CHAPTER ONE

INTRODUCTION

1.1 Background

An expert system or Knowledge Based System results when the knowledge of a Domain Expert is elicited and stored in a knowledge Base and an Inference Engine (software) is developed to sift through the knowledge Base in a manner that mimics the Domain Expert's thinking process when a problem requiring the Domain Experts knowledge occurs. James A. (2008) stated that it enables the expert System to arrive at a solution to the problem comparable to that of the Domain Expert.

An expert system development necessarily focuses on a narrow domain of human endeavor for which there is a domain expert. Chris et al. (2008) emphasised that it is also possible to distill the knowledge of a number of Experts in the same domain into one and the same expert system when each of such experts can be reached and made to work co-operatively in order to establish the Expert System. The advent of the Internet has made possible the collaboration of many experts in the same domain in widely dispersed geographic locations,. This is an important boost to Expert System development.

Bruce .G.(2007) was recorded to develop a knowledge base requires the services of a well trained Knowledge Engineer whose job is to elicit knowledge from relevant Domain Experts, codify the Knowledge and store same in a computer-based repository or knowledge base which will then be used by the Inference Engine when searching for expert-like solutions to problems. The Knowledge Engineer elicits tacit knowledge from Domain Experts who helps him to transform knowledge from tacit to explicit knowledge through mutual interaction. Simon Kendal (2007) recorded that to encourage a Domain Expert to

release his expert knowledge in whatever form is a task that requires great tact and a careful approach by the knowledge Engineer in order to reach the accurate knowledge in the brain of the Domain Expert. Often, such Knowledge is in the form of heuristics or educated shortcuts used by the Domain Expert when solving problems. These must be properly understood and codified by the Knowledge Engineer during Knowledge Based System development.

Inferencing implies deductive reasoning, or working from a set of inputs concerning a problem (symptoms) until the software progressively reaches the diagnosis of the problem and then presents the programmed solution, Hidehiko Tanaka (2000) wrote on Rule-Based Expert System, the knowledge consists of a set of rules which are traversed in search of a rule that satisfies the current symptoms of the problem for which solution is being sought.

Inductive Reasoning is used when a number of problems have been solved in the past and the software searches for a match to the current problem among already solved problem, and if found, presents the same solution that was applied before as the solution to the current problem emphasized by Anthony M. (2011). If not found, the software reverts to deductive reasoning.

Timothy J. (2006) inscribed that Fuzzy Logic may be used to solve problems represented by the inputs when the input variables are not precise but fuzzy, lying in a number of ranges called fuzzy sets. Fuzzy logic involves fuzzification (i.e. finding the fuzzy sets to which the inputs belong) and defuzzification (i.e. finding a crisp value that best represents the solution determined by the fuzzy logic.

1.1.1 Static Expert System

An Expert System is static when there is no means of improving its expertise once it is developed, Suzanne S. (1999) emphasized that it can only mimic the

intelligence found in Domain Expert(s) at the point of its development even if the situation has changed.

1.1.2 Dynamic Expert System

A Dynamic Expert System as the name implies, is dynamically kept up-to-date as more knowledge is gained. Gia .S. (2009) wrote that it is a useful means of managing the intellectual property that drives an organization forward so that it can be enhanced as knowledge increases and edited to eliminate obsolete knowledge or techniques. The dynamic expert system is thus able to keep track of best practices at any point in time and grows like a living organism to enhance organizational performance as it grows richer with best practices.

A dynamic expert system results when there is an initial expert system in a given domain and the domain experts are continuously monitored for improvements in their domain of expertise that could be used to upgrade the already developed expert system. When this is done continuously, the expert system performs better and behaves more like a living organism whose knowledge is dynamically upgraded.

In the context of a company, one is concerned with Intellectual Property (IP) vested in the individuals that work for the company. An initial expert system in this regard would be made up of best practices at every level of the organization for performing the operations of the firm. If through collaboration and knowledge sharing within the company, new best practices are evolved and used to replace the older but now obsolete best practices, then the intellectual property of such a company will be dynamically upgraded and the company can keep pace with changing technology. These dynamic growths in the company's intellectual property means that the company is now able to mature with time in capability in terms of   IP content even far beyond the levels represented in the initial expert systems. Such a growth is measurable and closely linked to the

competitiveness of the firm within its industry as argued by Cornelius T. (2001). It is expected that this research will develop   a suitable metrics for IP growth   evaluation among other things.

1.1.3 Intellectual Property Management

Multi-million and Multi-billion dollar patent settlement   regularly splash across news headlines. These dramatic financial implications of intellectual property (IP) rights make effective IP management more important than ever. Jeffsey H. (2004) mentioned that companies everywhere face a growing pressure to protect intellectual property and safeguard their technology assets. Intellectual property is an important measure of corporate value. The ability of firms to support the application of new knowledge depends increasingly on effective management of intellectual property (IP). Eric Yu et al, (2010) mentioned that effective IP Management enhances a firm's own potential for income and enables them exploit further research opportunities. Good IP management is important not only because of the financial returns that it can help generate for a firm, but because it can also contribute to their corporate aim and objectives, Taryana S. (2013) wrote that Effective IP management system is a vehicle for firms to organize profit-enhancing collaborations with competitors, suppliers etc.

Hazan E. A (2006) said that IP management is a crucial element of the business operations and strategy of any company. However, Hodgkinson D. & Clarkson .J (2006) further emphasized that IP management is a painstaking and time consuming process that requires a combined in-depth knowledge of engineering.

Matt .B. (2008) mentioned that the optimal exploitation of IP through its sale, licensing and other IP commercialization activity requires an effective IP management model. Paltrey M. (2007) wrote that the algorithm of IP management systems has to be robust enough to provide data analysis to

support effective management decisions in order to facilitate IP management work flow. Vinod .V (2016) Proposed an IP management system whose decision support algorithm stems from online convex optimization. Though this system optimizes coordination cost, however its evaluation of IP commercialization and rights transfer decision is unrealistic since it assumes that the organization is risk neutral. Yong .C. and Li .Z (2011) Modeled what is referred to as an enterprise aware IP management system. Its decision support analytics does not enable adaptive decision making since its algorithm is based on deterministic mathematical procedures.

Vinod V. (2016) emphasized that these conventional IP management models incorporate, in terms of input variables, only quantitative factors such as cost, cycle time and other magnitudes. A number of qualitative factors such as legal impact of IP rights, corporate beliefs, idiosyncratic behavioral patterns of firms as it touches on IP issues and other corporate psychology that substantially influence the IP landscape are not sufficiently accounted for by the existing IP management models, Furthermore these conventional models show limitation in the integration of IP management with the core business strategic planning of companies. In other words these models do not foster the benefits of the close and early collaboration between creators, managers, lawyers and other IP management professionals of the firm.

Yong .C. (2011) said that It is generally acknowledged by experts that unless R&D, marketing and IP decision are tightly integrated, a firm is unlikely to reap the full benefits of its IP right. Only a system that can simulate human reasoning and behavior can incorporate quantitative data and firms' beliefs, idiosyncrasies and other corporate psychology in modeling corporate IP management system. Such an intelligent system provides "rules of thumb" about the way IP management issues are to effectively evaluate either explicitly (experience of an expert) or implicitly (extracting rules from data). Hence a

more dynamic model becomes necessary for managing IP portfolios, if 21st century corporate bodies are to reap great benefits from their IP assets. Due to its ability to emulate the decision making ability of a human expert ensuring its dynamic ability to interpret processes across disciplines or functional areas of a company, a dynamic expert system approach to modeling IP management is proposed in this research.

1.2 Statement of Problem

IP is at the core of most corporate strategy. Its effective management is very vital to building corporate value. Existing IP management systems as pointed out in the background of this work, sits on the framework that is not aligned to organizational decision structure. These IP management models are found not able to handle the dynamic, uncertain interactions of corporate elements. Consequently, these solutions based on deterministic algorithms are not effective management decision for IP management. Therefore, this project is focused on the modeling of a dynamic expert system to address the problems of effective IP management of an organization.

1.3 Aim and Objectives

This research is aimed at modeling a dynamic expert system for Intellectual Property management in corporate bodies.

The objectives, in pursuance of this aim are:

1. To model an expert system for the automation of Intellectual Property of an organization.
2. To use knowledge elicitation techniques continuously to identify best practices to be used to dynamically optimize the decision rule of the expert system.

3. To carry out simulated evaluation of the proposed Dynamic Expert System model for IP management using Cost based Approach.

4. To fit a curve that represents the new Dynamic Expert System (DES) IP growth model using the simulation results.

5. To use Multiple Regression analysis to model patentability based on research output of Faculty of Engineering.
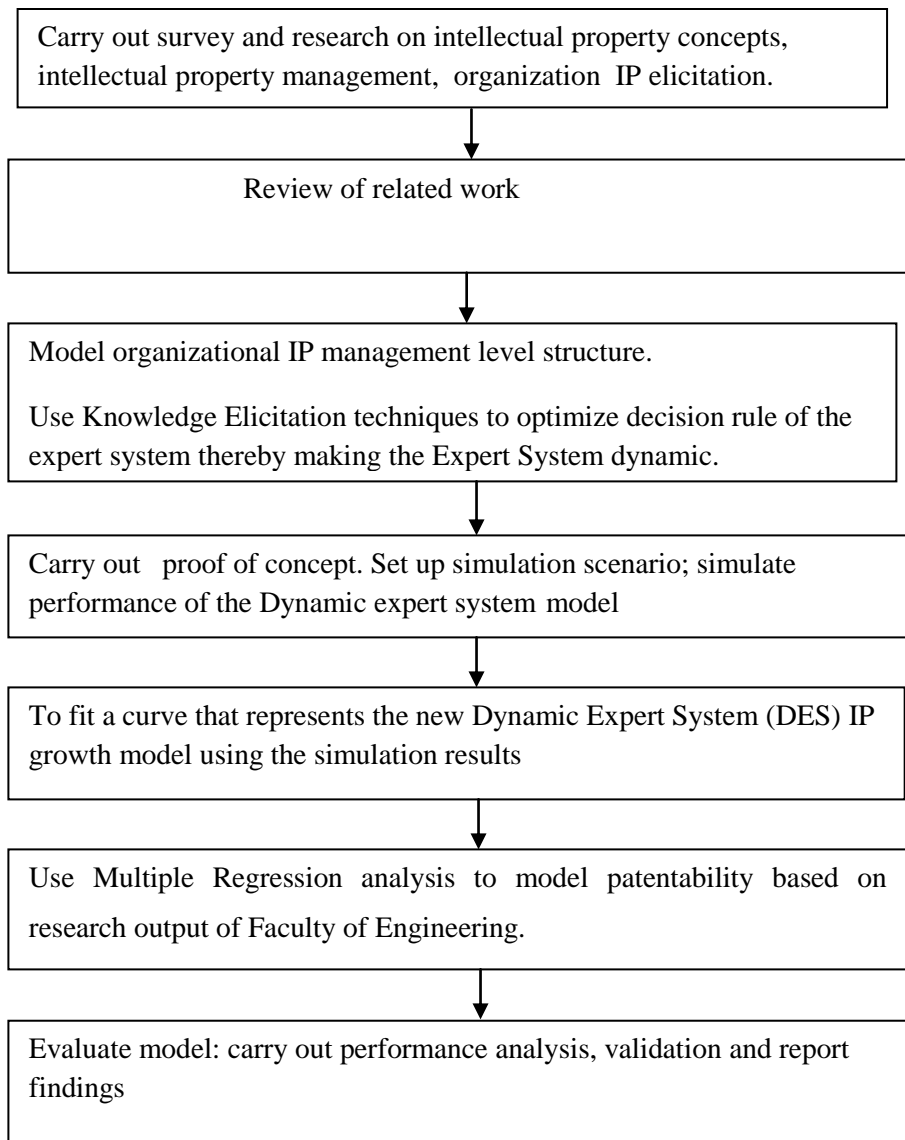
1.4 Significance of the Study

i. The proposed system will enable corporate firms to effectively pursue the quest for business intelligence through stronger intellectual property capacity building.

ii. It would provide data management functionality and data evaluation to enable and streamline the firms' efforts in knowledge sharing and IP growth evaluation.

iii. The proposed system should help to identify areas of improvement in terms of intellectual know-how and operational capacity.

iv. It facilitates the creation of new businesses centered on IP assets e.g Patent, copyright etc.

v. The proposed model also supports speedy resolution of IP disputes.

vi. A company may try to have an edge over its competitors by researching into better ways of carrying out their operations. The outcome of such research would no doubt make a new set of best practices and intellectual properties available to the company. These would amount to quantum leap in operational capacity for the company whenever such research efforts yield positive dividends.

1.5 Scope of the Study

The work covers the realization of a Dynamic expert system model for IP management and the modeling of organizational level structure, Further IP management concepts covered include IP Patent and remuneration, IP evaluation and reporting.

1.6 Overview of the project stages.

This covers the different stages that will be carried out in this research.

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│ Carry out survey and research on intellectual property        │
│ concepts, intellectual property management,  organization     │
│ IP elicitation.                                               │
└─────────────────────────────────────────────────────────────┘
                            │
                            ▼
┌─────────────────────────────────────────────────────────────┐
│                   Review of related work                      │
└─────────────────────────────────────────────────────────────┘
                            │
                            ▼
┌─────────────────────────────────────────────────────────────┐
│ Model organizational IP management level structure.          │
│ Use Knowledge Elicitation techniques to optimize decision     │
│ rule of the expert system thereby making the Expert System    │
│ dynamic.                                                      │
└─────────────────────────────────────────────────────────────┘
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                            ▼
┌─────────────────────────────────────────────────────────────┐
│ Carry out  proof of concept. Set up simulation scenario;      │
│ simulate performance of the Dynamic expert system model       │
└─────────────────────────────────────────────────────────────┘
                            │
                            ▼
┌─────────────────────────────────────────────────────────────┐
│ To fit a curve that represents the new Dynamic Expert System  │
│ (DES) IP growth model using the simulation results            │
└─────────────────────────────────────────────────────────────┘
                            │
                            ▼
┌─────────────────────────────────────────────────────────────┐
│ Use Multiple Regression analysis to model patentability       │
│ based on research output of Faculty of Engineering.           │
└─────────────────────────────────────────────────────────────┘
                            │
                            ▼
┌─────────────────────────────────────────────────────────────┐
│ Evaluate model: carry out performance analysis, validation    │
│ and report findings                                           │
└─────────────────────────────────────────────────────────────┘
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Figure 1.1: System block diagram of the project stages

1.7 Dissertation Organization:

This Dissertation is organized into five chapters:

Chapters One introduces the research, gives background information on the meaning, significance and impact of IP management systems within organizations. This chapter articulates the singular goal of this work in the statement of problem, outlines the project deliverables in terms of objectives to be met, articulates the significance of this work and defines the research scope.

Chapter two reviews literature relevant to the work.

Chapter three discusses the methodology adopted in pursuit of the actualization of the research objectives. Also discussed are the block diagram model of the proposed IP management expert system, the organization level tree model of an organization's IP management decision structure and the contextual and mathematical formalization of the proposed IP.

Chapter four reports the simulation testing of the workings and performance of the proposed IP management model.

Chapter five concludes the work and makes recommendations. It also identifies clearly the contributions to knowledge arising from this research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Intellectual Property

Richard P, (2008) defined Intellectual property (IP) rights are the legally recognized exclusive rights to a creation of the mind. Under intellectual property law, owners are granted certain exclusive rights to a variety of intangible assets such as musical, literary and artistic works, discoveries and inventions; and words, phrases, symbols and designs. Common types of intellectual property right include copyright, trademark, patents, industrial design, trade dress and in some jurisdiction trade secrets.

Although Mark A. (2005) wrote that historians acknowledged the fact that many of the legal principles governing intellectual property rights have evolved over centuries, it was not until the 19th century that the term intellectual property began to be used , and not until the late 20th century that it became commonplace in most of the world. Brad .S (1999) reported that the British statute of Anne (1710) and the statue of Monopolies (1624) are now seen as the origins of copyright and patent law respectively.

Common types of intellectual property rights documented in the literature include patent, copyright, industrial design rights, trademarks, trade dress, and in some jurisdiction trade secrets. West. L (2003) noted that there are also more specialized varieties of sui generis exclusive rights, such as circuit design rights (called mask work right in US Law, protected under the integrated circuit topography Act in Canadian law and in Europe Union Law by Directive 87/54/EEC of 16 December 1986 on the legal protection of topographies of semi conductor products). Plant breeder's right, plant variety rights, industrial design rights, supplementary

protection certificate for pharmaceutical product and database rights (in European law).

As documented in WIPO (2008), IPO (2011), a patent grants an inventor the right to exclude others from making, using, selling, offering to sell and importing an invention for a limited period of time, in exchange for the public disclosure of the invention. An invention is a solution to a specific technological problem, which may be a product or a process.

Peter .K. (2000), wrote that a copyright gives the creator of an original work exclusive right to it, usually for a limited time. Copyright may apply to a wide range of creative intellectual, or artistic forms, or work. Simon .S. (2001) emphasized that copyright does not cover ideas and information themselves, only the form or manner in which they are exposed.

An industrial design right protects the visual design of objects that are not purely utilization. An industrial design consists of the creation of a shape, configuration or composition of patterns or color, or combinations of pattern and color in three dimensional forms containing aesthetic value. An industrial design can be a two or three dimensional pattern used to produce a product, industrial commodity or handicraft.

IPO (2013) documented that a trademark is a recognizable sign, design or expression which distinguishes product or services of a particular trader from the similar products or services of other traders,

Merges et al (2007) wrote on Trade dress as a legal term of art that generally refers to a characteristic of the visual appearance of a product or its packaging (or even the design of a building) that signify the source of the product to consumers.

WIPO, (2000) documented that Trade secret is a formula, practice, design, instrument, pattern, or compilation of information which is not generally known

or reasonably ascertainable, by which a business can obtain an economic advantage over competitors or customers. Indicators from the survey of the literature shows that trade law varies from country to country.

2.1.1 Objectives of Intellectual Property Law

Based on the survey of the extant literature, the stated objective of most intellectual property law (with the exception of trademarks) is to "promote process"., Spine .I. (2007) wrote on his idea that by exchanging limited exclusive rights for disclosure of inventions and creative works, society and the patentee/copyright owner mutually benefit and an incentive is created for inventors and authors to create and disclose their work. Richard .T. (2005) commented have noted that the objective of intellectual property legislation and those who support its implementation appears to be "absolute protection". If some intellectual property is desirable because it encourages innovation they reason, more is better.

Lancini et al (1997) said that the thinking is that creators will not have more incentives to invest unless they are legally entitled to capture the full social value of their inventions.

2.2 Intellectual property management and Organizational Level Structure

Sullivan P.H (2003) strongly argued that there are substantial advantages in locating IP management functions within the organizational management structure. The argument advanced is that the organizational level structure has direct impact on the performance of the IP management processes.

However the position of a number of authors Mylopoulos J. (2006), Yu .E. (2000), Rivette K.G. (2003) is that to analyze the strategic significance of particular pieces of knowledge or intellectual property within an organizational and business context, an ontology that captures IP management is needed. Along this line of reasoning, Yu .E. (2000) proposed a strategic actor relationship modeling

framework to support IP management. In strategic actor relation, actors have goals, and know-how and resources for achieving goals. Patents restrict the use of know-how, thus prompting actors to reposition themselves within a network of dependency relationship.

This approach centered on strategic actor relationships which have been used for modeling and analyzing IP management issues, Yu .E. (2000) claimed that, this ontology made it possible to go beyond entity relationship and mechanistic behavior, to deal with the opportunistic behavior of strategic actors. Interdependencies among actors place constraints on their freedom of actions. Nevertheless, constraints can be violated due to agent autonomy (unlike in mechanistic system) as in the patent infringement case. Strategic actors seek to achieve goals by exploring and evaluating alternatives, taking into account the opportunities and vulnerabilities arising from various dependency relationships. Sullivan P.H. (2005) emphasizes systematic IP management processes and analysis particularly the quantification of economic value of intangible assets and intellectual property.

Rivette .K.G (2003) wrote on the increasing use of computational techniques, e.g. patent database search and retrieval and cluster analysis to determine distribution of patent among subject areas. There was no enhancement on the database.

Kodak (2012) developed a specific IT tool to support its intellectual property generation process, the so called invention tracker. The invention tracker manages the information processing between different departments and involved employees from idea finding and evaluation of patenting decisions and patent filing, it also uses the commercial database micro patent which enables Research & Development (R&D) employee to gather IP information. It has misguided patent procedure and it gives patent for free.

Schindler et al, (2016) developed an internal IP database storing ideas, invention disclosure and patent data. In the database, patents are classified according to defined criteria. The keywords of the classification are renews every two years. It include the market sustainability, technical aspects are assessed too. The challenge for schindler regarding the database is on the one side to provide firm-wide communication and to ensure confidentiality of the information. Data communication and communication between the database users is therefore implemented via a secured intranet, he established different levels of access authorization.

Smith and Hansen (2014) split the strategic management of IP in the activities of IP generation, protection and valuation and argue that firms must ensure that these activities are aligned with business strategy. They mentioned that firms must ensure that patent protection should be given out free but there was no means of growing the IP.
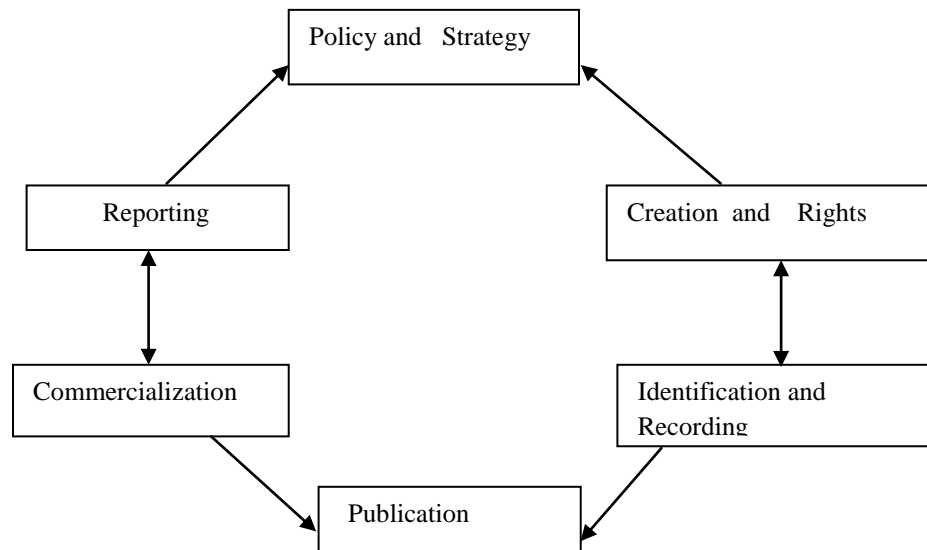
Carlsson et al (2008) conducted a case study research with 15 technology-based firms from US and developed a general IP mgt process consisting of the phases pushing for strategic IP inventors' activities, screening techniques & checklists and finally patent prosecution. There was no means of remunerating the inventors and a more comprehensive patent management is missing, IP protection should be given out free and no means of evaluation was mentioned. This research covers that.

William W. F (2013) developed an IP mgt framework where R&D strategy and legal functions are integrated. It allowed engineers, lawyers and business executives to manage IP assets, it is also used to exercise market power by employing IP right protection to increase profitability, hope to raise price above their competitors level and increase incentives so as to invent around the inventors. There was no mens of evaluating the IP mentioned.

Donald W. Wyatt (2017) wrote on Intellectual Property Management for Technology Professionals to make it easy to understand how to manage intellectual property while keeping it as a strategic asset. It is a primer that first explains what intellectual property is, and why it exists. The three fundamental models of its use are then mentioned, namely, the pricing power, the defensive bargaining, and the direct revenue generation models. He familiarizes intellectual property as the core driver of the decision making process, more so for the businesses of the digital age. He did not mention the dynamic aspect of it and a means of remunerating the inventors is missing. Yu .E (2014) Hold that IP management is increasingly connected with other activities in enterprise management. It is held that the strategic modeling approach by Sullivan and Patrick .H, (2010), provides a way to linking IP analysis to business strategy analysis and technology analysis. The recent trend towards the patenting of software and business processes and methods makes IP management a direct concern for information systems as well. A strategic conceptual modeling approach can thus provide a unifying framework for enterprise information systems, supporting decision making and the management of change across technical system development, business development and IP management. Catherine .E (2017) focuses strongly upon the international regulation of IP while attempting to address the power inbalance between developed and developing nations. Comprehensive intellectual property management is missing. Micheal .J (2016) wrote a book for managers and strategists about how decisions are made about patent strategy an similar real world IP decisionsinsisted on maintaining standard by managing IP and aligning it to business strategy. He did not write on how IP could be managed or created in a company. Mario .C (2017) addressed the effects of intellectual property rights on the processes of innovation with respect to developing countries. He mentioned that company should have an IP which should be protected by IP rights. It is static and has no means of enhancing the IP.

2.2.1 Intellectual Property Management Framework

It is clear from the survey of relevant literature that intellectual property management framework is said to be vital for companies and government agencies to effectively manage the intellectual property they own or use. Schwartz.M. (1981) argued that such framework identifies and encourages better practice in relation to the creation, use, sharing, protection and commercialization of intellectual property within the organization to optimize the economic, social and environmental benefits of the organization. It should also help companies to determine when professional   (for example, legal, financial or commercial) advice about IP should be sought. A number of research agencies and other organizations such as the world intellectual property organization (WIPO) is reported to have developed framework based principles and better practice guide for IP management. One of such intellectual property principles is one developed by the New South Wales Government. The principles as documented   in NSW (2005) are related to each other and cover the following areas:

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                    ┌─────────────────────┐
                    │ Policy and  Strategy │
                    └─────────────────────┘
           ↗                                    ↖
  ┌──────────────┐                      ┌──────────────────────┐
  │  Reporting   │                      │ Creation and  Rights │
  └──────────────┘                      └──────────────────────┘
         ↕                                          ↕
  ┌──────────────────┐                  ┌──────────────────────┐
  │ Commercialization│                  │ Identification and   │
  └──────────────────┘                  │ Recording            │
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                  ┌──────────────┐        ↙
                  │ Publication  │
                  └──────────────┘
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Figure 2.1: Intellectual Property Principles.

1. **Policy and Strategy**: This element of the principle or guideline specifies that organizations are to develop an IP policy based on a suitable framework which supports their   core functions and service delivery outcome.   It further specifies that organizations are to develop an implementation strategy for their IP policy.

2. **Creation and Right**: This specifies:

    Legally that   any IP developed by the organizations employees   in the course of the employment unless it is specifically agreed otherwise, is owned by the organization.

    i.   Companies are to ensure that their employees are aware of their legal obligation to respect the IP rights and others, including their moral rights.

    ii. In all circumstances in which IP must be created or acquired (including employee, out sourcing grants, procedures, consulting and contracting agreements) ownership of IP should be specifically addressed.

3. **Identification and Recording**: This specifies that the organizations should introduce mechanisms to identify and record any significant IP they own, control or use. This means bringing in computerization for effective IP management.

4. **Publication**: Specifies that the organizations are to establish policies and procedures to manage their publications and websites.

5. **Commercialization**: In making decisions about commercializing the company IP, the organization must be satisfied strategically. It will obtain the maximum benefit. It is noted that it may be in the best interest of the company to transfer the IP to another company or government agency, either for a fee, a non commercial fee, or free of charge. Further commercialization

decisions are to be made on the basis of appropriate legal, financial and commercial IP advice.

6. **Reporting**: Information on the management of IP is to be provided in a timely manner by an organization to its board of management, shareholders and other appropriate stakeholders.

2.2.2 Managing IP- Framework guidelines extracted from the reference reports Jeffery .H. (2004), Mark .A. (2005), NSW (2005) reported on the effective IP management, these involve the following four key areas:

    a) planning/risk management

    b) Responsibility

    c) Communication

    d) Evaluation and reporting

a. Planning/ Risk Management

An organizations IP management should be consistent with the policy and strategy contained in its adopted framework and wherever possible, be incorporated into the company's corporate planning, system, policies and objectives.

Organizations should adopt a risk management approach when implementing the framework and allocate appropriate resources to manage the risk. For example, if the extent of an organization IP is copyright in relation to its publication and website and the licenses bought by the agency to use computer software, then minimal resources may need to be allocated to manage the risk and implement the framework.

b. Responsibility

Management of IP should be a high priority within an organization. Responsibility of day-to-day IP management should be assigned to a senior competent officer or a team with appropriate skills and knowledge.

c. Communication

Everyone in the company should be aware of the IP policy and IP policy implementation strategy. The company's communication strategy in relation to IP will depend at least on the significance of IP to the organization and may include:

i. Incorporating key IP themes into staff induction, in-house benefits and forums for staff.

ii. Developing standard contracts that address IP issues.

iii. Providing relevant staff with training in contract management and related IP issues and

iv. Dedicating part of the organizations internet to IP and providing links to websites which provide more information and updates on developments in IP.

d. Evaluation and Reporting

The organization should develop a computerized system to record, report on and evaluate IP, with the aim of continuously improving the effectiveness of its IP management.

2.3 Evaluating the performance of Intellectual Property

Given the understanding that intellectual property needs to be at the core of a firm's strategy, there is a growing need for managers to professionally account for and evaluate the performance of IP management issues. This touches at measuring and managing IP performance. Systematically, evaluating performance of IP requires a model. One of such models reported is the IPERF model. The IPERF (International Institute for Industrial Research Performance) model has been developed as a tool to help managers to systematically manage performance of research departments. This model includes performance clusters that relate to IP creation and links them with overall corporate goals. With this model, organizations use quantitative key performance indicators (KPI) to evaluate

performances such as the number of IDFs (Invention Disclosure Form) or the number of patents granted to the company originating from the research department. However, it is argued by Samsonora .T. (2012) that the problem with using pure quantitative KPI is that aspects of quality are often neglected and wrong behavior can be simulated. As a result companies seeking protection for their innovations (IP) and taking the associated costs are at risk of investing in less valuable IP rights and ultimately erode the profits. Tao .J. (2005) stated that a further problem with IPERF model as reported is that measuring certain KPI quantities in an extreme situation, creates the perception that the IP performance of the organization is superb because all goals are outperformed although the generated IP assets only have very low value. Furthermore, this evaluation model is reported to be misaligned from the organizational structure and organizational goal,

2.3.1 Methods of Intellectual Property Valuation

This method addresses the methods used in valuing intellectual property, with particular emphasis on valuing patents, the methods are:

1. **Market based methods**: Market based methods value IP through comparison with prices achieved in recent comparable or similar IP transactions between independent parties. Observing the prices of comparable assets traded between parties in an active market gives a value to the subject IP. Susan .C. (2003) emphasized that the idea behind these approaches is that the market decides the accurate price and therefore the value of the IP. Market based methods include IP auctions, comparable market and comparable royalty rate methods. Its limitation is that the uniqueness of IP makes direct comparison difficult. There is a risk of comparing the subject IP with other IP which has been traded but which has

still not been utilized to the full extent possible. In these cases the IP can be undervalued.

2. **Option pricing based methods:** The theory behind option pricing was primarily developed for use in pricing financial options but can also be applied to a number of other situations other than directly financial assets. The valuation of IP still in development or being commercialized is one such framework. Option based methods essentially belong in the income based methods category as they too use expected future cash flows to measure value. The basic definition of an option is a right but not an obligation, at or before some specified time, to purchase or sell an underlying asset whose price is subject to some form of random variation. Options are priced using the Black -Scholes option -pricing model, which is a mathematical model for the valuation of options. Disadvantage of the real options method is the complexity of the model. It is difficult to understand and the evaluation can be costly to perform.

3. **Discounted Cash Flow:** The discounted cash flow (DCF) analysis represents the net present value (NPV) of projected cash flows available to all providers of capital, net of the cash needed to be invested for generating the projected growth. The concept of DCF valuation is based on the principle that the value of a business or asset is inherently based on its ability to generate cash flows for the providers of capital. Susan .C. (2003) stated that the DCF relies more on the fundamental expectations of the business than on public market factors, it is a more theoretical approach relying on numerous assumptions. The formula for calculating DCF is usually given something like this:

$$PV = CF_1 / (1+k) + CF_2 / (1+k)^2 + ... [TCF / (k - g)] / (1+k)^{n-1} \qquad (2.1)$$

Where:

PV = present value

CF_i = cash flow in year i

k = discount rate

TCF = the terminal year cash flow

g = growth rate assumption in perpetuity beyond terminal year

n = the number of periods in the valuation model including the terminal year

Although the calculations are complex, the purpose of DCF analysis is simply to estimate the money you receive from an investment and to adjust for the time value of money. DCF do have shortcomings, it is merely a mechanical valuation tool, which makes it subject to the axiom "garbage in, garbage out." Small changes in inputs can result in large changes in the value of a company. It performs well in a stable environment but can't be used in Nigeria now, because of turbulence and political instability.

4. Real Options Method: Recognizes that a patent has intrinsic value based on its projected cash flows discounted at the opportunity cost of capital for the owner of the patent. ROM incorporates the value associated with the uncertainty inherent in a business and the active decision making required for a patent-based business strategy to succeed. One disadvantage of using the ROM to value patents include the fact that patents contain adverse rights, not affirmative rights which run counter to the notion of "having an option".

5.Cost based methods: This is based on future cost. This means that the worth of an IP asset is greater than the costs to obtain or reproduce the assets. Cost based approaches measure, quantitatively, the value of IP through the calculation of the costs incurred if the company were to develop a similar asset either in -house or externally. The costs to produce the IP are taken to be its value. One advantage of the method is that IP becomes visible in the company's books and IP awareness is increased. Having compared the methods of valuating IP, this research is based on

cost based method, the company estimates the cost and uses less than the worth to remunerate the staff that found the IP.

2.4 Expert System

Jackson P. (1998) stated that in artificial intelligent (A1) an expert system is a computer software that emulates the decision-making ability of a human expert, Expert systems are designed to solve complex problems by reasoning about knowledge, represented primarily as if –then rules rather than through conventional procedural code. Sullivan P .H. (2010) wrote on the first expert systems were created in the 1970s and that proliferated in the 1980s, Expert systems were among the first truly successful forms of A1 software.

Hayes .R. et al (2009) wrote than an expert system is divided into two sub-systems: the inference engine and the knowledge base. The knowledge base represents facts and rules. The inference engine applies the rules to the known facts to deduce new facts. Inference engine can also deduce new facts. Inference engine can also include explanation and debugging capabilities.

2.4.1 Advantages of Expert System

The goal of knowledge based system is to make the critical information for the system to work explicit rather than implicit, Hayes. R. (1983). In a traditional computer program the logic is embedded in code that can typically only be received by an 1T specialist. Woolery, L.K (1994) stated that with an expert system, the goal was to specify the rules in a form that was intuitively and easily understood, reviewed, and even re-visited by domain experts rather than IT experts. The benefits of this explicit knowledge representation were rapid development and ease of maintenance. Some of the important advantages of expert systems are as follows. Ability to capture and preserve irreplaceable human experience.

i.   Ability to develop a system more consistent than human experts.

ii.   Minimize human expertise needed at a number of locations at the same time (especially in a hostile environment that is dangerous to human health).

iii.   Solutions can be developed faster than human experts.

2.4.2 Applications of expert system

In his work Hayes .R. (1983) divides expert system application into 10 categories as illustrated in table 2.3. It posited that while the categories provide an intuitive framework for describing the space of expert systems applications, they are not rigid categories and in some cases an application may show characteristics of more than one category.

Table 2.1: Categories of Areas of Application of Expert System (Salvaneschi 1996)

Category	Problem addressed	Example
Interpretation	Inferring situation description from sensor data	Hearsay (speech recognition) PROSPECTOR
Prediction	Inferring likely consequences of given situation	Pretirm birth Risk assessment, (Woolery .L.K. 1994)
Diagnosis	Inferring system malfunctions from observables	CADUCEUS, MYCIN, PUFF, MISTRAL.
Design	Configuring objects under constraints	Dendral, mortgage loan advisor, RI (Dec Vax configuration)
Planning	Designing actions	Mission planning for autonouse underwater vehicle (Kwak .S. H (1990).
Monitoring	Comparing observations to plant vulnerabilities	REACTOR (Kwak. S. H.(1990)
Debugging	Providing incremental solutions for complex problems	SAINT, MATHLAB, MACSYMA
Repair	Executing a plan to administer a prescribed remedy	Toxic spill crisis management
Instructor	Diagnosing, assessing, and repairing student behavior	SMH.PAL, intelligent clinical Training (Haddaway .P (2010), STEAMER (Hollan .J. 1984)
Control	Interpreting, predicating, repairing and mentoring system behaviors	Real time process control (Stanley G.M. (1991) space shuttle mission control Rasmussen et. al. (1990)

Hearsay was an early attempt at solving voice recognition through an expert systems approach. As reported, for the most part this category of expert systems was not all that successful. Hearsay and all interpretation system are essentially pattern recognition systems-looking for pattern in noisy data or in the case of hearsay, recognizing problems in an audio stream. Other early examples were analysis of sonar data to detect Russian submarines.

CADUCEUS and MYCIN were medical diagnosis system. The user describes their symptom to the computer as they would to a doctor and the computer returns a medical diagnosis.

Dendral was   a tool to study hypothesis formation in the identification of organic molecules. The general problem it solved - designing a solution given a set of constraints - was one of the most successful areas for early expert systems applied to business domain such as sales people configuration. Dec Vax computers and mortgage loan application development.

SMH. PAL is an expert system for the assessment of student with multiple disabilities, (Hofmeister and Alan (1994).

Mistral (Salvaneschi et al, 1996) is an expert system for the monitoring of dam safety developed in the 90s by Ismes (Italy). It gets data from an automatic monitoring system and performs a diagnosis of the state of the dam. Its   first copy, installed in 1992 on the Ridracoli. Lazzari et al stated that It has been installed on several dams in Italy and aboard (eg Itaipu Dam in Brazil), as well as on landslides under the name of Eydenet and on monuments under the name of Kaleidors.

2.5 Methods of Knowledge Elicitation from Domain Experts (Miller .J.C, Weibel .R, Langrange J.B, Salge .F, 2005).

Knowledge elicitation involves acquisition of knowledge but in this case, 'intellectual Property' from human expert. The knowledge may be specific to a problem domain or to the problem solving procedure.

Knowledge elicitation is not an easy task. Within the field of expert systems, the knowledge acquisition problem has been identified as one of the main bottlenecks in the expert system development process; Existing research in the field of knowledge acquisition has identified the problem domain as one of the key factors that should determine the success of an expert system project. Simply stated, the problem is how to efficiently and effectively acquire the specific knowledge for a well-defined problem domain from one or more experts. Because of the 'paradox of expertise', the experts have often proceduralized their knowledge to the point that they have difficulty in explaining exactly what they know and how they know it. It includes identifying the knowledge and extracting the intellectual property from the expert.

This elicitation is done by a knowledge engineer. Knowledge Engineering involves the cooperation of human expert in the domain experts in the domain who works with the knowledge engineer to make explicit the intellectual property that human experts use to solve real problems. The knowledge possessed by human experts is often unstructured and not explicitly expressed. A major goal of knowledge engineering is to help experts articulate what they know and document the knowledge in a reusable form.

2.5.1 The factors that add to the complexity of Knowledge elicitation:

- Experts may not know how to articulate their knowledge or may be unable to do so.
- Experts may lack time or may be unwilling to cooperate.
- Testing and refining knowledge is difficult.
- Methods to knowledge elicitation may be poorly defined.
- Problematic interpersonal communication factors may affect the knowledge engineer and the expert.

2.6 The characteristics and skills desirable in knowledge engineers:

- Tolerance and ambivalence
- Effective communication ability (sensitive, tact and diplomacy)
- Fast learning capabilities
- Empathy and patience
- Wide experience of knowledge engineering
- Advanced socially sophisticated verbal skills
- Self confidence

2.7 Different knowledge elicitation techniques

The techniques can be classified into three categories:

a. **Manual Method:** These are basically structured around an interview. The most commonly used knowledge elicitation is interview analysis. It involves a direct dialog between the expert and the knowledge engineer. Information is collected with the aid of conventional instruments (e.g. tape recorder or questionnaires) and it is subsequently transcribed and analyzed. In the interview, the expert is presented with the stipulated case or, if possible, with an actual problem of the type that expert system will be expected to solve. The expert is asked to talk the knowledge engineer through the solution. Sometimes this method is called the walk-through method. One variant of the interview approach begins with no information at all being given to the expert. Any facts the expert requires must be asked for explicitly. This variant makes the expert's path through the domain more evident, especially in terms of defining the input as expert system would require.

Three major manual methods of interview are:

i.   **Unstructured Interview:** Leondes and Correlios .T. 2002 explained it as an interview that is conducted informally, usually as a starting

point. Starting informally saves time and helps to move quickly to the basic structure of the domain. Data acquired from an unstructured interview are often unrelated, exist at varying levels of complexity and are difficult for the knowledge engineer to review, interpret, and integrate.

ii. **Structured Interview:** Miller .J.C (2005) explained it as a systematic goal oriented process. It forces organized communication between the knowledge engineer and the expert. The structure reduces the interpretation problems inherent in unstructured interviews and allows the knowledge engineer (KE) to prevent the distortion caused by the subjectivity of the domain expert. Here the knowledge engineer schedules and plans the interview using a form, the KE follows guideline for conducting interview, he may write sample question, focusing on question type, level and question techniques, the KE encourages the expert to prepare before the interview.

This project focuses on the structured interview, this is because the questions are pre-arranged as to capture the Intellectual Property in the brain of human experts.

Other Manual methods are:

iii. **Case analysis:** Experts are asked how they handle specific cases in the past. Usually this method involves analyzing documentation.

iv. **Commentaries:** With this method, the knowledge engineer ask experts to give a running commentary on what they are doing, this can be supported by videotaping the expert in action or asking an observer to do the commentary.

v. **Prototyping:** Working with a prototype of a system is a powerful approach to induce experts to contribute their knowledge. Experts like to criticize systems and changes can be made instantly.

b. **Semiautomatic Method:** Knowledge acquisition can be supported by computer based tools. These provide an environment in which knowledge engineers or experts can identify knowledge through an interactive process, Repertory grid analysis (RGA)n is a typical method. RGA is based on Kelly's model of human thinking called personal construct theory as recoded by Turba .E.(2007). According to this theory, each person is viewed as a personal scientist who seeks to predict and control events by forming theories, testing hypotheses and analyzing results of experiment.

c. **Automatic Knowledge-Discovery Methods:** In addition to semi automatic methods that use computers to support the knowledge elicitation process, there are situations where knowledge can be discovered from existing data. The process of using computers to extract knowledge from data is called 'knowledge discovery', and the methods of it include the following

i. Inductive Learning: Rules are induced from existing cases with known results.

ii. Neural Computing: Here historical cases are used for deriving solutions to new problems. It mimics the human brain by building artificial neurons and storing knowledge in the connection of neurons.

2.8 Fuzzy Logic

Fuzzy Logic is close to way human brain works, we aggregate data and form a number of partial truths which we aggregate further into higher truth. Fuzzy logic has been employed to handle the concept of partial truth, where the truth value may range between completely true and completely false. Furthermore, when linguistic variables are used, these degrees may be managed by specific membership functions.

Fuzzy logic is a rule-based system that can rely on the practical experience of an operator, particularly useful to capture experienced operator knowledge. Binary

logic is 0 & 1, but fuzzy is a value between 0 & 1. This may also be thought of as 0% to 100%. An example is the variable YOUNG. We may say that age 5 is 100% YOUNG, 18 is 50% YOUNG, and 30 is 0% YOUNG. HOT could be very HOT Moderately HOT, COLD.

2.9 Knowledge Verification and Validation

Knowledge elicited from experts need to be evaluated, validated and verified:

Evaluation: Its objective is to assess the intellectual property value gotten from expert. Through this process, you can know if it is usable, efficient, and cost effective as written by Lazzari (1999)

Validation: This is the process of knowing if the IP is accurate.

Verification: This is building the system right, or substantiating that the system is correctly implemented to its specifications.

Below are measures of validation:

1. Breadth: This is how well the domain of interest is covered.
2. Depth: The degree of detailed knowledge.
3. Accuracy: how well the IP reflects reality
4. Adaptability: Possibilities for future development, changes.
5. Usefulness: how adequate the knowledge is used.

2.10 Summary of Related literature

Lancini, Steferno, Lazzari, Marco, Masera & Alberto (1997) wrote that Intellectual property management involves concepts, operations and intersection of concepts and theories from multiple disciplines: law, management, engineering, science etc. Any model for effective IP management has to be integrated with organizational level structure. Given the understanding that intellectual property is at the core of a

firm's strategy, to address the growing need for managers to perform   IP management processes, an effective IP management model becomes necessary.

Hazam K.D (2001) proposed an IP management system whose decision support algorithm sets on online convex optimization. This technique aims to optimize coordination cost, it uses economic model in estimating the value of IP in other to evaluate management decision events. Helmbold .D.(2000) worked on a distributed, event driven database for IP management in big corporations. The system builds potential preference IP models by refining the local information database within the enterprise. Hazam K.D (2001) also emphasized that the system demonstrated effectiveness in managing patent, copyright and trademark data, including accurately tracking of IP right division, especially expiry. The inability of the system to interpret risk evolution model, decision support framework that aligns with the uncertainty within the IP landscape is held by domain   expert as shortening.

Helmbold .D. (2000) worked on system that handles planning, communication, publication, evaluation depreciation, evaluation depredation of intellectual property. It is said to optimize distribution of tasks to IP professionals within an organization. Its limitation is on its structure does not allow it to provide data that will enable performance evaluation of strategic IP management decision. According to Chen .J, (2009), the system is mainly viewed as only effective for IP management workflow. It is said to optimize distribution of tasks to IP professionals within an organization. Its limitation is that its structure does not allow it to provide data that enables performance evaluation of strategic IP management decision. Stewart K.E and Wright .M (2007) Proposed a model for an IP management system that enables managers to evaluate the value of created IP, measure and manage IP portfolios (e g patent) from a value-based perspective. The model as basis uses quantitative KPIs (Key Performance Indicators) to carry out this evolution. The problem with using pure quantitative KPIs is that aspects of

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quality are often neglected and wrong decisions are reported. It is posited that this proposal does not take consideration of the dynamic environment of the organization. Robert et al, (2003) developed what is referred to as an enterprise IP management system. This system made collaboration and communication on organizational IP issues effective. Furthermore their reporting and automated publication capability was reasoned to be excellent. However it is alleged to be weak in adaptation evaluation for supporting dynamic IP management decision, since its analytic computation is based on deterministic mathematical procedures. This makes it not able to account adequately for difficult constraints, such as accounting for legal aspects of intangible assets development, protection and transfer IP litigation risk evaluation.

Given the accelerating demand for innovations today, intangible assets in general and intellectual property (IP) in particular need to be at the core of a firm's strategy. In the context of a knowledge driven world, managing IP presents enormous challenges for managers at the operational, tactical and strategic levels. Hence whatever computerized IP management systems that should be deployed have to be based on dynamic algorithms that aligns with the organization structure, have to be able to handle uncertainties like humans do, have to be able to work with imprecise and noisy data which is found in the corporate IP management activities.

The weakness common with the above proposed IP management technologies is that their algorithms are mainly misaligned from the organizational decision structure and goals; they are not integrated into management cycles, element of the performance management cycle are not integrated into the model. They rely on measurement of simple and unrealistic quantitative KPIs in order to arrive at management decision support. This is because the analytic structures of their IP management models are deterministic and not dynamic.KPI neglects quality and bad behaviours are simulated.

Hence a more dynamic IP management model is vital. This dissertation proposes a dynamic expert system based IP management model. Furthermore, this work also models a fuzzy logic based patentability option.

The power of fuzzy logic enables it to directly use the expertise of human IP management professional; this enables the proposed model to avoid the limitation of making simplistic and unrealistic assumptions regarding IP patenting issues.

CHAPTER THREE

Methodology, Systems Analysis and Design

3.1 Methodology

The expert systems development methodology was used in this research. In this, the workforce of ELDI constitutes the domain experts, the researcher functions as knowledge engineer who elicits knowledge from the domain experts. The elicited knowledge is further verified, validated and graded according to quality by the workforce peers. The elicited, validated and graded new IPs are then codified and stored in the knowledge repository by the knowledge engineer. An inference engine (software) is developed that will sift through the knowledge base, when a new problem arises, mimicking the thinking process of the expert to come up with an expert-like solutions to the problem. To make the expert system dynamic rather than static, knowledge elicitation from the workforce is repeated every quarter in search of new IPs. The new IP claims are validated through peer review and successful ones are used to update the knowledge base of the expert system. Thus, the expert system is kept continuously up to date and relevant as new industry best practices are used to update the existing ones in the knowledge base. The Dynamic Expert System (DES) was then subjected to Monte Carlo Simulation for five years to see how it would fare as an instrument for rapid creation of new IP. Also, the patentability of Faculty of Engineering research output was modeled using Multiple Regression Analysis by evaluating one hundred (100) randomly selected research outputs of the Faculty.

In Dynamic Expert System Methodology (Fig 3.1), there is a static expert system initially that is enhanced through knowledge elicitation for an agreed time period. The continous knowledge elicitation every quarter of the year makes the system dynamic. Other methods used for the actualization of this research projects are:

   a. Development of Intellectual Property (IP) Model.

b. Modeling the proportion of completed project that is patentable.
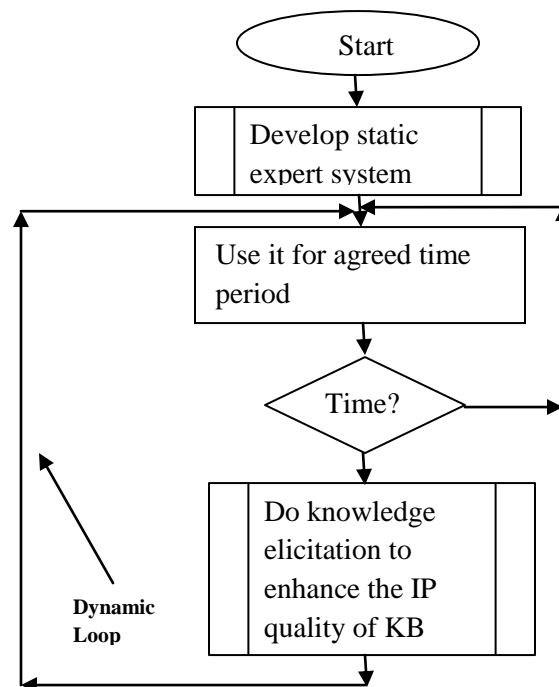
Fig 3.1: Dynamic Expert System Methodology

The intellectual property (IP) of the workforce constitutes the source of knowledge that will be stored into the knowledge base. The Researcher is the knowledge engineer, the workforce in the various productive activities of the company constitute the domain experts, each in his or her own activity group. The Knowledge Engineer interviews the workforce, searching for best practices in each operation done in the group of activities he or she belongs to. The direct supervisor of each worker together with the overall operations manager help the Knowledge Engineer to evaluate and ratify the knowledge elicited from the members of the workforce. The Knowledge Engineer codifies the elicited knowledge after transforming each from implicit to explicit knowledge. The codified explicit knowledge is then stored in the knowledge base. The Knowledge Engineer uses the structured interview to extract IP from Staff. The IP stored in the knowledge base represent the best practices used in the company for everything they do. The best practices are made accessible to the entire workforces who have access to that

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portion of the knowledge base accessible to them, every worker is expected to use only the best practice for every job he or she does. It is the responsibility of the direct supervisor or foreman to ensure that only the best practices are used by the workforce under him or her. To earn normal increment each year, a worker must satisfy the direct supervisor or foreman that only the best practices were used by him or her in all activities done in the company. Those workers found to possess IP best practices that would be to the advantage of the company if it is used to replace the existing one score promotional points and are further duly remunerated according to a scheme to be discussed in a later section. Knowledge elicitation is done quarterly from the workforce and the IP of the company grows like a living organism as old practices are replaced by new best practices. The company's bottom line improves because the customers are happy being served effectively and efficiently; the workers are happy because hard work is duly and promptly rewarded. Also the workforce appreciates in value and the company is always compliant with the current ways of meeting their customers needs. If any worker dies or retires or goes away in search of greener pasture or is sacked or suspended, someone easily takes over his or her job functions. The fact that the IP of the staff that is leaving must have been captured previously makes it easy for someone to be trained up quickly on best practices using the dynamic expert system. This minimizes losses due to the loss of services of any individual staff.

3.2 Analysis of the Proposed System

The key features of the existing system (Fig 3.2) are as follows:

1. There is no effort to capture the IP of each worker.
2. The notion of industry best practice is not used in the company. Each member of the workforce works with his or her own preferred style whether it is efficient or not.

3. The direct supervisors or foremen are satisfied that the job is done and do not bother how efficient it was done or what level of customer satisfaction was achieved in the process.

4. If a worker leaves the company for any reason or is incapacitated, it may often be difficult to find a matching talent to replace his job functions exactly. An incompetent hand may take over and cause customer disaffection. This affects the company's bottom-line as disappointed customers stop patronizing them.

5. Many abandoned projects may exist as the company may not be innovative enough to follow things through.

6. The company gradually becomes obsolete and unable to find its feet in the industry to which it belongs.

7. As the return on investment dwindles, the owners of the company disinvest and the company eventually becomes moribund.

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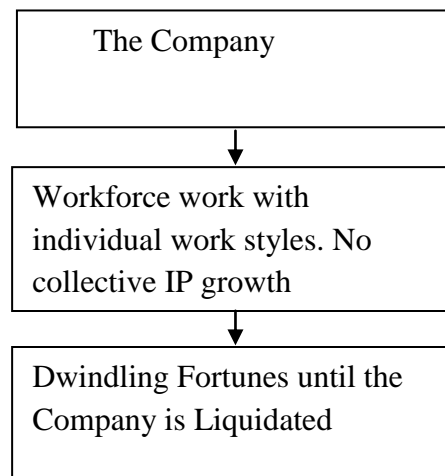
Fig 3.2: Overview of old System

3.3 Analysis of the New System (Fig 3.3)

1. The best practices for doing the company's work are captured from the company's workers quarterly through company-wide knowledge elicitation.

2. Each worker must use the best practices to serve the company or else he or she would not qualify for normal increment.

3. The direct Supervisor or foreman of each worker insists that the worker should use only best practices.

4. Best practices are updated on a quarterly basis and made readily accessible to the workforce.

5. If a staff leaves for whatever reasons, the IP of that staff is already captured and stored in the company's Knowledge Base. Someone can easily be trained to replace the staff that left.

6. The IP Knowledge Base is enhanced every quarter so that the company's workforce are continuously up to date with best practices.

7. The company may be blessed with Patentable projects which further enhances the IP knowledge base of the company.

8. The company is able to keep its head far above water in these days of stiff competition because of good customer satisfaction arising from its use of best practices.

9. The company grows as old practices are abandoned and new ones followed in line with current trends.

10. The quarterly enhancement of the company's IP Knowledge Base (IPKB) makes the Expert System Dynamic and continuously relevant to current customer demands.

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This Enhancement Loop makes the System Dynamic
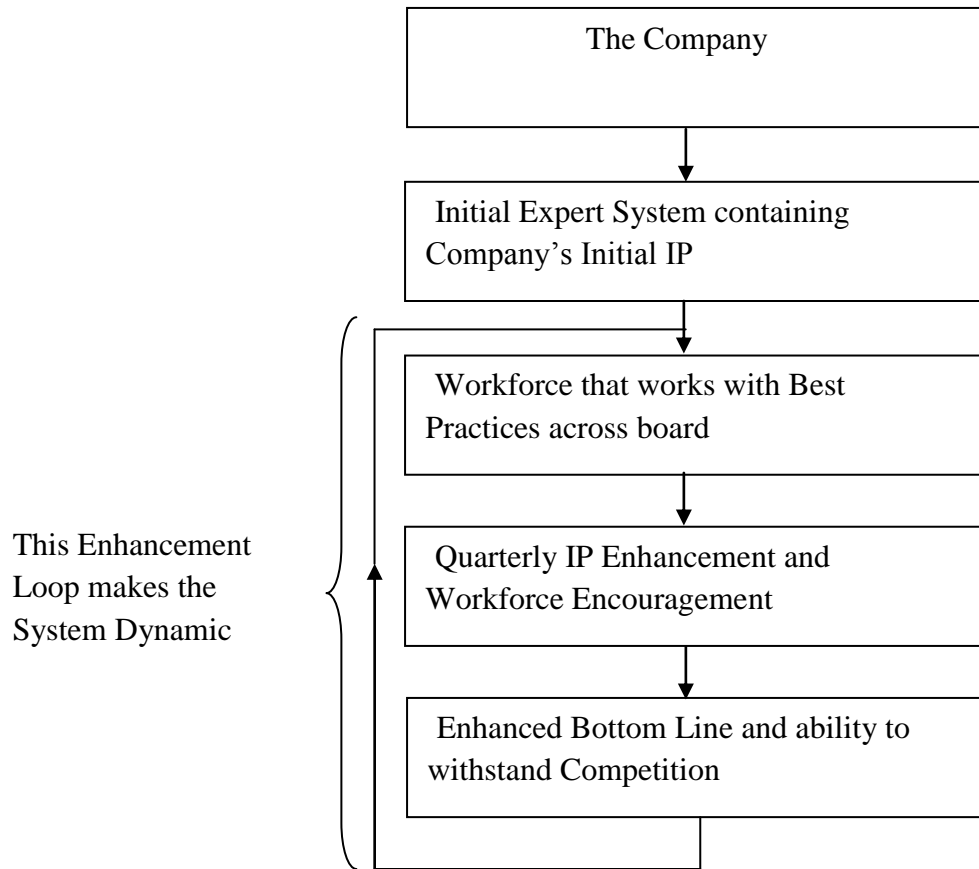
Fig 3.3: Overview of the New System

3.4 System Design

The key components of the model designed here are:

i.   Developing the Initial IP Management expert system.

ii. Modeling the dynamic expert system through quarterly knowledge elicitation. The re-use of knowledge elicitation every quarter to discover new IP that could replace some of the existing ones, means that the expert system is growing and continuously made relevant and up to date. It is therefore said to be dynamic.

iii. Remuneration structure for those who contributed and those that made use of the IP best practices stored in the knowledge base

iv. Research findings, cost of Research, Research Output Evaluation and Patenting issues.

3.4.1 Developing the initial Expert System

Fig 3.4 denotes the steps in the development of the initial expert system using elicited knowledge of the workforce. The outcome of the knowledge elicitation process is to capture the best work practices used in the company at all levels. This now constitute the primary intellectual property or knowledge repository which will begin to grow as knowledge elicitation process is repeated in subsequent quarters of the year. The foremen together with the operations manager of each workgroup verify and validate the knowledge elicited from members of the workgroup. The knowledge engineer codifies the successful elicited knowledge and stores them in the knowledge repository. An inference engine is made to sift through the repository in search of expert like solutions to a problem. An integration of inference engine and intellectual property knowledge repository forms the initial expert system.
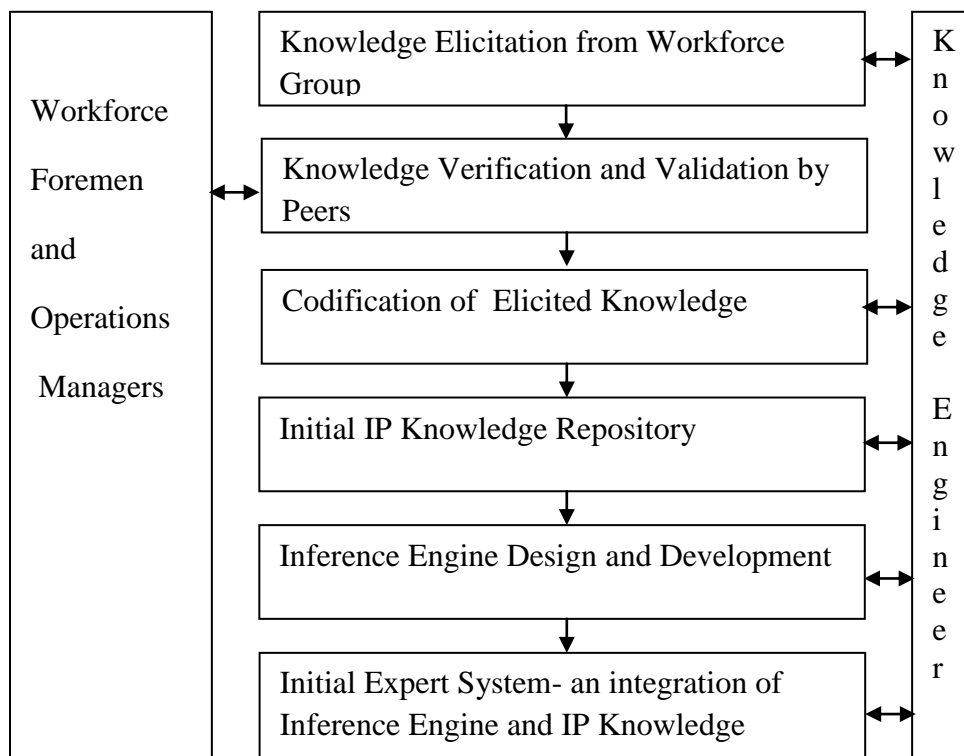
Fig 3.4: Steps in the development of the initial Expert System Using Elicited Knowledge of the Workforce

3.4.2 Modeling the Dynamic Expert System for IP Management

Fig 3.5 is the dynamic expert system model. The existing business practice of the organization at all levels are codified, i.e. changing it from implicit to explicit, the underlying idea is to extract the knowledge from experts and store in the knowledge base with formalized content about   specific tasks or problems. This knowledge base should then be accessed when similar problems occur in   future. There is an initial static expert system which is enhanced as more knowledge is gained and the newer knowledge used to replace the older ones. Knowledge can be obtained through a self improvement exercise or Research & Development (R&D) effort by the team of researchers, after which they are interviewed to elicit their new IP. This is used to update the knowledge repository. The elicited new IP is also made available to the entire workforce.
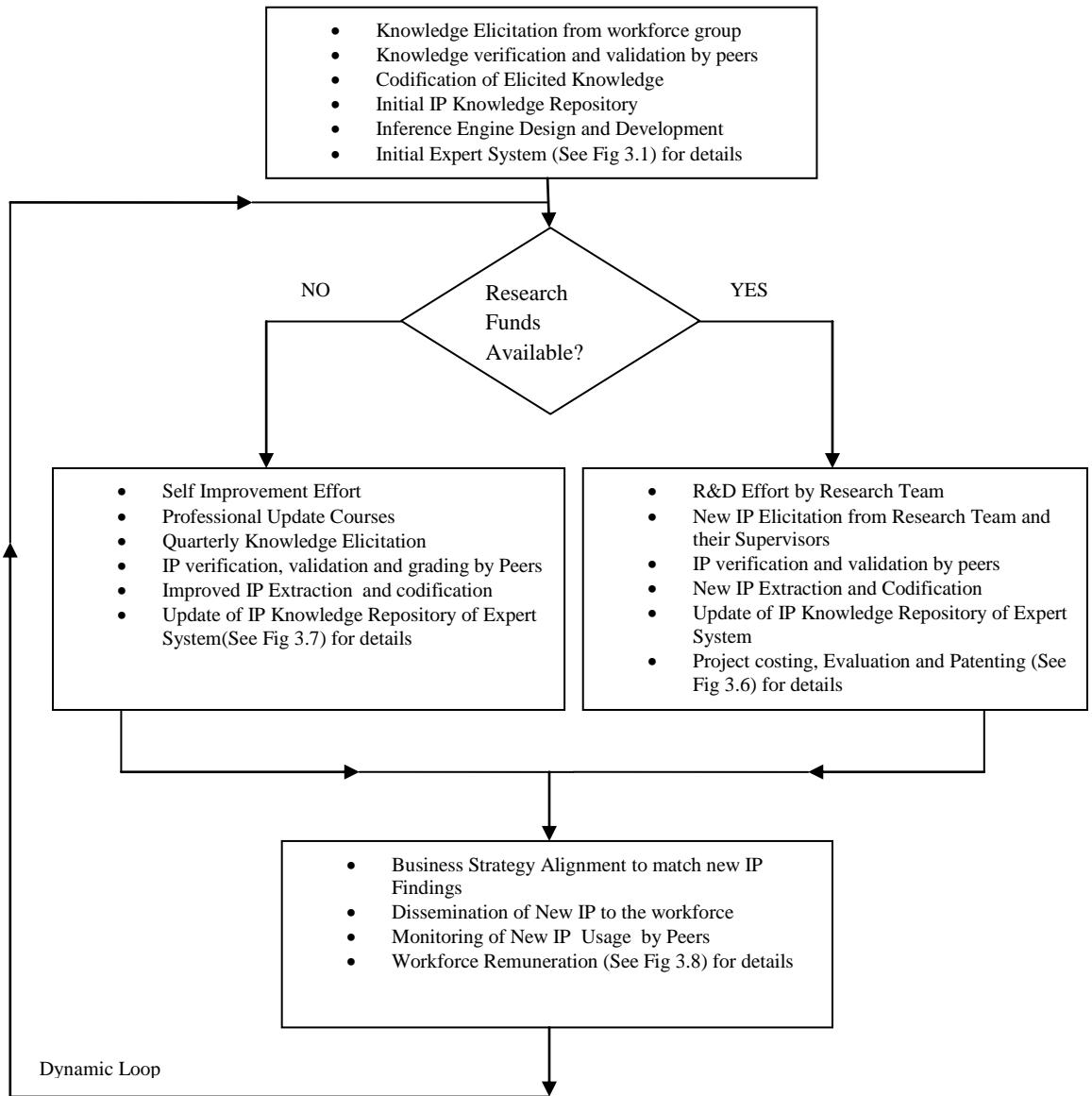
Fig 3.5: The Model of a Dynamic Expert System for IP Management in Corporate Bodies.

Fig 3.6 indicates the development of new business IP through research when R&D funds are provided, the research team makes R&D effort, the outcome of such research would no doubt make a new set of best practices and intellectual property available to the company. These are captured by the knowledge engineer, evaluated, ratified and graded by peers (workforce foremen and operations manager). The new extracted IP are codified by the knowledge engineer which is

used to update the expert system. Project costing, evaluation and patenting are done by the knowledge engineer and the Peers.
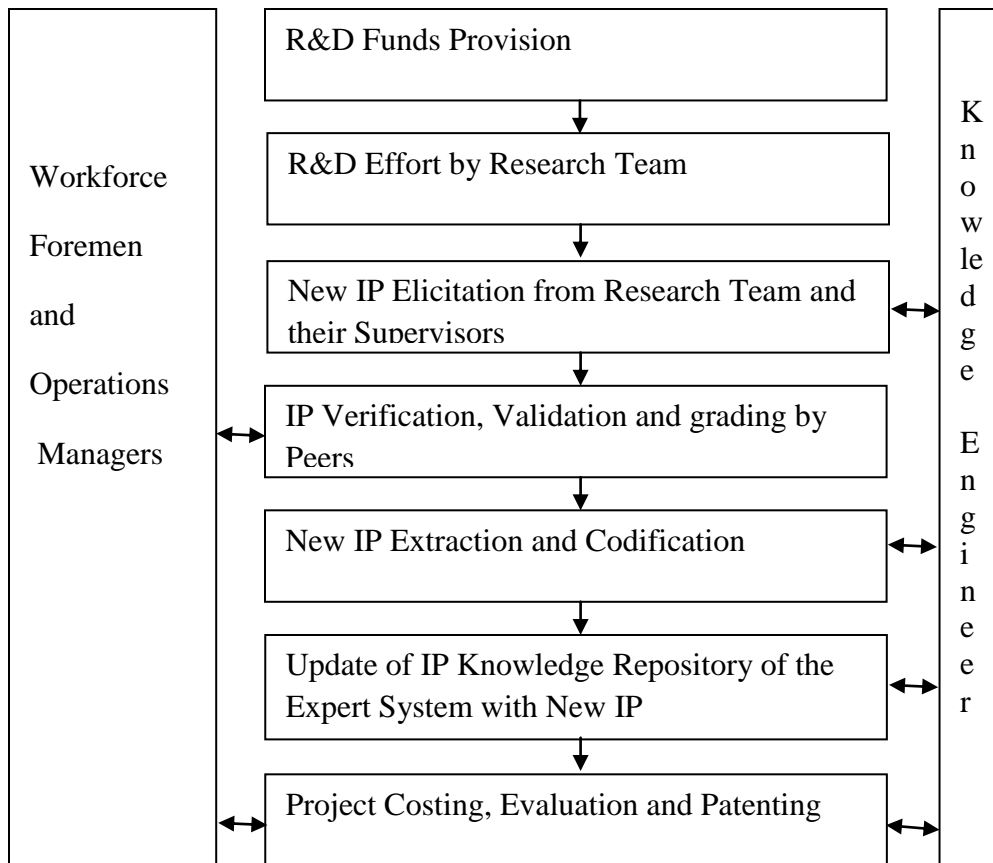
Fig 3.6: Development of new business IP through Research

Fig 3.7 explains the quarterly knowledge elicitation and knowledge repository update. When there is no research funds available (Fig 3.7), the researchers go for self- improvement effort, training in order to improve on their intellectual property (IP). The best practices for all identifiable job functions of each category of workers are elicited by the knowledge engineer, verified, validated and graded by the Peers (Workforce foremen and operations managers). The extracted IP are codified and used to update the knowledge repository. A new best practice may be found which leads to the deletion of the old practice and replacement with the new best practice in the knowledge repository. It makes the system behave like a living

organism whose knowledge is dynamically upgraded. Continuous quarterly elicitation of intellectual property or new best practices from the workforce makes the system dynamic.

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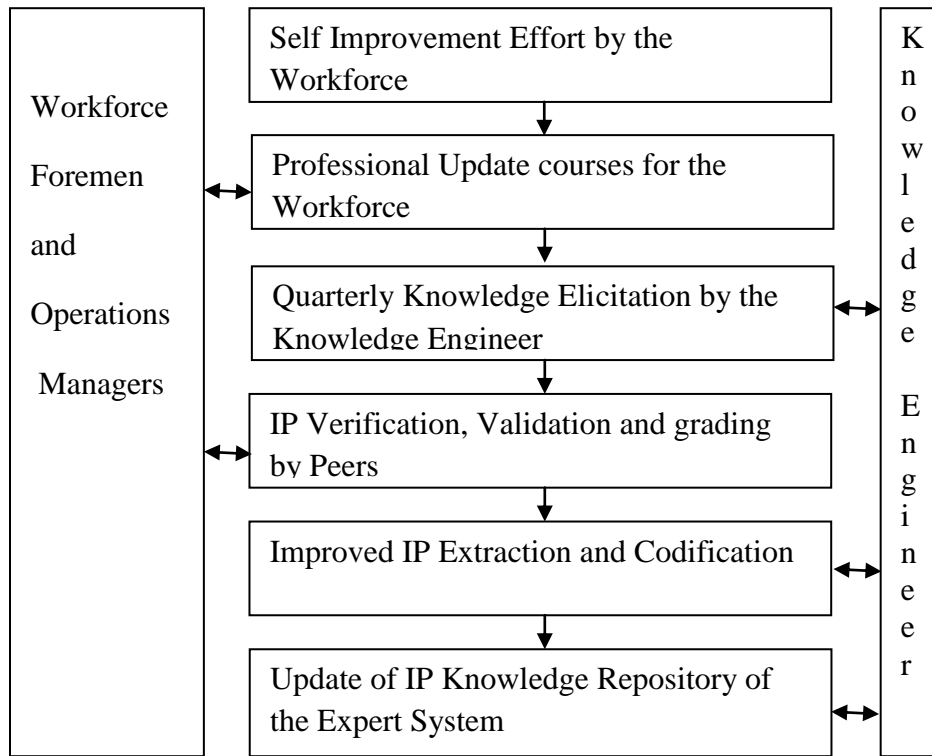
Fig 3.7: Quarterly Knowledge Elicitation and Knowledge Repository Update

$$\text{Example, if } KR_{size} = N \text{ records} \qquad (3.1)$$

Where KR is knowledge repository.

KR_{size} = Size of the knowledge repository

N = Number of enteries in the knowledge repository.

When knowledge is removed for enhancement, it becomes

$$KR_{del} = KR_{size} - 1 = N - 1 \qquad (3.2)$$

Where KR_{del} = Deleting a knowledge from the knowledge repository

In Eqn (2), an absolete knowledge is removed, therefore the knowledge base size becomes N − 1. If the removed IP is replaced by a better one, at that point, the knowledge base becomes N. So the overall number of IP in the knowledge base remains the same.

$$KR_{add} = (KR_{size} - 1) + 1 = KR_{size} = N \qquad\qquad (3.3)$$

Where KR_{add} = Adding a knowledge in the knowledge repository to replace the previously deleted knowledge.
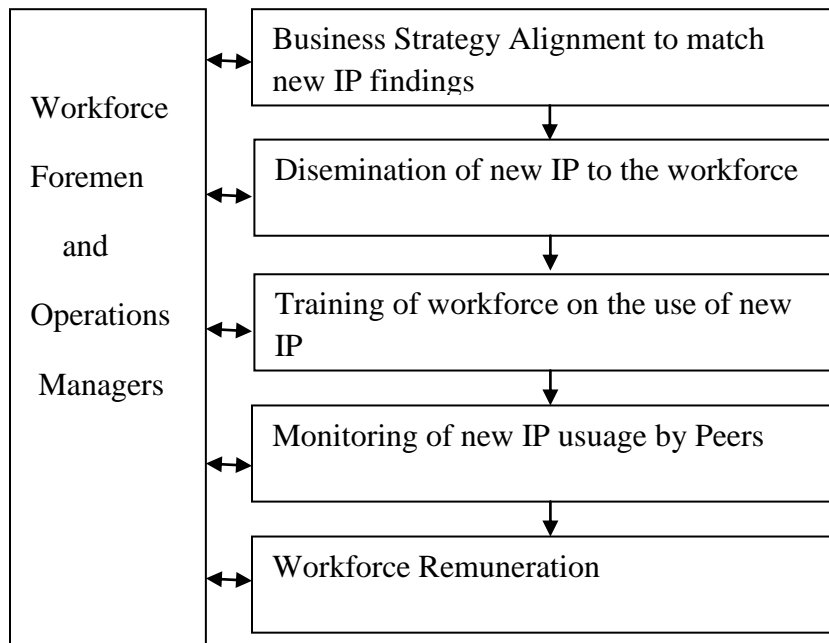
The enhancement of IP does not change the size of knowledge base. It removes what was there and adds a new IP.

After each research effort, a knowledge elicitation is done to search if new IPs have been found. The addition of new IP found for existing work processes follow the equations shown in equation 1 - 3. However if a new process is started then new IPs are developed to match the demands of the new process. Unlike the IPs used to replace the obsolete ones leaving the number of IPs in the knowledge repository the same, new IPs arising from a new process increase the number of IPs in the knowledge base, thus knowledge base grows in terms of number of new IPs added to it, This is shown in equation 4. If the number of entries in the knowledge repository N and M (where N & M are numbers) is the new IP meant to support a new process developed by the research team, then the size of knowledge base becomes;

$$\text{New Process IP}_{(size)} = M_{new}$$
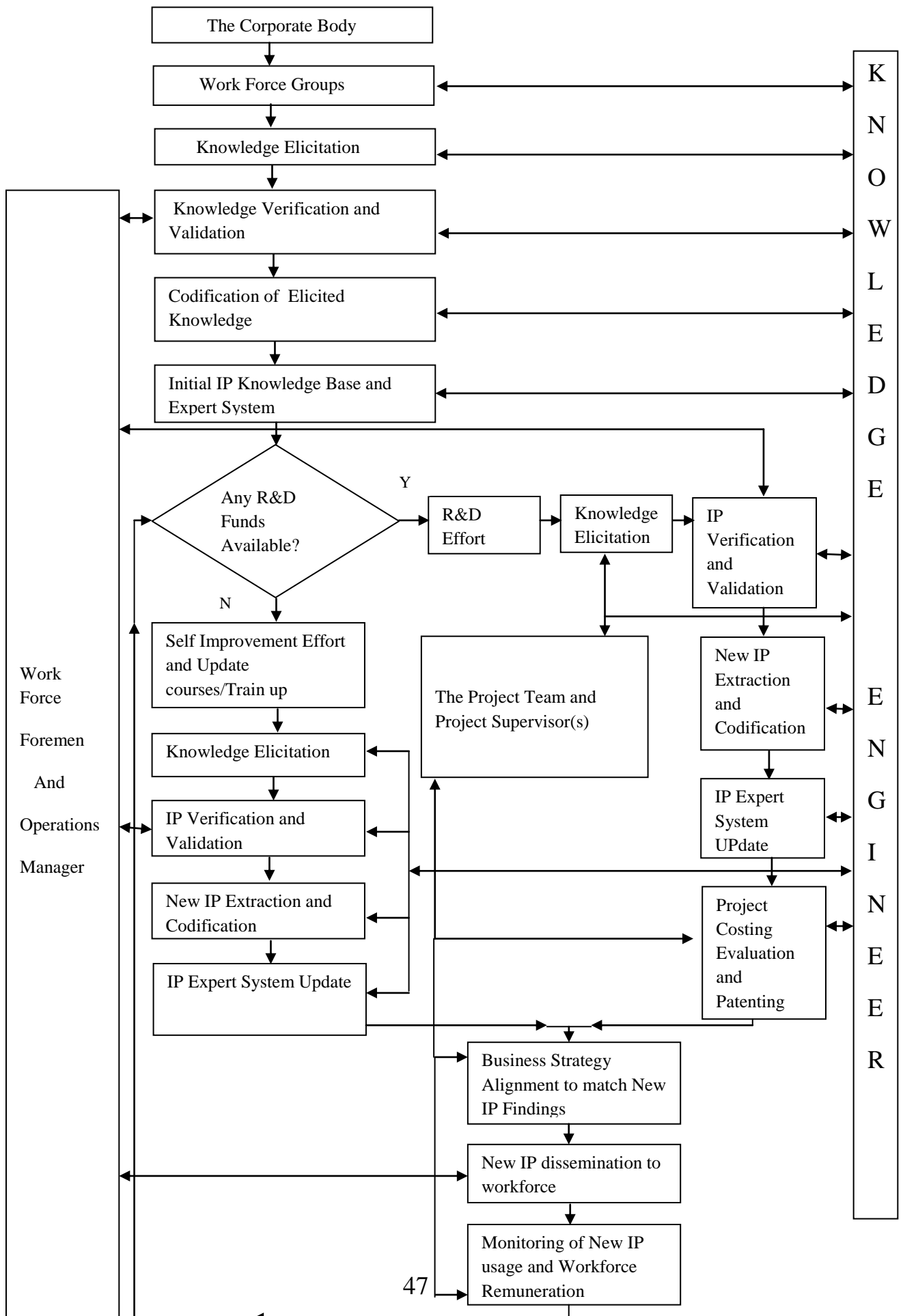$$KR_{(size)} = N + M_{new} \qquad\qquad (3.4)$$

Where N = Numbers of enteries in the knowledge repository and M_{new} = An entire new process.

There is a constant monitoring of new Intellectual Property. The staff are motivated to contribute by remunerating those who contributed their knowledge and also those that used the newly found best practices (Fig 3.8).

```
┌──────────────┐      ┌─────────────────────────────────────┐
│              │◄────►│ Business Strategy Alignment to match │
│  Workforce   │      │ new IP findings                      │
│              │      └─────────────────────────────────────┘
│  Foremen     │                      │
│              │◄────►┌─────────────────────────────────────┐
│  and         │      │ Disemination of new IP to the workforce │
│              │      └─────────────────────────────────────┘
│  Operations  │                      │
│              │◄────►┌─────────────────────────────────────┐
│  Managers    │      │ Training of workforce on the use of new IP │
│              │      └─────────────────────────────────────┘
│              │                      │
│              │◄────►┌─────────────────────────────────────┐
│              │      │ Monitoring of new IP usuage by Peers │
│              │      └─────────────────────────────────────┘
│              │                      │
│              │◄────►┌─────────────────────────────────────┐
│              │      │ Workforce Remuneration               │
└──────────────┘      └─────────────────────────────────────┘
```

Fig 3.8: Business Strategy Alignment and Workforce Remuneration

The new IPs from Fig 3.6 and 3.7 were used to update the knowledge repository. Business strategies are aligned to match the new IP findings of Fig 3.8 and made available to the entire workforce. The workforces are trained on the use of new IP. The workforce foremen make sure that each worker under him makes use of the best practices in all his/her job functions in the company. Else he/she will not be qualified for normal increment. The worker found to possess IP best practice used to replace the existing IP will be duly remunerated.

Fig 3.9: The Composite Dynamic Expert System Model

The Corporate Body

Work Force Groups

Knowledge Elicitation

Knowledge Verification and Validation

Codification of Elicited Knowledge

Initial IP Knowledge Base and Expert System

Any R&D Funds Available?

Y

N

R&D Effort

Knowledge Elicitation

IP Verification and Validation

Self Improvement Effort and Update courses/Train up

The Project Team and Project Supervisor(s)

New IP Extraction and Codification

Knowledge Elicitation

IP Verification and Validation

IP Expert System UPdate

New IP Extraction and Codification

Project Costing Evaluation and Patenting

IP Expert System Update

Business Strategy Alignment to match New IP Findings

New IP dissemination to workforce

47

Monitoring of New IP usage and Workforce Remuneration

Work Force Foremen And Operations Manager

KNOWLEDGE ENGINEER

This is the combination of Fig 3.6, 3.7 and 3.8 in one diagram (Fig 3.9). In this project, an elicitation technique that provides all the relevant knowledge in the minimum amount of time is required and that is the structured interview method. The domain expert has the knowledge while the knowledge engineer elicits the domain knowledge and represents it into a computer readable form. During the knowledge elicitation process, facts, rules, membership function and linguistic variables are also extracted and stored in the knowledge base. The knowledge base is able to store, access and analyze domain independent dynamic information. Updates are made on the knowledge base when a new idea is found; the older or obsolete ones are removed and replaced with the current new best practices thereby making the system to behave like a living organism that updates its knowledge from time to time.

After the Elicitation process, the Knowledge is converted from implicit to explicit, this is known as Externalization. When tacit knowledge is made explicit, it is codified into documents, manuals, etc, knowledge is crystallized, thus allowing it to be shared by others, and it becomes the basis of new knowledge. On the other hand, if there are Research & Development (R&D) funds, the company will pursue R&D and go for patent rights. Also it will align its business strategies and disseminate it to the affected levels in the organization.

 It is envisaged that by using the scheme shown in Fig 3.5 for the dynamic expert system, professional efficiency and improved operational effectiveness is achieved. It is an enhanced way of doing things, a way of enhancing the quality of service rendered to customers, in a speedier way. It enhances IP content of the workforce or their know how. It makes them be operationally more efficient and they render a faster service than their competitors. This enables them maintain their customer base or improve on it, and makes the organization to have an edge over its competitors.

3.5 The Organizational Structure

This is the modeling of the level structure of the organization as it relates to IP management. This provides the framework for examining management decision, making performance in quantifiable terms. Hence, the diagram (Fig 3.10) of the decision structure shows the Research Team, Production Team, Quality Control Team, Marketing Team and the Agricultural Team etc. Each Cadre has a foreman/controller (Principal Engineer) that reports to the Operations Manager (Deputy Director), who reports to the Director. All these work hand in hand with the Knowledge Engineer after which the output enters into the knowledge base.
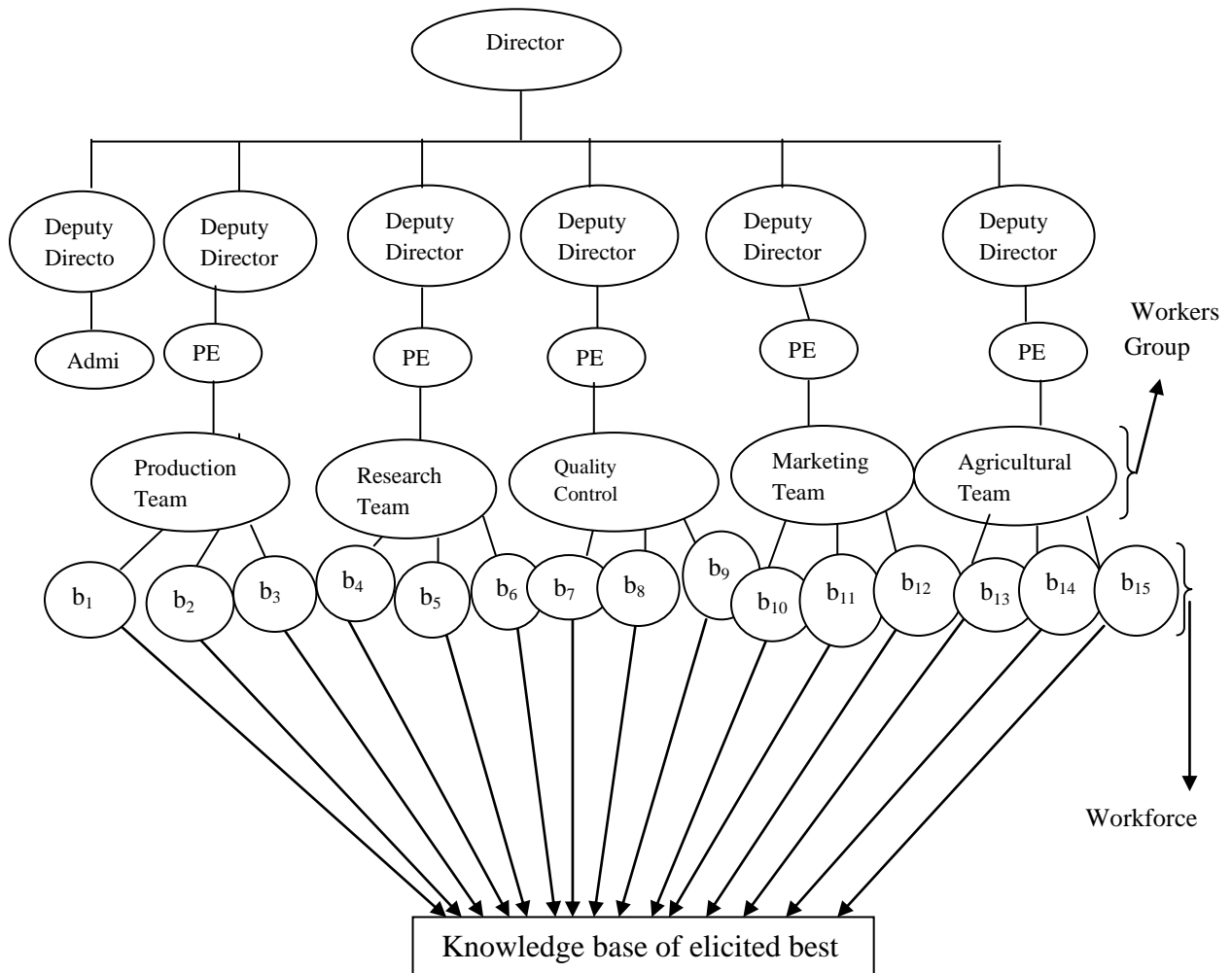
Figure 3.10: Model of IP management level structure.

3.6 Sample Knowledge Elicitation Questions

The following are the questions that may be asked to an expert of a company in order to elicit Intellectual Property from him/her.

i.   What is your name?
ii.   What is your Staff id?
iii.   In which section do you work in this company?
iv.   Can you give the detail of work done in this section one by one?
v.   Of all these jobs, is there any one you think can be improved upon compared to the style you are using now?
vi.   Which one if any?
vii.   What methods do you use to do this work?
viii.   What is the new method you are recommending?
ix.   Is there any other improvements that can be done anywhere in the section?
x.   Is there any other section you would like to be deployed in, in this company?
xi.   Which section if any?
xii.   State your reasons for wanting to be there?
xiii.   Would you like to ask us any question?

Table 3.1: Table Structure for Captured Expert Information

Table 3.1 is where the captured information is written down.

s/n	S-ID	JFN	OBP	NBP	Originator	Quality of IP			Date	V-No
						Grade1	Grade 2	Grade 3		

S-ID = Section Identification

JFN = Job Function (Job specifications done in the company)

OBP = Old best practice

NBP = New Best Practice

V-No = Version Number

Table 3.1 is the table structure where the captured information will be stored.

3.7 ELDI Section Lookup Table

Table 3.2 is a database table showing the different sections in ELDI, S-ID is the section identification number.

Table 3.2: Lookup Table for different sections in ELDI

S/N	S-ID	Section Name
1	Prd-001	Production Section
2	Res-002	Research Section
3	QC-003	Quality Control Section
4	Mkg-004	Marketing Section
5	Agc-005	Agricultural Section

3.8 Dynamic Expert System Knowledge Base

Table 3.3(a) Production Section Database

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
1	Prd-001	Giving each workforce a copy of policies and procedures that they are supposed to comply with immediately they are employed.	By CD or Physical Copy	001/05	21/2/2000	1
2	Prd-001	Staff Recruitment	Recruiting staff with good/high quality IP content	001/11	23/7/2008	1
3	Prd-001	Staff Orientation and Training	Inculcate/Pass new ideas to them	001/12	16/6/1999	1
4	Prd-001	Teaching Staff on the need to have spirit of cooperation within and between department	By doing a new project together and sharing ideas	001/15	19/5/2010	1
5	Prd-001	Communicating job expectations to Staff	By Example	001/02	30/7/1994	1
6	Prd-001	Planning the work stages	Use software tools	001/05	11/8/2012	1
7	Prd-001	Doing the work stages as staff watch	By Demonstrations	001/03	5/10/2007	1
8	Prd-001	Having a Score sheet containing names of every staff in this section	Having a list according to the staff id	001/11	29/9/1985	1

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
9	Prd-001	Scoring the workforce as they work	Be very objective. Do qualitative assessment	001/19	7/3/2000	1
10	Prd-001	Scoring the finished Product	Scoring, where the highest is 100% and the quality of work output is scored over 100%	001/32	28/4/2015	1
11	Prd-001	Coaching & Counseling the staff on best Practices	By Emphases	001/22	19/5/2000	1
12	Prd-001	Discipline those who deliberately refuse to obey instructions	Through Black-listing, Cautioning, Query and Reporting them to higher authority depending on the level of default	001/13	26/11/1990	1
13	Prd-001	Defining and Scheduling responsibilities to staff	By urging them to produce result within a stipulated time	001/29	15/12/1003	1
14	Prd-001	Being always handy to resolve problems	Be available as much as possible. Respond quickly to phone calls	001/31	26/11/2004	1
15	Prd-001	Monitoring and Maintenance of Quality	Enforcing the use of best practice	001/01	6/7/1981	1
16	Prd-001	Evaluation of new equipment & Technique	Use Manual. Check its ease of use, and its improvement over the old one	001/45	27/9/2001	1
17	Prd-001	Equipment Monitoring	By early report on faulty equipment	001/39	22/1/2006	1
18	Prd-001	Maintaining high professional and technical competence	Attending educational workshop, training and conferences within & abroad	001/40	22/10/1998	1
19	Prd-001	Making sure the section works as a team to achieve good result	Interaction by word of mouth during training and chatting during break time	001/36	11/4/1997	1

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
21	Prd-001	Generate product requirement specification for the selected products	Produce the production time table, Pricing and Marketing strategy for the product	001/11	24/4/1999	1
22	Prd-001	Customers satisfaction	Through Proven Market Research Strategy	001/02	30/2/2006	1
23	Prd-001	Recommends the nature of future product line	Review Product specifications and requirements	001/24	6/9/2005	1
24	Prd-001	Access Market competitions	Compare the market share of the company's product to competitor's products	001/38	27/7/2007	1
25	Prd-001	Ensure Product market share	Work with the marketing group to develop virile product marketing strategies	001/50	23/11/2003	1
26	Prd-001	Relates information to the top management	Prepare short and long term product sale forecast	001/48	9/9/2016	1
27	Prd-001	Facilitating inventory turnover and product availability	Reviewing and adjusting inventory levels and production schedules	001/15	17/10/2000	1
28	Prd-001	Marketing new Products	Develop a time integrated plans with sales, advertising and production	001/17	2/12/2007	1
29	Prd-001	Review of Product Pricing	Utilize Market research data	001/31	16/8/20003	1
30	Prd-001	Maintain Product Management staff	Recruiting, selecting, orienting and training employee	001/44	27/9/1997	1
31	Prd-001	Maintain product management staff job results	Counsel/discipline employees, planning, monitoring and appraising job result	001/07	21/1/1996	1

Table 3.3(a) is the database for Production section, comprising of job functions (JFN) and current best practices (CBP) done in Production SectionV- No is the Version Number

Table 3.3(b): Research Section Database

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
1	Res-002	Determine the goal of each research project	Develop sub objectives and milestones that indicate progress	002/16	15/10/2004	1
2	Res-002	Determines the best research method to adapt for each project	Through knowledge of the alternative practices on how the project could be done	002/12	24/1/2017	1
3	Res-002	Supervises a project	Work with team members with team spirit	002/22	26/1/2017	1
4	Res-002	Supervise the research staff	Set departmental and individual employee goals and provide routine evaluations of progress toward these goals. Identify and promote professional growth opportunities for staff. Ensure adherence to professional standards and ethics of prospect research	002/05	16/4/2004	1
4	Res-002	New Product Research	Conducts a thorough study to support the project, which includes determining product specifications, production costs and its time line, evaluation of the need for the product	002/07	23/10/2011	1
5	Res-002	New Product Development	New product is actually developed based on the requirements and ideas created during the research phase	002/19	18/12/2013	1

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
6	Res-002	Existing Product Updates	Evaluates the products offered by the company, resolve a problem with an existing product that malfunctions or to find a new solution if the manufacturing process must change.	002/19	2/11/2007	1
7	Res-002	Quality Checks	Has an intimate knowledge of the requirements and specifications of a particular project, collaborate with research and development on quality checks.	002/45	1/3/2003	1
8	Res-002	Innovation	Research and analyze the products other businesses are creating, as well as the new trends within the industry	002/38	20/12/2011	1
9	Res-002	Mixed methods research	Researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study	002/11	27/10/2010	1
10	Res-002	Repertory grid Interview	Carrying out an interview in a highly structured manner, using the interviewee's own language and setting out their responses in the form of a grid.	002/31	17/11/2008	1

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
12	Res-002	Analyses qualitative data	Researcher will start out with a theory, design a research process, collect data, analyze it and then review findings to see whether or not they support the hypothesis suggested by the theory.	002/43	27/4/2003	1
13	Res-002	Constructing a questionnaire	have its objectives in mind at all times, from the initial drafting of the questionnaire through to the revisions following pretesting	002/34	31/9/1997	1
14	Res-002	Conduct empirical research	observation and measurement of phenomena, compare data against a theory or hypothesis	002/15	15/9/1999	1
15	Res-002	Conducts research and development activities for an organization	Applies research theories, principles, and models when conducting experiments and research activities	002/02	29/7/2000	1

Table 3.3(c): Quality Control Section Database

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
1	QC-003	Developing a quality Control Program	Ensure the staff know how they will be appraised	003/03	6/6/1999	1
2	QC-003	Directing a quality control program	Ensure each aspect of the work of the company are done according to current best practice.	003/21	26/9/2000	1

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
3	QC-003	Coordinating a quality control program	Documenting your processes and ensuring that the way the work is actually done matches the documentation	003/11	31/8/2004	
4	QC-003	Utilizing team members in collecting construction materials	Write out the product accurately and its detailed specifications	003/19	15/11/2008	1
5	QC-003	Analyzing construction materials to see that they are top quality	Always insist on the best quality material for the work	003/23	28/5/2001	1
6	QC-003	Reviews laboratory practices and procedures	Ensure the practices and procedure include adequate safety measures	003/15	12/3/2011	1
7	QC-003	Evaluate Safety practices and procedures	Use laboratory and field analytical work as measures	003/34	18/9/2009	1
8	QC-003	Prepares report to management and agencies	Reports should be objectively factual and to the point	003/11	2/1/2007	1
9	QC-003	Maintains safety material, datasheet, records on chemical and compounds used	Ensure the staff understand how to handle such materials safely	003/10	20/4/2011	1
10	QC-003	measure and evaluate the performance of your staff	Use quality control scorecards in the review process.	003/09	17/12/2013	1
11	Agc-003	Identify quality issues	Reward employees who identify quality issues	003/34	23/3/2006	1
12	QC-003	Determine quality improvement parameters	Identify statistical methods relevant to manufacturing processes	003/25	17/7/2004	1
13	QC-003	Establish statistical confidence	Identify sample size and acceptable error, determines levels of confidence	003/24	24/7/2010	1

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
14	QC-003	Establish statistical reliability	Use mean time before failure, weibull 3-parameter distribution, reliability modeling and reliability demonstration test	003/18	20/3/2010	1
15	QC-003	Develop experiments	Apply full and fractional factorial techniques	003/28	23/5/1998	1
16	QC-003	Develop sampling plans	Apply attributes, variable, and sequential sampling methods	003/20	30/3/2005	1
s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
17	QC-003	Maintain statistical process controls	Apply demerits/Unit, zone charting, x2 charts for distributions and individual-medial/range for multistream processes	003/32	31/5/2009	1
18	QC-003	Analyzes data	Completing hypothesis, normal distribution and process capability analysis tests	003/11		1
19	QC-003	Prepares reports	Collecting, analyzing and summarizing data, making recommendations	003/12	23/11/2004	1
20	QC-003	Maintains professional and technical knowledge	Attending educational workshops, reviewing professional publications, establishing personal network benching state of the art practices	003/39	17/3/2003	1
21	QC-003	Contributes to team effort	By accomplishing related results as needed	003/43		

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
22	QC-003	Plans and directs activities concerned with development, application and maintenance of quality standard	Develops standard and methods for inspection, testing and evaluation	003/33	15/8/2007	1
23	QC-003	Devices sampling procedures and designs	Develop forms and instructions for recording, evaluating and reporting quality and reliable data	003/34	28/7/200	1

Table 3.3(d): Marketing Section Database

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
1	Mkg-004	Overseeing Company's marketing campaign	Ensure targeted advertising to the expected buyer population. Evaluate how successful the campaign	004/05	4/5/2009	1
2	Mkg-004	Communicates to the public the organization marketing message	Make the message catchy, share and with product quality well emphasized	004/01	25/6/2014	1
3	Mkg-004	Prepares and plans the publications of the company publicity material	Ensure the publication leave the public with a positive image of the company	004/09	20/12/2002	1
4	Mkg-004	Managing the publications of the company publicity material to maximize round promotion	Try to place adverts in between NEWS. Use also NEWS adjacency and public holiday periods	004/009	2/5/2010	1
5	Mkg-004	Working with the company eternal public relation agency to see the marketing campaign executed	The campaign must capture a larger share of the product market for the company	004/10	15/3/2004	1
6	Mkg-004	Information dissemination to customers who contributed in annual sales and marketing	Recommend bonus as necessary. Make sure people are in your mail list for updates on product	004/31	31/6/2001	1

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
7	Mkg-004	Project managing marketing events	Ensure the market events are in line with the marketing plans	004/19	16/11/2014	1
8	Mkg-004	Evaluate the effectiveness of all marketing activities	Use scientific tools and standards to achieve qualitative evaluation	004/18	6/6/2006	1
9	Mkg-004	Support the marketing manager in day to day marketing activities	Make up your mind to put up with work pressure without murmuring	004/29	17/11/2003	1
10	Mkg-004	Plan, develop and deliver campaign as agreed within time scales	Match the delivered campaign times with the planned times and query any discrepancy	004/37	21/2/2001	1
11	Mkg-004	Studies the Organization Competitors	Compares their product with their competitors so as to develop a more superior product & employ efficient marketing technique	004/21	2/6/2003	1
12	Mkg-004	Customer relationship management	Collects information from the company's sales, customer support, database, manages & shares that information with other employees	004/29	7/10/2000	1
13	Mkg-004	Employee Management	Assign duties and set targets and periodic performance evaluation of staff	004/1	25/7/1999	1

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
14	Mkg -004	Identify new business opportunity	Study the purchasing patterns of customers and identify the ON-peak and OFF peak demand period for their products	004/17	17/4/2007	1
15	Mkg -004	Analyze Market trends	Identifies unexploited new market strategy for the organizational products and services	004/11	19/2/2008	1
16	Mkg -004	Develop market strategy	Interview staff on the way they do marketing	004/15	16/9/1998	1
17	Mkg -004	Track trends and monitor competitors	Watch the competition to learn what they do best & identify their mistakes in order to avoid falling into theirs.	004/25	17/11/2005	1
18	Mkg -004	Work and transmit brand value	Create and disseminate images, messages & ideas that best communicate the brand name	004/16	15/12/2001	1
19	Mkg -004	Coordinate efforts with those of the marketing partners of the company	Contributor's work e.g. publishers, designers, journalist & consultants etc must align with the objectives of the company	004/06	26/11/2002	1
20	Mkg -004	Innovate	Work on new promotions, affiliate programs, customer relation technique	004/23	17/3/2007	1
21	Mkg -004	Communicate with the rest of the company	Individual interaction and meeting	004/34	2610/2009	1

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
22	Mkg-004	Improves sales processes and customers	Communicates with customers using empathy maps	004/18	28/10/1996	1
23	Mkg-004	Define strategic marketing plane	Draft a document setting out the objectives to be achieved, the actions to be taken, the strength of the company, the competition and target market	004/37	5/1/2007	1
24	Mkg-004	Manage marketing budget	Organize financial information, determine where you want to spend the marketing funds	004/19	29/9/2007	1
24	Mkg-004	Calculates the ROI of the company's actions				1

Table 3.3(e): Agricultural Section Database

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
1	Agc-005	Determine when the environment is overgrown with weeds	Your aim must be to present a pleasant environment at all times	005/03	29/4/2004	1
2	Agc-005	Apply chemicals on the weed	Apply when the workforce are not around especially on weekends for safety purposes	005/28	23/9/2002	1
3	Agc-005	Fumigate to avoid pest like bats	Staff must not inhale poisonous chemicals or gases while on duty	005/04	15/8/2000	1
4	Agc-005	Landscaping the environment	Plant flowers and tress for beautification	005/29	16/8/20015	1
5	Agc-005	Keeping the trees and flowers neat at all time	Trimming and cutting down as necessary	005/30	30/6/2011	1

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
6	Agc-005	Construct agricultural machines	Design agricultural machinery components and equipment, using computer-aided design technology, Create graphical representations of mechanical equipment	005/22	21/3/1998	1
7	Agc-005	Provide advice on water quality and issues related to pollution management	Advise others regarding green practices or environmental concerns.	005/31	19/4/2000	1
8	Agc-005	Test agricultural machinery and equipment to ensure adequate performance.	Test performance of electrical, electronic, mechanical, or integrated systems or equipment.	005/11	7/6/1992	1
9	Agc-005	Conduct educational programs that provide staff with information that can help them improve agricultural productivity.	Train personnel on proper operational procedures	005/3	15/2/2003	1
10	Agc-005	Design sensing, measuring, and recording devices, and other instrumentation used to study the presents of pests and animal	Design electronic or computer equipment or instrumentation	005/21	15/6/2001	1
11	Agc-005	Making Decisions and Solving Problems	Analyzing information and evaluating results to choose the best solution and solve problems.	005/25	26/5/2001	1

s/n	S-ID	Job Function (JFN)	Current Best Practice (CBP)	Originator	Date	V-No
12	Agc-005	Monitor processes, materials or surroundings	Monitoring and reviewing information from materials, events, or the environment, to detect or assess problems.	005/37	30/2/2005	1
13	Agc-005	Organizing, Planning, and Prioritizing Work	Developing specific goals and plans to prioritize, organize, and accomplish your work	005/23	19/10/2009	1

3.9 Process of Knowledge Engineering

Process of knowledge engineering is relationships among the activities of knowledge engineering (Fig 3.11). The acquired knowledge is coded into a representation scheme to build a knowledge base, which could be processes, facts, constraints, procedures for problem solving, heuristics and decision rules etc. The valid knowledge is used in a knowledge based system to solve new problems through machine inference and explain the provided recommendation.
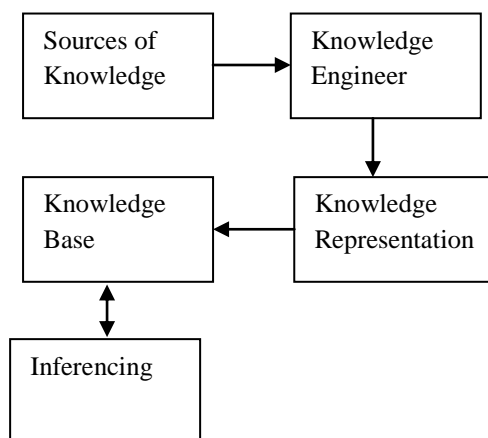
Fig 3.11: Process of Knowledge Engineering

3.10 Role of a knowledge engineer

The basic model of knowledge engineering portrays teamwork in which a knowledge engineer mediates between the expert and the knowledge base. Fig 3.12 shows the following task performed by the knowledge engineers at different stages of knowledge elicitation:

i. The knowledge engineer interacts with the workforce groups, each of which constitutes the domain experts in their respective domain of activity.

ii. The knowledge engineer asks the domain expert carefully prepared questions in order to elicit their knowledge (see section 3.6) for sample questions.

iii. The elicited knowledge is further verified and validated by group foremen (Principal engineer) and operation manager (Deputy Director).

iv. The knowledge engineer then encodes the elicited and validated knowledge and stores same in the intellectual property knowledge base.
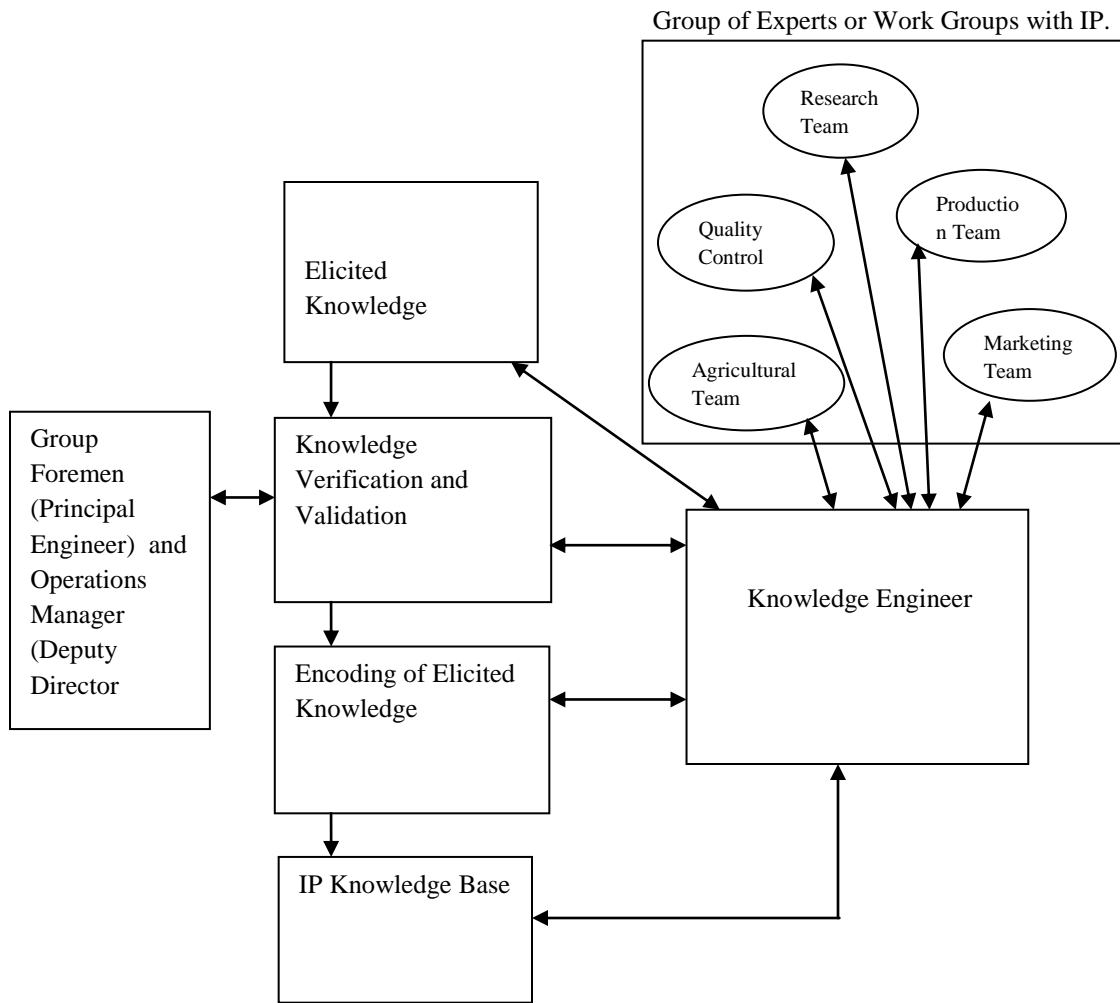
Fig 3.12: Knowledge Engineers roles in Interactive Knowledge Elicitation

3.11 The Inference Engine Usage

This shows the interaction between the user and the inference engine. User sends keyword (query), the inference engine matches the keyword with the IP in the knowledge base and outputs the corresponding IP.
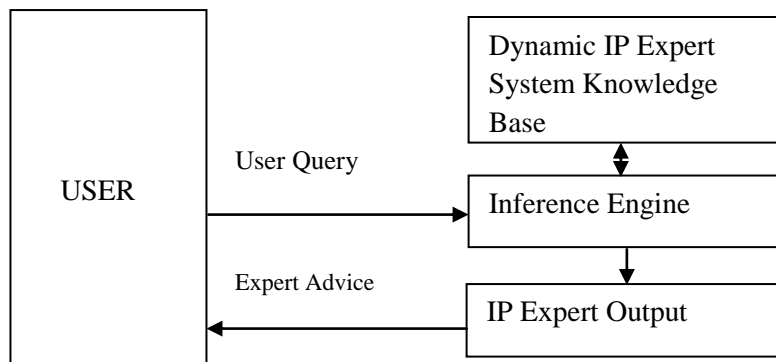
Fig 3.13: The Inference Engine

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User Query * Section Name of User

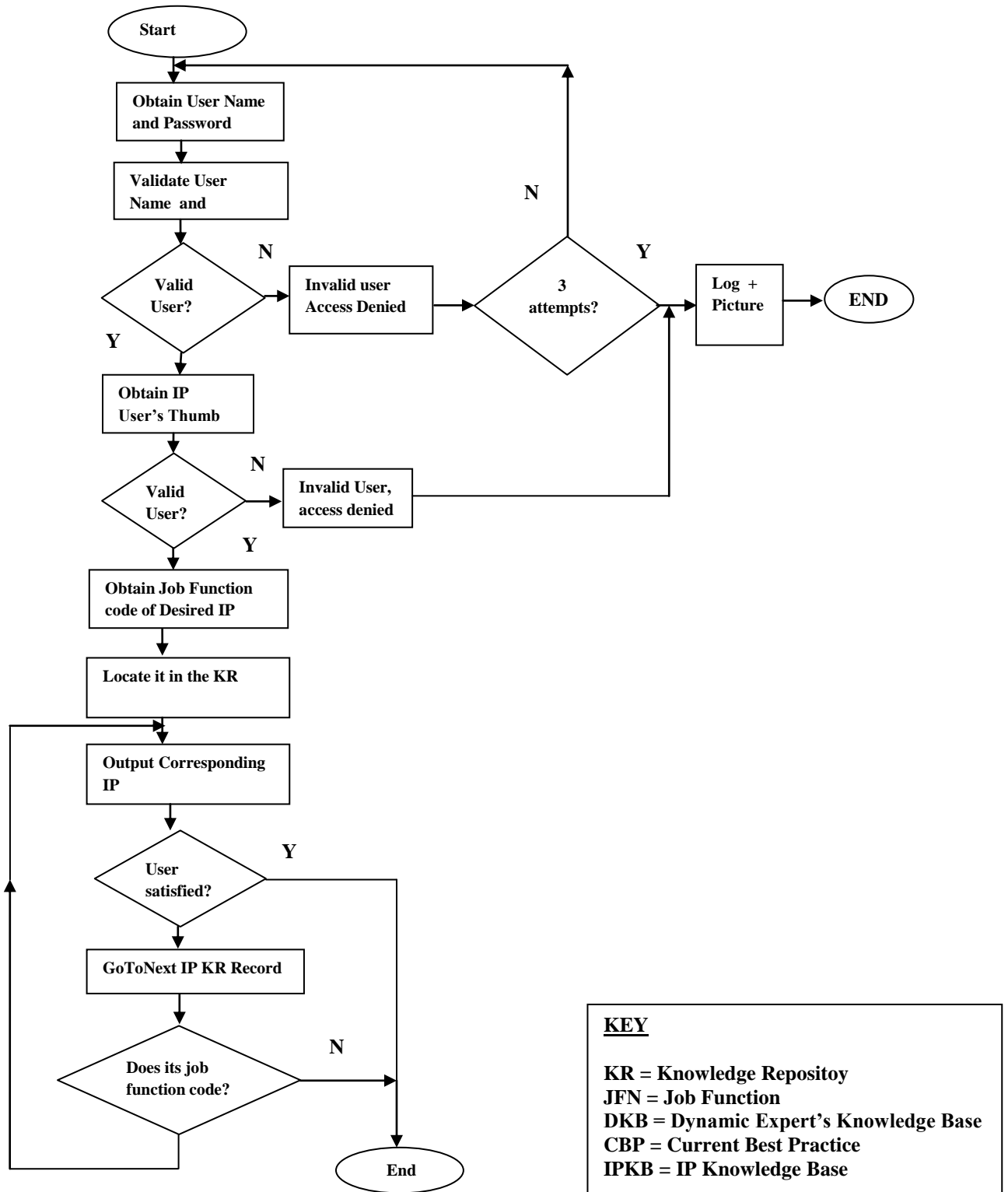   * Keywords where IP is desired

Inference Engine : Locates user section in the knowledge base

        * Searches for IP Matches

        * Outputs IP + Current Best Practices

3.12 The Inference Engine Flowchart

Inference Engine flowchart of Fig 3.14 show how user obtains IP from Knowledge base. A user who must be a staff of ELDI institute logs in with his user name and Password. The User name is the section name while the password is his staff ID, the system validates User and the section he/she belongs, if validation fails, it denies him access, if he attempts logging in up to 3 times, the system automatically takes his picture and logs his information, so as to capture his information, store it for future reference. If the validation is Yes, it obtains the user thumbprint and compares it with the staff thumbprint, user name and password else it will deny it access, takes picture and log the information. The user searches with keyword, the Inference engine searches through the knowledge base for matches for the keyword, it displays it if found, goes to the next KB record, validates the section again before the next search.

Fig 3.14: Inference Engine Flowchart

Start

Obtain User Name and Password

Validate User Name and

Valid User?

Invalid user Access Denied

3 attempts?

Log + Picture

END

Obtain IP User's Thumb

Valid User?

Invalid User, access denied

Obtain Job Function code of Desired IP

Locate it in the KR

Output Corresponding IP

User satisfied?

GoToNext IP KR Record

Does its job function code?

End

KEY

KR = Knowledge Repositoy
JFN = Job Function
DKB = Dynamic Expert's Knowledge Base
CBP = Current Best Practice
IPKB = IP Knowledge Base

3.13 CASE STUDY

The Company used as case study is ELDI Awka. Also, the University PG Research output of Nnamdi Azikiwe University, Faculty of Engineering was used when considering Patentability. This is because her R&D output is more suited for the analysis of Patentability.

The Group of workers participating to create a Dynamic IP expert system are:

    i.   Research Team

    ii.   Production Team

    ii.   Quality control Team

    iii.   Marketing Team

    iv.   Agricultural Team

IP knowledge is elicited from each group in turn and added to the IP expert system comprised essentially of best practices for each category of workers above. The best practice for each identifiable job function of each category of workers is elicited, codified and recorded in the IP knowledge base. The elicitation panel for each category of workers is comprised of the 1) Knowledge Engineer (Researcher), the foreman for that group of workers and the Operations Manager that is over and above every worker in all categories. These co-operated to elicit IP content of the workers they lead. While the knowledge Engineer guided all in the process of knowledge elicitation, the foreman listens as each worker under them was interviewed by the knowledge Engineer and help to attest to the veracity of the answers provided by the workers. Typical interview questions are shown in section 3.6. The Operations Manager was also handy to further validate the views of the foremen as the knowledge elicitation process progressed. The outcome of the knowledge elicitation process is the capture and storage of the best work practices used in the company (ELDI) at all levels. These now constituted the primary IP

knowledge base which will begin to grow as the knowledge elicitation process is repeated in subsequent quarters of the year. A new best practice may be found which then leads to the deletion of the old practice from the IP knowledge base and the inclusion of the new best practice in the upgraded IP knowledge base. A copy of the former IP KB is kept to facilitate a study on how IP grows in the company from quarter to quarter.

The quest for new Best Practice keeps the workers on ten-toes and they are able to become more and more efficient and effective. The recognition of those workers who bring in new Best Practices in terms of remuneration help to simulate workers for better performance. The foremen, the Operations Manager and the Knowledge Engineer agree on the right level of remuneration to ensure that the remuneration is significant but yet does not exceed the net worth of the best practices introduced in each case, in terms of their envisaged addition to the company's bottom line. In this respect, each new IP would have one of three grades, namely grade 1, grade 2 and grade 3 according to quality, with grade 1 being the new IP of the highest grade. The agreed remuneration is then as follows:

New IP grade 1 is worth 1 salary step to the originator

New IP grade 2 is worth ½ salary step to the originator

New IP grade 3 is worth ¼ salary step to the originator

Table 3.4: The Grade and Step Size of ELDI Staff

s/n	Grade	Step Size (₦)
1	01	360
2	02	500
3	03	644
4	04	718

5	05	870
6	06	930
7	07	1,600
8	08	1,900
9	09	2,300
10	10	2,600
11	11	2,700
12	12	7,000
13	13	7,690
14	14	7,990
15	15	8,100
16	16	12,900
17	17	14,502

Table 3.4 is the Grade and Step Size of ELDI Staff. Each Staff has different grade level and grade size attached to them. Grade Level 12-14 terminates at Step 11. Grade level 15-17 terminates at Step 9. Grade level 01-11 terminates at step 15.

Intellectual property is knowledge in the brain of a company's workforce. Its management is capturing the best practice for each job function and making each worker use only best practices in performing each job function. The IP KB of the dynamic expert system therefore contains the knowledge inside the workforce that can make the organization move faster, smoother and better, and on the bottom-line, have higher income and better integrity. The dynamic expert system is meant to improve the IP content of the workers so that they work with greater effectiveness measured in terms of the following:

1. Efficiency of Operation
2. Reduced cost of job function

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3. Reduced time spent on a job function

4. Customer satisfaction from the service rendered

5. Cost benefit analysis of the newly introduced Best Practices to ensure the company's bottom line is improved.

If any staff has an IP, the above will be used to judge it. Using cost benefit analysis, if the cost of the IP is more than its benefit, such IP is dropped, and therefore not recognized as a new Best Practice. If new jobs are added to a category of workers, the job's best practices are noted. The idea is that, the dynamic expert system contains the full best practices that are used in that company at any point in time. As things change, the older knowledge are weeded out as new best practices are introduced. So the IP of the company is growing dynamically with time. After several years, if a back log of all that were done previously is compared with the new practice, it will be found that there is growth. That way, the organization won't be obsolete for want of improvement.

In a nut shell, we want to capture the present best practice for every shade of work done in a company which is what represents a company on paper, if a staff of the company resigns, dies or goes away and a new personnel is hired and trained with those best practices, they will represent the company well because the best practices represent all that is done in a company in the best possible way. By doing these, the capacity of the company will not be lost. There are two occasions when an organization using the dynamic expert system envisaged here stand a chance of finding new additions to their IP stock of best practices. The first occasion is during their quarterly interview with the knowledge engineer in the presence of their foremen and operation's manager. The second occasion is at the end of each funded primary research. When a research effort is concluded, the knowledge Engineer together with the project supervisors and the researchers should conduct a serious IP knowledge elicitation process. The experts should try to find out if the

research output is patentable, or could lead to new products or could improve their old practices. This will be dealt with in more detail in a later section when the evaluation of a research effort is considered.

3.14 Patenting vs. Publishing

The research work carried out at the University or industry can be classified into two as in Table 3.5.

Table 3.5: View of the different Research carried out in University and Industry.

	Non-Patentable Research	Patentable Research
Type of Research	Basic research	Applied Research
Interest	Scientific application	Commercial Application
Aim	Improve Science	Improve Company Value
Outcome	Open	Protected
Right Granted	Copyright	Exclusive Right
Technology Protection	Yes, only the article text	Yes, on Patent claims
Financial Gain	No, only on appraisal points paper publications	Yes
Dissemination	Publishing	Patenting

Traditionally, academic research is deemed to be focused on questions of essential scientific interest, the so called basic research. This is usually intended to merely disclose new scientific and technical knowledge through publications. Publication is the most suitable way of knowledge dissemination for University as it permits fast and wide diffusion of research results. On the contrary, the applied research performed by the industry is normally aimed at commercializing the resulting innovation and allow them to recover the costs of research investment and equally fund themselves, it is therefore intended to increase the company's value. When Projects of students, both undergraduate and post graduate are being dumped on book shelves; there is no means of improving or carrying on their expertise or showcasing their work to the world. A means of managing the intellectual property is not to publish for knowledge dissemination; on the contrary, patenting the

project adds as much value as possible from intellectual property. A patent can be sold to another company for a good price. The patent holder may also add value to the patent by going into production using the Intellectual Property contained in the Patent. The holder could also go into a partnership venture with a suitable partner.

3.15 Design of the fuzzy knowledge base to determine Patentability

A database management system is required for the storage, representation and handling of the sort of vague and imprecise data often encountered in the patentability considerations. The fuzzy knowledge is realized in this design using fuzzy linguistic variables: High, Average and Low (Table 3.6).

Table 3.6: Factors that determine Patentability

Value of Worth of a Patent (determined by Expert Valuers)			Total Cost of Patenting (determined with the help of Researchers and industry based experts)			
HIGH	AVERAGE	LOW	HIGH	AVERAGE	LOW	FUZZY LINGUISTIC VARIABLES

The fuzzy metaknowledge base organize information that are imprecise or vague in nature. For the design of the fuzzy expert system's knowledge base for patentability consideration, a database conceptual model is required that handles representation of uncertainty. Since traditional logic allows for a very limited knowledge representation, FuzzyEER (Fuzzy Enhanced Entity Relationship) model and fuzzy database is used for the modeling and development of the expert system knowledge base. FuzzyEER is a conceptual model for fuzzy databases, Jose G. et al (2006). FuzzyEEE is an extension of the Enhanced Entity Relation (EER) model to create a model with fuzzy semantics and notation. This conceptual modeling technique brings the sort of expressiveness required to build the fuzzy

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knowledge base for the IP expert system. The fuzzy knowledge base as modeled using the fuzzyEER conceptual model is the part of the expert system containing collection of facts and rules (i.e. if….then rules). The rules represent knowledge of domain experts. The research team and research supervisors provided the project costing used in this project. The value or potential worth of a patent was obtained from experienced professors in academia and in industry as well as from operations managers.

SQLite is a relational database management system. This was used in this research to query the database. SQLite is a software library that implements a self-contained, serverless, zero-configuration, transactional SQL database engine. SQLite is the most widely deployed SQL database engine in the world.

3.16 University Patentable Research Output

One hundred (100) randomly selected projects of the faculty of Engineering NAU Awka is taken from library holdings. In statistics, it is best to work with a pure random sample, however this is not always possible for practical reasons, for example, in opinion polls involving a population of say 100 million people, it is not practical to represent all 100 million names and then begin to take a random sample of them. What is typically done is to divide the population into clusters and then take a random sample to represent each cluster. This was the path taken in this research. The faculty was divided into departments and some small departments were lumped into bigger department of similar orientation to form the clusters, then random samples were taken from each cluster according to Table 3.7.

Table 3.7: Random Sampling of each cluster

	Departments	Number in Random Sample
1	Chemical Engineering	17
2	Mechanical Engineering and Industrial/Production Engineering	17
3	Material & Metrological Engineering and Polymer & Textile Engineering	16
4	Civil Engineering	16
5	Electrical Engineering	17
6	Electronics &Computer Engineering	17

The One hundred (100) randomly selected projects were evaluated for patentability using the services of expert valuers. They considered the following:

   a. Novelty of the project
   b. Contribution to knowledge
   c. Ease of use and cost of adoption, the results are as follows in Table 3.8.

Table 3.8: University Patentable Research Output

S/N	Projects	Awards	Patentable(P)	Improved Practice(IP)
1	10	Distinction	4	10
2	20	Excellent	3	20
3	30	Very Good	2	30
4	30	Good	1	20
5	10	Fair	0	2
Total:	100		10%	82%

The outcome of the University research work evaluated is categorized into five (5). This is to identify the patentable and novel projects. Only 4 out of 10 distinction projects can go for patents, 3 out of the 20 excellent, 2 out of 30 very good, 1 out of 30 good projects are patentable, the rest are not. (Table 3.8). Thus about 10% of all Research outputs are patentable based on this random sampling.

3.9 Factors that determine Patentability and Usage of Intellectual Property

The following are the factors that determine if an IP could have a patent:

1. Novel Research Output
2. Cost of Patenting
3. Cost of Litigation, this is multiplied by the probability of litigation.

   i.e. cost of litigation * probability of litigation

4. Valuation of Patent, (Based on current prices) with attributes, High, Average, Low with the following assumptions:

$$\geq \text{₦10million} = \text{High}$$

$$< \text{₦10million} \ \text{and} \ \geq \text{₦5million} = \text{Average}$$

$$< \text{₦5million} = \text{Low}$$

5. Technological limitations when harnessing the Patent. This could be High, Average or Low, using fuzzy linguistic variables.

Total cost of Patenting = Cost of paper work and legal representation + Possible Cost of litigation + Cost of making up for Technological limitations.

$$CP = CPLR + PCL + CTL$$

Where, CP = Cost of Patenting

CPLR = Cost of paper work and legal representation

PCL = Possible cost of Litigation

CTL = Cost of technological limitations

These can be represented as in Table 3.8 for a Risk Averse Company

Table 3.10: Patent Evaluation Table for a Risk Averse Company.

Total Cost / Value of Patent	High	Average	Low
High	IP	P + IP	P + IP
Average	IP	IP	P + IP
Low	IP	IP	IP

IP = Intellectual Property and P = Patentable

This table is used to determine when an Intellectual property is worth Patenting. It should have a patent only on three conditions:

1. When the value of patent is high and the cost of patenting is Average.
2. If the value of Patent is High and total cost of patenting is Low
3. If the Value of Patent is Average and Total cost of patenting is low.

Table 3.9 can be represented using the 9(nine) Fuzzy logic Statements below:

if Value of Patent is High and Total cost is high then IP
if Value of Patent is High and Total cost is Average then P + IP
if Value of Patent is High and Total cost is Low then P + IP

if Value of Patent is Average and Total cost is high then IP
if Value of Patent is Average and Total cost is Average then IP
if Value of Patent is Average and Total cost is Low then P + IP

if Value of Patent is Low and Total cost is high then IP
if Value of Patent is Low and Total cost is Average then IP
if Value of Patent is Low and Total cost is Low then IP

Key: IP means enhanced Intellectual Property only. P + IP means enhanced Intellectual Property and Patent the research finding. Suppose the Company is risk neutral, Table 3.10 is prepared for a Risk Neutral Company.

Table 3.11: Patent Evaluation Table for Risk Neutral Company

Total Cost / Value of Patent	High	Average	Low
High	IP	P + IP	P + IP
Average	IP	P + IP	P + IP
Low	IP	IP	P + IP

Table 3.10 should have a patent only on five (5) conditions:
1. If the value of Patent is High and total cost of patenting is Average
2. If the Value of Patent is High and total cost of patenting is Low.
3. If the value of Patent is Average and total cost of patenting is Average
4. If the Value of Patent is Average and total cost of patenting is Low.
5. If the Value of Patent is Low and total cost of patenting is Low.

Table 3.10 can be represented using a 9(nine) Fuzzy logic Statements below:

if Value of Patent is High and Total cost of patenting is high then   IP
if Value of Patent is High and Total cost of patenting is Average then P + IP
if Value of Patent is High and Total cost of patenting is Low then P + IP

if Value of Patent is Average and Total cost of patenting is high then IP
if Value of Patent is Average and Total cost of patenting is Average then P + IP
if Value of Patent is Average and Total cost of patenting is Low then P + IP

if Value of Patent is Low and Total cost of patenting is high then IP
if Value of Patent is Low and Total cost of patenting is Average then IP
if Value of Patent is Low and Total cost of patenting is Low then P + IP

Table 3.11 is prepared for a Risk Seeking Company.

Table 3.11: Patent Evaluation Table for Risk Seeking Company

Total Cost Value of Patent	High	Average	Low
High	P + IP	P + IP	P + IP
Average	IP	P + IP	P + IP
Low	IP	IP	P + IP

It should have a patent only on six (6) conditions:
1. When the value of patent is high and the cost of patenting is High.
2. If the value of Patent is High and total cost of patenting is Average
3. If the Value of Patent is High and Total cost of patenting is Low.
4. If the value of Patent is Average and total cost of patenting is Average
5. If the Value of Patent is Average and Total cost of patenting is Low.
6. If the Value of Patent is Low and Total cost of patenting is Low.

Table 3.11 can be represented using a 9(nine) Fuzzy logic Statements below:

if Value of Patent is High and Total cost is high then P + IP
if Value of Patent is High and Total cost is Average then P + IP
if Value of Patent is High and Total cost is Low then P + IP

if Value of Patent is Average and Total cost is high then IP
if Value of Patent is Average and Total cost is Average then P + IP
if Value of Patent is Average and Total cost is Low then P + IP

if Value of Patent is Low and Total cost is high then IP
if Value of Patent is Low and Total cost is Average then IP
if Value of Patent is Low and Total cost is Low then P + IP

CHAPTER FOUR

EVALUATION AND DISCUSSION

4.1 The Dynamic Expert System Implementation

The Inference Engine of the Dynamic Expert System (DES) shown in the flowchart of Fig 3.14 was implemented using JAVA. The software details are in Appendix A.

4.2 Simulation of the Dynamic Expert System

A simulation of the Dynamic Expert System (DES) flowchart of Fig 3.14 was done to serve as a look ahead facility to see what the outcome of DES would be in the next 5 years. New IP discovery is captured every quarter, which is 4 times per year. The 5 years simulation therefore covered 20 quarters. On the average, each section of ELDI can add between 1 and 6 new IPs per quarter. Using Monte Carlo simulation, made it possible to work out numbers of new IPs per section per quarter via random number generation. In this, a random number N is generated for a section per quarter. N modulo 7 gives a remainder which has between 1 and 6 and serves as the number of new IPs for the section for that quarter. This is indicated in the 3rd column of Table 4.1. Also each new IP is rated as either grade 1 or grade 2 or grade 3. Again a random number M is generated and M modulo 7 (i.e. a number which lies between 1 and 6 inclusive) is found. If the M modulo 7 is 1 or 2, grade 1 new IP is assumed. If M modulo 7 is 3 or 4, grade 2 new IP is assumed and if M modulo 7 is 5 or 6 grade 3 new IP is assumed. This is the treatment given in the simulation to each new IP found and is informed by the current happenings in the company. It is envisaged by the expert valuers that each new IP could add as much as 9 times the step size in salary of the staff that discovered it if it is rated grade 1.

Grade 2 new IPs are deemed to be worth 6 times the step size in salary of the staff that discovered it while grade 3 new IPs add 3 times the step size in salary of the staff that found it. However, staff remuneration for each grade 1 new IP is only 1 step size in salary of the staff involved; grade 2 new IP attracts 0.5 step size in salary to the discoverer while grade 3 new IP attracts 0.25 step size in salary to the discoverer. This ensures that the worth of the IP to the Company is far ahead of the cost of remuneration demanded from the Company. Table 4.1 is the simulation result of the production section of ELDI. The Matlab software of Monte Carlo simulation of DES will be found in Appendix B. Table 4.1(b) through 4.1(e) shows the simulation results of the remaining sections of ELDI using the techniques developed for the production section. The tables for all the sections of ELDI would be found in Appendix C.

Table 4.1: Remuneration and Worth of IP for Production Section

s/n	Qtr	New IP	Section ID	GL	STEP	INC ₦	Quality of IP (Grade) 1 (1&2)	2 (3&4)	3 (5&6)	Remuneration ₦	Worth ₦
1	1	3	Prd-001	8	4	1,900	-	0.5	-	950	11,400
2	1		Prd-001	9	7	2,300	1	-	-	2,300	20,700
3	1		Prd-001	15	8	8,100	1	-	-	8,100	72,900
4	2	4	Prd-001	17	5	14,508	-	0.5	-	7,254	87,048
5	2		Prd-001	11	2	2,700	-	-	0.25	675	600
6	2		Prd-001	4	6	718	-	-	0.25	179.5	4,308
7	2		Prd-001	1	8	360	-	0.5	-	180	2,160
8	3	2	Prd-001	12	6	7,000	-	0.5	-	3,500	42,000
9	3		Prd-001	13	4	7,690	1	-	-	7,690	69,210
10	4	1	Prd-001	10	1	2,600	1	-	-	2,600	23,400
11	5	5	Prd-001	14	6	7,990	1	-	-	7,990	71,910
12	5		Prd-001	2	8	500	-	-	0.25	125	1,500
13	5		Prd-001	3	14	644	-	-	0.25	161	1,932
14	5		Prd-001	16	3	12,900	-	0.5	-	6,450	77,400
15	5		Prd-001	10	3	2,600	1	-	-	2,600	23,400
16	6	3	Prd-001	8	13	1,900	-	-	0.25	475	5,700
17	6		Prd-001	3	11	644	-	0.5	-	322	3,864

s/n	Qtr	New IP	Section ID	GL	STEP	INC ₦	Quality of IP (Grade)			Remuneration ₦	Worth ₦
							1 (1&2)	2 (3&4)	3 (5&6)		
18	6		Prd-001	7	15	1,600	1	-	-	1,600	14,400
19	7	1	Prd-001	9	2	2,300	-	0.5	-	1,150	13,800
20	8	6	Prd-001	3	13	644	-	0.5	-	322	3,864
21	8		Prd-001	8	11	1,900	1	-	-	1,900	17,100
22	8		Prd-001	7	2	1,600	1	-	-	1,600	14,400
23	8		Prd-001	5	5	870	1	-	-	870	7,830
24	8		Prd-001	4	7	718	-	0.5	-	359	4,308
25	8		Prd-001	2	9	500	-	-	0.25	125	1.500
26	9	2	Prd-001	1	15	360	1	-	-	360	3,240
27	9		Prd-001	11	1	2,700	-	0.5	-	1,350	16,200
28	10	4	Prd-001	8	8	1,900	-	-	0.25	475	5,700
29	10		Prd-001	4	9	718	-	-	0.25	179.50	4,308
30	10		Prd-001	1	13	360	-	0.5	-	180	2,160
31	10		Prd-001	6	4	930	-	-	0.25	232.50	2,790
32	11	2	Prd-001	9	9	2,300	-	0.5	-	1,150	13,800
33	11		Prd-001	2	4	500	1	-	-	500	4,500
34	12	2	Prd-001	4	3	718	-	-	0.25	179.50	2,154
35	12		Prd-001	7	14	1,600	1	-	-	1,600	14,400
36	13	2	Prd-001	9	5	2,300	-	0.5	-	1,150	13,800
37	13		Prd-001	11	11	2,700	1	-	-	2,700	2,430
38	14	6	Prd-001	13	3	7,990	-	-	0.25	1,997.50	23,970
39	14		Prd-001	17	4	14,502	1	-	-	14,502	130,518
40	14		Prd-001	3	8	644	-	0.5	-	322	3,864
41	14		Prd-001	6	9	930	-	-	0.25	232.50	2,790
42	14		Prd-001	12	3	7,000	-	-	0.25	1,750	21,000
43	14		Prd-001	16	7	12,900	-	0.5	-	6,450	77,400
44	15	1	Prd-001	9	4	2,300	-	0.5	-	1,150	13,800
45	16	2	Prd-001	4	9	718	1	-	-	718	6,462
46	16		Prd-001	2	1	500	1	-	-	500	4,500
47	17	6	Prd-001	7	3	1,600	-	-	0.25	800	4,800
48	17		Prd-001	11	11	2,700	-	-	0.25	1,350	8,100
49	17		Prd-001	17	5	14,502	1	-	-	14,502	130,518
50	17		Prd-001	13	8	7,690	-	0.5	-	3,845	46,140
51	17		Prd-001	8	5	1,900	-	0.5	-	950	11,400
52	17		Prd-001	4	8	718	1	-	-	718	6,462
53	18	3	Prd-001	2	1	500	-	-	0.25	125	3,000
54	18		Prd-001	3	6	644	-	-	0.25	161	1,932
55	18		Prd-001	7	10	1,600	1	-	-	1,600	14,400
56	19	2	Prd-001	16	6	12,900		0.5	-	6,450	137,400

s/n	Qtr	New IP	Section ID	GL	STEP	INC ₦	Quality of IP (Grade)			Remuneration ₦	Worth ₦
							1 (1&2)	2 (3&4)	3 (5&6)		
57	19		Prd-001	14	3	7,990	-	0.5	-	3,995	47,940
58	20	5	Prd-001	14	5	7,990	-	0.5	-	3,995	47,940
59	20		Prd-001	9	8	2,300	1	-	-	2,300	20,700
60	20		Prd-001	15	5	8,100	1	-	-	8,100	72,900
61	20		Prd-001	5	9	870	-	0.5	-	435	5,220
62	20		Prd-001	1	4	718	-	0.5	-	359	4,308
									Subtotal:	146,841,	431,848

Table 4.1 is Remuneration and Worth Table (RWT), generated using Monte-Carlos Simulation for the different sections (Production, Research, Quality Control, Marketing and Agricultural). Intellectual Property growth was simulated for (5) years. New IP's, grade level and step size were generated through random number generation from their probability function. From the first quarter, three (3) new IP's were generated and four (4) in the second quarter of the Production section etc. From table 3.9, the actual grade and step size values of the inventors are retrieved. INC represents the actual step increment value.

Remuneration is calculated as:

Quality of IP * Step value = Cost of IP
Grade 1* step value = 1 * step value = cost of IP
Grade 2 * step value = 0.5 * step value = cost of IP
Grade 3 * step value = 0.25 * step value = cost of IP

Worth of IP is the value the IP earns for the company.
Grade 1 worth 9 times the inventor's step size = 9 * Step Value
Grade 2 worth 6 times the inventor's step size = 6 * Step Value
Grade 3 worth 3 times the inventor's step size = 3 * Step Value
The new IP gained by all sections of ELDI workforce during the period covered by simulation (20 quarters or 5 years) is summarized in Table 4.2.

Table 4.2: New IP Gain for 5years (20 Quarters)

s/n	Section code	Section name	Total no of IP	Cost of IP	Worth of IP	Gain
1	Prd-001	Production	62	146,841	1,431,848	1,285,007
2	Res-002	Research	63	130,162.50	1,333,738	1,203,575.50
3	QC-003	Quality Control	67	271,059	2,201,988	1,930,929
4	Mkg-004	Marketing	46	114,233	1,208,892	1,094,659
5	Agc-005	Agriculture	44	145,814	1,503,834	1,358,020
		Total:	282	808,109.50	7,680,300	6,872,190

Table 4.2 shows the Gain the company gets after remunerating its staff that contributed the IP. The total number of IP for 20 quarters is 282. The company uses less than the Worth of IP to Remunerate Staff and also make their own gain. It is calculated as:

Gain = Worth of IP – Cost of IP (Remuneration)

i.e. Worth of IP in a section per 20 quarters – Cost of IP in a section per 20 quarters.

4.3 Evaluations of Dynamic Expert System (DES)

Table 4.2 is a Summary outcome of the Dynamic Expert System Simulation for 5 years (20 quarters). It shows that the total number of new IPs over the period of simulation is 282, while the cost to the company in terms of the remuneration paid to staff for the new IP contributed is ₦ 808,109.50. But the worth to the company of the new IPs introduced is ₦ 7,680,300. That means that this DES provides a cheap means of achieving a vital growth in IP at minimum cost. The gain to ELDI in this simulation is ₦ 7,680,300 – ₦ 808,109.50 = ₦ 6,872,190.50. This is important to the company's bottom line. Also DES ensures that the company is operated along best practices only and should therefore be very efficient and effective.

4.3.1 Evaluation of New IP Gained

Again DES can be evaluated in terms of the new IP gained during the five (5) years simulation period.

Table 4.3: Details of Yearly, Categorized IP.

Year	New Grade 1 IP (NGD1)	New Grade 2 IP (NGD2)	New Grade 3 IP (NGD3)	Total New IP for the Year (TNIP)
Year 1 Qtr 1 – Qtr 4	NGD1 = 19	NGD2 = 18	NGD3 = 21	TN IP YR 1 =58
Year 2 Qtr 5 – Qtr 8	NGD1 = 18	NGD2 = 23	NGD3 = 14	TN IP YR 2 = 55
Year 3 Qtr 9 – Qtr 12	NGD1 = 17	NGD2 = 16	NGD3 = 12	TN IP YR 3 = 45
Year 4 Qtr 13 – Qtr 16	NGD1 = 23	NGD2 = 19	NGD3 = 15	TN IP YR 4 = 57
Year 5 Qtr 17 – Qtr 20	NGD1 = 31	NGD2 =19	NGD3 = 17	TN IP YR 5 = 67
Totals	TGD1 = 108	TGD2 = 98	TGD3 = 78	Sum of IP for 5Yrs = 282

Table 4.3 shows the details of the new IP gained each year for the five (5) years simulation period, categorized according to grade of IP.
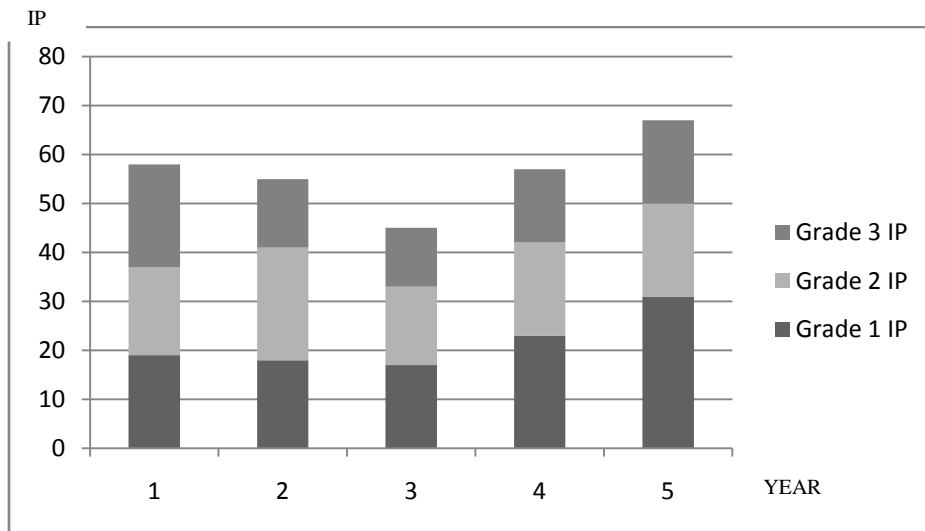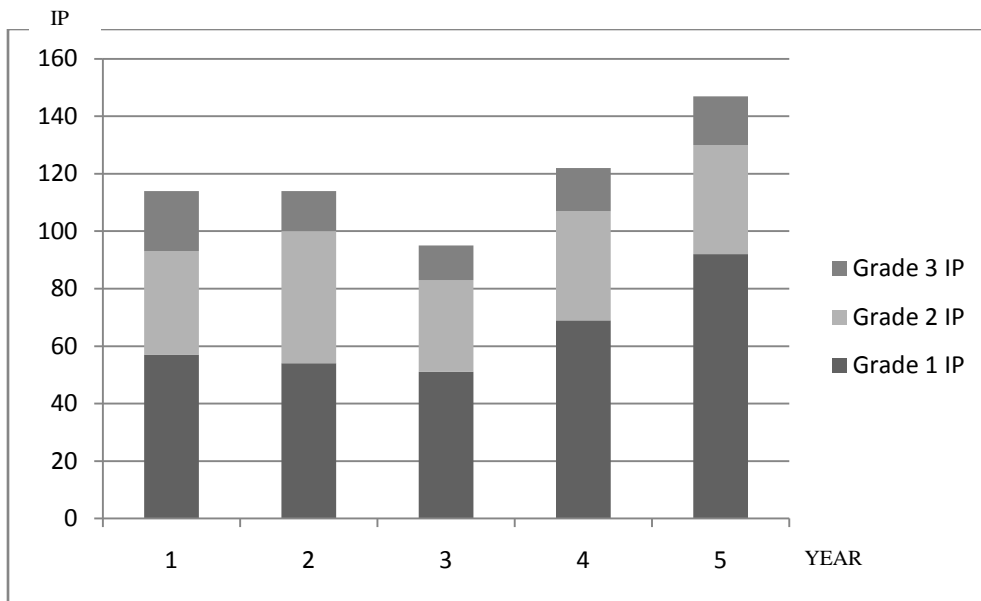

Fig 4.1: Stacked Column chart for yearly new IP findings

The bar chart of Fig 4.1 shows the yearly new IP findings, with each year segmented according to the quality of the IP namely, grade 1, grade 2 and grade 3. The bar chart shows a gradual fall in the number of new IP acquisition from year 1 to year 2 and then to year 3, which is the lowest. The new IP began to rise again in year 4 and was highest in year 5. In real life, this phenomenon can be explained as follows: When a new process is started, there often is considerable room for improvement, that is, new IP can easily be found hence the high value of new IP in year 1 of 58. As time goes on, the number of new IP added dwindles first to 55 and then to an all time low of 45 in the 3rd year. That shows that it is getting harder and harder to improve on the process with the technology in use. The number of new IP began to rise from year four, first from 57 to 67 in year five. In real life, this suggests that a new technology might have been found with new promise so that there is considerable room for new IP to be acquired. The all time high of 67 in year 5, suggests that the number of new IP has peaked for current technology in use and may be falling in subsequent years.

Table 4.4: Details of Yearly, Categorized IP with Quality Factor.

Year	New Grade 1 IP Quality factor = 3	New Grade 2 IP Quality factor = 2	New Grade 3 IP Quality factor = 1	Total New IP for the Year
Year 1 Qtr 1 – Qtr 4	NGD1 * QF = 57	NGD2 * QF = 36	NGD3 * QF =21	TN IP *QF =114
Year 2 Qtr 5 – Qtr 8	NGD1 * QF = 54	NGD2 * QF = 46	NGD3 * QF =14	TN IP *QF = 114
Year 3 Qtr 9 – Qtr 12	NGD1 * QF = 51	NGD2 * QF = 32	NGD3 * QF =12	TN IP *QF = 95
Year 4 Qtr 13 – Qtr 16	NGD1 * QF = 69	NGD2 * QF = 38	NGD3 * QF =15	TN IP *QF = 122
Year 5 Qtr 17 – Qtr 20	NGD1 * QF = 93	NGD2 * QF = 38	NGD3 * QF =17	TN IP *QF = 148
Totals*QualityFactor	TGD1 *QF = 324	TGD2 *QF = 190	TGD3 *QF = 79	Sum of QF = 593

Fig 4.2: Stacked column chart for Yearly IP with Quality Factor.

To take the quality factor into account properly, each grade 1 new IP is rated 3 units, a grade 2 new IP is rated 2 units and a grade 3 new IP is rated 1 unit. The three segments of IP grade 1, grade 2 and grade 3 are thus modified as in Table 4.4 with quality factor used as explained above. This was used to plot the stacked column chart of fig 4.2. Unlike Fig 4.1, where the quality factor was not used, Fig 4.2 shows that the performance in year 2 is actually equal to that of year 1 when the quality factor is taken into account.

Table 4.5: New IP gained in 5 Years

Year (X)	1	2	3	4	5
New IP	58	55	45	57	67
Cumulative New IP (V)	58	113	158	215	282

Table 4.6: Cumulative New IP with Quality Factor

Year (X_2)	1	2	3	4	5
New IP	114	114	95	122	148
Cumulative New IP(V_2)	114	288	323	445	593

Table 4.5 shows the cumulative new IP gained over the years of simulation.

Table 4.6 shows the cumulative new IP with Quality Factor taken into account. Thus, each new IP is qualified either as grade 1, grade 2 or grade 3 and is therefore multiplied by a quality factor (QF). A new IP of grade 1 has a QF of 3 unit; a new IP of grade 2 has a quality factor of 2 unit while a new IP of grade 3 has a quality factor of 1 unit. Utilizing the quality factor allows one to have a true measure of the real growth attained, because the new IP grows incrementally from year to year. What is really important in terms of growth is the yearly cumulative of the new IP multiplied with the quality factor (Table 4.6). The same cumulative for the number of new IPs but without the quality factor was also shown in Table 4.5. Fig 4.3 shows the values of new IP without the quality factor fitted to a straight line of best fit and then to a quadratic curve to show which fits better. The idea is to find out whether the outliers of the straight line graph suggest a quadratic fit. Indeed, this appears to be the case in fig 4.3. Again, Fig 4.4 shows the values of new IP qualified with quality factor as in Table 4.6 fitted to a straight line and at the same time to a curve of quadratic nature. The quadratic curve seem to be a better fit for the values in table 4.6. The Matlab software of Appendix D was used to generate the graphs of fig 4.3 and fig 4.4. This was further butteressed by the coefficient of determination for both the linear and the quadratic fit worked out in Table 4.7,

where the quadratic fit has a higher percentage (98.63%) compared to the straight line fit(90.94%) using the formulae:

$$R^2 = \frac{\text{Explained Variation}}{\text{Total Variation}} - \frac{\Sigma (Y_1 - \overline{Y})^2}{\Sigma (\overline{Y}_2 - Y)^2} \quad * \quad 100\ \% \qquad (4.1)$$

Where, R^2 = coefficient of determination

R^2 = The square of the correlation coefficient (R)

Table 4.7: Coefficient of determination for quadratic fit

X	Y_1	Y_2	$Y_2 - \overline{Y}$	$(Y_2 - \overline{Y})^2$	$Y_1 - \overline{Y}$	$(Y_1 - \overline{Y})^2$
1	114	120.86	-231.74	53,703.43	-238.6	56,929.96
2	288	221.78	-130.82	17,113.87	-124.6	15,525.16
3	323	334.56	-18.04	325.44	-29.6	876.16
4	445	459.2	106.6	11,363.56	92.4	8,537.76
5	593	595.7	243.1	59,097.61	240.4	57,792.16
	Σ1763			Σ141,603.91		Σ 139,661.2

$$\Sigma Y = \frac{Y_1}{5} = \frac{1763}{5} = \overline{Y}$$

$$\overline{Y} = 352.6$$

Subtituting in equation (1) becomes;

$$R^2 = \frac{\text{Explained Variation}}{\text{Total Variation}} - \frac{\Sigma (Y_1 - Y)^2}{\Sigma (Y_2 - Y)^2} - \frac{139,661.2}{141,603.91}\ *100\%$$

Coefficient of Determination for the quadratic fit, R^2 becomes,

$$R^2 = 98.63\%$$

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Table 4.8: Coefficient of determination for the linear fit

X	Y_1	Y_2	$Y_2\text{-}\overline{Y}$	$(Y_2\text{-}\overline{Y})^2$	$Y_1\text{-}\overline{Y}$	$(Y_1\text{-}\overline{Y})^2$
1	114	109	-243.6	59,340.96	-238.6	56,929.96
2	288	227,7	-124.9	15,600.01	-64.6	4,173.16
3	323	346.4	-6.2	38.44	-29.6	876.16
4	445	465.1	112.5	12,656.25	92.4	8,537.76
5	593	583.8	231.2	53,453.44	240.4	57,792.16

$\Sigma 1763$ $\Sigma 141,089.1$ $\Sigma\ 128,309.2$

$$\Sigma Y = \frac{Y_1}{5} = \frac{1763}{5} = \overline{Y}$$

$$\overline{Y} = 352.6$$

$$R^2 = \frac{\text{Explained Variation}}{\text{Total Variation}} - \frac{\Sigma\,(Y_1 - \overline{Y})^2}{\Sigma\,(Y_2 - \overline{Y})^2} - \frac{128,309.2}{141,089.1}\ *100\%$$

Coefficient of Determination for Linear fit, R^2 becomes,

$$R^2 = 90.94\%$$

The software details for used to generate the graph showing cumulative new IP gained over the years of simulation and graph showing cumulative new IP gained over the years of simulation multiplied with the quality factor are in Appendix D.

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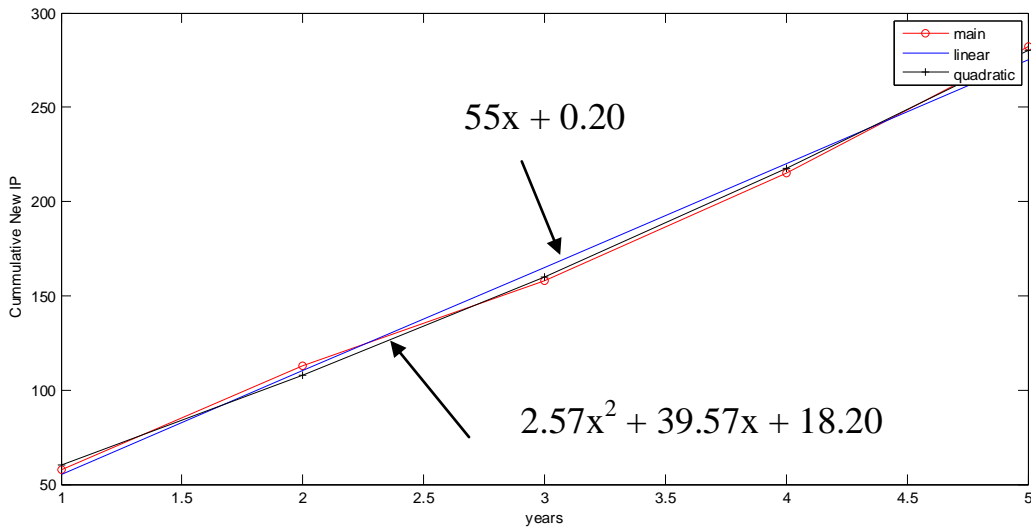
Fig 4.3: Graph showing cumulative new IP gained over the years of simulation.
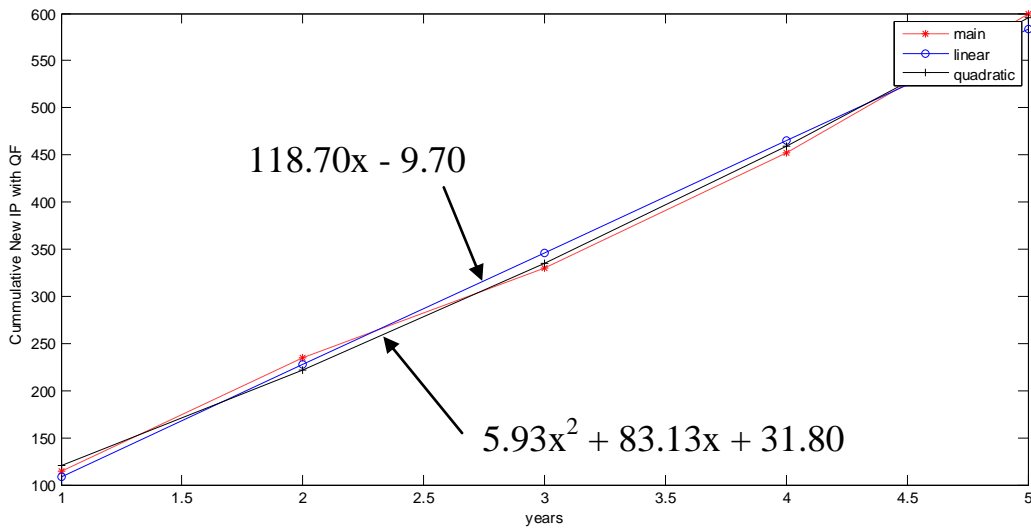
Fig 4.4: Graph showing cumulative new IP gained over the years of simulation multiplied with the quality factor.

4.4: Simulation of Research Throughput and Patentability

1. Only about 10% of Faculty of Engineering Projects are currently Patentable (What if the quality of engineering projects improves such that 20%, 30%, 40%, 50%, or 60% are patentable (Table 4.8))

2. Also about 50 projects are done in a session currently (What if the situation improves and up to 60, 70, 80, 90, 100 projects are completed per session (Table 4.10)). Based on these points, a MATLAB software (Appendix E) was written to generate Table 4.9, 4.10, 4.11 and 4.12 along with their 3-D surface plots.
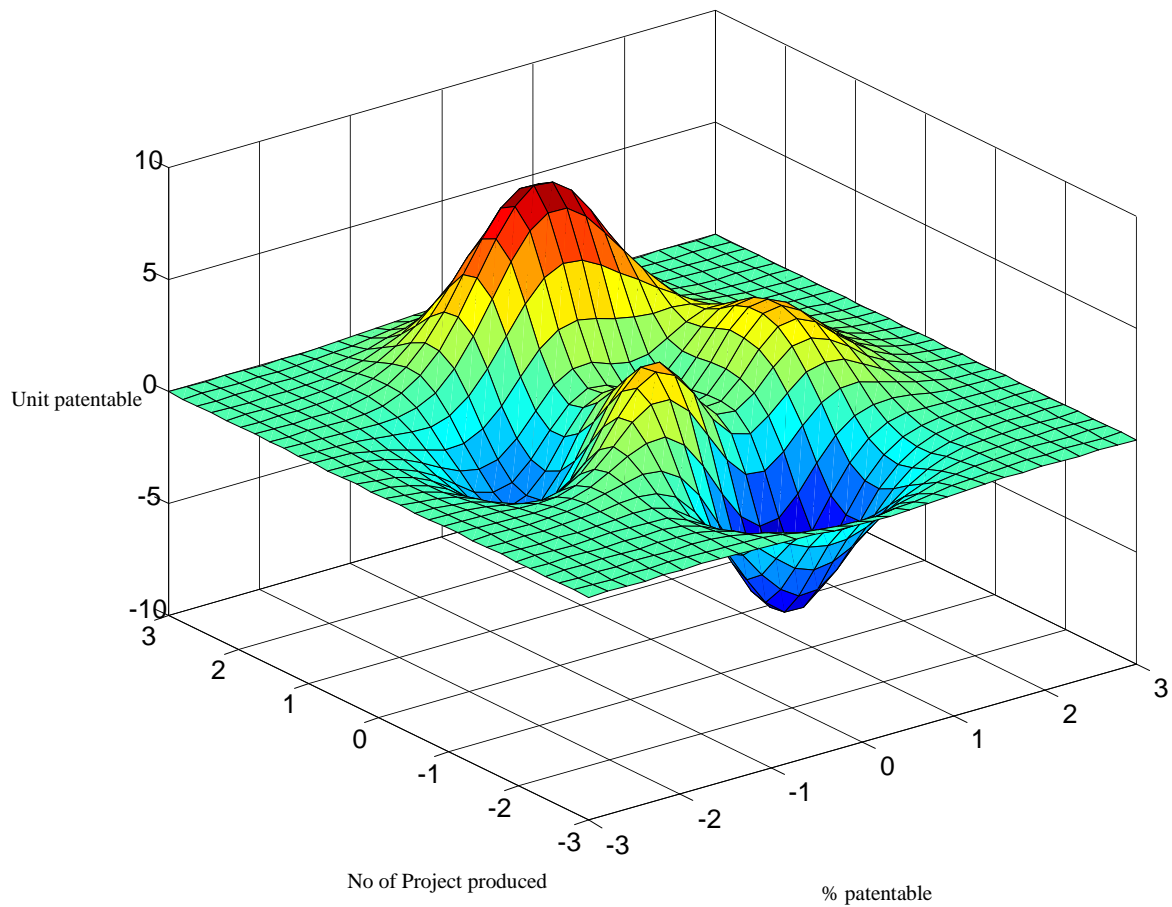
Table 4.9: Research Throughput

No of Projects per yr / % tage patentable	50	60	70	80	90	100
10	5	6	7	8	9	10
20	10	12	14	16	18	20
30	15	18	21	24	27	30
40	20	24	28	32	36	40
50	25	30	35	40	45	50
60	30	36	42	48	54	60

Table 4.9 is a research throughput representing the number of Faculty of Engineering projects completed per year against the percentage of the projects that are patentable. For example, 10% of 50 projects is 5 patentable projects for that year, if 60 projects were completed, then 10% patentable is 6 and so. The higher the number of projects, the higher the number of patentable ones. Also, the higher the percentage of the projects that are patentable (i.e. quality) the higher the number of patentable projects (Table 4.10). The 3-D surface plot for Table 4.9 is shown in Fig 4.5.

Matlab defines a mesh surface by z-coordinates of points above a rectangular grid in the x-y plane. It forms a mesh plot by joining adjacent points with straight lines. The result looks like a fishing net with knots of the data points. A surface plot looks like a mesh plot, except that the spaces between the lines, called patches are filled.

Figure 4.5 Surface plot of peaks:Research Throughput

Fig 4.5: 3-D surface plot for Research Throughput.

Fig 4.5 is a three-dimensional surface plot. The function plots the values in matrix z as heights above a grid in the *x-y* plane defined by x and Y. The function also uses z for the color data, so color is proportional to height.
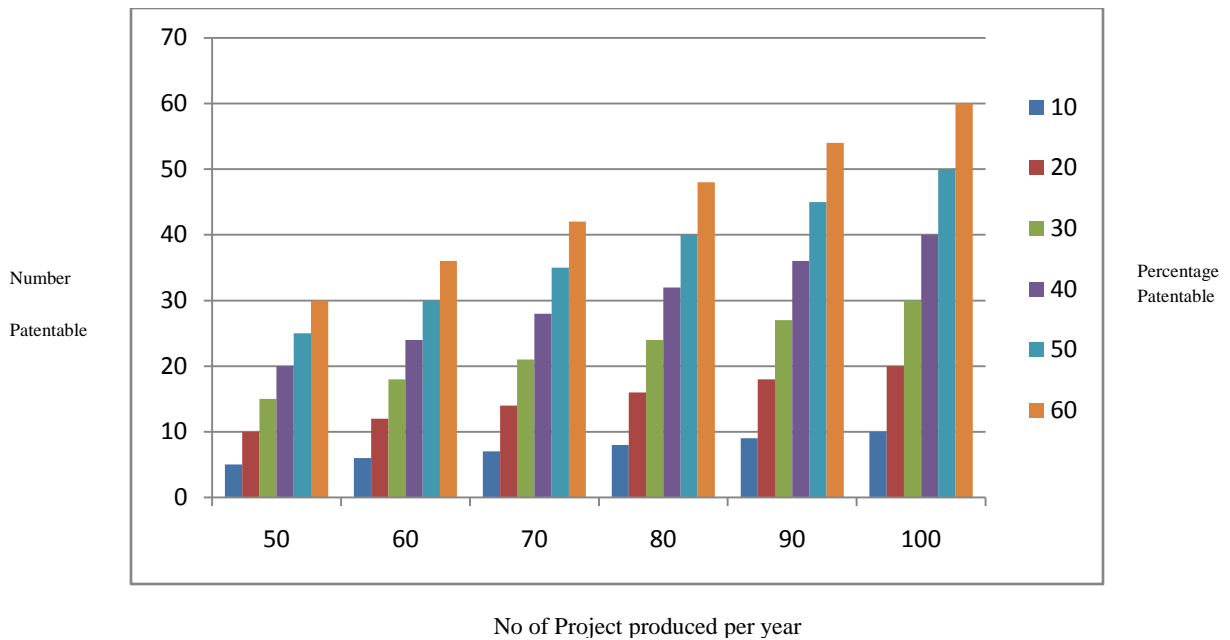
Fig 4.6: Bar Chart for Research Throughput

This is a pictorial representation of research throughput. It is a bar chart representing the numbers of projects produced per year, the number patentable and the percentage patentable. It plots the number patentable versus number of projects produced per year. The more the number of projects produced per year, the more the patentability and the more the percentage patentable. For example where the number of project is 50, the number patentable is 30 at 60% patentability, and when the project increased to 100, it produces 60 at 60% patentable.

With the expert advice from experienced valuers, it is envisaged that the

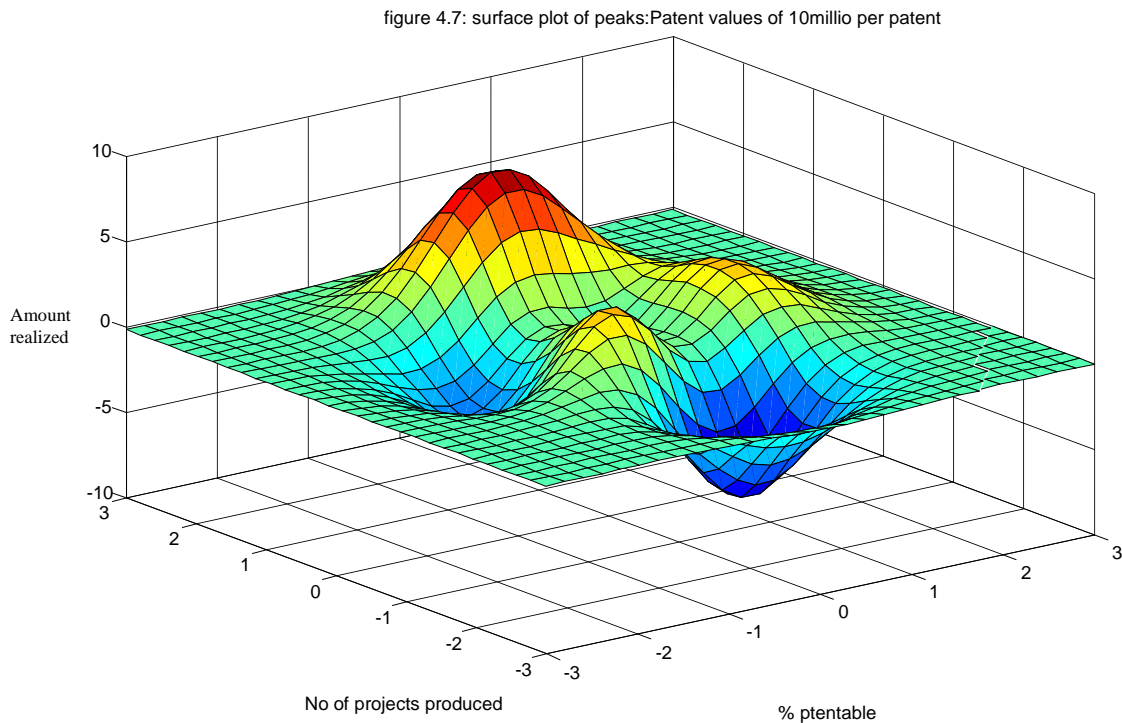Current value of a Patent is 10million naira if sold;

Value of a Patent is 15million naira if exploited in a partnership;

And the value of a Patent is 20million naira if exploited alone, (i.e. if the Faculty

of Engineering decides to float a company to produce the product in the patent)

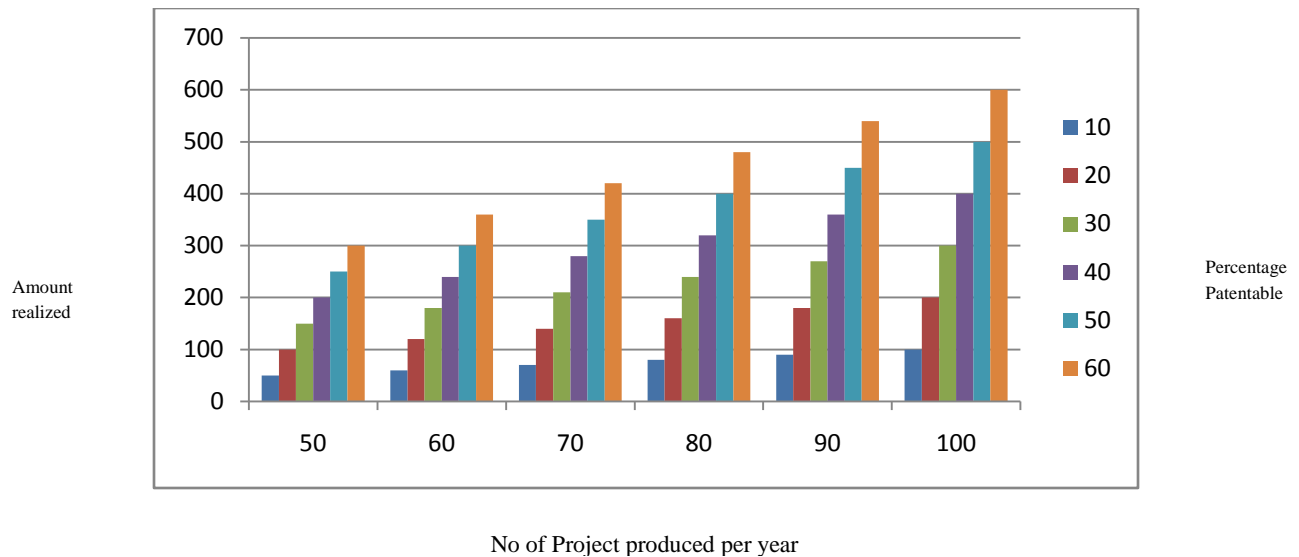**Table 4.10: Patent Value at 10million per patent**

% tage patentable \ No of Projects per yr	50	60	70	80	90	100
10	50m	60m	70m	80m	90m	100m
20	100m	120m	140m	160m	180m	200m
30	150m	180m	210m	240m	270m	300m
40	200m	240m	280m	320m	360m	400m
50	250m	300m	350m	400m	450m	500m
60	300m	360m	420m	480m	540m	600m

Table 4.10 shows the value of Patents in Table 4.9 if sold for 10million each. Multiplying percentage that are patentable with the value of patent sold at 10million gives total value of money for the number of projects that year. The 3D surface plot of Table 4.10 is shown in Figure 4.7.

figure 4.7: surface plot of peaks:Patent values of 10millio per patent

Fig 4.7: 3-D Surface Plot for Patent Value at 10million per Patent

700
600
500
400
300
200
100
0

Amount
realized

	10
	20
	30
	40
	50
	60

Percentage
Patentable

50   60   70   80   90   100

No of Project produced per year

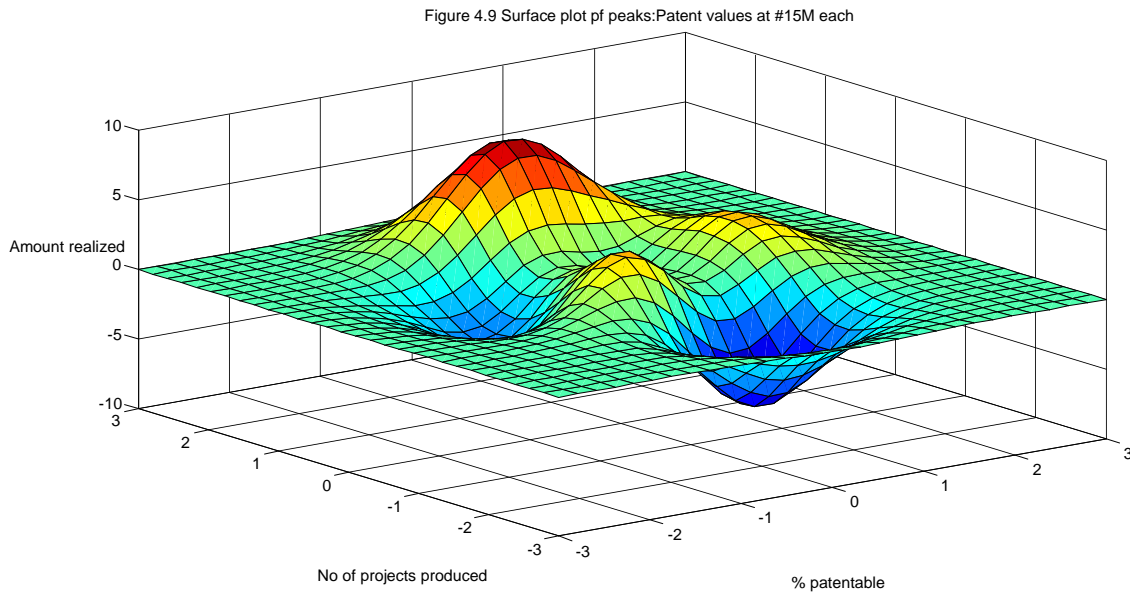**Fig 4.8: Bar Chart for Patent Value at 10million per Patent**

Fig 4.8 denotes that the more the number of projects per year, the more the money earned. For example, when number of total number of project done in a year is 50, at 50% patentability, the Faculty will realize ₦250million, if the number of project increase to 100 per year, at 50% patentability, the Faculty would realize ₦500million. As the project increases, the amount realized increases also. The Faculty will do well by increasing the number of quality projects.

Table 4.11: Patent Values at 15million per partnership

No of Projects per yr / % tage patentable	50	60	70	80	90	100
10	75m	90m	105m	120m	135m	150m
20	150m	180m	210	240m	270m	300m
30	225m	270m	315m	360m	405m	450m
40	300m	360m	420m	480m	540m	600m
50	375m	450m	525m	600m	675m	750m
60	450m	540m	630m	720	810	900m

Table 4.11 shows what happens when the faculty goes into partnership venture with a suitable partner. The value of Patent if exploited in a Partnership is

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15million. Multiplying the proportion patentable in Table 4.9 with 15million, gives a value for the number of projects done for that year. These values are recorded in Table 4.11. The 3-D Surface Plot of Table 4.11 is shown in Figure 4.9.

Figure 4.9 Surface plot pf peaks:Patent values at #15M each

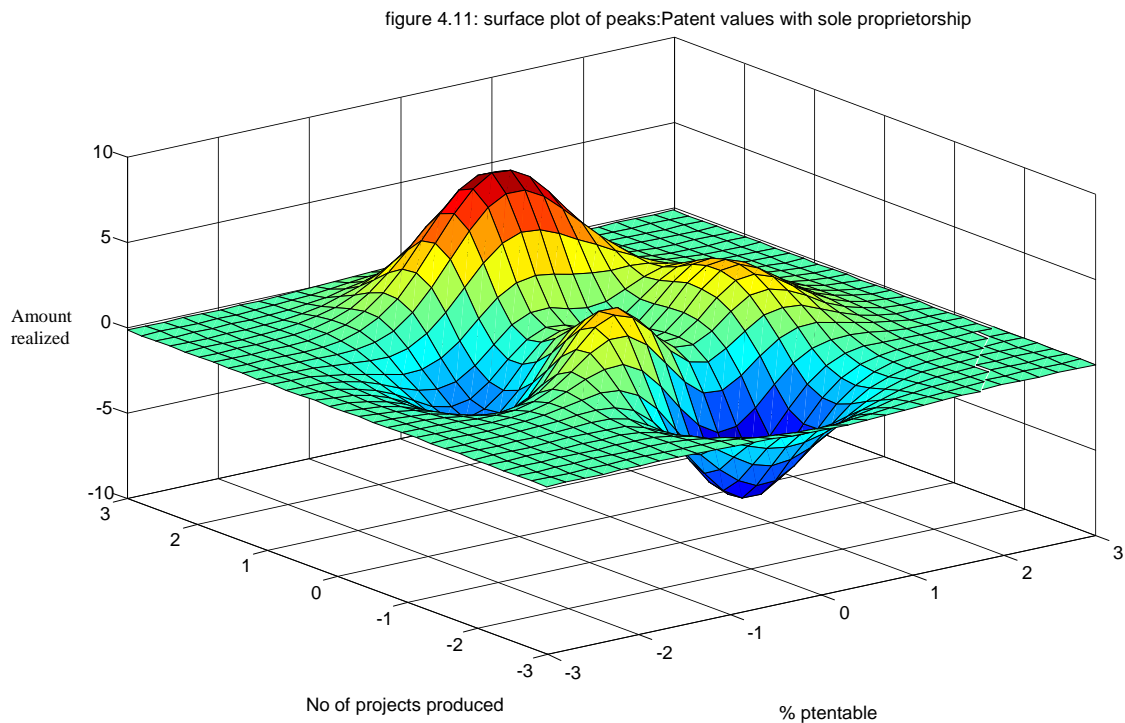**Fig 4.9: 3-D Surface Plot for Patent Values at 15million per partnership**
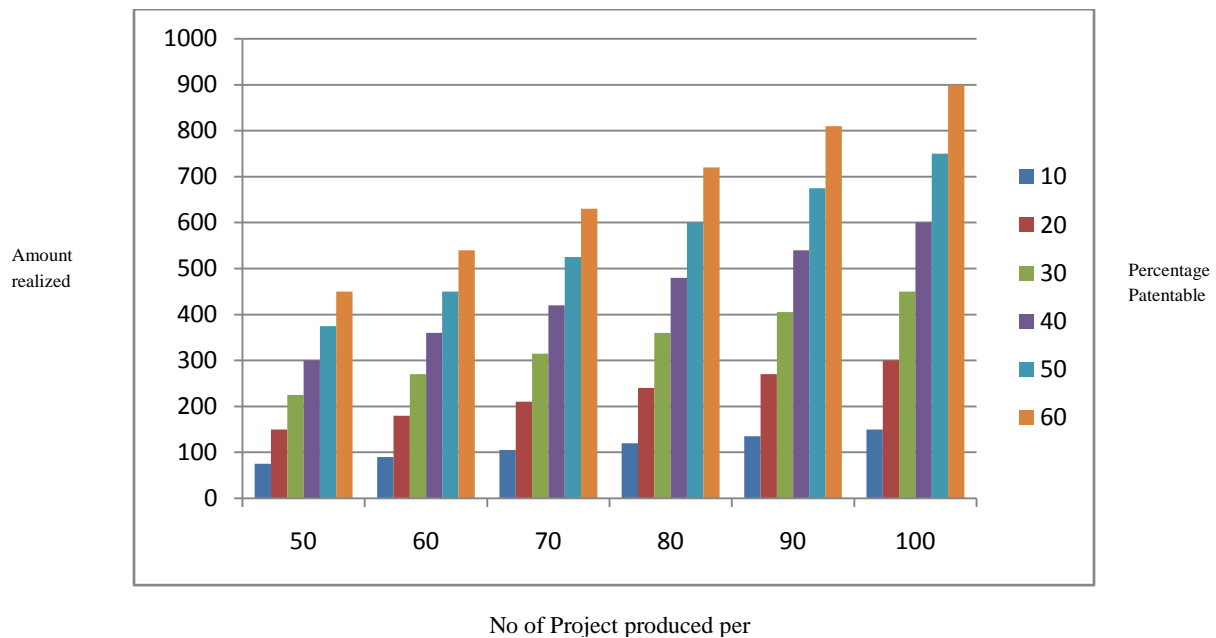
Fig 4.10: Bar Chart for Patent Value at 15million per Patent

This is the same as Fig 4.8, the difference is that each patent is worth 15million each when they go into partnership venture with a suitable partner.

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Table 4.12: Patent Values at 20million Sole Proprietary

No of Projects per yr / % tage patentable	50	60	70	80	90	100
10	100m	120m	140m	160m	180m	200m
20	200m	240m	280m	320m	360m	400m
30	300m	360m	420m	480m	540m	600m
40	400m	480m	560m	640m	720m	800m
50	500m	600m	700m	800m	900m	1,000m
60	600m	720m	840m	960m	1,080m	1,200m

Table 4.12, shows the scenario where the Faculty may choose to add value to the Patent by going into production using the IP content in the Patent. Here, the value of each Patent is ₦ 20m. If the percentage patentable were to be 60% and 100 projects were completed that year, then 60% * 100 = 60, 60 * ₦20 m = ₦ 1200m. The higher the number of Patentable work, the bigger the potential earning of the Faculty (Table 4.12). The 3-D Surface Plot of Table 4.12 is shown in Figure 4.11.

figure 4.11: surface plot of peaks:Patent values with sole proprietorship

Fig 4.11: 3-D Surface Plot for Patent Values at 20million Sole Proprietary
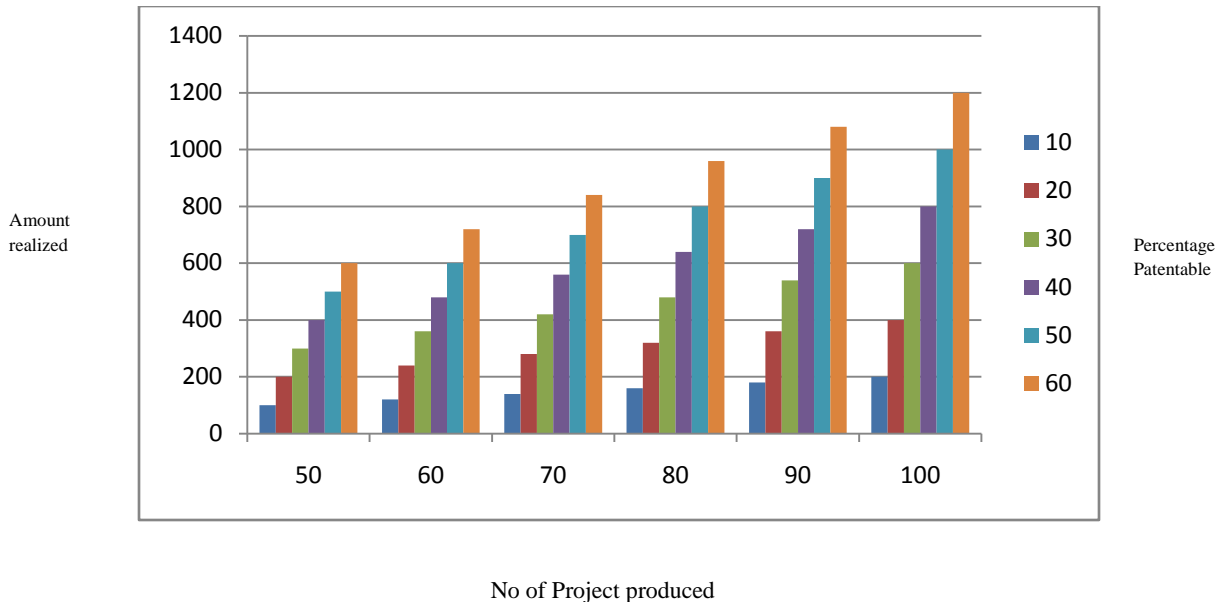
Fig 4.12: Bar Chart for Patent Value at 20million Sole Proprietary

Fig 4.12 is a chart that explains the amount the faculty will make if it goes into production alone. Each patent is worth 20million. As the number of projects increases, the money realized by the faculty increases.

4.5 Multiple Regression Analysis

The number of research output per year and the percentage of it that is patentable shown in Table 4.8 is subjected to multiple regression analysis of the type:

$$Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \varepsilon \qquad (4.2)$$

Where Y = the dependent variable and X_1, X_2 are independent variables representing the number of projects completed per year (X_1) and the percentage of it that is patentable (X_2).

And β_o, β_1, β_2 are coefficient while ε represent the error.

From the multiple regression done using the Matlab software in Appendix F, it was found that, Using the equation;

$$\underline{\beta} = (X^TX)^{-1} X^TY \qquad (4.3)$$

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where $\underline{\beta} = \begin{bmatrix} \beta_o \\ \beta1 \\ \beta2 \end{bmatrix}$ $X = \begin{pmatrix} 1 & 50 & 10 \\ 1 & 100 & 10 \\ 1 & 60 & 20 \\ 1 & 90 & 20 \\ 1 & 70 & 30 \\ 1 & 80 & 30 \\ 1 & 70 & 40 \\ 1 & 60 & 50 \\ 1 & 80 & 40 \\ 1 & 50 & 60 \\ 1 & 90 & 50 \\ 1 & 100 & 60 \end{pmatrix}$ $Y = \begin{pmatrix} 5 \\ 10 \\ 12 \\ 18 \\ 21 \\ 24 \\ 28 \\ 30 \\ 32 \\ 30 \\ 45 \\ 60 \end{pmatrix}$

$\beta_o = -26.25$
$\beta_1 = 0.35$
$\beta_2 = 0.75$

Therefore, $Y = -26.25 + 0.35X_1 + 0.75X_2$ (4.4)

The F* test of utility was applied to the Multiple regression results;

Ho (null hypothesis) says β_o, β_1 and β_2 has nothing to do with the filled curve of y in terms of X_1 and X_2. H_1 (alternative hypothesis) is taken if H_O is rejected. To perform test for utility of the regression;

F*(F Statistics or Test Statistics) was calculated as $\dfrac{MSR}{MSE}$ This is the ratio of mean square for regression (MSR) to the mean Square for error (MSE).

And to be: $F* = \dfrac{MSR}{MSE} = 61.0396$ using Matlab software (Appendix F)

This is much higher than the cut off value for H_o to be true. Therefore, Ho is rejected and H1 is taken. The regression shows a correct relationship between y, X_1 and X_2. Appendix F shows the Matlab software for Multiple Regression Analysis and also software used to do the test for utility of the multiple regression.

4.6 Summary of Mathematical and Graphical Representations

IP growth equations

The equations showing the growth of IP over 5years of simulation are thus:

$$\text{New IP} = 55x + 0.20 \tag{4.5}$$

Where x = number of years, when a straight line is fitted

For a quadratic fit, the equation becomes:

$$\text{New IP} = 2.57x^2 + 39.57x + 18.20 \tag{4.6}$$

Where x = number of years

When the quality factor is taken into consideration, the linear fit equation becomes:

$$\text{New IP} = 118.70x - 9.70 \tag{4.7}$$

For a quadratic fit, the equation becomes:

$$\text{New IP} = 5.93x^2 + 83.13x + 31.80 \tag{4.8}$$

The graph shows that in both cases the quadratic fit is better

Multiple regression analysis was used to show the relationship between the number of projects that are patentable per year (Y) and two variables namely, X_1 (total number of projects completed per year), and X_2 (percentage of it that is patentable).

$$Y = -26.25 + 0.35x_1 + 0.75x_2 \tag{4.9}$$

4.7 Comparism of Research Findings

This compares this research work with other jobs similar to it with the following parameters;

Table 4.16: Comparism of the Research Findings

s/n	Parameter Comparism	DES	IP databse storing idea, invention disclosure and Patent data	Intellectual Property Mgt in a global Economy using KPI	Kodak's Invention Tracker	Strategic mgt of IP; An Integrated Approach
1	Continuous search for new IP through quarterly knowledge elicitation exercise	Yes	Yes, Biannually	No	No	No
2	Remuneration package to encourage in-house new IP build up	Yes	Yes	Yes	Not stated	Yes
3	New IP validation through peer review of claimed new IP contribution	Yes	No	No	No	No
4	IP knowledge base enhancements through the replacement of old practices with the newly discovered industry best practices	Yes	No	No	Not Stated	No
5	Reduced cost of IP acquisition through the cost effective 1approach used	Yes	No	No	No	No
6	Provision of a means of measuring the net worth of new IP in a co-operate body	Yes	No	No	No	No
7	Simulation of workability of the dynamic expert system model	Yes	No	No	No	No
8	Encouragement for timely quality research output in engineering faculties of the universities by highlighting their potential earnings through such timely and patentable research	Yes	No	No	No	No
9	Expert IP valuation using the cost method	Cost based approach	Market based approach	KPI approach	Not stated	Not stated
10	Ability to make a company grow in effectiveness and capacity and remain continuously relevant through the adoption of the dynamic expert system model	Yes	No	No	No	No

CHAPTER FIVE

SUMMARY AND CONCLUSION

5.1 Summary and Conclusion

A Dynamic expert system for corporate bodies has been designed and implemented in the course of this research, using ELDI Awka as a case study. The importance of high quality research projects has also been emphasized, using Faculty of Engineering NAU as a case study. The study looked at the number of projects completed in an academic year in the faculty, the proportion of the finished projects that are patentable and the likely rewards that could accrue to the faculty of Engineering if the patents were sold or committed to a production line in partnership with others or committed to a production line set up and owned by the faculty alone. The research underlined the importance of high quality (patentable) research projects completed without much delay within the faculty of Engineering. The higher the number of projects completed in the faculty within a year and the greater the proportion of them that are patentable, the higher the potential earnings accruable to the Faculty from completed research work. The dynamic expert system was also simulated to see how it would fare within the next five (5) years. A Scheme of remuneration to staff in a corporate body for evolving new IP, that keeps the inventors happy, even though the new IP is worth several times the remuneration paid out to them, was worked out in this research. The simulation shows that using a dynamic expert system would reduce the cost of IP acquisition, enhance IP growth of the company's workforce, lead to greater customer satisfaction and improve earnings to the corporate body. The dynamic expert system is clearly an innovative way to manage intellectual property in a corporate body.

5.2 Problems Encountered and Solution

It was not very easy to get the cooperation of the staff members of ELDI Awka, but this was done after much effort in conjunction with the project supervisor. It was not easy to obtain patenting information from the patent office at Enugu, see Appendix C. Also, the issue of valuation of IP and of project patents required a careful search for valuers who have expertise in the area of interest of the research. However, this bottleneck was overcome by leveraging the expert knowledge of the project supervisor and his years of his liaison in the industry based experts including the immediate past director of ELDI, Prof. Michael Ndinechi.

5.3 Contribution to knowledge

- A new cost effective way for growing the Intellectual Property (IP) content of the workforce in a corporate body has been formalized and modeled in this research, through the concept of the dynamic expert system. This method traps productive IP of a corporate body within the corporate body with the result that even if key officers resign or withdraw their services for any reason, the company's productive capacity would not be much affected; other hands can easily be trained up to expectation by means of the dynamic expert system. Thus those who leave the company could easily be replaced without much loss to the corporate body.

- The model for new IP creation is given by New IP $Y = 5.93x^2 + 83.13x + 31.80$ with coefficient of determination $R^2 = 98.63\%$, which shows that the model can be used for forcasting purposes.

- Patentability was then modeled using multiple regression analysis. It was found that the higher the number of good quality projects(X_1) completed annually within the faculty of Engineering, the higher the proportion of them(X_2) that would be patentable and the higher the money accruable to

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the faculty from research work. Thus the number of patentable projects $Y = -26.25 + 0.35X_1 + 0.75X_2$.

5.4 Peer Contribution

It must be emphasized at this point that the in-depth knowledge of the operational factors mentioned in the foregoing would not have been possible without the profound cooperation which the researcher and her supervisor received from immediate past director of ELDI. The immediate past director was on seat at the inception of this project but now he serves as a professor of communication and Computer Engineering in a federal university in Nigeria. Also, the project supervisor, Prof. Inyiama has worked at University of Manchester, Institute of Science & Technology (UMIST) as a special research assistant for years and is familiar with patentability issues, he also did his PhD in the same institution and his research was sponsored by the British Science Research Council (BSRC) because of its novel nature. He has been a professor of Computer Engineering for more than 20 years and was a professional colleague of the said ELDI director, he has also served as post graduate (PG) coordinator for four (4) continuous years at Unizik Awka, Nigeria. Thus we had all the cooperation needed for the in-depth information presented above. This model can be is applied to a company order than ELDI, but a similar in-depth cooperation is required from the company's leaders if reliable model result is to be realized.

5.5 Conclusion

An expert system Model for the automation of intellectual property (IP) for an organization has been presented in a manner that traps IPs or new IPs used for production within the corporate body. In the approach used in this research, the Intellectual property of the workforce is used to develop best practices and these best practices were evaluated by the foremen or the production manager or their

equivalents. The efficiency and effectiveness of the company's workforce were kept at their best levels by insisting that every worker use only best practices for his or her job functions. Initially, a static expert system was developed and then dynamically updated (every quarter) through knowledge elicitation techniques, knowledge base editing, and inclusion in the knowledge base of newly discovered best practices. This process was summed up in the dynamic expert system table of figure 3.3. An inference engine was also developed to facilitate decision making based on the knowledge base (see Fig 3.14).

The decision structure of the case study organization, ELDI, was organized according to the groups of workforce namely: Production, Research, Quality Control, Marketing and Agriculture and a subset of the dynamic expert system knowledge base catered for each of these production unit and ensured that the best practices patterning to them are kept together and made easily accessible to the workforce by means of the inference engine. A simulation of the dynamic expert system was also carried out to cover a period of five (5) years (20 quarters) to provide a look-ahead way of evaluating the performance of the dynamic expert system. Cost based approach was used in the evaluation of the performance of the dynamic expert system and research work patentability. This was done after considering other evaluation approaches (section 2.3.1) and it was found that the cost based was more suitable for the research.

5.6 Recommendation

It is strongly recommended that the faculty of Engineering NAU should insist on high quality (Patentable) timely research output because this enhances their earning capacity in terms of patentable outputs and patronage. The faculty should not be shy about floating companies to produce output in line with research findings. It is possible to run such companies along best practices as suggested by the dynamic expert system developed in this research. It is the view of the

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researcher that a research project is not really completed until it is featured as part of a production line somewhere in industry. Adopting such a system catalyzes the rapid emergence of viable, well-run indigenous companies and should lead to an increase pace of industrialization in Nigeria.

5.7 Suggestion for Further Research

The Dynamic Expert System (DES) as developed in this work focused primarily on Corporate Bodies that may well be using the Internet for one thing or the other but are not majorly based on CyberSpace. Further research is required to extend DES to firms that are fully Internet based and that do not have a conventional office site. Such firms are web- based, use e-commerce and can be interacted with from anywhere in the globe. There is also much potential for Intellectual Property creation in such firms with respect to the marketing hypes, payment system used, web-page design and Cyber Security arrangements.

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APPENDIX A: Software details of the Inference Engine of the Dynamic Expert System.

Command Line for the Console

```
/*
 * To change this license header, choose License Headers in Project Properties.
 * To change this template file, choose Tools | Templates
 * and open the template in the editor.
 */
package inferenceengine;

/**
 *
 * @author Lois
 */

import java.sql.*;
import java.util.logging.*;
import com.github.sarxos.webcam.Webcam;
import java.io.File;
import java.io.IOException;
import javax.imageio.*;
import java.util.Scanner;
import java.util.logging.Logger;

import com.digitalpersona.onetouch.*;
import com.digitalpersona.onetouch.capture.DPFPCapture;
import com.digitalpersona.onetouch.capture.DPFPCapturePriority;
import com.digitalpersona.onetouch.capture.event.DPFPDataEvent;
import com.digitalpersona.onetouch.capture.event.DPFPDataListener;
import com.digitalpersona.onetouch.capture.event.DPFPReaderStatusAdapter;
import com.digitalpersona.onetouch.capture.event.DPFPReaderStatusEvent;
import com.digitalpersona.onetouch.processing.DPFPEnrollment;
import com.digitalpersona.onetouch.processing.DPFPFeatureExtraction;
import com.digitalpersona.onetouch.processing.DPFPImageQualityException;
import com.digitalpersona.onetouch.readers.DPFPReaderDescription;
import com.digitalpersona.onetouch.readers.DPFPReadersCollection;
import com.digitalpersona.onetouch.verification.DPFPVerification;
import com.digitalpersona.onetouch.verification.DPFPVerificationResult;
import java.util.concurrent.LinkedBlockingQueue;

public class InferenceEngine {

  /**
   * @param args the command line arguments
   */
  //private static final String JDBC_DRIVER = "com.mysql.dbc.Driver";
  private static final String DB_PATH = "db.db";
  private static final String DB_URL = "jdbc:sqlite:" + DB_PATH;
  private static final Logger LOGGER = Logger.getLogger(Logger.GLOBAL_LOGGER_NAME);
  private static Webcam webcam;
  private boolean isValidated = false;
  private boolean isFingerPrintMatched = false;
  private int attemptCount = 0;
  private Connection conn;
  private Statement stmt;
  private String userID;
```

```java
/*
   This method checks if the user is valid and has a record in the database
   if he/her has one, the method returns true, else returns false
*/
private boolean validateUser(){
   String sql = "SELECT * FROM users WHERE id = " + this.userID + " AND section_no = " + this.userSection;
   try{
      ResultSet result = this.stmt.executeQuery(sql);
      while(result.next()){
         return true;
      }
      return false;
   } catch(SQLException e){
      System.out.println("Error fetching user from DB:");
      System.out.println(e.getMessage());
   }catch(Exception e){
      e.printStackTrace();
   }
   return false;
}

/*
   This method requests the user to enter a search keyword for querying the KB
*/
private String getKeywords(){
   System.out.println("Enter your search keywords");
   return (new Scanner(System.in)).nextLine();
}

/*
   This method queries the database for entries that match the given keywords and displays them
*/
private ResultSet getSearchResults(String keywords){
  String sql = "SELECT * FROM KB WHERE section_no = " + this.userSection + " AND JFN LIKE '%";
  String [] keywordArr = keywords.split(" ");
  for(int i = 0; i < keywordArr.length; i++){
   if(i+1 != keywordArr.length){
      sql += keywordArr[i] + "%' OR JFN LIKE '%";
   } else {
      sql += keywordArr[i] + "%';";
   }
  }
  System.out.println("Search query:");
  System.out.println(sql);

  try{
     return this.stmt.executeQuery(sql);
  } catch(SQLException e){
     System.out.println("Error fetching user from DB:");
     System.out.println(e.getMessage());
  }
  return null;
}

/*
   Activates the finger print scanner and returns scanned finger print data
*/
private DPFPSample getPrint(){
   DPFPReadersCollection readers = DPFPGlobal.getReadersFactory().getReaders();
```

```java
        if(readers == null || readers.size() == 0){
            System.out.println("There are no finger print readers connected!");
            return null;
        }
        DPFPReaderDescription chosenReader = readers.get(0);
        try{
            return this.getSample(chosenReader.getSerialNumber(), "Place your finger on reader " +
chosenReader.getProductName());
        } catch(InterruptedException e){
            System.out.println("Failed to capture finger, try again");
            e.printStackTrace();
        }
        return null;
    }

    /*
        Checks the fingerprint database for a fingerprint matching the user ID. If the inputted print matches database
entry,
        return true, else false
    */
    private boolean matchPrint(DPFPSample fingerPrint){
        String sql = "SELECT * FROM prints WHERE user_id = " + this.userID + " AND print = " +
fingerPrint.hashCode();
        try{
            ResultSet rs = this.stmt.executeQuery(sql);
            while(rs.next()){
                return true;
            }
            return false;
        }catch(SQLException e){
            System.out.println("Error fetching user print from DB:");
            System.out.println(e.getMessage());
        }
        return false;
    }

    /*
        Gets fingerprint sample from reader
    */
    private DPFPSample getSample(String activeReader, String prompt)
        throws InterruptedException
        {
            final LinkedBlockingQueue<DPFPSample> samples = new LinkedBlockingQueue<DPFPSample>();
            DPFPCapture capture = DPFPGlobal.getCaptureFactory().createCapture();
            capture.setReaderSerialNumber(activeReader);
            capture.setPriority(DPFPCapturePriority.CAPTURE_PRIORITY_NORMAL);
            capture.addDataListener((DPFPDataEvent e) -> {
            if (e != null && e.getSample() != null) {
                try {
                    samples.put(e.getSample());
                } catch (InterruptedException e1) {
                    e1.printStackTrace();
                }
            }
        });
            capture.addReaderStatusListener(new DPFPReaderStatusAdapter()
            {
                    int lastStatus = DPFPReaderStatusEvent.READER_CONNECTED;
                        public void readerConnected(DPFPReaderStatusEvent e) {
```

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```java
                                if (lastStatus != e.getReaderStatus())
                                        System.out.println("Reader is connected");
                                lastStatus = e.getReaderStatus();
                        }
                        public void readerDisconnected(DPFPReaderStatusEvent e) {
                                if (lastStatus != e.getReaderStatus())
                                        System.out.println("Reader is disconnected");
                                lastStatus = e.getReaderStatus();
                        }

            });
            try {
                capture.startCapture();
                System.out.print(prompt);
                return samples.take();
            } catch (RuntimeException e) {
                System.out.printf("Failed to start capture. Check that reader is not used by another application.\n");
                throw e;
            } finally {
                capture.stopCapture();
            }
        }
/*
    Registers a new user
*/

private void register(){
    System.out.println("Enter user section");
    String section = (new Scanner(System.in)).nextLine();
    String sql = "INSERT INTO users (section_no) VALUES ("+section+")";
    try{
    ResultSet rs = this.stmt.executeQuery(sql);
    System.out.println("User id: "+rs.getInt("id"));
    }catch(Exception e){
        e.printStackTrace();
    }
}
/*
    Application actions
*/
private void applications(){
    System.out.println("Enter an action:");
    System.out.println("register: Registers new user");
    System.out.println("auth: Allows you log into the system");
    System.out.println("ui: Use the graphical user interface version");
    String action = (new Scanner(System.in)).nextLine();
    switch(action){
        case "register":
            this.register();
        break;
        case "ui":
            UI ui = new UI();
            ui.setLocationRelativeTo(null);
            ui.setVisible(true);
            break;
        case "auth":
        default:
        break;
    }
```

```java
      }
   /*
      This is the application's main method and handles the sequential execution of the program logic
   */
   public static void main(String[] args) {
      // TODO code application logic here
      InferenceEngine engine = new InferenceEngine();
      engine.applications();
      while(!engine.isValidated){
         //Make at most 3 attempts to validate the user, then exit if validation fails.
         engine.attemptCount += 1;
         engine.getUserInfo();
         engine.isValidated = engine.validateUser();
         if(engine.isValidated) break;
         if(engine.attemptCount >= 3){
            InferenceEngine.LOGGER.setLevel(Level.SEVERE);
            InferenceEngine.LOGGER.severe("Unauthorized user authentication attempt");
            InferenceEngine.webcam.open();
            try{
               ImageIO.write(webcam.getImage(), "PNG", new File("intruders/intruder.png"));
            } catch(IOException e){
               System.out.println("Failed to save intruder picture");
               System.out.println(e.getMessage());
            }
            System.exit(0);
         }
         engine.isFingerPrintMatched = true; //engine.matchPrint(engine.getPrint());
         if(!engine.isFingerPrintMatched){
            //If user finger print does not exist in the user DB
            InferenceEngine.LOGGER.setLevel(Level.SEVERE);
            InferenceEngine.LOGGER.severe("Finger print matching failed");
            InferenceEngine.webcam.open();
            try{
               ImageIO.write(webcam.getImage(), "PNG", new File("intruders/intruder.png"));
            } catch(IOException e){
               System.out.println("Failed to save intruder picture");
               System.out.println(e.getMessage());
            }
            System.exit(0);
         }
      }
   /*
      Authentication successful and user verified.
      Request keyword from user and output best practices
   */
      try{
         ResultSet sr = engine.getSearchResults(engine.getKeywords());
         System.out.println("Best practices:");
         while(sr.next()){
            System.out.println(sr.getString("JFN"));
         }
      }catch(SQLException e){
         System.out.println("Failed to get best practices");
         System.out.println(e.getMessage());
      }
   }

}
```

```
package inferenceengine;
/**
 * @author Lois
*/

//Import libraries required to develop application, use camera, and interface with fingerprint sensor
import com.digitalpersona.onetouch.DPFPFingerIndex;
import com.digitalpersona.onetouch.DPFPTemplate;
import com.github.sarxos.webcam.Webcam;
import javax.swing.JOptionPane;
import java.awt.Container;
import java.io.File;
import java.io.IOException;
import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.ResultSet;
import java.sql.SQLException;
import java.sql.Statement;
import java.util.Date;
import java.util.logging.Level;
import java.util.logging.Logger;
import javax.imageio.ImageIO;
import javax.swing.JFrame;
import java.util.EnumMap;

public class UI extends javax.swing.JFrame {

    private static final String DB_PATH = "db.db";  //Path to database storage
    private static final String DB_URL = "jdbc:sqlite:" + DB_PATH;  //Type of database implemented
    private static final Logger LOGGER = Logger.getLogger(Logger.GLOBAL_LOGGER_NAME);  //Logs
messages
    private static Webcam webcam;  //Webcam object
    private boolean isFingerPrintMatched = false;  //True if fingerprint matches a database entry, else false
    private int attemptCount = 0;  //Holds the number of times userr attempted to log in
    private Connection conn;  //Holds database connection
    private Statement stmt;
    /**
     * Creates new user graphical user interface and initializes the database
     */
    public UI() {
        try{
            conn = DriverManager.getConnection(DB_URL);
            stmt = conn.createStatement();
            System.out.println("Creating tables");
            this.createDBTables();
        } catch(SQLException e){
            conn = null;
            stmt = null;
            System.out.println("Failed to initialize database:");
            e.printStackTrace();
            System.exit(0);
        }
        this.webcam = Webcam.getDefault();
        if(webcam == null){
            System.out.println("No webcam detected!");
            System.exit(0);
        }
```

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```java
        initComponents();
    }
//The initComponents method below renders the user interface
@SuppressWarnings("unchecked")
// <editor-fold defaultstate="collapsed" desc="Generated Code">//GEN-BEGIN:initComponents
private void initComponents() {

    jLabel1 = new javax.swing.JLabel();
    userIDInputBox = new javax.swing.JTextField();
    jLabel2 = new javax.swing.JLabel();
    loginButton = new javax.swing.JButton();
    jLabel3 = new javax.swing.JLabel();
    sectionIDInputBox = new javax.swing.JTextField();
    jLabel5 = new javax.swing.JLabel();
    jMenuBar1 = new javax.swing.JMenuBar();
    jMenu1 = new javax.swing.JMenu();
    signOut = new javax.swing.JMenuItem();
    jMenu2 = new javax.swing.JMenu();

    setDefaultCloseOperation(javax.swing.WindowConstants.EXIT_ON_CLOSE);
    setResizable(false);

    jLabel1.setText("User ID");

    userIDInputBox.addActionListener(new java.awt.event.ActionListener() {
        public void actionPerformed(java.awt.event.ActionEvent evt) {
            userIDInputBoxActionPerformed(evt);
        }
    });

    jLabel2.setText("Section ID");

    loginButton.setBackground(new java.awt.Color(10, 200, 10));
    loginButton.setText("Login");
    loginButton.addActionListener(new java.awt.event.ActionListener() {
        public void actionPerformed(java.awt.event.ActionEvent evt) {
            loginButtonActionPerformed(evt);
        }
    });

    jLabel3.setFont(new java.awt.Font("Tahoma", 0, 36)); // NOI18N
    jLabel3.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
    jLabel3.setText("Login");

    sectionIDInputBox.addActionListener(new java.awt.event.ActionListener() {
        public void actionPerformed(java.awt.event.ActionEvent evt) {
            sectionIDInputBoxActionPerformed(evt);
        }
    });

    jLabel5.setFont(new java.awt.Font("Tahoma", 1, 48)); // NOI18N
    jLabel5.setText("Secure Best Practices System");

    jMenu1.setText("File");

    signOut.setText("Sign Out");
    signOut.addActionListener(new java.awt.event.ActionListener() {
        public void actionPerformed(java.awt.event.ActionEvent evt) {
            signOutPerformed(evt);
```

```java
            }
        });
        jMenu1.add(signOut);

        jMenuBar1.add(jMenu1);

        jMenu2.setText("Edit");
        jMenuBar1.add(jMenu2);

        setJMenuBar(jMenuBar1);

        javax.swing.GroupLayout layout = new javax.swing.GroupLayout(getContentPane());
        getContentPane().setLayout(layout);
        layout.setHorizontalGroup(
            layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
            .addGroup(layout.createSequentialGroup()
                .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
                    .addGroup(layout.createSequentialGroup()
                        .addContainerGap()
                        .addComponent(jLabel5))
                    .addGroup(layout.createSequentialGroup()
                        .addGap(188, 188, 188)
                        .addComponent(jLabel3, javax.swing.GroupLayout.PREFERRED_SIZE, 342,
javax.swing.GroupLayout.PREFERRED_SIZE))
                    .addGroup(layout.createSequentialGroup()
                        .addGap(136, 136, 136)
                        .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
                            .addComponent(jLabel1)
                            .addComponent(jLabel2))
                        .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.UNRELATED)
                        .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.TRAILING)
                            .addComponent(loginButton)
                            .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING, false)
                                .addComponent(userIDInputBox)
                                .addComponent(sectionIDInputBox, javax.swing.GroupLayout.Alignment.TRAILING,
javax.swing.GroupLayout.PREFERRED_SIZE, 367, javax.swing.GroupLayout.PREFERRED_SIZE)))))
                .addContainerGap(32, Short.MAX_VALUE))
        );
        layout.setVerticalGroup(
            layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
            .addGroup(layout.createSequentialGroup()
                .addGap(33, 33, 33)
                .addComponent(jLabel5)
                .addGap(49, 49, 49)
                .addComponent(jLabel3)
                .addGap(35, 35, 35)
                .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.BASELINE)
                    .addComponent(userIDInputBox, javax.swing.GroupLayout.PREFERRED_SIZE,
javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE)
                    .addComponent(jLabel1))
                .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.UNRELATED)
                .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.BASELINE)
                    .addComponent(sectionIDInputBox, javax.swing.GroupLayout.PREFERRED_SIZE,
javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE)
                    .addComponent(jLabel2))
                .addGap(18, 18, 18)
                .addComponent(loginButton)
                .addContainerGap(182, Short.MAX_VALUE))
        );
```

```java
        pack();
    }// </editor-fold>//GEN-END:initComponents
    //No implementation yet
    private void signOutPerformed(java.awt.event.ActionEvent evt) {//GEN-FIRST:event_signOutPerformed
        // TODO add your handling code here:
    }//GEN-LAST:event_signOutPerformed
    //No implementation yet
    private void sectionIDInputBoxActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_sectionIDInputBoxActionPerformed
        // TODO add your handling code here:
    }//GEN-LAST:event_sectionIDInputBoxActionPerformed
    //Initializes user verification process once the log in button is clicked
    private void loginButtonActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_loginButtonActionPerformed
        String userID = this.userIDInputBox.getText().trim();
        String sectionID = this.sectionIDInputBox.getText().trim();
        boolean isValidated = false;
        if(userID.length() == 0 || sectionID.length() == 0){
            JOptionPane.showMessageDialog(null,"No user ID or Section ID entered!", "Invalid Input!",
JOptionPane.WARNING_MESSAGE);
            return;
        }
        //Make at most 3 attempts to validate the user, then exit if validation fails.
        this.attemptCount += 1;
        isValidated = this.verifyUser(userID, sectionID);
        if(!isValidated && this.attemptCount < 3){
            JOptionPane.showMessageDialog(null,"Invalid user ID or section ID! \n Try again", "User not found!",
JOptionPane.WARNING_MESSAGE);
            return;
        }
        if(this.attemptCount >= 3){
            this.LOGGER.setLevel(Level.SEVERE);
            this.LOGGER.severe("Unauthorized user authentication attempt");
            try{
                String path = "c://intruders/";
                File directory = new File(path);
                if(directory.exists()){
                    directory.mkdir();
                    System.out.println("Created directory");
                }
                this.webcam.open();
                ImageIO.write(webcam.getImage(), "PNG", new File("c://intruders/intruder_" + new Date().getTime() +
".png"));
            } catch(IOException e){
                System.out.println("Failed to save intruder picture");
                System.out.println(e.getMessage());
                this.exitApp();
                System.exit(0);
            } catch (NullPointerException e) {
                System.out.println("Failed to save intruder picture");
                System.out.println(e.getMessage());
                this.exitApp();
                System.exit(0);
            }
            this.exitApp();
            System.exit(0);

        }
```

```java
        EnumMap<DPFPFingerIndex, DPFPTemplate> templates = null;
        VerificationDialog vd = new VerificationDialog(this, templates, 1);
        vd.setVisible(true);
    }//GEN-LAST:event_loginButtonActionPerformed
    //No implementation yet
    private void userIDInputBoxActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_userIDInputBoxActionPerformed
        // TODO add your handling code here:
    }//GEN-LAST:event_userIDInputBoxActionPerformed

    /**
     * @param args the command line arguments
     */
    public static void main(String args[]) {
        /* Set the Nimbus look and feel */
        //<editor-fold defaultstate="collapsed" desc=" Look and feel setting code (optional) ">
        /* If Nimbus (introduced in Java SE 6) is not available, stay with the default look and feel.
         * For details see http://download.oracle.com/javase/tutorial/uiswing/lookandfeel/plaf.html
         */
        try {
            for (javax.swing.UIManager.LookAndFeelInfo info : javax.swing.UIManager.getInstalledLookAndFeels()) {
                if ("Nimbus".equals(info.getName())) {
                    javax.swing.UIManager.setLookAndFeel(info.getClassName());
                    break;
                }
            }
        } catch (ClassNotFoundException ex) {
            java.util.logging.Logger.getLogger(UI.class.getName()).log(java.util.logging.Level.SEVERE, null, ex);
        } catch (InstantiationException ex) {
            java.util.logging.Logger.getLogger(UI.class.getName()).log(java.util.logging.Level.SEVERE, null, ex);
        } catch (IllegalAccessException ex) {
            java.util.logging.Logger.getLogger(UI.class.getName()).log(java.util.logging.Level.SEVERE, null, ex);
        } catch (javax.swing.UnsupportedLookAndFeelException ex) {
            java.util.logging.Logger.getLogger(UI.class.getName()).log(java.util.logging.Level.SEVERE, null, ex);
        }
        //</editor-fold>

        /* Create and display the form */
        java.awt.EventQueue.invokeLater(new Runnable() {
            public void run() {
                JFrame UI = new UI();
                UI.setLocationRelativeTo(null);
                UI.setVisible(true);
            }
        });
    }

    // Variables declaration - do not modify//GEN-BEGIN:variables
    private javax.swing.JLabel jLabel1;
    private javax.swing.JLabel jLabel2;
    private javax.swing.JLabel jLabel3;
    private javax.swing.JLabel jLabel5;
    private javax.swing.JMenu jMenu1;
    private javax.swing.JMenu jMenu2;
    private javax.swing.JMenuBar jMenuBar1;
    private javax.swing.JButton loginButton;
    private javax.swing.JTextField sectionIDInputBox;
    private javax.swing.JMenuItem signOut;
    private javax.swing.JTextField userIDInputBox;
```

```java
    // End of variables declaration//GEN-END:variables
    /*
    looks up the user with the inputted user id and section id from the database
    If the user exists it returns true and if the user doesn't, returns false.
    */
    private boolean verifyUser(String userID, String sectionID) {
        String sql = "SELECT * FROM users WHERE id = " + userID + " AND section_no = " + sectionID;
        try{
            ResultSet result = this.stmt.executeQuery(sql);
            while(result.next()){
                return true;
            }
            return false;
        } catch(SQLException e){
            System.out.println("Error fetching user from DB:");
            System.out.println(e.getMessage());
        }catch(Exception e){
            e.printStackTrace();
        }
        return false;
    }
    /*
    This function closes the application when the user verification (fingerprint
    & user di,section id fails
    */
    private void exitApp(){
        //Exits the application
        Container frame = this;
        while(!(frame instanceof JFrame));
        ((JFrame) frame).dispose();
    }
    /*
    This function creates the database tables at the application's first run
    */
    private void createDBTables(){
        //if(!(new File(DB_PATH)).exists()){
            try{
                String[] dbTablesQuery = {
                    "CREATE TABLE IF NOT EXISTS users (id INTEGER PRIMARY KEY, user_id VARCHAR(3),
section_no VARCHAR(4))",
                    "CREATE TABLE IF NOT EXISTS KB (id INTEGER PRIMARY KEY, section_no VARCHAR(4)
NOT NULL, JFN TEXT NOT NULL)",
                    "CREATE TABLE IF NOT EXISTS prints (id INTEGER PRIMARY KEY, user_id INTEGER NOT
NULL, print TEXT NOT NULL)",
                    "INSERT OR REPLACE INTO users (id, user_id, section_no) values ((SELECT id FROM users
WHERE id = 1), 001, 001)"
                };
                System.out.println("Creating database tables");
                for (String q : dbTablesQuery) {
                    this.stmt.addBatch(q);
                }
                this.stmt.executeBatch();
                this.stmt.clearBatch();
                System.out.println("Database tables created");
            }catch(SQLException e){
                System.out.println("Failed to create database tables:");
                e.printStackTrace();
            }
        //}
```

```
      }
   //This function displays the user interface after app has initialized
   private void showFingerPrintPrompt() {
      this.getContentPane().removeAll();
      java.awt.EventQueue.invokeLater(new Runnable() {
         public void run() {
            JFrame UI = new UI();
            UI.setLocationRelativeTo(null);
            UI.setVisible(true);
         }
      });
   }
}




UI Software


//This loads the login form
/*
 * To change this license header, choose License Headers in Project Properties.
 * To change this template file, choose Tools | Templates
 * and open the template in the editor.
 */
package inferenceengine;
/**
 *
 * @author Lois
 */

//Import libraries required to develop application, use camera, and interface
//with fingerprint sensor and manage database
import com.digitalpersona.onetouch.DPFPFingerIndex;
import com.digitalpersona.onetouch.DPFPTemplate;
import com.github.sarxos.webcam.Webcam;
import javax.swing.JOptionPane;
import java.awt.Container;
import java.io.File;
import java.io.IOException;
import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.ResultSet;
import java.sql.SQLException;
import java.sql.Statement;
import java.util.Date;
import java.util.logging.Level;
import java.util.logging.Logger;
import javax.imageio.ImageIO;
import javax.swing.JFrame;
import java.util.EnumMap;

public class UI extends javax.swing.JFrame {

   private static final String DB_PATH = "db.db";  //Path to database storage
   private static final String DB_URL = "jdbc:sqlite:" + DB_PATH;  //Type of database implemented
   private static final Logger LOGGER = Logger.getLogger(Logger.GLOBAL_LOGGER_NAME);  //Logs
messages
   private static Webcam webcam;   //Webcam object
```

```java
private boolean isFingerPrintMatched = false;  //True if fingerprint matches a database entry, else false
private int attemptCount = 0;  //Holds the number of times userr attempted to log in
private Connection conn;    //Holds database connection
private Statement stmt;     //Holds the database queries
private boolean unVerifiedLoginBTNClicked;
/**
 * Creates new user graphical user interface and initializes the database
 * Also checks for webcam
 */
public UI() {
   //Creates database at first run then initializes it
   try{
      conn = DriverManager.getConnection(DB_URL); //Tell application the type of database to use (SQL)
      stmt = conn.createStatement(); //Create an SQL statement object for type of database
      System.out.println("Creating tables"); //Output database creation initialization message to console
      this.createDBTables(); //Create database
   } catch(SQLException e){
      //If an error occurs with the query while creating the database,
      //Print the cause of the error and exit the application
      conn = null;
      stmt = null;
      System.out.println("Failed to initialize database:");
      e.printStackTrace();
      System.exit(0);
   }
   //Check for webcam
   this.webcam = Webcam.getDefault();
   if(webcam == null){
      System.out.println("No webcam detected!");
      System.exit(0);
   }
   //Display user interface
   initComponents();
}

//The initComponents method below renders the user interface
@SuppressWarnings("unchecked")
// <editor-fold defaultstate="collapsed" desc="Generated Code">//GEN-BEGIN:initComponents
private void initComponents() {

   jLabel1 = new javax.swing.JLabel();
   userIDInputBox = new javax.swing.JTextField();
   jLabel2 = new javax.swing.JLabel();
   loginButton = new javax.swing.JButton();
   jLabel3 = new javax.swing.JLabel();
   sectionIDInputBox = new javax.swing.JTextField();
   jLabel5 = new javax.swing.JLabel();
   unVerifiedLogin = new javax.swing.JButton();
   jMenuBar1 = new javax.swing.JMenuBar();
   jMenu1 = new javax.swing.JMenu();
   signOut = new javax.swing.JMenuItem();
   jMenu2 = new javax.swing.JMenu();

   setDefaultCloseOperation(javax.swing.WindowConstants.EXIT_ON_CLOSE);
   setResizable(false);

   jLabel1.setText("User ID");

   userIDInputBox.addActionListener(new java.awt.event.ActionListener() {
```

```java
        public void actionPerformed(java.awt.event.ActionEvent evt) {
            userIDInputBoxActionPerformed(evt);
        }
    });

    jLabel2.setText("Section ID");

    loginButton.setBackground(new java.awt.Color(10, 200, 10));
    loginButton.setText("Login");
    loginButton.addActionListener(new java.awt.event.ActionListener() {
        public void actionPerformed(java.awt.event.ActionEvent evt) {
            loginButtonActionPerformed(evt);
        }
    });

    jLabel3.setFont(new java.awt.Font("Tahoma", 0, 36)); // NOI18N
    jLabel3.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
    jLabel3.setText("Login");

    sectionIDInputBox.addActionListener(new java.awt.event.ActionListener() {
        public void actionPerformed(java.awt.event.ActionEvent evt) {
            sectionIDInputBoxActionPerformed(evt);
        }
    });

    jLabel5.setFont(new java.awt.Font("Tahoma", 1, 48)); // NOI18N
    jLabel5.setText("Secure Best Practices System");

    unVerifiedLogin.setText("Unverified Login");
    unVerifiedLogin.addActionListener(new java.awt.event.ActionListener() {
        public void actionPerformed(java.awt.event.ActionEvent evt) {
            unVerifiedLoginActionPerformed(evt);
        }
    });

    jMenu1.setText("File");

    signOut.setText("Sign Out");
    signOut.addActionListener(new java.awt.event.ActionListener() {
        public void actionPerformed(java.awt.event.ActionEvent evt) {
            signOutPerformed(evt);
        }
    });
    jMenu1.add(signOut);

    jMenuBar1.add(jMenu1);

    jMenu2.setText("Edit");
    jMenuBar1.add(jMenu2);

    setJMenuBar(jMenuBar1);

    javax.swing.GroupLayout layout = new javax.swing.GroupLayout(getContentPane());
    getContentPane().setLayout(layout);
    layout.setHorizontalGroup(
        layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
        .addGroup(layout.createSequentialGroup()
            .addContainerGap(javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE)
            .addComponent(jLabel5)
```

```java
                    .addContainerGap(javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE))
                .addGroup(layout.createSequentialGroup()
                    .addContainerGap(javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE)
                    .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
                        .addComponent(jLabel1)
                        .addComponent(jLabel2))
                    .addGap(18, 18, 18)
                    .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.TRAILING)
                        .addGroup(layout.createSequentialGroup()
                            .addComponent(unVerifiedLogin)
                            .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.UNRELATED)
                            .addComponent(loginButton))
                        .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING, false)
                            .addComponent(userIDInputBox)
                            .addComponent(sectionIDInputBox, javax.swing.GroupLayout.Alignment.TRAILING,
javax.swing.GroupLayout.PREFERRED_SIZE, 367, javax.swing.GroupLayout.PREFERRED_SIZE))
                        .addComponent(jLabel3, javax.swing.GroupLayout.Alignment.LEADING,
javax.swing.GroupLayout.PREFERRED_SIZE, 342, javax.swing.GroupLayout.PREFERRED_SIZE))
                    .addContainerGap(javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE))
        );
        layout.setVerticalGroup(
            layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
            .addGroup(layout.createSequentialGroup()
                .addContainerGap(33, Short.MAX_VALUE)
                .addComponent(jLabel5)
                .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED, 72, Short.MAX_VALUE)
                .addComponent(jLabel3)
                .addGap(35, 35, 35)
                .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.BASELINE)
                    .addComponent(userIDInputBox, javax.swing.GroupLayout.PREFERRED_SIZE,
javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE)
                    .addComponent(jLabel1))
                .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.UNRELATED)
                .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.BASELINE)
                    .addComponent(sectionIDInputBox, javax.swing.GroupLayout.PREFERRED_SIZE,
javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE)
                    .addComponent(jLabel2))
                .addGap(18, 18, 18)
                .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.BASELINE)
                    .addComponent(loginButton)
                    .addComponent(unVerifiedLogin))
                .addContainerGap(159, Short.MAX_VALUE))
        );

        pack();
    }// </editor-fold>//GEN-END:initComponents
    //No implementation yet
    private void signOutPerformed(java.awt.event.ActionEvent evt) {//GEN-FIRST:event_signOutPerformed
        // TODO add your handling code here:
    }//GEN-LAST:event_signOutPerformed
    //No implementation yet
    private void sectionIDInputBoxActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_sectionIDInputBoxActionPerformed
        // TODO add your handling code here:
    }//GEN-LAST:event_sectionIDInputBoxActionPerformed
    //Initializes user verification process once the log in button is clicked
    private void loginButtonActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_loginButtonActionPerformed
        String userID = this.userIDInputBox.getText().trim();
```

```java
        String sectionID = this.sectionIDInputBox.getText().trim();
        boolean isValidated = false;
        if(userID.length() == 0 || sectionID.length() == 0){
            JOptionPane.showMessageDialog(null,"No user ID or Section ID entered!", "Invalid Input!",
JOptionPane.WARNING_MESSAGE);
            return;
        }
        //Make at most 3 attempts to validate the user, then exit if validation fails.
        this.attemptCount += 1;
        isValidated = this.verifyUser(userID, sectionID);
        if(!isValidated && this.attemptCount < 3){
            //If user section_no and id validation fails, display a notification
            JOptionPane.showMessageDialog(null,"Invalid user ID or section ID! \n Try again", "User not found!",
JOptionPane.WARNING_MESSAGE);
            return;
        }
        if(this.attemptCount >= 3){
            //If user verification fails thrice, log activity
            this.LOGGER.setLevel(Level.SEVERE);
            this.LOGGER.severe("Unauthorized user authentication attempt");
            //Take picture of intruder and save in C://intruders
            try{
                String path = "c://intruders/";
                File directory = new File(path);    //Create a new file object that points to the directory to save intruder
photos.
                if(directory.exists()){
                    //Check if the directory exists, if not, create it.
                    directory.mkdir();
                    System.out.println("Created directory");
                }
                //Take intruder picture
                this.webcam.open();
                //Save intruder picture with current date appended to name
                ImageIO.write(webcam.getImage(), "PNG", new File("c://intruders/intruder_" + new Date().getTime() +
".png"));
            } catch(IOException e){
                //If an error occured while saving intruder picture,
                //Print the error, and exit the application
                System.out.println("Failed to save intruder picture");
                System.out.println(e.getMessage());
                this.exitApp();
                System.exit(0);
            } catch (NullPointerException e) {
                //If camera malfunctions, print error and exit app
                System.out.println("Failed to save intruder picture");
                System.out.println(e.getMessage());
                this.exitApp();
                System.exit(0);
            }
            //exit the application
            this.exitApp();
            System.exit(0);

        }
        //if user section no and id validation is successful
        //Request user finger print
        if(!unVerifiedLoginBTNClicked){
            //If normal login button is clicked
            EnumMap<DPFPFingerIndex, DPFPTemplate> templates = null;
```

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```java
            VerificationDialog vd = new VerificationDialog(this, templates, 1);
            vd.setVisible(true);
        } else {
            this.setVisible(false);
            new BestPractices(userID, sectionID);
        }
    }//GEN-LAST:event_loginButtonActionPerformed
    //No implementation yet
    private void userIDInputBoxActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_userIDInputBoxActionPerformed
        // TODO add your handling code here:
    }//GEN-LAST:event_userIDInputBoxActionPerformed

    private void unVerifiedLoginActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_unVerifiedLoginActionPerformed
        // TODO add your handling code here:
        this.unVerifiedLoginBTNClicked = true;
        this.loginButtonActionPerformed(evt);
    }//GEN-LAST:event_unVerifiedLoginActionPerformed

    /**
     * @param args the command line arguments
     */
    public static void main(String args[]) {
        /* Set the Nimbus look and feel */
        //<editor-fold defaultstate="collapsed" desc=" Look and feel setting code (optional) ">
        /* If Nimbus (introduced in Java SE 6) is not available, stay with the default look and feel.
         * For details see http://download.oracle.com/javase/tutorial/uiswing/lookandfeel/plaf.html
         */
        try {
            for (javax.swing.UIManager.LookAndFeelInfo info : javax.swing.UIManager.getInstalledLookAndFeels()) {
                if ("Nimbus".equals(info.getName())) {
                    javax.swing.UIManager.setLookAndFeel(info.getClassName());
                    break;
                }
            }
        } catch (ClassNotFoundException ex) {
            java.util.logging.Logger.getLogger(UI.class.getName()).log(java.util.logging.Level.SEVERE, null, ex);
        } catch (InstantiationException ex) {
            java.util.logging.Logger.getLogger(UI.class.getName()).log(java.util.logging.Level.SEVERE, null, ex);
        } catch (IllegalAccessException ex) {
            java.util.logging.Logger.getLogger(UI.class.getName()).log(java.util.logging.Level.SEVERE, null, ex);
        } catch (javax.swing.UnsupportedLookAndFeelException ex) {
            java.util.logging.Logger.getLogger(UI.class.getName()).log(java.util.logging.Level.SEVERE, null, ex);
        }
        //</editor-fold>

        /* Create and display the form */
        java.awt.EventQueue.invokeLater(new Runnable() {
            public void run() {
                JFrame UI = new UI();
                UI.setLocationRelativeTo(null);
                UI.setVisible(true);
            }
        });
    }

    // Variables declaration - do not modify//GEN-BEGIN:variables
    private javax.swing.JLabel jLabel1;
```

```java
    private javax.swing.JLabel jLabel2;
    private javax.swing.JLabel jLabel3;
    private javax.swing.JLabel jLabel5;
    private javax.swing.JMenu jMenu1;
    private javax.swing.JMenu jMenu2;
    private javax.swing.JMenuBar jMenuBar1;
    private javax.swing.JButton loginButton;
    private javax.swing.JTextField sectionIDInputBox;
    private javax.swing.JMenuItem signOut;
    private javax.swing.JButton unVerifiedLogin;
    private javax.swing.JTextField userIDInputBox;
    // End of variables declaration//GEN-END:variables
    /*
    looks up the user with the inputted user id and section id from the database
    If the user exists it returns true and if the user doesn't, returns false.
    */
    private boolean verifyUser(String userID, String sectionID) {
        String sql = "SELECT * FROM users WHERE user_id = '" + userID + "' AND section_no = '" + sectionID +
"'";
        try{
            ResultSet result = this.stmt.executeQuery(sql);
            while(result.next()){
                result.close();
                return true;
            }
            return false;
        } catch(SQLException e){
            System.out.println("Error fetching user from DB:");
            System.out.println(e.getMessage());
        }catch(Exception e){
            e.printStackTrace();
        }
        return false;
    }
    /*
    This function closes the application when the user verification (fingerprint
    & user di,section id fails
    */
    private void exitApp(){
        //Exits the application
        Container frame = this;
        while(!(frame instanceof JFrame));
        ((JFrame) frame).dispose();
    }
    /*
    This function creates the database tables at the application's first run
    */
    private void createDBTables(){
        //if(!(new File(DB_PATH)).exists()){
            try{
                String[] dbTablesQuery = {
                    "CREATE TABLE IF NOT EXISTS users (id INTEGER PRIMARY KEY, name VARCHAR(256)
NOT NULL, user_id VARCHAR(3), section_no VARCHAR(4), template VARCHAR(256) NOT NULL)",
                    "CREATE TABLE IF NOT EXISTS KB (id INTEGER PRIMARY KEY, section_no VARCHAR(4)
NOT NULL, JFN TEXT NOT NULL, CBP TEXT NOT NULL, grade TINYINT(3), originator INTEGER NOT
NULL, date TIMESTAMP NOT NULL)",
                    "INSERT OR REPLACE INTO users (id, name, user_id, section_no, template) values ((SELECT id
FROM users WHERE id = 1), 'Okafor Ikenna', '919', '191', 'alphaadmin')"
                };
```

```java
            System.out.println("Creating database tables");
            for (String q : dbTablesQuery) {
               this.stmt.addBatch(q);
            }
            this.stmt.executeBatch();
            this.stmt.clearBatch();
            System.out.println("Database tables created");
         }catch(SQLException e){
            System.out.println("Failed to create database tables:");
            e.printStackTrace();
         }
      //}
   }
   //This function displays the user interface after app has initialized
   private void showFingerPrintPrompt() {
      this.getContentPane().removeAll();
      java.awt.EventQueue.invokeLater(new Runnable() {
         public void run() {
            JFrame UI = new UI();
            UI.setLocationRelativeTo(null);
            UI.setVisible(true);
         }
      });
   }
}




Verification Dialog

//This displays the fingerprint verification form, also verifies the user.
package inferenceengine;

import com.digitalpersona.onetouch.*;
import com.digitalpersona.onetouch.verification.*;
import com.digitalpersona.onetouch.ui.swing.DPFPVerificationControl;
import com.digitalpersona.onetouch.ui.swing.DPFPVerificationEvent;
import com.digitalpersona.onetouch.ui.swing.DPFPVerificationListener;
import com.digitalpersona.onetouch.ui.swing.DPFPVerificationVetoException;



import javax.swing.*;

import java.awt.*;
import java.awt.event.*;
import java.util.*;

/**
 * Enrollment control test
 */
public class VerificationDialog
        extends JDialog
{
   private EnumMap<DPFPFingerIndex, DPFPTemplate> templates;
   private int farRequested;
   private int farAchieved;
   private DPFPVerificationControl verificationControl;
   private boolean matched;
```

```java
    static final String FAR_PROPERTY = "FAR";
    static final String MATCHED_PROPERTY = "Matched";

    public VerificationDialog(Frame owner, EnumMap<DPFPFingerIndex, DPFPTemplate> templates, int
farRequested) {
                super(owner, true);
                this.templates = templates;
                this.farRequested = farRequested;

                setTitle("Fingerprint Verification");
        setResizable(false);

                verificationControl = new DPFPVerificationControl();
                verificationControl.addVerificationListener(new DPFPVerificationListener()
                {
                        public void captureCompleted(DPFPVerificationEvent e) throws
DPFPVerificationVetoException
                        {
                                final DPFPVerification verification =

        DPFPGlobal.getVerificationFactory().createVerification(VerificationDialog.this.farRequested);
                                e.setStopCapture(false);    // we want to continue capture until the dialog is
closed
                                int bestFAR = DPFPVerification.PROBABILITY_ONE;
                                boolean hasMatch = false;
                                for (DPFPTemplate template : VerificationDialog.this.templates.values()) {
                                        final DPFPVerificationResult result =
verification.verify(e.getFeatureSet(), template);
                                        e.setMatched(result.isVerified());              // report matching status
                                        bestFAR = Math.min(bestFAR, result.getFalseAcceptRate());
                                        if (e.getMatched()) {
                                                hasMatch = true;
                                                break;
                                        }
                                }
                                setMatched(hasMatch);
                                setFAR(bestFAR);
                        }
                });

                getContentPane().setLayout(new BorderLayout());

                JButton closeButton = new JButton("Close");
                closeButton.addActionListener(new ActionListener() {
                        public void actionPerformed(ActionEvent e) {
                                setVisible(false);            //End Dialog
                        }
                });

                JPanel center = new JPanel();
                center.add(verificationControl);
                center.add(new JLabel("To verify your identity, touch fingerprint reader with any enrolled
finger."));

                JPanel bottom = new JPanel();
                bottom.add(closeButton);

                add(center, BorderLayout.CENTER);
```

```java
                    add(bottom, BorderLayout.PAGE_END);

                    pack();
        setLocationRelativeTo(null);
    }

    public int getFAR() {
            return farAchieved;
    }

    protected void setFAR(int far) {
                    final int old = getFAR();
                    farAchieved = far;
                    firePropertyChange(FAR_PROPERTY, old, getFAR());
    }

    public boolean getMatched() {
            return matched;
    }

    protected void setMatched(boolean matched) {
                    final boolean old = getMatched();
                    this.matched = matched;
                    firePropertyChange(MATCHED_PROPERTY, old, getMatched());
    }

    /**
     * Shows or hides this component depending on the value of parameter
     * <code>b</code>.
     *
     * @param b if <code>true</code>, shows this component;
     *          otherwise, hides this component
     * @see #isVisible
     * @since JDK1.1
     */
    public void setVisible(boolean b) {
       if (b) {
          matched = false;
          verificationControl.start();
       } else {
          if (!matched)
             verificationControl.stop();
       }
       super.setVisible(b);
    }
}
```

PracticeViewer

```
//This displays a pop up with the current best practice data after the user has
//Searched and picked one from the results table.
/*
 * To change this license header, choose License Headers in Project Properties.
 * To change this template file, choose Tools | Templates
 * and open the template in the editor.
```

```java
 */
package inferenceengine;

import java.util.Vector;

/**
 *
 * @author Lois
 */
public class PracticeViewer extends javax.swing.JFrame {
    private String [] row;
    //private Vector columnNames;

    /**
     * Creates new form PracticeViewer
     */
    PracticeViewer(String [] row) {

        this.row = row;    //The data to be displayed in the row
        initComponents();
        showTable();
    }

    private void showTable(){
        jfnView.setText(row[0]);
        pView.setText(row[1]);


    }
    /**
     * This method is called from within the constructor to initialize the form.
     * WARNING: Do NOT modify this code. The content of this method is always
     * regenerated by the Form Editor.
     */
    @SuppressWarnings("unchecked")
    // <editor-fold defaultstate="collapsed" desc="Generated Code">//GEN-BEGIN:initComponents
    private void initComponents() {

        jButton1 = new javax.swing.JButton();
        jButton2 = new javax.swing.JButton();
        jScrollPane2 = new javax.swing.JScrollPane();
        jfnView = new javax.swing.JTextPane();
        jScrollPane3 = new javax.swing.JScrollPane();
        pView = new javax.swing.JTextPane();
        jLabel1 = new javax.swing.JLabel();
        jLabel2 = new javax.swing.JLabel();

        setPreferredSize(new java.awt.Dimension(700, 400));
        setResizable(false);

        jButton1.setText("Edit");

        jButton2.setBackground(new java.awt.Color(240, 10, 10));
        jButton2.setText("Close");
        jButton2.addActionListener(new java.awt.event.ActionListener() {
            public void actionPerformed(java.awt.event.ActionEvent evt) {
                jButton2ActionPerformed(evt);
            }
        });
```

```
            jfnView.setEditable(false);
            jScrollPane2.setViewportView(jfnView);

            pView.setEditable(false);
            jScrollPane3.setViewportView(pView);

            jLabel1.setText("JFN");

            jLabel2.setText("Practice");

            javax.swing.GroupLayout layout = new javax.swing.GroupLayout(getContentPane());
            getContentPane().setLayout(layout);
            layout.setHorizontalGroup(
                layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
                .addGroup(javax.swing.GroupLayout.Alignment.TRAILING, layout.createSequentialGroup()
                    .addGap(68, 68, 68)
                    .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.TRAILING)
                        .addGroup(layout.createSequentialGroup()
                            .addComponent(jLabel2)
                            .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED, 22,
Short.MAX_VALUE)
                            .addComponent(jScrollPane3, javax.swing.GroupLayout.PREFERRED_SIZE, 440,
javax.swing.GroupLayout.PREFERRED_SIZE))
                        .addGroup(layout.createSequentialGroup()
                            .addComponent(jLabel1)
                            .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED,
javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE)
                            .addComponent(jScrollPane2, javax.swing.GroupLayout.PREFERRED_SIZE, 440,
javax.swing.GroupLayout.PREFERRED_SIZE)))
                    .addGap(84, 84, 84))
                .addGroup(javax.swing.GroupLayout.Alignment.TRAILING, layout.createSequentialGroup()
                    .addContainerGap(javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE)
                    .addComponent(jButton1)
                    .addGap(18, 18, 18)
                    .addComponent(jButton2)
                    .addGap(98, 98, 98))
            );
            layout.setVerticalGroup(
                layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
                .addGroup(layout.createSequentialGroup()
                    .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
                        .addGroup(layout.createSequentialGroup()
                            .addGap(58, 58, 58)
                            .addComponent(jScrollPane2, javax.swing.GroupLayout.PREFERRED_SIZE, 74,
javax.swing.GroupLayout.PREFERRED_SIZE))
                        .addGroup(layout.createSequentialGroup()
                            .addGap(90, 90, 90)
                            .addComponent(jLabel1)))
                    .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
                        .addGroup(layout.createSequentialGroup()
                            .addGap(18, 18, 18)
                            .addComponent(jScrollPane3, javax.swing.GroupLayout.PREFERRED_SIZE, 86,
javax.swing.GroupLayout.PREFERRED_SIZE))
                        .addGroup(layout.createSequentialGroup()
                            .addGap(52, 52, 52)
                            .addComponent(jLabel2)))
                    .addGap(18, 18, 18)
                    .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.BASELINE)
                        .addComponent(jButton1)
```

```java
                .addComponent(jButton2))
            .addGap(0, 31, Short.MAX_VALUE))
    );

    pack();
  }// </editor-fold>//GEN-END:initComponents

  private void jButton2ActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_jButton2ActionPerformed
      // TODO add your handling code here:
  }//GEN-LAST:event_jButton2ActionPerformed

  /**
   * @param args the command line arguments
   */
  public static void main(String args[]) {
      /* Set the Nimbus look and feel */
      //<editor-fold defaultstate="collapsed" desc=" Look and feel setting code (optional) ">
      /* If Nimbus (introduced in Java SE 6) is not available, stay with the default look and feel.
       * For details see http://download.oracle.com/javase/tutorial/uiswing/lookandfeel/plaf.html
       */
      try {
        for (javax.swing.UIManager.LookAndFeelInfo info : javax.swing.UIManager.getInstalledLookAndFeels()) {
          if ("Nimbus".equals(info.getName())) {
            javax.swing.UIManager.setLookAndFeel(info.getClassName());
            break;
          }
        }
      } catch (ClassNotFoundException ex) {
        java.util.logging.Logger.getLogger(PracticeViewer.class.getName()).log(java.util.logging.Level.SEVERE,
null, ex);
      } catch (InstantiationException ex) {
        java.util.logging.Logger.getLogger(PracticeViewer.class.getName()).log(java.util.logging.Level.SEVERE,
null, ex);
      } catch (IllegalAccessException ex) {
        java.util.logging.Logger.getLogger(PracticeViewer.class.getName()).log(java.util.logging.Level.SEVERE,
null, ex);
      } catch (javax.swing.UnsupportedLookAndFeelException ex) {
        java.util.logging.Logger.getLogger(PracticeViewer.class.getName()).log(java.util.logging.Level.SEVERE,
null, ex);
      }
      //</editor-fold>

      /* Create and display the form */
      java.awt.EventQueue.invokeLater(new Runnable() {
        public void run() {
          //new PracticeViewer().setVisible(true);
        }
      });
  }

  // Variables declaration - do not modify//GEN-BEGIN:variables
  private javax.swing.JButton jButton1;
  private javax.swing.JButton jButton2;
  private javax.swing.JLabel jLabel1;
  private javax.swing.JLabel jLabel2;
  private javax.swing.JScrollPane jScrollPane2;
  private javax.swing.JScrollPane jScrollPane3;
  private javax.swing.JTextPane jfnView;
```

```
    private javax.swing.JTextPane pView;
    // End of variables declaration//GEN-END:variables
}



New User

//This allows the user enter and save a new user.
/*
 * To change this license header, choose License Headers in Project Properties.
 * To change this template file, choose Tools | Templates
 * and open the template in the editor.
 */

package inferenceengine;

import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.ResultSet;
import java.sql.SQLException;
import java.sql.Statement;
import java.util.HashMap;
import java.util.Map;
import javax.swing.JOptionPane;

/**
 *
 * @author Lois
 */
public class NewUser extends javax.swing.JFrame {

    private static final String DB_PATH = "db.db";  //Path to database storage
    private static final String DB_URL = "jdbc:sqlite:" + DB_PATH;  //Type of database implemented
    private Connection conn;    //Holds database connection
    private Statement stmt;     //Holds the database queries
    Map<String, String> sections = new HashMap<>();
    /** Creates new form NewUser */
    public NewUser() {
        //Initializes the new user screen and displays the form
        try{
            conn = DriverManager.getConnection(DB_URL); //Tell application the type of database to use (SQL)
            stmt = conn.createStatement();  //Create an SQL statement object for type of database
        } catch(SQLException e){
            //If an error occurs with the query while creating the database,
            //Print the cause of the error and exit the application
            conn = null;
            stmt = null;
            System.out.println("Failed to initialize database:");
            e.printStackTrace();
            System.exit(0);
        }

        sections.put("Production", "001");
        sections.put("Research", "002");
        sections.put("Fabrication", "003");
        sections.put("Marketing", "004");
        sections.put("Sales", "005");
        initComponents();
```

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```java
    }

    /** This method is called from within the constructor to
     * initialize the form.
     * WARNING: Do NOT modify this code. The content of this method is
     * always regenerated by the Form Editor.
     */
    @SuppressWarnings("unchecked")
    // <editor-fold defaultstate="collapsed" desc="Generated Code">//GEN-BEGIN:initComponents
    private void initComponents() {

        jPanel1 = new javax.swing.JPanel();
        jLabel1 = new javax.swing.JLabel();
        jLabel2 = new javax.swing.JLabel();
        firstNameInput = new javax.swing.JTextField();
        lastNameInput = new javax.swing.JTextField();
        jLabel3 = new javax.swing.JLabel();
        userSectionInput = new javax.swing.JComboBox();
        jLabel4 = new javax.swing.JLabel();
        unThumbedRegister = new javax.swing.JButton();
        registerBtn = new javax.swing.JButton();
        userIDLabel = new javax.swing.JLabel();
        userIDInput = new javax.swing.JTextField();

        setResizable(false);

        jLabel1.setText("First Name");

        jLabel2.setText("Last Name");

        firstNameInput.setText("First Name");
        firstNameInput.addFocusListener(new java.awt.event.FocusAdapter() {
            public void focusGained(java.awt.event.FocusEvent evt) {
                firstNameInputFocusGained(evt);
            }
        });
        firstNameInput.addActionListener(new java.awt.event.ActionListener() {
            public void actionPerformed(java.awt.event.ActionEvent evt) {
                firstNameInputActionPerformed(evt);
            }
        });

        lastNameInput.setText("Last Name");
        lastNameInput.addFocusListener(new java.awt.event.FocusAdapter() {
            public void focusGained(java.awt.event.FocusEvent evt) {
                lastNameInputFocusGained(evt);
            }
        });
        lastNameInput.addActionListener(new java.awt.event.ActionListener() {
            public void actionPerformed(java.awt.event.ActionEvent evt) {
                lastNameInputActionPerformed(evt);
            }
        });

        jLabel3.setFont(new java.awt.Font("Tahoma", 1, 14)); // NOI18N
        jLabel3.setText("Register new user");

        userSectionInput.setModel(new javax.swing.DefaultComboBoxModel(new String[] { "Production",
"Fabrication", "Marketing", "Sales", "Research" }));
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        userSectionInput.addActionListener(new java.awt.event.ActionListener() {
            public void actionPerformed(java.awt.event.ActionEvent evt) {
                userSectionInputActionPerformed(evt);
            }
        });

        jLabel4.setText("Section");

        unThumbedRegister.setText("Register without print");
        unThumbedRegister.addActionListener(new java.awt.event.ActionListener() {
            public void actionPerformed(java.awt.event.ActionEvent evt) {
                unThumbedRegisterActionPerformed(evt);
            }
        });

        registerBtn.setText("Register");
        registerBtn.addActionListener(new java.awt.event.ActionListener() {
            public void actionPerformed(java.awt.event.ActionEvent evt) {
                registerBtnActionPerformed(evt);
            }
        });

        userIDLabel.setText("User ID");

        userIDInput.setText("User ID");
        userIDInput.addFocusListener(new java.awt.event.FocusAdapter() {
            public void focusGained(java.awt.event.FocusEvent evt) {
                userIDInputFocusGained(evt);
            }
        });
        userIDInput.addActionListener(new java.awt.event.ActionListener() {
            public void actionPerformed(java.awt.event.ActionEvent evt) {
                userIDInputActionPerformed(evt);
            }
        });

        javax.swing.GroupLayout jPanel1Layout = new javax.swing.GroupLayout(jPanel1);
        jPanel1.setLayout(jPanel1Layout);
        jPanel1Layout.setHorizontalGroup(
            jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
            .addGroup(javax.swing.GroupLayout.Alignment.TRAILING, jPanel1Layout.createSequentialGroup()
                .addContainerGap(javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE)
                .addComponent(jLabel3, javax.swing.GroupLayout.PREFERRED_SIZE, 132,
javax.swing.GroupLayout.PREFERRED_SIZE)
                .addGap(132, 132, 132))
            .addGroup(jPanel1Layout.createSequentialGroup()
                .addContainerGap(58, Short.MAX_VALUE)
                .addGroup(jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING, false)
                    .addGroup(jPanel1Layout.createSequentialGroup()
                        .addComponent(jLabel1)
                        .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.UNRELATED)
                        .addComponent(firstNameInput))
                    .addGroup(jPanel1Layout.createSequentialGroup()
                        .addGroup(jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
                            .addComponent(jLabel2)
                            .addComponent(jLabel4)
                            .addComponent(userIDLabel))
                        .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.UNRELATED)
                        .addGroup(jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING,
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false)
                    .addGroup(javax.swing.GroupLayout.Alignment.TRAILING,
jPanel1Layout.createSequentialGroup()
                        .addComponent(unThumbedRegister)
                        .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED, 38,
Short.MAX_VALUE)
                        .addComponent(registerBtn))
                    .addComponent(userSectionInput, 0, javax.swing.GroupLayout.DEFAULT_SIZE,
Short.MAX_VALUE)
                    .addComponent(lastNameInput)
                    .addComponent(userIDInput))))
            .addContainerGap(61, Short.MAX_VALUE))
    );
    jPanel1Layout.setVerticalGroup(
        jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
        .addGroup(jPanel1Layout.createSequentialGroup()
            .addContainerGap()
            .addComponent(jLabel3, javax.swing.GroupLayout.PREFERRED_SIZE, 26,
javax.swing.GroupLayout.PREFERRED_SIZE)
            .addGap(8, 8, 8)
            .addGroup(jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.BASELINE)
                .addComponent(jLabel1)
                .addComponent(firstNameInput, javax.swing.GroupLayout.PREFERRED_SIZE,
javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE))
            .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED)
            .addGroup(jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.BASELINE)
                .addComponent(jLabel2)
                .addComponent(lastNameInput, javax.swing.GroupLayout.PREFERRED_SIZE,
javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE))
            .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED)
            .addGroup(jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
                .addComponent(userIDLabel)
                .addComponent(userIDInput, javax.swing.GroupLayout.PREFERRED_SIZE,
javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE))
            .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED)
            .addGroup(jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.BASELINE)
                .addComponent(userSectionInput, javax.swing.GroupLayout.PREFERRED_SIZE,
javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE)
                .addComponent(jLabel4))
            .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.UNRELATED)
            .addGroup(jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
                .addComponent(unThumbedRegister)
                .addComponent(registerBtn))
            .addContainerGap(34, Short.MAX_VALUE))
    );

    javax.swing.GroupLayout layout = new javax.swing.GroupLayout(getContentPane());
    getContentPane().setLayout(layout);
    layout.setHorizontalGroup(
        layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
        .addComponent(jPanel1, javax.swing.GroupLayout.Alignment.TRAILING,
javax.swing.GroupLayout.PREFERRED_SIZE, javax.swing.GroupLayout.DEFAULT_SIZE,
javax.swing.GroupLayout.PREFERRED_SIZE)
    );
    layout.setVerticalGroup(
        layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
        .addGroup(layout.createSequentialGroup()
            .addContainerGap()
            .addComponent(jPanel1, javax.swing.GroupLayout.DEFAULT_SIZE,
```

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javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE)
        .addContainerGap())
    );

    pack();
  }// </editor-fold>//GEN-END:initComponents

  private void firstNameInputActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_firstNameInputActionPerformed
    // TODO add your handling code here:
  }//GEN-LAST:event_firstNameInputActionPerformed

  private void lastNameInputActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_lastNameInputActionPerformed
    // TODO add your handling code here:
  }//GEN-LAST:event_lastNameInputActionPerformed

  private void userSectionInputActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_userSectionInputActionPerformed
    // TODO add your handling code here:
  }//GEN-LAST:event_userSectionInputActionPerformed

  private void registerBtnActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_registerBtnActionPerformed
    // TODO add your handling code here:
  }//GEN-LAST:event_registerBtnActionPerformed

  private void unThumbedRegisterActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_unThumbedRegisterActionPerformed
    // TODO add your handling code here:
    //Registers the user's thumb print'
    register("DefaultTemplateString");
  }//GEN-LAST:event_unThumbedRegisterActionPerformed

  private void firstNameInputFocusGained(java.awt.event.FocusEvent evt) {//GEN-
FIRST:event_firstNameInputFocusGained
    // TODO add your handling code here:
    //Highlights the First name when input is focused
    firstNameInput.setSelectionStart(0);
    firstNameInput.setSelectionEnd(firstNameInput.getText().length());
  }//GEN-LAST:event_firstNameInputFocusGained

  private void lastNameInputFocusGained(java.awt.event.FocusEvent evt) {//GEN-
FIRST:event_lastNameInputFocusGained
    // TODO add your handling code here:
    //Highlights the last name when input is focused
    lastNameInput.setSelectionStart(0);
    lastNameInput.setSelectionEnd(lastNameInput.getText().length());
  }//GEN-LAST:event_lastNameInputFocusGained

  private void userIDInputActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_userIDInputActionPerformed

  }//GEN-LAST:event_userIDInputActionPerformed

  private void userIDInputFocusGained(java.awt.event.FocusEvent evt) {//GEN-
FIRST:event_userIDInputFocusGained
    // TODO add your handling code here:
    //Highlights the user ID when input is focused
```

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        userIDInput.setSelectionStart(0);
        userIDInput.setSelectionEnd(userIDInput.getText().length());
    }//GEN-LAST:event_userIDInputFocusGained

    private void register(String fingerTemplate){
        //Registers a new user
        String firstName = firstNameInput.getText().trim(); //User's first name
        String lastName = lastNameInput.getText().trim();   //User's last name
        int userID;
        String name = firstName + " " + lastName; //Name concatenation

        try{
            //Checks if the user ID is a number
            userID = Integer.parseInt(userIDInput.getText().trim());
        } catch (NumberFormatException e){
            //If it isn't, display an error
            JOptionPane.showMessageDialog(this, "Invalid user ID value! Must be a valid User ID no.", "Invalid
input!", JOptionPane.WARNING_MESSAGE);
            return;
        }
        String sectionName = (String) userSectionInput.getSelectedItem(); //Get's user's section name from drop down
        String userSection = sections.get(sectionName);
        if(firstName.length() == 0 || lastName.length() == 0){
            //If user does not enter first or last name, display error message
            JOptionPane.showMessageDialog(this, "First name or Last name not entered!", "Incomplete data",
JOptionPane.WARNING_MESSAGE);
            return;
        }
        //If all data is properly entered, save it in database
        String q = "INSERT INTO users (user_id, section_no, template, name) VALUES ('" +
userIDInput.getText().trim() + "', '" + userSection + "', '"
                + fingerTemplate + "', '" + name + "')";
        try{
            ResultSet rs = this.stmt.executeQuery("SELECT * FROM users WHERE user_id = '" + userID + "' AND " +
"section_no = '" + userSection + "'");
            while(rs.next()){
                //If another user exists with the same credentials, fail to save
                //and notify user
                JOptionPane.showMessageDialog(this, "A user with this ID already exists!", "User exists!",
JOptionPane.WARNING_MESSAGE);
                return;
            }

            //If user was successfully saved, notify user
            this.stmt.executeUpdate(q);
            JOptionPane.showMessageDialog(this, "User successfully registered!", "registration successful",
JOptionPane.INFORMATION_MESSAGE);
        } catch(SQLException e){
            System.out.println("Error saving new user:");
            System.out.println(e.getMessage());
        }
    }
    /**
     * @param args the command line arguments
     */
    public static void main(String args[]) {
        /* Set the Nimbus look and feel */
        //<editor-fold defaultstate="collapsed" desc=" Look and feel setting code (optional) ">
        /* If Nimbus (introduced in Java SE 6) is not available, stay with the default look and feel.
```

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         * For details see http://download.oracle.com/javase/tutorial/uiswing/lookandfeel/plaf.html
         */
        try {
            for (javax.swing.UIManager.LookAndFeelInfo info : javax.swing.UIManager.getInstalledLookAndFeels()) {
                if ("Nimbus".equals(info.getName())) {
                    javax.swing.UIManager.setLookAndFeel(info.getClassName());
                    break;
                }
            }
        } catch (ClassNotFoundException ex) {
            java.util.logging.Logger.getLogger(NewUser.class.getName()).log(java.util.logging.Level.SEVERE, null,
ex);
        } catch (InstantiationException ex) {
            java.util.logging.Logger.getLogger(NewUser.class.getName()).log(java.util.logging.Level.SEVERE, null,
ex);
        } catch (IllegalAccessException ex) {
            java.util.logging.Logger.getLogger(NewUser.class.getName()).log(java.util.logging.Level.SEVERE, null,
ex);
        } catch (javax.swing.UnsupportedLookAndFeelException ex) {
            java.util.logging.Logger.getLogger(NewUser.class.getName()).log(java.util.logging.Level.SEVERE, null,
ex);
        }
        //</editor-fold>

        /* Create and display the form */
        java.awt.EventQueue.invokeLater(new Runnable() {
            public void run() {
                new NewUser().setVisible(true);
            }
        });
    }

    // Variables declaration - do not modify//GEN-BEGIN:variables
    private javax.swing.JTextField firstNameInput;
    private javax.swing.JLabel jLabel1;
    private javax.swing.JLabel jLabel2;
    private javax.swing.JLabel jLabel3;
    private javax.swing.JLabel jLabel4;
    private javax.swing.JPanel jPanel1;
    private javax.swing.JTextField lastNameInput;
    private javax.swing.JButton registerBtn;
    private javax.swing.JButton unThumbedRegister;
    private javax.swing.JTextField userIDInput;
    private javax.swing.JLabel userIDLabel;
    private javax.swing.JComboBox userSectionInput;
    // End of variables declaration//GEN-END:variables

}



New Process

//This allows the user save a new practice
/*
 * To change this license header, choose License Headers in Project Properties.
 * To change this template file, choose Tools | Templates
 * and open the template in the editor.
 */
```

```java
package inferenceengine;

import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.ResultSet;
import java.sql.SQLException;
import java.sql.Statement;
import java.sql.Timestamp;
import java.util.Date;
import java.util.HashMap;
import java.util.Map;
import java.util.logging.Level;
import java.util.logging.Logger;
import javax.swing.JOptionPane;

/**
 *
 * @author Lois
 */
public class NewPractice extends javax.swing.JFrame {

    /**
     * Creates new form NewPractice
     */
    private static final String DB_PATH = "db.db";  //Path to database storage
    private static final String DB_URL = "jdbc:sqlite:" + DB_PATH;  //Type of database implemented
    private Connection conn;    //Holds database connection
    private Statement stmt;     //Holds the database queries
    private String userID;
    private String userSection;
    Map<String, Double> grades = new HashMap<>();

    public NewPractice(String userID, String sectionID) {
        this.userID = userID;
        this.userSection = sectionID;

        grades.put("One (1)", 1.0);
        grades.put("Half (0.5)", 0.5);
        grades.put("One Third (0.3)", 0.3);
        try{
            conn = DriverManager.getConnection(DB_URL); //Tell application the type of database to use (SQL)
            stmt = conn.createStatement();  //Create an SQL statement object for type of database
        } catch(SQLException e){
            //If an error occurs with the query while creating the database,
            //Print the cause of the error and exit the application
            conn = null;
            stmt = null;
            System.out.println("Failed to initialize database:");
            e.printStackTrace();
            System.exit(0);
        }
        initComponents();
    }

    /**
     * This method is called from within the constructor to initialize the form.
     * WARNING: Do NOT modify this code. The content of this method is always
     * regenerated by the Form Editor.
     */
```

```java
    @SuppressWarnings("unchecked")
    // <editor-fold defaultstate="collapsed" desc="Generated Code">//GEN-BEGIN:initComponents
    private void initComponents() {

        jPanel1 = new javax.swing.JPanel();
        jLabel1 = new javax.swing.JLabel();
        jLabel2 = new javax.swing.JLabel();
        jScrollPane1 = new javax.swing.JScrollPane();
        jfcTextInput = new javax.swing.JTextArea();
        jLabel3 = new javax.swing.JLabel();
        jScrollPane2 = new javax.swing.JScrollPane();
        practiceTextInput = new javax.swing.JTextArea();
        jLabel4 = new javax.swing.JLabel();
        gradeCombo = new javax.swing.JComboBox();
        saveButton = new javax.swing.JButton();
        cancelBtn = new javax.swing.JButton();

        setDefaultCloseOperation(javax.swing.WindowConstants.EXIT_ON_CLOSE);
        setResizable(false);

        jLabel1.setFont(new java.awt.Font("Tahoma", 1, 14)); // NOI18N
        jLabel1.setText("New Practice Form");

        jLabel2.setText("JFC");

        jfcTextInput.setColumns(20);
        jfcTextInput.setLineWrap(true);
        jfcTextInput.setRows(5);
        jScrollPane1.setViewportView(jfcTextInput);

        jLabel3.setText("Practice");

        practiceTextInput.setColumns(20);
        practiceTextInput.setLineWrap(true);
        practiceTextInput.setRows(5);
        jScrollPane2.setViewportView(practiceTextInput);

        jLabel4.setText("Grade");

        gradeCombo.setModel(new javax.swing.DefaultComboBoxModel(new String[] { "One (1)", "Half (0.5)", "One
Third (0.3)" }));

        javax.swing.GroupLayout jPanel1Layout = new javax.swing.GroupLayout(jPanel1);
        jPanel1.setLayout(jPanel1Layout);
        jPanel1Layout.setHorizontalGroup(
            jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
            .addGroup(jPanel1Layout.createSequentialGroup()
                .addGap(35, 35, 35)
                .addGroup(jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.TRAILING)
                    .addComponent(jLabel3)
                    .addComponent(jLabel2)
                    .addComponent(jLabel4))
                .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.UNRELATED)
                .addGroup(jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING, false)
                    .addComponent(jScrollPane1, javax.swing.GroupLayout.DEFAULT_SIZE, 245, Short.MAX_VALUE)
                    .addComponent(jScrollPane2)
                    .addComponent(gradeCombo, 0, javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE))
                .addContainerGap(72, Short.MAX_VALUE))
            .addGroup(javax.swing.GroupLayout.Alignment.TRAILING, jPanel1Layout.createSequentialGroup()
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                    .addContainerGap(javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE)
                    .addComponent(jLabel1, javax.swing.GroupLayout.PREFERRED_SIZE, 164,
javax.swing.GroupLayout.PREFERRED_SIZE)
                    .addContainerGap(javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE))
        );
        jPanel1Layout.setVerticalGroup(
            jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
            .addGroup(jPanel1Layout.createSequentialGroup()
                .addContainerGap()
                .addComponent(jLabel1)
                .addGap(18, 18, 18)
                .addGroup(jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
                    .addComponent(jLabel2)
                    .addComponent(jScrollPane1, javax.swing.GroupLayout.PREFERRED_SIZE,
javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE))
                .addGap(12, 12, 12)
                .addGroup(jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
                    .addGroup(jPanel1Layout.createSequentialGroup()
                        .addComponent(jLabel3)
                        .addGap(0, 0, Short.MAX_VALUE))
                    .addComponent(jScrollPane2, javax.swing.GroupLayout.DEFAULT_SIZE, 113,
Short.MAX_VALUE))
                .addGap(13, 13, 13)
                .addGroup(jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.BASELINE)
                    .addComponent(jLabel4)
                    .addComponent(gradeCombo, javax.swing.GroupLayout.PREFERRED_SIZE,
javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE))
                .addGap(19, 19, 19))
        );

        saveButton.setBackground(new java.awt.Color(10, 240, 10));
        saveButton.setFont(new java.awt.Font("Tahoma", 1, 11)); // NOI18N
        saveButton.setText("Save");
        saveButton.addActionListener(new java.awt.event.ActionListener() {
            public void actionPerformed(java.awt.event.ActionEvent evt) {
                saveButtonActionPerformed(evt);
            }
        });

        cancelBtn.setBackground(new java.awt.Color(240, 10, 10));
        cancelBtn.setFont(new java.awt.Font("Tahoma", 1, 11)); // NOI18N
        cancelBtn.setText("Cancel");
        cancelBtn.addActionListener(new java.awt.event.ActionListener() {
            public void actionPerformed(java.awt.event.ActionEvent evt) {
                cancelBtnActionPerformed(evt);
            }
        });

        javax.swing.GroupLayout layout = new javax.swing.GroupLayout(getContentPane());
        getContentPane().setLayout(layout);
        layout.setHorizontalGroup(
            layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
            .addComponent(jPanel1, javax.swing.GroupLayout.DEFAULT_SIZE,
javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE)
            .addGroup(javax.swing.GroupLayout.Alignment.TRAILING, layout.createSequentialGroup()
                .addContainerGap(javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE)
                .addComponent(saveButton)
                .addGap(18, 18, 18)
                .addComponent(cancelBtn)
```

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                    .addGap(77, 77, 77))
        );
        layout.setVerticalGroup(
            layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
            .addGroup(layout.createSequentialGroup()
                .addComponent(jPanel1, javax.swing.GroupLayout.PREFERRED_SIZE,
javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE)
                .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED)
                .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.BASELINE)
                    .addComponent(saveButton)
                    .addComponent(cancelBtn))
                .addContainerGap(javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE))
        );

        pack();
    }// </editor-fold>//GEN-END:initComponents

    private void cancelBtnActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_cancelBtnActionPerformed
        // TODO add your handling code here:
        //Hide the new practice form, when the close button is clicked
        this.setVisible(false);
    }//GEN-LAST:event_cancelBtnActionPerformed

    private void saveButtonActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_saveButtonActionPerformed
        // TODO add your handling code here:
        //Saves a new practice when the save button is clicked
        String JFC = jfcTextInput.getText().trim();
        String practice = practiceTextInput.getText().trim();
        Double grade;

        grade = grades.get((String) gradeCombo.getSelectedItem());
        //If no data is entered in the form, alert user.
        if(JFC.length() == 0 || practice.length() == 0){
            JOptionPane.showMessageDialog(this, "All fields are required", "Required!",
JOptionPane.WARNING_MESSAGE);
            return;
        }
        //If inputted data is okay, save.
        saveNewPractice(JFC, practice, grade);
    }//GEN-LAST:event_saveButtonActionPerformed

    /**
     * @param args the command line arguments
     */
    public static void main(String args[]) {
        /* Set the Nimbus look and feel */
        //<editor-fold defaultstate="collapsed" desc=" Look and feel setting code (optional) ">
        /* If Nimbus (introduced in Java SE 6) is not available, stay with the default look and feel.
         * For details see http://download.oracle.com/javase/tutorial/uiswing/lookandfeel/plaf.html
         */
        try {
            for (javax.swing.UIManager.LookAndFeelInfo info : javax.swing.UIManager.getInstalledLookAndFeels()) {
                if ("Nimbus".equals(info.getName())) {
                    javax.swing.UIManager.setLookAndFeel(info.getClassName());
                    break;
                }
            }
```

```
      } catch (ClassNotFoundException ex) {
        java.util.logging.Logger.getLogger(NewPractice.class.getName()).log(java.util.logging.Level.SEVERE,
null, ex);
      } catch (InstantiationException ex) {
        java.util.logging.Logger.getLogger(NewPractice.class.getName()).log(java.util.logging.Level.SEVERE,
null, ex);
      } catch (IllegalAccessException ex) {
        java.util.logging.Logger.getLogger(NewPractice.class.getName()).log(java.util.logging.Level.SEVERE,
null, ex);
      } catch (javax.swing.UnsupportedLookAndFeelException ex) {
        java.util.logging.Logger.getLogger(NewPractice.class.getName()).log(java.util.logging.Level.SEVERE,
null, ex);
      }
      //</editor-fold>

      /* Create and display the form */
      java.awt.EventQueue.invokeLater(new Runnable() {
        public void run() {
          new NewPractice("001", "001").setVisible(true);
        }
      });
    }

    // Variables declaration - do not modify//GEN-BEGIN:variables
    private javax.swing.JButton cancelBtn;
    private javax.swing.JComboBox gradeCombo;
    private javax.swing.JLabel jLabel1;
    private javax.swing.JLabel jLabel2;
    private javax.swing.JLabel jLabel3;
    private javax.swing.JLabel jLabel4;
    private javax.swing.JPanel jPanel1;
    private javax.swing.JScrollPane jScrollPane1;
    private javax.swing.JScrollPane jScrollPane2;
    private javax.swing.JTextArea jfcTextInput;
    private javax.swing.JTextArea practiceTextInput;
    private javax.swing.JButton saveButton;
    // End of variables declaration//GEN-END:variables

    private void saveNewPractice(String JFN, String practice, Double grade) {
      //Query that saves new practice
      String q = "INSERT INTO KB (section_no, JFN, CBP, grade, originator, date)"
          + " VALUES (" + this.userSection + ", '"
          + JFN + "', '" + practice + "', " + grade + ", "
          + this.userID + ", '" + new Timestamp(new Date().getTime()) + "')";
      System.out.println(q);
      try {
        //Save new practice
        this.stmt.executeUpdate(q);
        JOptionPane.showMessageDialog(null,"New entry saved", "Success!",
JOptionPane.INFORMATION_MESSAGE);
      } catch (SQLException ex) {
        //If error occurs while saving, notify user.
        ex.printStackTrace();
        JOptionPane.showMessageDialog(null,"Error saving new practice", "Error!",
JOptionPane.WARNING_MESSAGE);
        return;
      }
```

```
        }
}




Current Best Practice

//This displays the main application interface after login success. Allows user
//search database for best practices, loads the new user form and the new practice form.
package inferenceengine;

/*
 * To change this license header, choose License Headers in Project Properties.
 * To change this template file, choose Tools | Templates
 * and open the template in the editor.
 */

/**
 *
 * @author Lois
 */
import java.awt.event.MouseAdapter;
import java.awt.event.MouseEvent;
import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.ResultSet;
import java.sql.SQLException;
import java.sql.Statement;
import java.time.LocalTime;
import java.time.format.DateTimeFormatter;
import java.util.ArrayList;
import java.util.Arrays;
import java.util.Date;
import java.util.LinkedList;
import java.util.List;
import java.util.Vector;
import javax.swing.JOptionPane;
import javax.swing.JScrollPane;
import javax.swing.JTable;
import javax.swing.table.AbstractTableModel;
import javax.swing.table.DefaultTableModel;
import javax.swing.table.TableModel;

public class BestPractices extends javax.swing.JFrame {

    /**
     * Creates new form BestPractices
     */

    private static final String DB_PATH = "db.db";  //Path to database storage
    private static final String DB_URL = "jdbc:sqlite:" + DB_PATH;  //Type of database implemented
    private Connection conn;    //Holds database connection
    private Statement stmt;     //Holds the database queries
    private String userID;  //Holds the user ID after successful authentication
    private String sectionID;   //Holds the section ID after successful authentication
    private String searchTerm;  //Holds the user inputted search term
    private String queryTerms[];    //Holds the generated query terms

    //Creates a connection to the database and save user credentials to
```

```java
//variables
public BestPractices(String userID, String userSection) {
    this.userID = userID;
    this.sectionID = userSection;

    try{
        conn = DriverManager.getConnection(DB_URL); //Tell application the type of database to use (SQL)
        stmt = conn.createStatement();  //Create an SQL statement object for type of database
        System.out.println("Creating tables");  //Output database creation initialization message to console
    } catch(SQLException e){
        //If an error occurs with the query while creating the database,
        //Print the cause of the error and exit the application
        conn = null;
        stmt = null;
        System.out.println("Failed to initialize database:");
        e.printStackTrace();
        System.exit(0);
    }
    initComponents();
    this.setLocationRelativeTo(this);
    this.setVisible(true);
}

/**
 * This method is called from within the constructor to initialize the form.
 * WARNING: Do NOT modify this code. The content of this method is always
 * regenerated by the Form Editor.
 */
@SuppressWarnings("unchecked")
// <editor-fold defaultstate="collapsed" desc="Generated Code">//GEN-BEGIN:initComponents
private void initComponents() {

    jLabel1 = new javax.swing.JLabel();
    jLabel2 = new javax.swing.JLabel();
    searchText = new javax.swing.JTextField();
    searchButton = new javax.swing.JButton();
    tableContainer = new javax.swing.JScrollPane();
    searchResultTable = new javax.swing.JTable();
    welcomeString = new javax.swing.JLabel();
    jMenuBar1 = new javax.swing.JMenuBar();
    jMenu1 = new javax.swing.JMenu();
    jMenuItem1 = new javax.swing.JMenuItem();
    newPracticeBtnClicked = new javax.swing.JMenuItem();
    jMenu2 = new javax.swing.JMenu();

    setDefaultCloseOperation(javax.swing.WindowConstants.EXIT_ON_CLOSE);

    jLabel1.setFont(new java.awt.Font("Tahoma", 1, 18)); // NOI18N
    jLabel1.setText("Best Practices");

    jLabel2.setText("Search Knowledge Base");

    searchText.setText("Search database");
    searchText.addFocusListener(new java.awt.event.FocusAdapter() {
        public void focusGained(java.awt.event.FocusEvent evt) {
            searchTextFocusGained(evt);
        }
    });
```

```java
        searchButton.setText("Search");
        searchButton.addActionListener(new java.awt.event.ActionListener() {
            public void actionPerformed(java.awt.event.ActionEvent evt) {
                searchInitiated(evt);
            }
        });

        tableContainer.setViewportBorder(javax.swing.BorderFactory.createLineBorder(new java.awt.Color(0, 0, 0)));

        searchResultTable.setAutoCreateColumnsFromModel(false);
        searchResultTable.setModel(new javax.swing.table.DefaultTableModel(
            new Object [][] {
                {null, null, null, null}
            },
            new String [] {
                "Title 1", "Title 2", "Title 3", "Title 4"
            }
        ) {
            boolean[] canEdit = new boolean [] {
                false, false, false, false
            };

            public boolean isCellEditable(int rowIndex, int columnIndex) {
                return canEdit [columnIndex];
            }
        });
        tableContainer.setViewportView(searchResultTable);

        welcomeString.setText("Welcome user " + this.userID);

        jMenu1.setText("File");

        jMenuItem1.setText("New User");
        jMenuItem1.addActionListener(new java.awt.event.ActionListener() {
            public void actionPerformed(java.awt.event.ActionEvent evt) {
                newUserOptionClicked(evt);
            }
        });
        jMenu1.add(jMenuItem1);

        newPracticeBtnClicked.setText("New Practice");
        newPracticeBtnClicked.addActionListener(new java.awt.event.ActionListener() {
            public void actionPerformed(java.awt.event.ActionEvent evt) {
                newPracticeBtnClickedActionPerformed(evt);
            }
        });
        jMenu1.add(newPracticeBtnClicked);

        jMenuBar1.add(jMenu1);

        jMenu2.setText("Edit");
        jMenuBar1.add(jMenu2);

        setJMenuBar(jMenuBar1);

        javax.swing.GroupLayout layout = new javax.swing.GroupLayout(getContentPane());
        getContentPane().setLayout(layout);
        layout.setHorizontalGroup(
            layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
```

```java
          .addGroup(javax.swing.GroupLayout.Alignment.TRAILING, layout.createSequentialGroup()
            .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.TRAILING)
              .addGroup(javax.swing.GroupLayout.Alignment.LEADING, layout.createSequentialGroup()
                .addContainerGap(95, Short.MAX_VALUE)
                .addComponent(jLabel2)
                .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.UNRELATED)
                .addComponent(searchText, javax.swing.GroupLayout.PREFERRED_SIZE, 364,
javax.swing.GroupLayout.PREFERRED_SIZE)
                .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.UNRELATED)
                .addComponent(searchButton)
                .addGap(0, 86, Short.MAX_VALUE))
              .addGroup(layout.createSequentialGroup()
                .addContainerGap()
                .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.TRAILING)
                  .addComponent(tableContainer)
                  .addGroup(layout.createSequentialGroup()
                    .addGap(0, 0, Short.MAX_VALUE)
                    .addComponent(welcomeString, javax.swing.GroupLayout.PREFERRED_SIZE, 144,
javax.swing.GroupLayout.PREFERRED_SIZE)))))
            .addContainerGap())
          .addGroup(javax.swing.GroupLayout.Alignment.TRAILING, layout.createSequentialGroup()
            .addGap(0, 0, Short.MAX_VALUE)
            .addComponent(jLabel1)
            .addContainerGap(javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE))
    );
    layout.setVerticalGroup(
      layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
      .addGroup(javax.swing.GroupLayout.Alignment.TRAILING, layout.createSequentialGroup()
        .addGap(4, 4, 4)
        .addComponent(welcomeString)
        .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED)
        .addComponent(jLabel1)
        .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.UNRELATED)
        .addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.BASELINE)
          .addComponent(jLabel2)
          .addComponent(searchText, javax.swing.GroupLayout.PREFERRED_SIZE, 28,
javax.swing.GroupLayout.PREFERRED_SIZE)
          .addComponent(searchButton))
        .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED)
        .addComponent(tableContainer, javax.swing.GroupLayout.DEFAULT_SIZE, 391, Short.MAX_VALUE)
        .addContainerGap())
    );

    pack();
  }// </editor-fold>//GEN-END:initComponents

  private void searchInitiated(java.awt.event.ActionEvent evt) {//GEN-FIRST:event_searchInitiated
    // TODO add your handling code here:
    //Verifies if user entered a valid search term
    String searchTerm = this.searchText.getText().trim();
    if(searchTerm.length() <= 0){
      //If an invalid search term is entered, displays an error message
      JOptionPane.showMessageDialog(null,"No search term entered!", "Invalid Input!",
JOptionPane.WARNING_MESSAGE);
      return;
    }
    //No error? Search database for values matching search term
    this.searchTerm = searchTerm;
    try{
```

```java
        this.displaySearchResult(this.searchDB());
    } catch (Exception e){
        e.printStackTrace();
        JOptionPane.showMessageDialog(this, "Unable to fetch list of best practices!", "Error",
JOptionPane.WARNING_MESSAGE);
    }
}//GEN-LAST:event_searchInitiated

private void searchTextFocusGained(java.awt.event.FocusEvent evt) {//GEN-
FIRST:event_searchTextFocusGained
    // TODO add your handling code here:
    //Highlight the content of the search box when focused
    searchText.setSelectionStart(0);
    searchText.setSelectionEnd(searchText.getText().length());
}//GEN-LAST:event_searchTextFocusGained

//Displays a form that allows a currently authenticated user register another user
private void newUserOptionClicked(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_newUserOptionClicked
    // TODO add your handling code here:
    //Creates a new dialog when the file menu option to create new user us clicked
    NewUser newUser = new NewUser();
    newUser.setLocationRelativeTo(null);
    newUser.setVisible(true);
}//GEN-LAST:event_newUserOptionClicked

/*
Displays a form that allows the authenticated user Enter a new practice
*/
private void newPracticeBtnClickedActionPerformed(java.awt.event.ActionEvent evt) {//GEN-
FIRST:event_newPracticeBtnClickedActionPerformed
    // TODO add your handling code here:
    NewPractice newPractice = new NewPractice(this.userID, this.sectionID);
    newPractice.setLocationRelativeTo(null);
    newPractice.setVisible(true);
}//GEN-LAST:event_newPracticeBtnClickedActionPerformed

/**
 * @param args the command line arguments
 */
public static void main(String args[]) {
    /* Set the Nimbus look and feel */
    //<editor-fold defaultstate="collapsed" desc=" Look and feel setting code (optional) ">
    /* If Nimbus (introduced in Java SE 6) is not available, stay with the default look and feel.
     * For details see http://download.oracle.com/javase/tutorial/uiswing/lookandfeel/plaf.html
     */
    try {
        for (javax.swing.UIManager.LookAndFeelInfo info : javax.swing.UIManager.getInstalledLookAndFeels()) {
            if ("Nimbus".equals(info.getName())) {
                javax.swing.UIManager.setLookAndFeel(info.getClassName());
                break;
            }
        }
    } catch (ClassNotFoundException | InstantiationException | IllegalAccessException |
javax.swing.UnsupportedLookAndFeelException ex) {
        java.util.logging.Logger.getLogger(BestPractices.class.getName()).log(java.util.logging.Level.SEVERE,
null, ex);
    }
    //</editor-fold>
```

```java
        //</editor-fold>

        /* Create and display the form */
        java.awt.EventQueue.invokeLater(new Runnable() {
            public void run() {
                new BestPractices("001", "001").setVisible(true);
            }
        });
    }

/*
Searches the database for values that have keywords matching the user's search terms.

Splits the users search term into separate words and queries the database for them
e.g. If the user searches for "Making soaps". This search term is split into
"Making", "soaps" and "Making soaps, and the database is queried for any entries
that have these words.
*/
private ResultSet searchDB(){
    String sql = "SELECT * FROM KB WHERE section_no = " + this.sectionID + " AND JFN LIKE '%";
    String [] keywordArr = this.searchTerm.split(" ");
    for(int i = 0; i < keywordArr.length; i++){
      if(i+1 != keywordArr.length){
        sql += keywordArr[i] + "%' OR JFN LIKE '%";
      } else {
        sql += keywordArr[i] + "%';";
      }
    }
    System.out.println("Search query:");
    System.out.println(sql);

    try{
        ResultSet qr = this.stmt.executeQuery(sql);
        //qr.close();
        return qr;
    } catch(SQLException e){
        System.out.println("Error fetching user from DB:");
        System.out.println(e.getMessage());
    }
    return null;
}

private void displaySearchResult(ResultSet rs) throws SQLException{
    //Displays the search result in rows
    String [] cols = {"JFN", "CBP", "Originator", "Date"};
    searchResultTable = new JTable();
    DefaultTableModel model = new DefaultTableModel()
    {
        @Override
        public boolean isCellEditable(int row, int column)
        {
         return false;//This causes all cells to be not editable
        }
    };
    model.setColumnIdentifiers(cols);
    //rs.beforeFirst();
    while(rs.next()){
        Object[] o = new Object[5];
```

```java
            o[0] = rs.getString("JFN");
            o[1] = rs.getString("CBP");
            o[2] = rs.getString("originator");
            o[3] = rs.getDate("date").toLocalDate().format(DateTimeFormatter.ISO_DATE);
            model.addRow(o);
        }
        rs.close();
        searchResultTable.setModel(model);
        searchResultTable.addMouseListener(new MouseAdapter(){
            @Override
            public void mouseClicked(MouseEvent e){
                if(e.getClickCount() == 2){
                    searchResultTable.rowAtPoint(e.getPoint());
                    Object row = model.getDataVector().elementAt(searchResultTable.rowAtPoint(e.getPoint()));
                    String [] roww = new String[2];
                    roww[0] = model.getValueAt(0, 0).toString();
                    roww[1] = model.getValueAt(0, 1).toString();
                    PracticeViewer thisPractice = new PracticeViewer(roww);
                    thisPractice.setLocationRelativeTo(null);
                    thisPractice.setVisible(true);
                }
            }
        });//.rowAtPoint(null);
        tableContainer.setViewportView(searchResultTable);
        /*
        TableModel tbl = new DisplayTableModel(rs);
        searchResultTable = new JTable(tbl);
        tableContainer.setViewportView(searchResultTable);
        */
        /*
        try{

            while(rs.next()){
                String [] rowData = {rs.getString("JFN"), rs.getString("CBP"), rs.getString("originator"),
rs.getString("date")};
            }
        } finally {
            rs.close();
        }
        searchResultTable = new JTable(data, columns);
        tableContainer.setViewportView(searchResultTable);
*/
    }
    // Variables declaration - do not modify//GEN-BEGIN:variables
    private javax.swing.JLabel jLabel1;
    private javax.swing.JLabel jLabel2;
    private javax.swing.JMenu jMenu1;
    private javax.swing.JMenu jMenu2;
    private javax.swing.JMenuBar jMenuBar1;
    private javax.swing.JMenuItem jMenuItem1;
    private javax.swing.JMenuItem newPracticeBtnClicked;
    private javax.swing.JButton searchButton;
    private javax.swing.JTable searchResultTable;
    private javax.swing.JTextField searchText;
    private javax.swing.JScrollPane tableContainer;
    private javax.swing.JLabel welcomeString;
    // End of variables declaration//GEN-END:variables
}
```

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APPENDIX B: Simulation Software of the Dynamic Expert System

```
LKUP = [360 500 644 718 870 930 1600 2300 2600 2700 7000 7690 7900 8100 12900
14502];
Q = [1 1 1 2 2 2 3 3 3];
%GROUP = CHAR('PRD-001' 'RES-002'  'QC-003' 'MKG-004'  'AGC-005');
RQ = [ 1 0.5 0.25];
n = 20;
sn = 1
QTR = 1
GN = 1
%for i = 1:n
b = rand (1, 1)
P = fix (b (1) * 100) + 1;
 P1 = fix (P/6)*6;
STEP  = P - P1;
if  STEP < 1
NEWIP = 1
else
NEWIP = STEP
end
for  j = 1: NEWIP
b = rand (1,1)
P = fix (b (1) * 100) + 1
m = fix (P/16)*16
GL = P - m
if GL < 1
GL = 1
end
INC = LKUP(GL)
b = rand (1,1)
P = fix (b(1) * 10) + 1
m = fix((P/5) * 5) + 1
ID = P - m
if ID > 4
SID = 'PRD-001'
end
if ID > 3
SID = 'RES-002'
end
if ID > 2
SID = 'QC-003'
end
if ID > 1
SID = 'MKG-004'
end
if ID >0
SID = 'AGC-005'
end
if  GL < 12
b = rand (1, 1)
P = fix (b (1) * 100) + 1
 P1 = fix (P/15)*15
P3 = P - P1
STEP = P3
end
if GL > 11
b = rand (1, 1)
```

```
P = fix (b (1) * 100) + 1;
P1 = fix (P/11)*11;
STEP = P  -  P1;
end
L1 = STEP
if GL == 13
STEP = L1
end
if GL == 14
STEP = L1
end
if  GL > 14
b = rand (1, 1)
P = fix (b (1) * 100) + 1;
 P1 = fix (P/9)*9;
STEP = P  - P1;
QN = STEP
end
%b = rand (1, 1)
%P = fix (b (1) * 100) + 1;
 %P1 = fix (P/6)*6;
%STEP  = P - P1;
%if  STEP < 1
%NEWIP = 1
%else
%NEWIP = STEP
%end
b = rand (1, 1)
P = fix (b (1) * 100) + 1;
P1 = fix (P/5)*5;
GN= P - P1;
if GN > 4
SID  = 'Agc'
end
if  GN > 3
SID  =  'Mkg'
end
if GN > 2
SID  = 'QC'
end
if GN > 1
SID  =  'Prd'
end
if  GN  >  0
SID  =  'Res'
end
b = rand (1, 1)
P = fix (b (1) * 100) + 1;
 P1 = fix (P/9)*9;
QN = P - P1;
if QN == 0
  QN = 1
end
q = Q(QN)
if   q == 1
 WORTH  =  9 * INC
end
if   q == 2
 WORTH  =  6 * INC
end
```

```
if   q == 3
 WORTH  =  3 * INC
end
REMU = RQ(q)  * INC
sn = sn + 1
end
```

APPENDIX C: Simulation results of the Dynamic Expert System for the work group sections in Eldi

Table 4.1(a): Remuneration and Worth of IP Table for Production Section

s/n	Qtr	New IP	Section ID	GL	STEP	INC ₦	Quality of IP (Grade) 1 (1&2)	2 (3&4)	3 (5&6)	Remuneration ₦	Worth ₦
1	1	3	Prd-001	8	4	1,900	-	0.5	-	950	11,400
2	1		Prd-001	9	7	2,300	1	-	-	2,300	20,700
3	1		Prd-001	15	8	8,100	1	-	-	8,100	72,900
4	2	4	Prd-001	17	5	14,508	-	0.5	-	7,254	87,048
5	2		Prd-001	11	2	2,700	-	-	0.25	675	600
6	2		Prd-001	4	6	718	-	-	0.25	179.5	4,308
7	2		Prd-001	1	8	360	-	0.5	-	180	2,160
8	3	2	Prd-001	12	6	7,000	-	0.5	-	3,500	42,000
9	3		Prd-001	13	4	7,690	1	-	-	7,690	69,210
10	4	1	Prd-001	10	1	2,600	1	-	-	2,600	23,400
11	5	5	Prd-001	14	6	7,990	1	-	-	7,990	71,910
12	5		Prd-001	2	8	500	-	-	0.25	125	1,500
13	5		Prd-001	3	14	644	-	-	0.25	161	1,932
14	5		Prd-001	16	3	12,900	-	0.5	-	6,450	77,400
15	5		Prd-001	10	3	2,600	1	-	-	2,600	23,400
16	6	3	Prd-001	8	13	1,900	-	-	0.25	475	5,700
17	6		Prd-001	3	11	644	-	0.5	-	322	3,864
18	6		Prd-001	7	15	1,600	1	-	-	1,600	14,400
19	7	1	Prd-001	9	2	2,300	-	0.5	-	1,150	13,800
20	8	6	Prd-001	3	13	644	-	0.5	-	322	3,864
21	8		Prd-001	8	11	1,900	1	-	-	1,900	17,100
22	8		Prd-001	7	2	1,600	1	-	-	1,600	14,400
23	8		Prd-001	5	5	870	1	-	-	870	7,830
24	8		Prd-001	4	7	718	-	0.5	-	359	4,308
25	8		Prd-001	2	9	500	-	-	0.25	125	1.500
26	9	2	Prd-001	1	15	360	1	-	-	360	3,240
27	9		Prd-001	11	1	2,700	-	0.5	-	1,350	16,200
28	10	4	Prd-001	8	8	1,900	-	-	0.25	475	5,700
29	10		Prd-001	4	9	718	-	-	0.25	179.50	4,308
30	10		Prd-001	1	13	360	-	0.5	-	180	2,160
31	10		Prd-001	6	4	930	-	-	0.25	232.50	2,790
32	11	2	Prd-001	9	9	2,300	-	0.5	-	1,150	13,800

s/n	Qtr	New IP	Section ID	GL	STEP	INC ₦	1 (1&2)	2 (3&4)	3 (5&6)	Remuneration ₦	Worth ₦
33	11		Prd-001	2	4	500	1	-	-	500	4,500
34	12	2	Prd-001	4	3	718	-	-	0.25	179.50	2,154
35	12		Prd-001	7	14	1,600	1	-	-	1,600	14,400
36	13	2	Prd-001	9	5	2,300	-	0.5	-	1,150	13,800
37	13		Prd-001	11	11	2,700	1	-	-	2,700	2,430
38	14	6	Prd-001	13	3	7,990	-	-	0.25	1,997.50	23,970
39	14		Prd-001	17	4	14,502	1	-	-	14,502	130,518
40	14		Prd-001	3	8	644	-	0.5	-	322	3,864
41	14		Prd-001	6	9	930	-	-	0.25	232.50	2,790
42	14		Prd-001	12	3	7,000	-	-	0.25	1,750	21,000
43	14		Prd-001	16	7	12,900	-	0.5	-	6,450	77,400
44	15	1	Prd-001	9	4	2,300	-	0.5	-	1,150	13,800
45	16	2	Prd-001	4	9	718	1	-	-	718	6,462
46	16		Prd-001	2	1	500	1	-	-	500	4,500
47	17	6	Prd-001	7	3	1,600	-	-	0.25	800	4,800
48	17		Prd-001	11	11	2,700	-	-	0.25	1,350	8,100
49	17		Prd-001	17	5	14,502	1	-	-	14,502	130,518
50	17		Prd-001	13	8	7,690	-	0.5	-	3,845	46,140
51	17		Prd-001	8	5	1,900	-	0.5	-	950	11,400
52	17		Prd-001	4	8	718	1	-	-	718	6,462
53	18	3	Prd-001	2	1	500	-	-	0.25	125	3,000
54	18		Prd-001	3	6	644	-	-	0.25	161	1,932
55	18		Prd-001	7	10	1,600	1	-	-	1,600	14,400
56	19	2	Prd-001	16	6	12,900		0.5	-	6,450	137,400
57	19		Prd-001	14	3	7,990	-	0.5	-	3,995	47,940
58	20	5	Prd-001	14	5	7,990	-	0.5	-	3,995	47,940
59	20		Prd-001	9	8	2,300	1	-	-	2,300	20,700
60	20		Prd-001	15	5	8,100	1	-	-	8,100	72,900
61	20		Prd-001	5	9	870	-	0.5	-	435	5,220
62	20		Prd-001	1	4	718	-	0.5	-	359	4,308
									Subtotal:	146,841,	1,431,848

Table 4.1(b): Remuneration and Worth of IP Table for Research Section

s/n	Qtr	New IP	Section ID	GL	STEP	INC ₦	Quality of IP (Grade)			Remuneration ₦	Worth ₦
							1 (1&2)	2 (3&4)	3 (5&6)		
1	1	4	Res-002	5	3	870	-	-	0.25	217.50	2,610
2	1		Res-002	1	5	360	1	-	-	360	3,240
3	1		Res-002	5	8	870	-	-	0.25	217.50	2,610

4	1		Res-002	15	5	8,100	-	0.5	-	4,050	48,600
5	2	3	Res-002	10	3	2,600	-	-	0.25	650	7,800
6	2		Res-002	14	6	7,990	-	-	0.25	1,997.50	23,970
7	2		Res-002	11	6	2,700	-	-	0.25	675	8,100
8	3	2	Res-002	3	4	644	-	-	0.25	161	1,932
9	3		Res-002	3	4	644	1	-	-	644	5,796
10	4	5	Res-002	14	7	7,990	-	0.5	-	3,995	47,940
11	4		Res-002	6	9	930	1	-	-	930	8,370
12	4		Res-002	2	8	500	-	0.5	-	250	3,000
13	4		Res-002	13	4	7,690	-	-	0.25	1,922.50	23,070
14	4		Res-002	6	13	930	1	-	-	930	8,370
15	5	1	Res-002	1	3	1,800	-	0.5	-	900	10,800
16	6	4	Res-002	4	13	718	-	-	0.25	179.50	2,154
17	6		Res-002	15	1	360	-	0.5	-	180	2,160
18	6		Res-002	7	5	1,600	-	0.5	-	800	9,600
19	6		Res-002	9	12	2,300	-	0.5	-	1,150	13,800
20	7	2	Res-002	3	13	7,690	-	0.5	-	3,845	46,140
21	7		Res-002	8	10	1,900	1	-	-	1,900	17,100
22	8	1	Res-002	17	2	14,502	-	-	0.25	3,625.50	43,506
23	9	1	Res-002	15	5	8,100	1	-	-	8,100	72,900
24	10	6	Res-002	14	7	7,990	-	0.5	-	3,995	47,940
25	10		Res-002	12	9	7,000	-	-	0.25	1,750	21,000
26	10		Res-002	11	5	2,700	1	-	-	2,700	24,300
27	10		Res-002	1	1	360	-	0.5	-	180	2,160
28	10		Res-002	8	2	1,900	-	-	0.25	475	5,700
29	10		Res-002	8	3	1,900	-	0.5	-	950	11,400
30	11	1	Res-002	1	13	360	-	0.5	-	180	2,160
31	12	4	Res-002	6	14	930	1	-	-	930	8,370
32	12		Res-002	9	3	2,300	1	-	-	2,300	20,700
33	12		Res-002	3	4	644	1	-	-	644	5,796
34	12		Res-002	2	3	500	1	-	-	500	4,500
35	13	3	Res-002	4	14	718	1	-	-	718	6,462
36	13		Res-002	8	15	1,900	-	-	0.25	475	5,700
37	13		Res-002	12	9	7,000	1	-	-	7,000	63,000
38	14	2	Res-002	10	7	2,600	-	-	0.25	650	7,800
39	14		Res-002	17	8	14,502	1	-	-	14,502	130,518
40	15	6	Res-002	2	4	500	-	0.5	-	250	3,000
41	15		Res-002	1	9	360	-	0.5	-	180	2,160
42	15		Res-002	2	3	500	-	0.5	-	250	3,000
43	15		Res-002	10	6	2,600	-	0.5	-	1,300	15,600
44	15		Res-002	9	4	2,300	-	0.5	-	1,150	13,800

s/n	Qtr	New IP	Section ID	GL	STEP	INC	1	2	3	Remuneration	Worth
45	15		Res-002	4	9	718	1	-	-	718	6,462
46	16	4	Res-002	2	10	500		0.5	-	250	3,000
47	16		Res-002	7	13	1,600	-	-	0.25	400	4,800
48	16		Res-002	11	1	2,700	-	-	0.25	675	8,100
49	16		Res-002	14	5	7,990	-	0.5	-	3,995	47,940
50	17	2	Res-002	10	8	2,600	1	-	-	2,600	23,400
51	17		Res-002	8	2	1,900	1	-	-	1,900	17,100
52	18	3	Res-002	14	8	7,990	-	-	0.25	1,997.50	23,970
53	18		Res-002	12	9	7,000	-	0.5	-	3,500	42,000
54	18		Res-002	3	3	644	-	0.5	-	161	3,864
55	19	6	Res-002	17	8	14,502	1	-	-	14,502	130,518
56	19		Res-002	12	6	7,000	-	0.5	-	3,500	42,000
57	19		Res-002	11	13	2,700	1	-	-	2700	24,300
58	19		Res-002	10	3	2,600	-	0.5	-	1,300	15,600
59	19		Res-002	10	8	2,600	1	-	-	2,600	23,400
60	19		Res-002	7	5	1,600	-	-	0.25	400	4,800
61	20	4	Res-002	15	5	8,100	1	-	-	8,100	72,900
62	20		Res-002	11	4	2,700	-	-	0.25	675	8,100
62	20		Res-002	6	4	930	1	-	-	930	8,370
63	20		Res-002	2	12	500	1	-	-	500	4,500

Subtotal: 130,162.50, 1,333,738

Table 4.1(c): Remuneration and Worth of IP Table for Quality Control Section

s/n	Qtr	New IP	Section ID	GL	STEP	INC ₦	Quality of IP (Grade)			Remuneration ₦	Worth ₦
							1 (1&2)	2 (3&4)	3 (5&6)		
1	1	6	QC-003	15	5	8,100	-	-	0.25	2,025	24,300
2	1		QC-003	11	6	2,700	-	0.5	-	1,350	16,200
3	1		QC-003	2	8	500	-	-	0.25	125	1,500
4	1		QC-003	1	15	360	-	0.5	-	180	2,160
5	1		QC-003	8	13	1,900	-	-	0.25	475	5,700
6	1		QC-003	4	16	718	-	0.5	-	359	4,308
7	2	1	QC-003	15	4	8,100	-	-	0.25	2,025	24,300
8	3	4	QC-003	13	2	7,690	-	-	0.25	1,922.5	23,070
9	3		QC-003	11	9	2,700	1	-	-	2,700	24,300
10	3		QC-003	10	14	2,600	-	-	0.25	650	7,800
11	3		QC-003	4	9	718	1	-	-	718	6,462
12	4	2	QC-003	13	1	7,690	-	0.5	-	47,760	46,140
13	4		QC-003	13	4	7,690	-	-	0.25	1,922.50	23,070

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14	5	3	QC-003	10	3	2,600	-	-	0.25	650	7,800
15	5		QC-003	11	7	2,700	1	-	-	2,700	24,300
16	5		QC-003	9	3	2,300	-	0.5	-	1,150	13,800
17	6	3	QC-003	1	1	360	-	0.5	-	180	2,160
18	6		QC-003	17	1	1,600	-	0.5	-	800	9,600
19	6		QC-003	7	3	1,600	-	0.5	-	800	9,600
20	7	2	QC-003	8	15	1,900	-	0.5	-	950	11,400
21	7		QC-003	4	12	718	1	-	-	718	6,462
22	8	5	QC-003	17	6	14,502	-	-	0.25	7,251	87,012
23	8		QC-003	17	6	14,502	1	-	-	14,502	130,518
24	8		QC-003	1	17	360	-	0.5	-	180	2,160
25	8		QC-003	14	3	7,990	-	-	0.25	1,997.5	23,970
26	8		QC-003	17	3	14,502	1	-	-	14,502	130,518
27	9	1	QC-003	10	10	2,600	1	-	-	2,600	23,400
28	10	3	QC-003	15	2	8,100	1	-	-	8,100	72,900
29	10		QC-003	16	3	12,900	-	-	0.25	3,225	38,700
30	10		QC-003	17	5	14,502	1	-	-	14,502	130,518
31	11	4	QC-003	9	14	2,300	1	-	-	2,300	20,700
32	11		QC-003	8	13	1,900	-	0.5	-	950	11,400
33	11		QC-003	9	11	2,300	-	-	0.25	575	6,900
34	11		QC-003	16	4	12,900	-	-	0.25	3,225	38,700
35	12	3	QC-003	8	6	1,900	-	0.5	-	950	11,400
36	12		QC-003	15	3	8,100	1	-	-	8,100	72,900
37	12		QC-003	9	12	2,300	-	0.5	-	1,150	13,800
38	13	3	QC-003	5	13	870	-	0.5	-	435	5,220
39	13		QC-003	14	8	7,990	1	-	-	7,990	71,910
40	13		QC-003	12	14	7,000	1	-	-	7,000	63,000
41	14	4	QC-003	12	1	7,000	1	-	-	7,000	63,000
42	14		QC-003	12	13	7,000	1	-	-	7,000	63,000
43	14		QC-003	16	6	12,900	1	-	-	12,900	116,100
44	14		QC-003	6	14	930	1	-	-	930	8,370
45	15	1	QC-003	1	11	360	-	0.5	-	180	2,160
46	16	5	QC-003	2	14	500	-	-	0.25	125	1,500
47	16		QC-003	17	7	14,502	-	-	0.25	3,625.50	43,506
48	16		QC-003	6	1	930	-	-	0.25	232.50	2,790
49	16		QC-003	4	5	718	-	0.5	-	359	4,308
50	16		QC-003	8	8	1,900	1	-	-	1,900	17,100
51	17	1	QC-003	2	12	500	1	-	-	500	4,500
52	18	6	QC-003	13	7	7,690	1	-	-	7,690	69,210
53	18		QC-003	3	9	644	1	0.5	-	7,690	69,210
54	18		QC-003	13	13	7,690	-	0.5	-	322	3,864

s/n	Qtr	New IP	Section ID	GL	STEP	INC	1	2	3	Remuneration	Worth
55	18		QC-003	1	8	360	-	0.5	-	180	2,160
56	18		QC-003	1	16	360	1	-	-	360	3,240
57	18		QC-003	12	13	7,000	1	-	-	7,000	63,000
58	19	6	QC-003	16	2	12,900	1	-	-	12,900	116,100
59	19		QC-003	14	9	7,990	-	-	0.25	1,997.5	23,970
60	19		QC-003	17	5	14,502	-	-	0.25	3,625.50	43,506
61	19		QC-003	5	9	870	1	-	-	870	7,830
62	19		QC-003	13	14	7,690	-	-	0.25	1,922.50	23,070
62	19		QC-003	16	6	12,900	1	-	-	12,900	116,100
63	20	5	QC-003	12	1	7,000	1	-	-	7,000	63,000
64	20		QC-003	1	3	360	1	-	-	360	3,240
65	20		QC-003	3	6	644	1	-	-	644	5,796
66	20		QC-003	2	8	500	1	-	-	500	4,500
67	20		QC-003	10	5	2,600	-	-	0.25	650	7,800

Subtotal: 271,059, 2,201,988

Table 4.1(d): Remuneration and Worth of IP Table for Marketing Section

s/n	Qtr	New IP	Section ID	GL	STEP	INC ₦	Quality of IP (Grade) 1 (1&2)	2 (3&4)	3 (5&6)	Remuneration ₦	Worth ₦
1	1	2	Mkg-004	14	9	7,990	1	-	-	7,990	71,910
2	1		Mkg-004	11	15	2,700	-	-	0.25	675	8,100
3	2	4	Mkg-004	11	6	2,700	1	-	-	2,700	24,300
4	2		Mkg-004	16	1	12,900	-	-	0.25	3,225	38,700
5	2		Mkg-004	7	13	1,600	-	0.5	-	800	9,600
6	2		Mkg-004	17	1	14,502	-	0.5	-	7,251	87,012
7	3	1	Mkg-004	3	15	644	1	-	-	644	5,796
8	4	5	Mkg-004	6	11	930	1	-	-	930	8,370
9	4		Mkg-004	7	2	1,600	1	-	-	1,600	14,400
10	4		Mkg-004	11	9	2,700	-	0.5	-	1,350	16,200
11	4		Mkg-004	10	3	2,600	-	0.5	-	1,300	15,600
12	5	6	Mkg-004	17	8	14,502	-	0.5	-	7,251	87,012
13	5		Mkg-004	3	11	644	1	-	-	644	5,796
14	5		Mkg-004	7	12	1,600	-	0.5	-	800	9,600
15	5		Mkg-004	13	3	7,690	-	0.5	-	3,845	46,140
16	5		Mkg-004	2	7	500	-	0.5	-	250	3,000
17	5		Mkg-004	4	2	718	-	0.5	-	359	4,308
18	6	1	Mkg-004	8	10	1,900	-	0.5	-	950	11,400
19	7	2	Mkg-004	9	9	2,300	-	0.5	-	1,150	13,800

s/n	Qtr	New IP	Section ID	GL	STEP	INC ₦	1 (1&2)	2 (3&4)	3 (5&6)	Remuneration ₦	Worth ₦
20	7		Mkg-004	3	6	644	-	0.5	-	322	3,864
21	8	4	Mkg-004	13	11	7,690	-	-	0.25	1,922.50	23,070
22	8		Mkg-004	5	7	870	-	-	0.25	217.50	2,610
23	8		Mkg-004	2	4	500	1	-	-	500	4,500
24	8		Mkg-004	13	6	7,690	-	-	0.25	1,922.50	23,070
25	9	1	Mkg-004	10	8	2,600	1	-	-	2,600	23,400
26	10		Mkg-004	13	15	7,690	-	0.5	-	3,845	46,140
27	11	2	Mkg-004	8	15	1,900	-	-	0.25	475	5,700
28	11		Mkg-004	7	12	1,600	-	0.5	-	800	9,600
29	12	1	Mkg-004	12	5	7,000	1	-	-	7,000	63,000
30	13	1	Mkg-004	10	8	2,600	1	-	-	2,600	23,400
31	14	3	Mkg-004	10	8	2,600	-	0.5	-	1,300	15,600
32	14		Mkg-004	12	9	7,000	-	0.5	-	3,500	42,000
33	14		Mkg-004	4	2	718	-	-	0.25	179.50	2,154
34	15	2	Mkg-004	7	5	1,600	1	-	-	1,600	14,400
35	15		Mkg-004	9	13	2,300	-	-	0.25	575	6,900
36	16	1	Mkg-004	8	14	1,900	1	-	-	1,900	17,100
37	17	2	Mkg-004	10	4	2,600	-	-	0.25	650	7,800
38	17		Mkg-004	11	7	2,700	-	-	0.25	675	8,100
39	18	4	Mkg-004	12	1	7,000	-	0.5	-	3,500	42,000
40	18		Mkg-004	16	4	12,900	1		-	12,900	116,100
41	18		Mkg-004	1	14	360	1	-	-	360	3,240
42	18		Mkg-004	8	9	1,900	1	-	-	1,900	17,100
43	19	1	Mkg-004	15	6	8,100	-	0.5	-	4,050	48,600
44	20	4	Mkg-004	11	9	2,700	-	-	0.25	675	8,100
45	20		Mkg-004	15	4	8,100	1	-	-	8,100	72,900
46	20		Mkg-004	16	7	12,900		Subtotal:			114,233	1,208,892

Table 4.1(e): Remuneration and Worth of IP Table for Agricultural Section

s/n	Qtr	New IP	Section ID	GL	STEP	INC ₦	Quality of IP (Grade)			Remuneration ₦	Worth ₦
							1 (1&2)	2 (3&4)	3 (5&6)		
1	1	1	Agc-005	9	4	2,300	1	-	-	2,300	20,700
2	2	4	Agc-005	17	4	14,502	-	0.5	-	7,251	87,012
3	2		Agc-005	15	3	8,100	1	-	0.25	8,100	72,900
4	2		Agc-005	12	7	7,000	-	-	0.25	1,750	21,000
5	2		Agc-005	13	9	7,690	1	-	-	7,690	69,210
6	3	2	Agc-005	5	11	870	-	-	0.25	217.50	2,610

7	3		Agc-005	10	2	2,600	1	-	-	2,600	23,400
8	4	2	Agc-005	15	6	8,100	-	0.5	-	4,050	48,600
9	4		Agc-005	13	7	7,990	-	0.5	-	3,995	47,940
10	5	1	Agc-005	2	11	500	1	-	-	500	4,500
11	6	4	Agc-005	14	7	7,990	1	-	-	7,990	71,910
12	6		Agc-005	6	16	930	-	0.5	-	465	5,580
13	6		Agc-005	9	5	2,300	1	-	-	2,300	20,700
14	6		Agc-005	11	4	2,700	-	-	0.25	1,350	8,100
15	7	1	Agc-005	13	5	7,990	-	0.5	-	3,995	47,940
16	8	1	Agc-005	17	1	14,502	1	-	-	14,502	130,518
17	9	2	Agc-005	6	8	930	-	0.5	-	465	5,580
18	9		Agc-005	15	1	8,100	1	-	-	8,100	72,900
19	10	2	Agc-005	16	4	12,900	-	0.5	-	6,450	77,400
20	10		Agc-005	10	6	2,600	-	0.5	-	1,300	15,600
21	11	1	Agc-005	8	1	360	-	0.5	-	180	2,160
22	12	2	Agc-005	11	7	500	-	-	0.25	125	1,500
23	12		Agc-005	16	3	12,900	-	0.5	-	6,450	77,400
24	13	3	Agc-005	5	14	644	1	-	-	644	5,796
25	13		Agc-005	2	1	500	1	-	-	500	4,500
26	13		Agc-005	8	1	1,900	-	0.5	-	950	11,400
27	14	2	Agc-005	7	11	1,600	-	-	0.25	400	4,800
28	14		Agc-005	3	2	644	-	0.5	-	322	3,864
29	15	1	Agc-005	2	4	500	1	-	-	500	4,500
30	16	3	Agc-005	9	5	2,300	1	-	-	2,300	20,700
31	16		Agc-005	14	1	7,990	1	-	-	7,990	71,910
32	16		Agc-005	17	9	14,502	-	0.5	-	7,251	87,012
33	16		Agc-005	7	14	1,600	-	-	0.25	400	4,800
34	16		Agc-005	8	13	1,900	-	-	0.25	475	5,700
35	16		Agc-005	9	1	2,300	-	-	0.25	575	6,900
36	17	5	Agc-005	9	15	2,300	-	0.5	-	1,150	13,800
37	17		Agc-005	12	12	7,000	-	-	0.25	1,750	21,000
38	17		Agc-005	1	10	360	1	-	-	360	3,240
39	17		Agc-005	7	11	1,600	-	0.5	-	800	9,600
40	17		Agc-005	15	2	8,100	-	-	0.25	2,025	24,300
41	18	1	Agc-005	17	3	14,502	-	0.5	-	7,251	87,012
42	19	2	Agc-005	10	7	2,600	-	0.5	-	1,300	15,600
43	19		Agc-005	16	9	12,900	1	-	-	12,900	116,100
44	20	1	Agc-005	13	6	7,690	-	0.5	-	3,845	46,140
									Subtotal:	145,814	1,503,834

APPENDIX D: Graph plotting software fornew IP gain over 5 years of simulation

```
% MATLAB script for plotting polyfit of new IP
% Linear Regression and Polyfit of the cummulative new IP of Table 4.4
v=[58 113 158 215 282];
x=[1 2 3 4 5];
y=polyfit(x,v,1); % Generate the coeefficients of m and c in the equation
V=mx + c
p=polyval(y,x); % predicting the values of y using x
m=polyfit(x,v,2);% Generate the coefficient of a,b and c in the equation
V=ax^2+bx+c
g=polyval(m,x);% predicting the values of M using x
% c=polyfit(x,v,3);
% b=polyval(c,x);
%a=polyfit(x,v,4);
% k=polyval(a,x);
figure
plot(x,v,'-or')
hold on
plot(x,p,'b')
hold on
plot(x,g,'-+k')
legend('main','linear','quadratic')
xlabel('years')
ylabel('Cummulative New IP')
% applying quality factor QF to the cummulative New IP
% NEw IP multiplied by Quality Factor is a measure of the actual
% intellectual property achieved
v2=[114 288 323 445 593];
x2=[1 2 3 4 5];
y2=polyfit(x2,v2,1)% Generate the coeefficients of m and c in the equation
V2=mx2 + c
p2=polyval(y2,x2) % predicting the values of y2 using x2
m2=polyfit(x2,v2,2);% Generate the coefficient of a,b and c in the equation
V2=ax^2+bx+c
g2=polyval(m2,x2);% predicting the values of M using x
figure(2)
plot(x2,v2,'--*r')
hold on
plot(x2,p2,'-ob')
hold on
plot(x2,g2,'-+k')
legend('main','linear','quadratic')
xlabel('years')
ylabel('Cummulative New IP with QF')
f1=poly2str(y,x);
f2=poly2str(y2,x2);
u=polyval(y2,10)
```

```
% initialise arrays and variables
x=[50 60 70 80 90 100];
y=[10;20;30;40;50;60];
nx=6;
ny=6;
Z1=zeros(nx,ny);
Z2=zeros(nx,ny);
Z3=zeros(nx,ny);
Z4=zeros(nx,ny);
% compute Z1, which is the number of patentable projects based on x and y
% values
for r=1:nx
    for c=1:ny
        %now compute patentable research throughput
        Z1(r,c)=x(r)*(y(c)./100);
        %compute at the same time Z2, the patent value at 10million
        %naria,Z3 the patent value at 15 million naira per patentship and
        %Z4 the patent value at 20 million naria per sole proprietorship
        Z2(r,c)=Z1(r,c)*10;
        Z3(r,c)=Z1(r,c)*15;
        Z4(r,c)=Z1(r,c)*20;
    end
end
% plot the surface plot for Z1 research throughput
[x,y,Z1]=peaks(30);
surf(x,y,Z1)
xlabel('x-axis')
ylabel('y-axis')
zlabel('z-axis')
title('Figure 4.5 Surface plot of peaks:Research Throughput')
% plot the surface plot for Z2, patent values at 10 million naria per
% patent
figure(2)
[x,y,Z2]=peaks(30)
surf(x,y,Z2);
xlabel('x-axis')
ylabel('y-axis')
zlabel('z-axis')
title('Figure 4.7 Surface plot of peaks:Patent values at #10M per
patentship')
figure(3)
[x,y,Z3]=peaks(30)
surf(x,y,Z3)
xlabel('x-axis')
ylabel('y-axis')
zlabel('z-axis')
title('Figure 4.9 Surface plot pf peaks:Patent values at #15M each')
figure(4)
[x,y,Z4]=peaks(30)
surf(x,y,Z4)
xlabel('x-axis')
ylabel('y-axis')
zlabel('z-axis')
title('figure 4.11 surface plot of peaks:Patent values with sole
proprietorship')
```

APPENDIX F: Software for Multiple Regression Analysis

```
% Y=B0+B1X1+B2X2+E multiple Regression
Y=[5;10;12;18;21;24;28;30;32;30;45;60];
X=[1 50 10;1 100 10;1 60 20;1 90 20;1 70 30;1 80 30;1 70 40;1 60 50;1 80 40;1
50 60;1 90 50;1 100 60];
n=12;
k=2;
B=inv(X'*X)*X'*Y
% calculate Standard Error for the Regression SSE
SSE=(Y'*Y)-(B'*X'*Y);
G=n-(k+1);
zeta=sqrt(SSE/G);
zy=0;
zy2=0;
for r=1:n
    zy=zy+Y(r);
    zy2=Y(r)^2+zy2;
end
SSY=zy2-(zy)^2/12
%calculate mean square for regressiob MSR
MSR=(SSY-SSE)/k
SSR=SSY-SSE
%calculate mean square for error(MSE)
MSE=zeta^2
Ftest=MSR/MSE
%This is the ratio mean square for regresssion (MSR) to the mean Square for
%error
```

APPENDIX G: PATENT FORM

FORM NO. 1.

PATENTS ACT 1992 **(as amended)**

Reference No. of Applicant or Authorised Agent ……………….

REQUEST FOR THE GRANT OF A PATENT

The applicant(s) named herein hereby request(s) the grant of:

a Full Term patent (20 year)		**OR**	a Short Term patent (10 year)	

on the basis of the information furnished hereunder.

1. Applicant(s) (Full name and address of the person **or** of the company applying.)*

Name(s):	
Address(es):	
Nationality(ies):	
Telephone(s):	
Email(s):	

*[Extra sheet available for multiple applicants]

2. Legal Representative

The following is authorised to act as agent in all proceedings connected with the obtaining of a patent to which this request relates and in relation to any patent granted:

Name:	
Address:	
Telephone:	
Email:	

3. Address for Service (within the EEA, to which correspondence is to be sent)

If different to address at 1 or 2
Address:
Telephone:
Email:

Please tick box if you wish the Office to correspond with you by email in relation to this application	☐

4. Title of Invention

5. Declaration of Priority (If you have filed any application(s) for the same invention within the last 12 months, please enter the relevant information where a right to priority is claimed)

Country:	Date:	Number:

6. Inventor(s)*

The applicant(s) is/are the sole/joint inventor(s)	YES ☐	NO ☐
If no, please specify the full name(s) and address(es) of the inventor(s) below:		
Name(s):		

Address(es):	
Telephone(s):	
Email(s):	

*[Extra sheet available for multiple inventors]

7. Statement of right to be granted a Patent (To be completed if applicant(s) is/are not the sole/joint inventor(s))

Please state how the applicant derived the right from the inventor to be granted a patent

By Deed of Assignment		By Contract of Employment	
Other (please specify)			

8. Divisional Application(s)

The following information is applicable to the present application.	YES		NO	

Earlier Application No:	Filing Date of Earlier Application:

9. Items accompanying this Request

Please tick the appropriate boxes for items sent with this application form.

(a)	Filing fee (₦)	
(b)	A written description	
(c)	A written claims section	
(d)	Drawings referred to in the descriptions or claims	
(e)	An abstract	
(f)	Copy of previous application(s) in respect of which priority is claimed	
(g)	Translation of previous application in respect of which priority is claimed	
(h)	Authorisation of agent [Form No. 5]	
(i)	General authorisation of agent filed on a previous application.	

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Earlier Application No:	Filing Date of Earlier Application:	

(j)	Supplementary sheet identifying other applicants	
(k)	Supplementary sheet identifying other inventors	

10. Signature:	
If a company, state the position within the company of the person signing	

Name in BLOCK CAPITALS	

Date:	

Extra Sheet : TO BE ATTACHED TO MAIN BODY OF APPLICATION FORM IF REQUIRED

1. Applicant(s) (Full name and address of the person **or** of the company applying.)

Name(s):	
Address(es):	
Nationality(ies):	
Telephone(s):	
Email(s):	

Name(s):	
Address(es):	
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Telephone(s):	
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Name(s):	
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Email(s):	

Extra Sheet : TO BE ATTACHED TO MAIN BODY OF APPLICATION FORM IF REQUIRED

6. Inventor(s)

The applicant(s) is/are the sole/joint inventor(s)	YES		NO	

If no, please specify the full name(s) and address(es) of the inventor(s) below:	
Name(s):	
Address(es):	
Telephone(s):	
Email(s):	

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