specifically to master the Web. PHP instructions can beembedded with HTML right in the Web page so that whenever the page is loaded, PHP can execute its code. PHP made processing forms easier by providing automatic interpretation of

form variables. It allowed for interaction with databases. It enabled users to create simple dynamic Web sites. The toolset Rasmus Lerdorf developed was so popular that in 1997, PHP/FI

2.0 was released. [9] Due to the popularity of this new release, Lerdorf was soon joined by a core group of developers, who continued to provide improvements and enhancements to the new language. By this time, there where thousands of users and approximately 50,000 Web sites running PHP/FI pages; Zeev Suraski and Andi Gutmans, two students attending TechnionIsrael Institute of Technology, needed a language for their university e-commerce project. They chose PHP/FI for their project. Dissatisfied with its limitations and bugs, they put their project aside, and rewrote PHP almost from scratch. PHP 3.0 was a significant departure from the previous code base. The new language supported add-on modules and had a much more consistent syntax. At this time, the meaning of the acronym changed as well. PHPnow stands for PHP: Hypertext Preprocessor. PHP 3.0 was released in 1998 and is the closest version to PHP today. By May 2000, PHP 4 was released. The core of PHP 4 was entirely rewritten to improve the performance of complex Web applications and improve modularity of the platform. Zeev Suraski and Andi Gutmans, the authors of PHP 3, introduced a new parsingengine, called the Zend engine, which is the scripting language that powers PHP today. Becauseof their internationally recognized authority, Suraski and Gutmans founded Zend Technologies,the PHP Company, and their contributions to PHP have been a major reason for its explosive worldwide growth. The term Zend is a portmanteau, a word created by combining the letters in their first names: Zeev and Andrew Version 4 offered an open Application Programming Interface (API), allowing other programmers to write modules for PHP, modules that would extend its functionality, modules that allowed PHP 4 to support most of the available databasesand Web servers available. With this release, PHP became a serious programming language and platform for developing and deploying complex Web applications. The latest incarnation of PHP was released in July 2004. PHP 5 added a whole new object-oriented model to the language. The new model is based on

Zend Engine 2 and greatly improves PHP performance and capabilities. Most of the functionality is backward compatible, allowing programs written in older versions to continueworking. [9]

b. JavaScript

JavaScript is Netscape's built-in, cross-platform scripting language. Like HTML, it will workon all platforms. JavaScript allows you to enhance the functionality of your Web pages byembedding applications directly into your HTML. You can use JavaScript to build applicationsthat range from adding interactivity to your pages to applications that interact with databases. Although Netscape created JavaScript, it will work on most modern browsers, including Microsoft's Internet Explorer (IE). However, IE doesn't directly support JavaScript. IE has its

own scripting language—JScript—that supports most of the features found in JavaScript. In the few instances in which the languages differ, those differences are pointed out and a workaround is presented. As these are the two main browsers on the market, the scripts we willbe writing will focus on them. It was introduced to increase the speed of web applications by working behind the scene with the database, retrieving and storing data without reloading the whole page. JavaScript is not used to pass sensitive data such as passwords in view that the codes are executed at the client side where the system can be vulnerable to malicious attacks.
[8]

c. Html

HTML, acronym for HyperText Markup Language, is a markup language used to describe theformatting of text in a document. It is useful in the sense that it allows text to be structuredaccording to its purpose, namely as a heading, paragraph and so on. This is accomplished by writing the HTML in 'tags' that describes to the web browser how the text is to be displayed.A scripting language such as PHP and JavaScript can be easily embedded in HTML to enhancethe functionality of HTML.

d. Netbeans 8.0.2 IDE

Netbeans 8.0.2 IDE was selected for this project because of its ability to automatically indents lines, matches words and brackets, and highlights source code syntactically and semantically. It lets you easily refactor code, with a range of handy and powerful tools, while it also providescode templates, coding tips, and code generators. Keeping a clear overview of large applications, with thousands of folders and files, and millions of lines of code, is a daunting task. NetBeans IDE provides different views of your data, from multiple project windows to helpful tools for setting up your applications and managing them efficiently, letting you drill down into your data

quickly and easily. Finally it was chosen because its ability to recognize Javascipt, Ajax, CSS,and PHP codes with code hinting and bug detection.

4.4.3 Operation Platform

The Windows 7 operating system was selected as the platform for the development of this system. The fact that the potential users are already using and are familiar with the Windows 7environment played an important role in the selection. Since the inception of the operating system, the developers of Windows7 have continually improved its stability while providing auser-friendly environment.

4.5 Database Implementation

MySQL is a database system used on the web. Basically, a MySQL database allows you to create a relational database structure on a web-server somewhere in order to store data or automate procedures. If you think of it in comparison to Microsoft Access, MySQL is what holds all of your tables, PHP acts as your queries (among other things), and your forms are basically web pages with fields in them. With all of this combined, you can create truly spectacular projects on the web. MySQL uses the client/server model; that is, a database server(MySQL) that serves (communicates) with multiple clients (application programs), where the clients may or may not be on the same computer. It also supports SQL, the structured query language, a standardized language used by most modern databases for working with data and administering the database.
[10]

4.5.1 Advantages of MySQL and PHP

Certain technologies play together better than others. PHP, a simple and powerful scripting language, and MySQL, a solid and reliable database server, make a perfect marriage between two modern technologies for building database driven, dynamic Web sites. Some of the advantages of both PHP and MySQL are: a. High performance

b. Built-in libraries

c. Extensibility

d. Relatively low cost

e. Portability

f. Developer community

g. Ease of learning

4.6 Software Testing

This defines the test requirement which the software should meet and then it is progressively integrated into a complete package. The process of test plan is concerned with ensuring that a package produces correct and expected result for all possible input data. For this software testing, we have four basic testing that should be adopted. These include:

1. Unit Testing
2. Integration Testing
3. System Testing
4. User acceptance Testing

4.6.1 Unit Testing

The unit testing involves testing of each module in the software to verify that they meet their respective objectives. Unit testing is carried out to ensure that information flows properly in and out of the program module under test. The unit testing is also done to ensure the functionality of each unit such as the InventoryManagement module, Financial Management module, Customer Relationship Management Module and the Human Resource module are functioning properly.

4.6.2 Integration Testing

Integration testing has shown that, though sometimes, the modules can perform their respectivefunctions but when put together they fail to function and produce the expected results.Integration testing is a logical extension of unit testing. Hence, integration testing was done to the entire program structure to uncover errors associated with interfacing. These errors were debugged to produce desired results. The essence of integration testing is to ascertain that thesemodules do not lose their efficiency and reliability.

4.6.3 System Testing

The system testing is testing conducted on a complete, integrated system to evaluate the systems compliance with its specified requirement. In the Automotive Plant Management System, each routine must have been written according to specification and tested to completesatisfaction. Also bugs must have been removed completely and the software produces exactlywhat is required when data is being given to it.

4.6.4 User Acceptance Testing (UAT)

This is also called beta testing, application testing, and end user testing. This is a phase of software development in which the software is tested in the “real world” by the intended audience. The UAT done on this system is the in house testing in which volunteers use the software. The experience of these test users are then put into consideration

5, SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

Automotive Plant Management System has been developed to eliminate the challenges faced at an Automotive Plant (Innoson Vehicle Manufacturing Ltd.) in carrying out its daily activities. The system was developed to provide integration of data throughout the company, by managing financial data, providing inventory of assembly parts, providing a customer relationship management (CRM) system and by managing staff information.

5.1.1 Achievements

The achievements in this system can be summarized below:

1. Provides a computerized way of storing files such as invoices, orders, receiptsreplacing the manual method.
2. Provides easy and flexible access to employee and department information.
3. Provides an easy way of sending invoices to customers.
4. Provides a CRM system to manage customers.

5.1.2 Difficulties Experienced

The difficulties encountered during the development of this project are highlighted below:

1. Limited time to develop a system that covers all operations of the company.
2. Limited access to the internet.
3. Power supply problems
4. Insufficient access to company's information.

With India's aim to transform its automobile industry by focussing on e-mobility, it is mandatory to address the knowledge gap as lack of awareness of potential barriers in EV adoption. As a limited study has been conducted in this field in India, identifying and classifying these barriers into various groups is necessary. The aim of this project is to determine the factors influencing consumers' intention of electric vehicle adoption in India. Based on the components grouped, six factors were identified and named as financial factors, vehicle performance factors, lack of charging infrastructure, environmental concern, societal influence and awareness of electric vehicles.
Based on the results the factors found in this study are similar to some of the factors found by Noel et al. (Citation2020). Financial barriers, vehicle performance barriers and lack of charging infrastructure facilities are found to be the major factor in adoption of EV's in Indian context.

The findings of this research can be used by manufacturers and suppliers of the automobile industry, the private and public institutions dealing with e-mobility, sustainability or green business solutions as well as the governments. This could further help them to develop and provide strategies with the goal to overcome the adoption barriers currently existing. Overcoming these barriers would then attract larger number of consumers to Electric Vehicles.

The study was restricted to one metropolitan city in India, which is an IT hub. The sample size was limited to only 172 respondents and mostly in the age group of 25–34 with salaried people. There is a need to replicate the study in other cities to understand the influencing factors. Further studies can focus on the influence of the factors identified in this study and also on acceptance of new technology when buying electric vehicles

REFERENCES

1. http://www.plex.com/industries-and solutions/industries/automotive.html/#sthash.bjcXMEFG.d puf

2. www.nac.org.ng/industries-genesis.php

3. www.nac.org.ng/industries-problems.php

4. www.dspi.com/home/manufacturing.php

5. www.madehow.com/voulme-1/Automobile.html

6. Lawrence S. Gould, *How ERP Systems must meet the challenges of Automotive Suppliers*. 66.192.177.249/articles/119808.html

7. Roger S. Pressman, Ph.D. (2010) *Software Engineering, A Practitioners Approach, Seventh Edition*, New York, McGraw-Hill.

8. Dan Barrett (1999), *Essential Javascript for web professionals*, Prentice Hall, NewYork.

9. Ellie Quigley with Marko Gargenta (2009).*PHP and MySQL by example.*

10. Paul raj Ponniah. (2003). *Database Design and Development: An Essential Guide for IT Professionals*. John Wiley and Sons.

11. KPMG International. (2013). *The cloud takes shape.* KPMG International.

12. Gould, L. (2014, Febuary). Dassault Goes To The Cloud. *Automotive Design andProduction*, pp. 34-35.

13. Peter Dicken (2003), *Global Shift: Reshaping the globl economic map in the 21st Century*. New York , Sage Publications Ltd.

14. Center for Automotive Research (CAR). (2014), *Advanced Information TechnologySolutions: An Engine of Innovation*, www.cargroup.com .

15. Ivan Marsic (2012), *Software Engineering*, New Jersey, Rutgers University.