SAFE MINER ANDROID APPLICATION

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By

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Submitted in partial fulfilment of the requirements for the degree of

BSc Honours Information Systems

Department of Computer Science and Information Systems

in the

Faculty of Science and Technology

at the

Midlands State University

Gweru

October 2019

Supervisor: **Mrs T.G Zhou**

ABSTRACT

Due to the current economic situation and the growth in world demand, the mining industry is undergoing a period of spectacular development. The current need to increase production at mine sites coincides with the development of managerial capacities, the use of new industrial methods and equipment, and increased use of skilled workforce. Despite such developments, a number of researchers view the mining sector among the world's most uncertain and hazardous industries. Therefore, the major problem is, in Zimbabwean market there is no effective system that allows miners to access manuals, work schedules, maps and location easily wherever they are. Development of this project remains a goal to be attained so as to enhance reliability of decisions and make mining organizations safer and more secure. The developer further investigated how the current systems work and in-depth understanding of the problem area was gained through the use of interviews, observations and questionnaires. The system comprised of android application developed in android studio. A literature review was conducted so as to provide a strong foundation for advancing knowledge about the project, overview of the mining sector was provided and how mining is carried out in the mines and a list of the mining products. Technology is changing rapidly and there is need to adjust so as to improve the economy and how businesses operate in Zimbabwe, technology has impacted the mining sector in a positive way and modifications were made to the mining sector. There is no doubt that the future landscape of mining will be a digital landscape soon. Companies must invest in tools and analytics that will allow them to become a modern digital mining company. The future will be digital that is, digital camera, videos, electronic document storage, network data collection, intelligent search software to see trends and optimise operations. The dissertation also focused on the actual system design structure to clarify how the system works, architectural design, physical design of the developed system, database design, program design which is explained through the package and class diagrams, interface design of the system. The application was tested and deployed successfully.

DECLARATION

I, **Thelma R Machakaire** hereby declare that I am the sole author of this dissertation. I authorize the **Midlands State University** to lend this dissertation to other institutions or individuals for the purpose of scholarly research.

Signature: ……. Date: …….

APPROVAL

This dissertation, entitled **"Safe Miner Android Application"** by **Thelma R Machakaire** meets the regulations governing the award of the degree of **BSc Honours Information Systems** of the **Midlands State University,** and is approved for its contribution to knowledge and literary presentation.

Supervisor's Signature: …….

Date: …….

ACKNOWLEDGEMENTS

I would like to extend my gratitude to the Almighty for taking me this far. My project supervisor Mrs T.G Zhou for her sterling efforts to make this project a success.

I would also want to thank my colleagues, my family and my friends for the support they gave during the writing this project.

DEDICATION

My dedication goes to Simbarashe Pande who has always been there for me throughout my university life, my brothers and sister-in-law and my parents who would have been proud of me if they were here.

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LIST OF ACRONYMS

AHS……Autonomous Haulage Systems

AI……Artificial Intelligence

AR……..Augmented Reality

CBM……Coal-Bed Methane

COMZ……..Chamber Mines of Zimbabwe

DFD……. Data Flow Diagram

EER…….Enhanced Entity Relationship Diagram

FK……Foreign Key

GIS……Geographic Information Systems

GUI……Graphical User Interface

KT…….....Kilotonne

LAN…….Local Area Network

IOT…….Internet of Things

MT……Metric Tonnes

PGM…….Platinum Group Metals

ND…….No Date

PK……..Primary Key

TPA……..Tonnes Per Annum

TCF……..Trillion Cubic Feet

SDK…….Software Development Kit

SMA…….Safe Miner Application

UAS……..Unmanned Aerial System

UI……..User Interface

UML…….....Unified Modelling Language

VR……Virtual Reality

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CHAPTER 1: INTRODUCTION

1.1 Introduction

The mining industries in Zimbabwe need to make use of the evolving technology and target to work with information systems that will assist surveyors and mining engineers when carrying out their work. Developing a mobile mining application is of great significance as it will aid in decision making when extracting minerals. The mining application will improve information about the mining environments, improve safety for the workers and increase productivity which will lead to an increase in jobs for the nation at large through the investment in advanced technologies. Miners should be looking forward in the investment of new technologies and make use of applications which will increase the efficiency levels that will allow mining companies to meet the expectations and demand from the domestic market. Justification to the consideration is done to ensure that the system can be practical and at the end a hypothesis on development tools for the project is made before concluding the chapter.

This chapter will look at the background of the study explaining how the mining industry operates and its activities, problem definition, aim of the research study, objectives, instruments and method to be used, justification and rational and lastly the conclusion.

1.2 Background of the study

Zimbabwe has been endowed with a wealthy of natural resources that have fostered its growth and development. The discovery of resources such as gold or oil has resulted in major population shifts and rapid growth for formally remote regions of the country such as Zvishavane and Kwekwe.

The mining industry contains five segments, which are defined by the resources they produce which are oil and gas extraction, coal mining, metal ore mining, non-metalic mineral mining and quarrying, and support activities for mining. The coal mining industry segment produces coal. Zimbabwe has vast high-grade coal deposits occurring as fossilized carbon. These include Limpopo basin in the south of the country host about 12 billion tonnes of good quality coal. About 29 localities are known but major producers are Hwange colliery and Makomo resources. Like oil, coal is formed over millions of years from plant and animal matter, but unlike oil, coal is a solid and therefore miners must go into the earth to recover it.

Hawkins (2015), asserts that surface mining of coal typically uses the method known as strip mining, which is usually more cost effective than underground mining and requires fewer workers to produce the same quantity of coal. In strip mining, workers use huge earth moving equipment such as power shovels or draglines, to scope off the layers of soil and rock covering the coal seal. Once the coal is exposed, it is broken up by using explosives, and then smaller shovels lifts it from the ground and load it into the trucks. The metal ore mining industry segment covers the extraction of metal ore primarily gold, silver, iron, copper, lead and zinc. The mining is currently being carried out in Mimosa, Ngezi and Unki platinum mines. Most metals do not exist in concentrated form but rather in small traces in rock called ore. Like coal mines metal ore mines are found in both surface and underground varieties, depending on where the ore deposit is located. In addition to strip mining, surface ore mines also use the open-pit mining technique according to Hawkins (2015). These mines are huge holes in the ground that are mined by blasting rock from the sides and bottom with explosives, carrying out the broken-up material in tucks ad then repeating the process. Non-metalic mineral mining and quarrying industry segment covers a wide range of mineral extraction. The majority of the industry produces crushed stone, sand and gravel for using in construction of roads and buildings. The mining is currently being done at Shurugwi and Zimasco. In quarrying operations, workers use machines to extract the stone. Stone (granite and limestone) is quarried by using explosives to break material off from a massive rock surface. Then the resulting rocks are crushed further an shipped off for the production of asphalt or concrete. The final industry segment is support activities for mining. The activities of this industry are often the same as those of the other industry segments, but the work is done by contract companies that specialise in one aspect of resource extraction.

During the 1990's, commodity prices were relatively stable at low levels, causing production to stagnate and limiting the creation of new drilling and mining operations. Using a variety of methods, on land and at sea, small cruise of specialised workers searches for geologic formations that are likely to contain pockets of oil or gas. Sophisticated equipment and advanced computer technology have increased the productivity of exploration. Maps of potential deposits now are made using remote- sensing satellites unlike back in the day when they were no these advanced tools.

Seismic prospecting is a technic based on measuring the time it takes for sound waves to travel through underground formations and return to the surface has successfully revolutionised the oil and

gas exploration, (transforming mining industry n.d.). Computers and advanced software analyze seismic data to provide three dimensional models of sub-surface rock formations. Another method of searching for oil and gas is based on collecting and analysing core samples of rock, clay and sand in the earth's layers.

1.3 Problem definition

According to Chemuturi (2013), problem definition is a definite or clear expression statement about an area of concern, a condition to be improved upon, a difficulty to be eliminated, or a troubling question that exists in scholarly literature, in theory, or within existing practice that points to a need for meaningful understanding and deliberate investigation. A problem definition does not state how to do something, offer a vague or broad proposition, or present a value question, in theory as well in practice that urges the need of meaningful understanding and careful examination when correcting it rather it needs solutions to solve it, following are problems that were defined during research on the present manual system. Surveyors have problems in working corporately as many of them are based in different locations of research. Surveyors fail to locate the best landscape with the best minerals because of old outdated manual maps they have. They face problems in gathering information, there is duplication of data, inaccurate calculations, and time wastage while camping in the field of research. Also, surveyors have identified problems in the operational systems landscape and applications landscape as complex and fragmented that there are significant data quality issues to access data is neither timely. Miners have difficulties with falling rocks and falling ground while underground mining due to poor surveying.

Therefore, the major problem is, in Zimbabwean market there is no effective system that allows miners to access manuals, work schedules, maps and location easily wherever they are.

1.4 Aim of the research study

The main aim of the project is to develop a mobile mining application that will assist surveyors and mining engineers to improve the mining environments, improve safety in mines, increase productivity in mining companies and reduce costs during operations of the plant and equipment.

1.5 Objectives of the research

Forgue (2017), asserts that objectives are the steps you are going to take to answer your research questions or a specific list of tasks needed to accomplish the goals of the project. Objectives are used by individuals and organizations. In general, individuals set objectives in regard to their career and professional pursuits. Now the basic features for the safe miner android mobile system are:

- The application will allow calculations, conversions, products information and other important data while minimizing the need for blasting engineers to venture into the field with manuals.
- It will support both portrait and landscape view for surveyors using the new version of google maps.
- It will allow cloud sharing and cloud storing for surveyors to take pictures of sample stones, soils, land for data mining and recognition.
- The surveyors will be able to access their manuals directly on the application and they will be able to work offline in places where there's no internet coverage using the Firebase database.

1.6 Instruments and methods

The research was done by acquiring knowledge and guidelines from various sources that are available. Instruments and methods that were used in conducting research will be discussed below.

1.6.1 Instruments

With an overview of the system requirements for the android application, the author propose to mechanize the system and disconnect manual processes by developing a comprehensively integrated and efficient Safe Miner Android Application to appropriately implement this proposal, selected below are the software tools to model and develop the system.

A number of tools used to build the proposed system include Kotlin for the server-side operations. Kotlin is a new computer programming language that is concurrent, class based and object oriented. It is designed to have a few implementation dependencies as possible.

In the front-end of the application, Extensible Markup Language (XML) will be used to create responsive layouts of the application. This programming language can also be used to develop android applications. API is another tool used in the development of the application. It is a set of procedures, rules and tools for developing applications. Furthermore, Firebase database will be used for the application database. It is a real-time database management system that is embedded into end program of an application and suitable for use on embedded system such as mobile phones. Also, in the backend Restful Webservice will be used for other external dependencies. Restful web services allow the requesting systems to access and manipulate textual representations of web resources by using a uniform and predefined set of stateless operations.

1.6.2 Methods

Methods refer to issues which are related to maintaining integrity of data when carrying out a research, the primary rationale for preserving data integrity is to support the detection of errors in the data collection process. Fowler (2016), ascertain that data collection is defined as the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes, accurate data collection is essential to maintaining the integrity of research. The author undertook a thorough review using data collection methods which are interviews, observations and questionnaires.

Interviews - structured and unstructured interviews were carried out with distinguished miners and surveyors to have an insight on problems faced during mining activities which led to the design of the proposed system.

Observations - were a dynamic way of obtaining data to verify some issues that need clarification that the miners would have not reviewed during the interviews.

Questionnaires – questionnaires were designed after going through a few similar research studies on mining activities. A number of the questionnaires were administered to the miners and surveyors together with a letter explaining the purpose of the study which assured anonymity of respondents and their departments and provided instructions on how and who should complete the questionnaire.

1.7 Justification and rationale for the research study

The safe miner android application will be a great development as it will reduce workload for surveyors as the data analysis will be done on the application and the application will analyze and record all places accessed depending on the period stated and also allow other surveyors to access individual areas of data capture and analysis.

The safe miner system has an integrated database which will decrease data idleness and unnecessary reputation of bookkeeping via strict authentication and automation. The application improves the integrity of data, reliability; eliminate data consistency and error free data. The application will also help the surveyors with decisions that may seem difficult and will improve performance in processing procedures. User can also store their information (manuals, safety guides and work schedules) online. This makes the information more secured. A well-maintained integrated system with the quality content targeting the needs and adding value to the targeted clients.

Moreover, the system uses Google maps made by Google. This is a reliable mapping service providing location information through satellite imagery. This will give miners the ability to check possible routes and landmarks using their android mobile phones. It also provides the layout of roads, the locations of cities and towns, state boundaries, geographical features and satellite images.

1.8 Conclusion

In conclusion, the introduction and problem definition has been clearly outlined. Objectives of the system where clearly stated. The problems of not having a system were outlined with consultation from surveyors, mineworkers and engineers. The project is on the development of a system that is user friendly, whose purpose is to solve the problems by introducing a more technically easy way of assistance requesting that is not time consuming but efficient and effective thus satisfying the needs of mineworkers. There is need to improve the ways in which surveyors find productive sites during their surveying research in the fields. Developing and implementing the safe miner android application for surveyors and mineworkers will help them obtain better results on the field of study. In the next session which is chapter two the researcher will be looking at the literature review for the proposed application

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Chemuturi, (2013) defined literature review as an appraisal of all relevant existing literature to realise what is known and what is unknown yet about a particular topic. A solid literature review is a critical aspect of any academic research as it provides a firm with the strong foundation for advancing knowledge. The core purpose of literature review is to convey to the reader what knowledge and ideas have been established on a particular project to be reviewed. Although there are many types and goals of literature reviews, it is found that all of them can be improved using a tool chain of free and open source software and methods. This chapter will mainly provide a clear framework for safety issues in mines in Zimbabwe, benefits and drawbacks of the new system in conjunction with old system.

2.2 Overview of the mining sector

According to Chamber of Mines of Zimbabwe (COMZ) 2017, "Annual Report", In 2017, Ericsson and Gibbon observed that the "Zimbabwean mining is much diversified in terms of minerals produced, the number of operating mines and dispersal of control over the mine production. More than 40 minerals are mined; the number of operating mines is 800-900; the most important mining company, Anglo American, controls 25 percent of the value of total mining output and state ownership is not dominant. This situation contrasts sharply with the situation in most African countries. Most mining countries in Africa depend on one single or possibly two or three minerals, there are usually only a few large-scale mines and only a handful, usually transnational mining companies dominate the industry or there is a large state ownership. Underneath is the overview of each mining section found in Zimbabwe

2.2.1 Gold

Gold output peaked in 1916 at 29 tonnes and in the first one hundred years (1890-1989) of modern mining 1.54kt were produced. In 1979, gold replaced asbestos as Zimbabwe's most valuable mineral produced and it competed with ferrochromium as the premier mineral export until 2013 when platinum took over the lead. The 2013 record was nearly surpassed in 2015 when 27 tonnes were produced, but thereafter there was a steady decline due to the economic

meltdown to 3.6t in 2017. Since adoption of the multi-currency system in 2009, production has rapidly recovered, to 13t in 2018. Gold is still produced by numerous small mines, but the bulk of production comes from a few medium-sized mines. The state used to give comprehensive aid to the numerous small-scale gold mines by providing expertise, assaying, loans, hire of equipment, and by guaranteeing a fixed gold price (by the Reserve Bank of Zimbabwe). In addition, the state roasting plant in Kwekwe used to custom treat refractory ores. In 2014 the state gold refinery was opened in Msasa with a capacity of 90 tpa, well above the foreseeable national needs, to cater for refining from other states in the region. However, it was shut in 2016 when gold miners were authorised to market their own production (under the Gold Trade Act).

2.2.2 Platinum Group Metals (PGM)

According to African Union (2016), The Great Dyke of Zimbabwe contains the second largest known deposits of platinum in the world. The Great Dyke resources are estimated at 1.68 Gt (billion tonnes) grading 5.54 g/ton (grams per ton) PGM's (86%) and Au (14%) with 0.2% Ni and 0.15% Cu. There are currently three operating mines operating namely, Zimplats (Implats), Mimosa (Aquarius & Implats) and Unki Platinum (Anglo Platinum). Current platinum production is at 188 000 ounces per year. Five other platinum projects are at different stages of resource identification (e.g. ZMDC: Bokai and Ngezi-Mhondoro). Besides gold, the platinum industry appears to have the greatest immediate prospect for rapid expansion. The sector has huge potential especially for further expansion and greater value addition (all production is exported as concentrate or matte/leach alloy for refining in South Africa). Below is a diagram to show where platinum mines are found in Zimbabwe.

Figure 2.1 platinum mines Adapted from Implats 2015

2.2.3 Coal

Maloney et al (2015), coal production over the 20 years between 1965 to 1985 remained fairly static between 3.0 and 3.5 Mt, however, production was substantially expanded in 1986 with the commissioning of an opencast operation to supply the new Hwange Power Station, at about 5 Mt annually. The major coal resource areas are: 1) the Mid-Zambezi basin: Hwange (1900 Mtonnes), Gwai River Valley (3675 Mtonnes), Binga (3604 Mtonnes), Gokwe (1150 Mtonnes) and 2) the Sabi-Limpopo basin: Sabi-Lundi (379 ktonnes), 21 Bubye (291 ktonnes) and Tuli (127 ktonnes). In addition, the Coal-bed Methane (CBM) resources in the Hwange/Lupane basins are estimated at over 27-40 TCF (trillion cubic feet) of sulphur-free methane gas, which rank Zimbabwe's resources at 11 globally, after South Africa, but other coal basins are also known to have substantial CBM resources (example, the Sengwa Basin) which still need to be delineated.

2.2.4 Other minerals

Hawkins (2015), stated that, the most important by value were: limestone, phosphates, silver, graphite, lithium minerals, tantalite concentrates, cobalt and rough emeralds. The most important of these in terms of world output, is lithium (petalite concentrate) which was approximately 7.6% of world production in 1988. All lithium minerals were produced by Bikita Minerals (Pvt) Ltd, which used to be owned by RTZ plc (50.5%), but is now Zimbabwean owned.

2.2.5 Mining sector core functions and its activities

Mining overall functions consists of: Administer the Mines and Minerals Act (Chapter 21:05), formulate, monitor and evaluate implementation of mining development policies, design mechanisms geared at effective accounting for the country's mineral resources, administer and review mining and explosives laws, develop and maintain an up-to-date data bank on present/future mineral deposits, attract investment to the mining industry, promote beneficiation and value addition of mineral resources, promote and develop small-scale mining, Facilitate the indigenization of the mining sector, monitor exploration activities across the province, collection and analysis of mineral production data and liaise with technical departments in the Ministry, (McMahon 2017).

Mining operations are complex, the beginning of any mining project begins with the exploration stage. The most common mining methods used in mines are open pits with shovel and truck teams and opencast mines with large draglines. In underground coal mining, the most common methods are mechanical excavation with continuous miners and longwall shearers. Some coals, mostly coals mined underground, may require processing in a preparation plant to produce marketable products. Mining can include the following components exploration and development, drilling, blasting or mechanical excavating, loading, hauling, crushing, grinding, classifying, separating, dewatering, and storage or disposal. Separation of valuable minerals from their ores may be by physical or chemical means, or by a combination of processes. The final step is smelting, this involves melting the concentrate in a furnace to extract the metal from its ore. The ore is then poured into moulds, producing bars of precious metal which are ready for sale (Jourdan 2017).

2.3 Safety issues in the mining sector

In Zimbabwe, the Ministry of Mines and Mining Development governs the safety issues**.** The mission of the department is “To promote sustainable mining practices and management through the regulation of the mining industry for the purpose of creating safe and healthy mine environment”. This department is also responsible for enhancing sustainable exploitation of mineral resources, eliminating accidents and incidents and monitoring of the working

environment with respect to air, noise and water quality. Regional inspectors are continuously working with employers and trade unions to address specific problems in their areas. Safety operations also include working together with international mining consultants and reviewing mine design and support parameters to present best practice guidelines to the department according to Chamber of Mines of Zimbabwe (COMZ) 2017, “Annual Report”.

Research suggests that the mining industry has, over the years, been marred by recurrent accidents that have killed and maimed dozens of workers, if not scores while on the other hand official estimates indicate that about three mining accidents take place in the artisanal and small-scale miners per day. Research also found that little attention is given to the setting up of solid infrastructure underground to minimise instances of mine collapse since a lot of artisanal and small-scale miners go down the shafts without proper equipment or protective clothing. Reported leading types of accidents in the mining sector include being hit by falling objects, suffocation from chemical fumes, and crushing injuries. Other occupational health hazards in mining include exposure to intense heat, poor ventilation, vibration, poisoning, dust, explosion, fumes, and improper choice of working tools, absence of personal protective equipment and being trapped or buried Chamber of Mines of Zimbabwe (COMZ) 2017, “Annual Report”. The majority of mining-related accidents, fatalities, and ailments are likely undocumented, and as a result are underrepresented in national and international statistics. This is because mining activities often take place in rural areas and frequently operate extra legally. The greatest impact of mining accidents can be found amongst the victims and those family members left behind. The government has taken strong stance on mining safety and has expressed a commitment towards increasing safety for mineworkers.

2.3.1 Definition of safety in relation to the mining sector

Hammel (2015) ascertain that, mine safety is a broad word that refers to the practice of monitoring and handling a wide variety of risks connected with mining-related activities ' life cycle. Mine safety practice includes implementing legally, socially and morally acceptable levels of recognized hazard checks and reducing the hazards connected with mining operations. While the basic concept of mine safety is to eliminate mine workers ' health and security risks, mining

safety practices may also concentrate on reducing the danger of planting along with the mine's structure and body. Hammel (2015) stated mining safety as the management of operations and events within the mining industry, for protecting miners by minimizing hazards, risk and accidents.

2.4 Impact of technology use in the mining sector

Rapid developments in technological innovation are having a basic effect on the mining industry, including through automation, digitization and electrification. Autonomous vehicles, automated drilling and tunnel boring systems, drones and intelligent sensors are some of the innovations that reshape the industry. It opened the door to fresh work possibilities and transformed activities, increasing demand for effective manufacturing. Through the modifications that technology has made for the mining sector, companies can expect effectiveness through automation, decreased expenses, and enhanced responsiveness in all activities. Some of the most important techniques will be discussed. Through the modifications that technology has made for the mining sector, companies can expect effectiveness through automation, decreased expenses, and enhanced responsiveness in all activities. Some of the most important techniques will be addressed.

According to (trends in modern mining technology n.d.) mining industry's latest technological innovations include spatial data visualisation which include three-dimensional (3D) modelling which creates a viewable, life-like impression with depth perception that allows the human brain to understand and relate to complex interrelated issues. 3D modelling supports firms by reimagining the mine more efficiently. Virtual Reality (VR) is an artificially-created software environment that uses real-life data. The virtual environment immerses people into a user-created 3-D environment. VR presents an enhanced impression to help miners experience what it is like working in a mine or planning a new mine without being out in the field. Augmented Reality (AR) overlays a digital visualization onto a real-world environment. AR accomplishes this by enhancing the user's visual field with computer-generated inputs such as sound, video, applications, and graphics. Miners use augmented reality to train using virtual simulators, which also helps the industry reduce equipment maintenance costs. By using new technology like spatial data effectively, the mining industry gains insights into mine systems at a reduced cost and impact on the environment.

Another technological innovation is geographic information systems which is an integral tool that allows a deeper look at how geographic relationships influence the world around us. With the help of GIS, miners are able to solve real-life issues where location and accessibility are critical. Geospatial data represents an object's location, size, and shape. By visualising this kind of data, miners gain more insight into the represented system or mine environment. GIS is used to gain insight into mineral exploration, geochemical and hydrology data, report generation and sustainability and regulatory compliance. Geospatial data software train mine managers and employees in new ways, and improve long-term understanding of mining with virtual interpretations of real-life environments.

Artificial intelligence (AI) now leads the decision-making at insight-driven firms. They use smart data and machine learning to improve operational efficiency, mine safety, and production workflow. Implementing artificial intelligence technology generates day to day data in half the time than what has been used previously in the field (trends in modern mining technology n.d.). The mining industry evolves rapidly, so machine learning and artificial intelligence impact the way mines operate, the latest technology in artificial intelligence impacts the working mine in mineral processing and exploration, companies can find minerals more easily by using high performance AI technology. Autonomous vehicles and drillers, firms across the globe have used autonomous vehicles in their pit to pit operations. Self-driving trucks can easily navigate through narrow tunnels with AI. Now, drilling systems are also simplified with a single operator that controls several drill rigs at once. As the mining industry attempts to reduce costs and lessen its environmental impact, using mining equipment like AI helps to ensure safety and reliability for both miners and the land that mines use.

Automated drones or unmanned aerial systems (UAS) have started to make headway across the mining industry. UAS now produce the same results as a helicopter at a lower cost. Drones, when set to perform operational tasks, improve the industry by providing safety and surveillance in hazardous areas, asset management, time-lapse photography, measuring stockpile inventory, infrastructure upkeep and inspection and site mapping.

2.4.1 Definition of technology in relation to the study

Hughes (2017), stated that, technology is either the application of science expertise to the practical purposes of human existence or the modification and manipulation of the human environment. Technology and enhanced regulation have resulted in mine safety improvements and have helped make mining a less hazardous profession. According to Hughes (2017), mine operators can make their facilities safer and more efficient by investing in wireless underground communications, using data to improve mine safety, automating mining activities, using drones for mining safety and implementing systems that avoid collisions underground.

2.4.2 Overview of technology use in the mining sector

Mining is set to become more automated in years to come, increasing the need for mining equipment finance. With new innovations constantly transforming the way mine workers do their job, the need for up to date machinery and equipment that is safe and efficient is essential in this competitive industry.

Miners embrace digital technologies to streamline their business models and enhance key operational procedures to create a value chain for mining that is more effective and secure. This digital mining era also changes the risk pattern for miners, especially from the cyber risk view. Some of the main variables contributing to this change are the increasing adoption of technology such as automation and robotics, big data and analytics and the Internet of Things (IoT) combined with changing customer behaviors. Increasing the implementation of independent and electric cars (EVs) and the creation of more fuel-efficient motors, for instance, help to reduce energy consumption in the mining industry, according to (technology developments in the mining sector n.d.) Technological transformation is driving the industry, the mining industry has traditionally been conservative in its approach towards new technological developments. Miners are deploying a range of technologies including robotics and automation, sensors, wearables, drones and integrated remote operations. Robots in the mining industry include devices with artificial intelligence or self-learning capabilities that can assist in excavation, haulage, sampling, survey and mapping, as well as drilling and explosives handling, and can also monitor mining operations, such as temperature, rock stability and other conditions to improve worker safety.

Hawkins (2015), asserts that, automation in mining refers to usage of centralised control systems and software, and advanced communication systems to coordinate and monitor equipment, with the emerging use being seen in self-driving or autonomous ore carrying vehicles. Robotics and automation of mobile and fixed assets are helping miners drive productivity gains, optimize cost and improve safety. However, as robotics and autonomous technology becomes further entrenched into mining operations, companies are exposed to a significantly greater risk of network failures, physical damage, business interruption, product liability, and third-party liability.

Growth of 3D printing, 3D printing is a technology that is slowly making an appearance, it is already being used in the aerospace industry for a variety of different reasons. 3D printing allows miners to make custom parts on demand, which can reduce project delays and cut the need for unplanned maintenance. This kind of technology is originally known for its consumer content; however, it has certainly changed the way tasks get done in the engineering space, (3d printing new dimension to mining 2017).

The availability of mobile phones access in the mines, it used to be that managers at mining companies could not easily relay information to workers, or vice versa, this impacted worker productivity and safety, if there was a problem deep in the mine, it was difficult to notify decision makers above. Communication in the mines is one of the most important elements to ensuring a safe and productive working environment. With technology advancement and the ability for everyone to have access to mobiles, companies are now able to relay information to workers faster and more effectively. This has also increased worker production, since the convenience and ease of communication makes everything smoother. Mobile phones do not only benefit workers because of the ability to contact each other, but these devices give off alerts to warn or notify decision makers above if there is danger around them and also it allows managers to configure workers' mobile devices so they receive alerts when entering dangerous zones through the use of geofencing, (Goadrich and Rogers 2015).

The use of smart data solutions helps in more data driven decisions, in order to be more sustainable in the mines, new developments in information technology and data have allowed management to change their approach and decrease unnecessary load. Smart data solutions help

management to relay important data such as water pressure, temperature and other important information. With data like these, managers can take fast, decisive action to increase efficiency, improve safety and increase the operation's sustainability. By combining smart devices with algorithms that accurately determine electricity needs, mining operations will be able to save money. Technology has brought about access to information through the cloud, workers have access to mobile phones and technology which allows them to recall information, whenever and wherever they are. Cloud technology allows employees to quickly access essential information, wherever they need it, which unfortunately welcomes the threat of cybersecurity, (cloud computing in the mining industry n.d.).

Mining companies will have to adopt a more rigorous approach towards cybersecurity. They will need to be more vigilant and resilient if they expect improved growth, better cost-efficiencies and more control. Driverless vehicles which are starting to make an entrance, if companies start rolling out more autonomous vehicles and machinery to make operations smoother, it will also result in better safety, greater efficiency and cheaper running costs. (technology transforming mining industry n.d.)

2.5 Lessons learnt from other countries that have successfully integrated technology in the mining sector

The mining sector needs to foster innovation to remain competitive, integrating technological innovation into its practices can result in reduced costs, increased productivity and improved worker safety for the mining sector.

Launched in 2008, Rio Tinto's Mine of the Future program has made strides in automation, helping the company become the most automated mining operation in the world. The goal of the program was to find innovative ways of extracting minerals while reducing environmental impacts and improving worker safety (Bliss 2018).

At Rio Tinto's iron ore mines in Western Australia, the integration of automation has resulted in a number of advancements. The company is now the world's largest owner and operator of autonomous haulage systems (AHS). With 71 automated trucks operating at this mine site moving approximately 20 per cent of the operations' materials, automation has helped ensure

that the material can be moved more efficiently and safely. Productivity is also improving, the AHS trucks can operate nearly 24 hours per day, every day of the year, no longer stopping for shift changes and employee breaks but only for refuelling and maintenance, (Bliss 2018).

Cost savings from automation have made Rio Tinto more resilient to highs and lows in commodity prices, while establishing the company as the lowest-cost iron ore producer in the region. Worker safety has also improved since the program's founding with employee exposure to hazards and risks associated with operating heavy equipment, such as fatigue, exposure to noise and dust or soft tissue issues, decline. The company has also seen the autonomous fleet outperform the manned fleet by an average of 14 per cent and operating costs fall by 13 per cent.

Labour costs are high for many mining companies, with large wage premiums in the sector due to skills shortages and an aging workforce. Automated technologies allow companies to remove staff from dangerous working conditions. Efficiency and productivity gains can be substantial, particularly for those companies operating in remote areas with high fuel costs. The costs of such technology are falling, sometimes rapidly, giving companies further opportunities to reduce and manage their operating costs in the face of volatile commodity markets. And as these technologies are increasingly proven to be commercially viable, the risks associated with their adoption decrease and companies themselves face pressures to compete with technology leaders. For example, in Australia it is estimated that utilizing smart sensors could create USD 34 billion in value for the mining industry by facilitating predictive maintenance, improving equipment utilization, reducing downtimes and equipment failures, and lowering the frequency of health and safety incidents. Digitization, through improved health and safety, could also save an estimated 1000 lives and avoid 44000 injuries (Bliss 2018).

Technology is also improving efficiency and safety at a personal level. Collection of real time data for visualisation and analytics through sensors, using IoT technology, enables more robust planning and control and miners are embracing wearable technologies for field maintenance and real-time inspection, and to improve safety. Rio Tinto and Anglo American have deployed wearable technology (SmartCap) in Australian coal mines, while BHP has deployed this technology in Chile for improving safety performance. BHP´s Olympic Dam mine in South

Australia is using drones to inspect overhead cranes, towers and roofs of tall buildings. Another example is of Montego's Taylor mine in Nevada rediscovering a huge but abandoned silver deposit, by deploying drones to produce 3D maps of the mine's subsurface, according to (trends in modern mining technology n.d.).

Adoption of these technological advancements is helping miners to effectively control and manage their operations on a near real time basis through remote operating centers. The industry adoption of such remote operating centers and innovative technology is rising and helping miners improve productivity and safety, however, these real time technologies expose miners to the risk of loss of data and software as well as reputational damage liability and also introduce new risks including an increased exposure to hacking, cyber-crime resulting in business interruption incidents.

2.6 Overview of the proposed project

The proposed system will use various technologies for maximum performance. Some of the technologies used in the android safe miner project consists of Integrated Google maps, Online Firebase database, Online calculations and conversions of prices and support different Platforms. The backend of the proposed system will use Kotlin programming language which is a newer language running on java virtual machines. Some of the main goals of Kotlin over other languages is efficient and presents a familiar development tooling that is meant to boost developers' productivity. It is a better compiler and this language also provides an enhanced run-time performance. Other technology adopted in the proposed system is Online Firebase database. Firebase supports a real time database where users can store data (JSON) and data is synchronized continuously to all connected clients effectively. This feature also provides instant UI libraries and SDKs for authenticating client across application using email id, password or username. Storage is another advantage of adopting firebase. It is very useful for storing and serving files of users such as images and videos.

Firebase notifications will also be used in the proposed system. It has the notification console GUI where one can create and send notifications to targeted users.

2.7 Conclusion

Mining is an occupation fraught with many dangers, the operations take place underground which is in some cases may be several kilometres underground therefore it requires maximum caution and the observance of safety regulations designed to minimise the dangers inherent in mining and ensure safety of miners. The safety health environment regulations should deal with the responsibilities of managers and owners, surface protection, protection in working places, shafts, outlets of underground mines to the surface, ventilation, gases, dust, mine surveying, coal mines and fiery mines, winding, underground vehicles, raising and lowering people out of and into the mine, machinery, boilers, compressors and pressure vessels, elevators and electrical apparatus. They also set out the powers and duties of inspectors and the procedures to be followed in the event of an accident.

CHAPTER 3: ANALYSIS PHASE

3.1 Introduction

The evaluation of the old system and the assessment of the new system's objectives which was clarified in the previous chapter created a path to the analysis phase of the new system that is to be developed. According to Lahaye et al (2014), system analysis is a method that focuses on the inspection, modelling and transformation of information with the goal of bringing out data that is valid since a standard and good deliverable artefact is the one that suites the operators' anticipations. This chapter will basically focus on the information gathering techniques that were used to gather information in development of the project, their advantages, disadvantages and findings, weaknesses of the existing systems, rationale of the proposed system, requirements analysis which aspects at functional and non-functional requirements, functionality and processes related with the current system and the direction of flow in relation to how they will be connecting and synchronizing with the new system and the conclusion.

3.2. Information gathering techniques

These are procedures used to obtain information from different sources, the information obtained will be used to identify the problem of the current system and possible ways to resolve them (Roach, 2019). The methods were engaged so as to obtain comprehensive, practical and realistic information from people involved in the activities of the existing system. Roach (2019), suggested that a data gathering technique is aimed to define the procedures to be followed so as to obtain relevant information needed. Interviews, internet, library books and newspaper classifieds were used in obtaining the required information.

3.2.1 Interviews

According to Roach (2019), an interview refers to a chat between two or more people, one being the interviewer and the other being the interviewee so as to get data concerning a specific subject. Fourteen individuals were questioned regarding the operation of the existing system at Jena Mine near Kwekwe. The interviews involved the two surveyors, four engineers and eight miners who have knowledge on how the mining process is accomplished. The interviews were

conducted in two ways namely structured and unstructured interviews. This was done to obtain vast information about the current system.

3.2.1.1 Structured Interviews

Roach (2019), hypothesized that a structured interview is an evaluation process that is created to rate candidates' work-related capabilities through a logical inquiry in relation to their past know-how behavior and how they tend to act in theoretical scenarios. It was regarded to be a personal method as evaluated to others because the interviewee would be answering the same scheduled questions in the same sequence of order.

3.2.1.2 Unstructured Interviews

This type of interview did not make use of scheduled questions as it intends to obtain as much data as possible. The interviews were conducted secretly by the researcher. The employees were approached and asked about the current status of the existing system and how viable it was at the moment.

3.2.1.3 Recommendation

The unstructured interviews tended to be the best as compared to the structured interview since interviewees ended up sharing information which the interviewer would not have asked for and some of the points they would highlight are of great importance. The interviewees were given the platform to air out all their ideas and to explain. Contrasting with the structured questions where the interviewee was only guided with the provided questions and was only required to answer a given question. Use of the unstructured interviews allowed the researcher to gather all the particulars regarding the existing system.

3.2.1.4 Advantages of interviews

- The data obtained was reliable since the interviewer had a chance to ask where he or she was not understanding. Clarity was given to questions that the interviewees did not understand through this process it made the source more reliable.

- The mine workers felt being part of the project and this enabled them to be free and open to the questions being asked by the interviewer since every mine assures safety first.

3.2.1.5 Disadvantages of interviews

- Some mine workers participated very well during the course of interviews however they were other workers who were not willing to participate and even to collaborate with the interviewer. This has made interviews difficult to conduct and some information was never clear to the interviewer.

- The majority of the mine workers have no vital information about what is really happening in the mining process, so the interviewer had to look for the supervisors.

- The major problem faced was that some of the mine workers wanted to provide false information due to fear of the unknown to the introduction of the new system.

- Various mines operate twenty-four hours a day so it was difficult conducting the interviews since the interviewer had to wait for the targeted people to finish their business and daily activities.

3.2.1.6 Findings from interviews

Interviews were conducted with various interested parties from different field areas at the mine such as safety, health and environment department, mining sector itself and the health service team. From these interviews the interviewee obtained various information about mines, how mining itself is done, what challenges are they facing as mine workers and what equipment is needed.

3.2.2 Questionnaires

Roach (2019), is of the view that questionnaires are kind of questions arranged in a manner that suites a certain section provided or set by the researcher. The questionnaire may include a number of alternatives where people would select accordingly, there can be yes or no responses and the kind of responses delivered can be simply transformed into quantitative information that is useful to the project research.

3.2.2.1 Recommendation

The questionnaires were kind of questions that needed response above one word and they may be in various methods, some maybe a sentence, a paragraph or a list. They were not focused on one-word feedback and some of the questions required further clarification.

3.2.2.2 Advantages of questionnaires

- The researcher obtained more detailed information about mines within a short period of time and it was very cost effective, questionnaires were distributed to different sections of the mine and each miner was given room to answer at his or her own free time.
- The researcher quickly and easily quantified the results of the questionnaires and it made possible for the researcher to compare and contrast other researches and she used the questionnaires to measure change.

3.2.2.3 Disadvantages of questionnaires

- The researcher had challenges with mine workers who had no idea about the mining process. The responses were vague and made it so difficult for the researcher to come up with a conclusion on those provided responses.
- Some of the responses tend to be more biased.
- Some responses obtained by the researcher lacked systematic responses because some mine workers were not competent enough to answer the questionnaire.

3.2.2.4 Finding from questionnaires

Questionnaires provided vital information on health condition required for a mine worker to be able to work in the mine and the answers indicated that a worker has to go through medical testing and review first before starting work and the safety issues associated with mining.

3.2.3 Observations

According to Roach (2019), an observation is a method normally used for case readings. This is a process whereby the researcher visits a place of operation to investigate how operations are carried out, competence of the existing system and its methods of operations. The technique encompasses physical interaction and noticing how the subordinates will be handling their operations.

3.2.3.1 Advantages of observations

- This procedure of conducting observations offered the researcher admission to some circumstances where the use of questionnaires and interviews would not spread.
- The researcher's results were less biased since the mine workers were not aware of what was taking place at the particular time.

3.2.3.2 Disadvantages of observation

- During the course of the process the researcher was not able to get the adequate information because sometimes human behavior is unpredictable. The actions of the subordinates at that particular time were not constant so coming with the correct judgement was difficult.
- The scheduled time made by the researcher sometimes would clash with some activities because they were happening the usual times.

3.2.3.3 Finding from observations

The researcher managed to acquire information such as how many people are needed and what do miners need to wear when they are working underground. The mine workers need to comply with the safety rules and regulations and wear safety clothes such as helmets, day and night vision googles, safety shoes and work-suits.

3.3 Weaknesses of the existing systems

In this modern world information and communication technology is critical in determining how business processes are being completed and handled. Completion of this project will help miners have better operating environments and quick sharing of information among them which will govern better service and healthier and safer environment to the workers and the people around. The existing way of operating causes surveyors to have problems in working together corporately as many of them will be based in different locations of research. Due to the use of outdated manual maps being used surveyors are failing to locate the best landscape with the best minerals. Miners have had difficulties with falling rocks and falling ground while underground mining due to poor surveying. Miners face problems in gathering information, data duplication, inaccurate calculations and time wastage while camping in the field of research.

3.4 Rationale of the proposed system

The proposed system will assist surveyors and miners to improve the mining environments and processes, improve safety in mines, increase productivity in mining companies and reduce costs during operations of the plant and equipment. The system will help in reducing workload for surveyors as the data analysis will be done on the application and the application will analyze and record all places accessed depending on the period stated and also allow other surveyors to access individual areas of data capture and analysis.

The application will also help the surveyors with decisions that may seem difficult and will improve performance in processing procedures.

3.5 Requirements Analysis

Grady (2014), defined requirement analysis as a stage that is conducted to understand the user requirements and anticipations from the system they want, it gives the professional systems engineer the tools to set up a proper and effective analysis of the resources, schedules and parts needed to successfully undertake and complete any large, complex project. The requirement analysis phase of the proposed application could be determined by considering the user's requirements and anticipations of the application. It was perceived as a portrayal of how an application must act or an explanation of application elements. Requirements are divided into functional and non-functional requirements which will be discussed below. Functional requirements are tasks that the system must support, whilst non- functional requirements are constraints on various attributes of these tasks (Hamilton 2015).

3.5.1 Functional Requirements

Roger (2013), is of the view that functional requirements explains a set of same features which involves inputs, processes, outputs and the information required for the gratification of application aims. It also indicated the key system's functionality and also considers the requirement in terms of handling of information, technicality and also the proposed limitations. The suggested systems functional requirements are as follows:

- The application should have a security mechanism in a way that no intruder can access it.

- The system should allow surveyors to come up with comprehensive, precise decisions since they will be sharing of information from different views and places.

3.5.1.1 Use Case Diagram

Kuinam (2017), defined a use case diagram as a graphical representation of the user interactions with the system. The diagram shows all the different interactions that the user is involved in and it provides a sequence of actions the user takes when using the system. It shows the behaviour of the system, the user goals and the functional requirements. The use case diagram is shown below for the Safe Miner Android application:

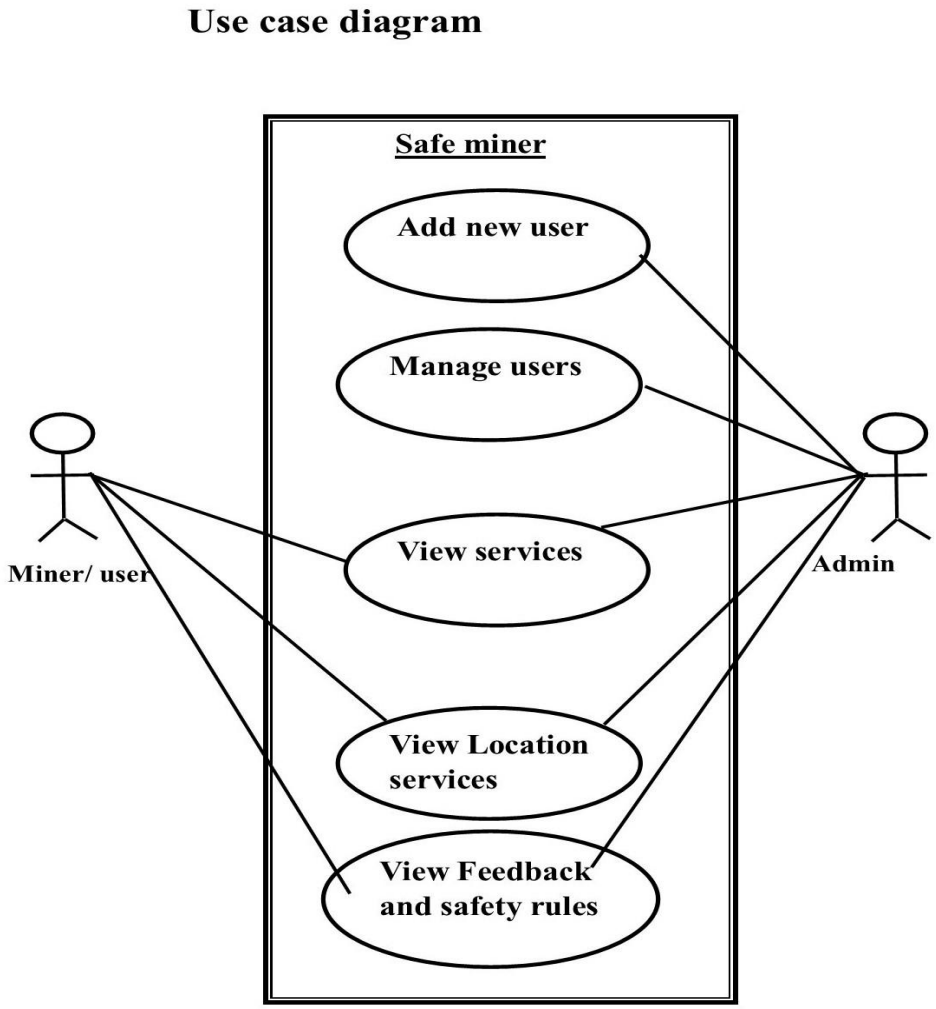

Figure 3.1 use case diagram

3.5.2 Non-functional requirements

Roger (2013), indicated that non- functional requirements seeks to explain the attributes and qualities of the suggested application. They put some limitations on the system being created. They are limitations that propounds the competences of the application with relative to its presentation in terms of safety, response time, ease of use and reliability. The following are the non-functional requirements linked with the suggested application.

- User friendly- it should be friendly and easy to work with.
- Professional interface- the core interface must be easy to interpret.
- Error handling- it should give a space for error retrieval.
- Response time- the system should be fast to respond to the queries.
- Ease of use- it should not be unclear, it must be simple to control.
- Security- the system must provide a robust security mechanism to cater for private information.

3.5.2.1 Constraints

- Adequate funds- the funds could fail to sustain the completion of the project due to under estimations.
- Costs- the developer might fail to meet the costs associated with system development.
- Time frame- due to some hindrances or delays the project mighty fail to be completed within a specified time.

3.6 Conclusion

In conclusion, the use of new technologies in the connected world is inevitable, as it offers the best in class means of secure and cost-effective communication with thousands of points today. Information and communication technology can be applied to the entire mining and mineral extraction value chain and lifecycle. There is no doubt that the future landscape of mining will be a digital landscape soon. Companies must invest in tools and analytics that will allow them to become a modern digital mining company. The future will be digital- digital camera, videos, electronic document storage, network data collection, intelligent search software to see trends and optimise operations. The minerals industry is no exceptions, even though it can be slow to accept new technology. Mining industry as we have seen it in the past has been a laggard when it comes to technology adoption. It is time new tools and mobile applications are used for data collection and analysis.

CHAPTER FOUR: DESIGN PHASE

4.1 Introduction

This part of the chapter outlined, for example, the design stages to be undertaken by a project; it explored the improvement of the new system by achieving part of the analysis as well as fully understanding the needs of the new system to be developed. The chapter will focus on the actual system design structure to clarify how the system works, architectural design, physical design of the developed system, database design, program design which is explained through the package and class diagrams, interface design, pseudo code is written and the security design will also be discussed.

4.2 System Design

The purpose of this step was to form procedural clarifications that satisfied the project's helpful needs. There was a well-designed description written in the mining industry during the project lifecycle at that stage, which included a complete explanation of the operational requirements. This was more like preparing the new system component specification, so different system parts were built.

The features included in the system design were as follows:

Maintainability

The system was simple to keep in the event of innovations or modifications. Added characteristics resulted in external information alteration, therefore, these modifications were flexible.

Effectiveness

To decrease costs for mines, it was simple to run the system and as a consequence gave some advantages. During the process of creating the new system, however, anyone who was to run the system had to be included in order to use the system effectively through information collection methods.

Reliability

This implied that the new system to be created had to stay reliable, which is to be the right place if an application has to detect a customer location. The inputs, procedures and output anticipated from the suggested scheme were presented below:

4.2.1 Context Diagram

There was a difference in the current system context diagram to the new system in that additional entities were added to ensure smooth process flow and efficiency.

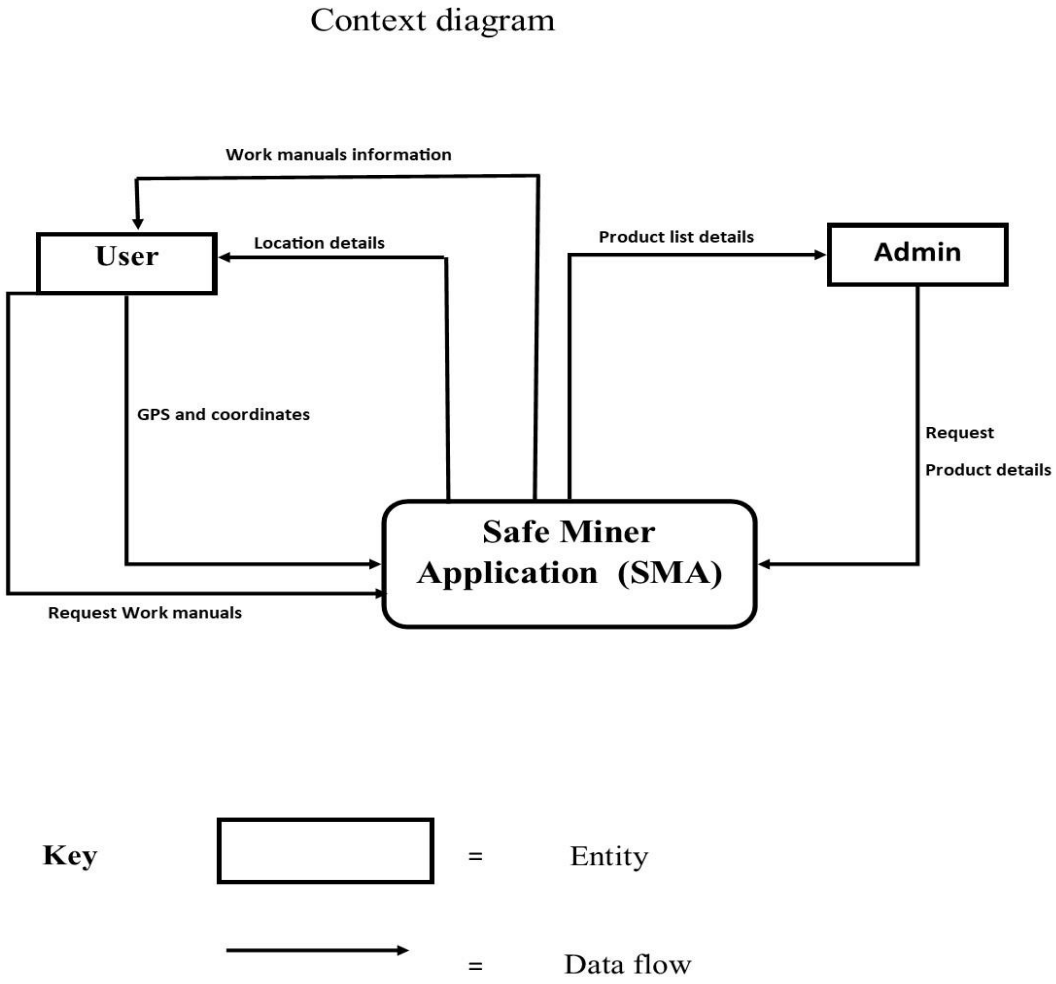

Figure 4.1 Context diagram

4.2.2 Data Flow Diagram

Pierce (2015), described an information flow diagram as a drawing that demonstrates how the link of entities, procedures and information to a system setting is made. Data flows are also represented in the information flow diagram by linking the main procedures, sources, destinations and data stores. Data flow diagram components lead straight to physical design, with processes proposing composite programs and procedures, information flows, and information shops proposing information entities, files, and databases. The suggested system's data flow diagram is shown in figure 4.2 on the next page:

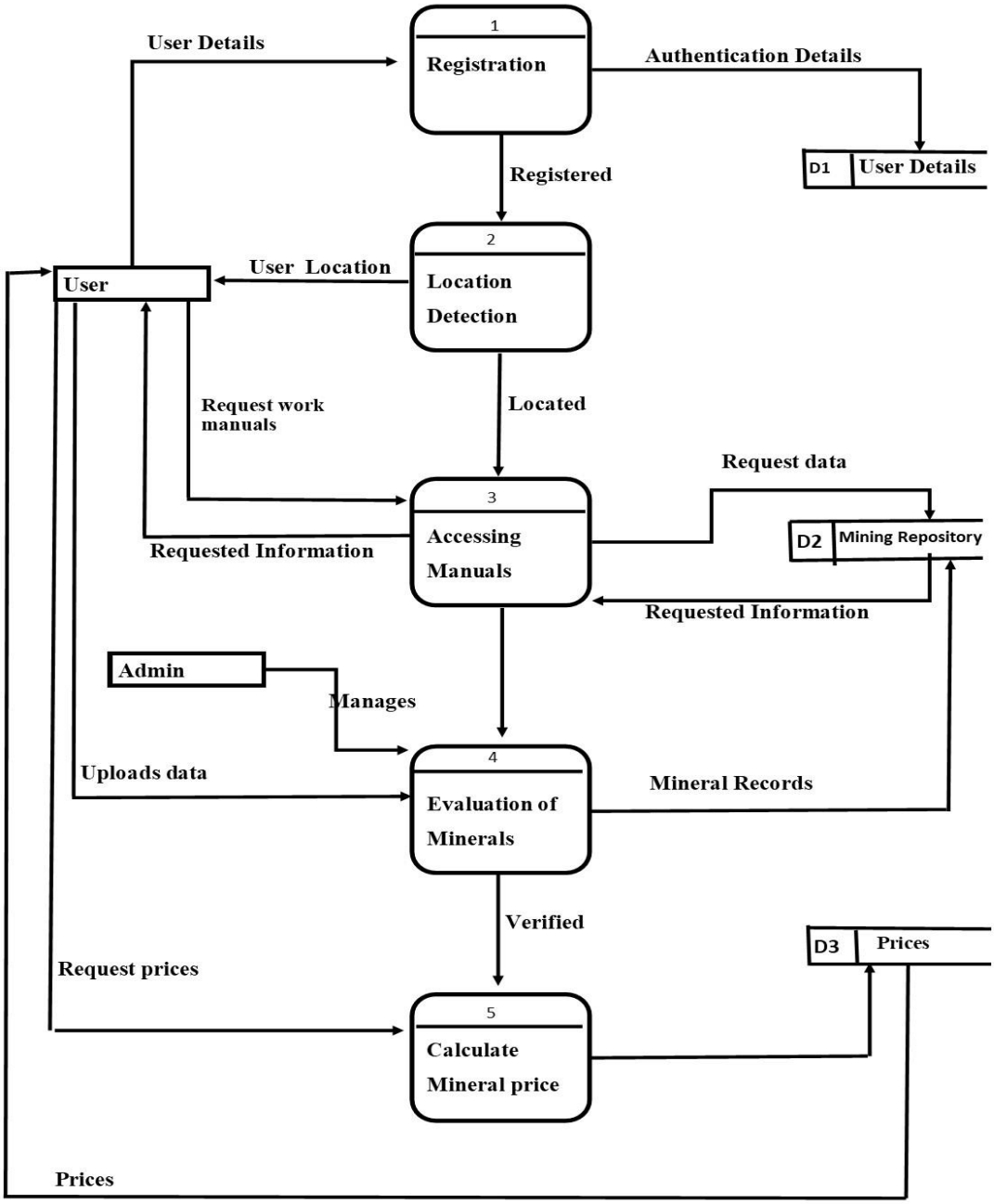

Figure 4.2 Data flow diagram

4.3 Architectural Design

According to Ulrich (2016), architecture relates to the collection of important choices about software system organisation, choice of structural components and necessary system interfaces as the system's behavior. In the design of the architecture, communication between significant system parts is also recognized. The main goal of architecture design is to develop a modular program structure. It also melds the structure of the program and the structure of the database, defining interfaces that allow information to flow through the scheme. This was aimed at recognizing the system components that were used and included data control and flow between those components and the functions to be performed such as information input and output. These designs comprised of:

Server – All the data that organizations use for storage was collected and maintained. The user used a web browser to request web pages from the web server. This led in the user web browser being brought out the desired page. The default browser used was Mozilla Firefox.

Network cable- they were used to allow communication between Wide Area Network and Local Area Network links.

Client android device – A machine linked to the internet or a network and accessing another machine known as the server required distinct types of resources to save data. It has also been used to conduct certain duties or functions. It is also referred to as the requesting machine because the server requests information.

4.3.1 Client server approach

Schreiner (2016), hypothesized that it was an effort which tend to show the communication which occurred between the client and the server. Furthermore, the database acted as server which implied that each and every query that is made by the client would be acted upon through the use of the database hence defining this kind of the approach, as illustrated below:

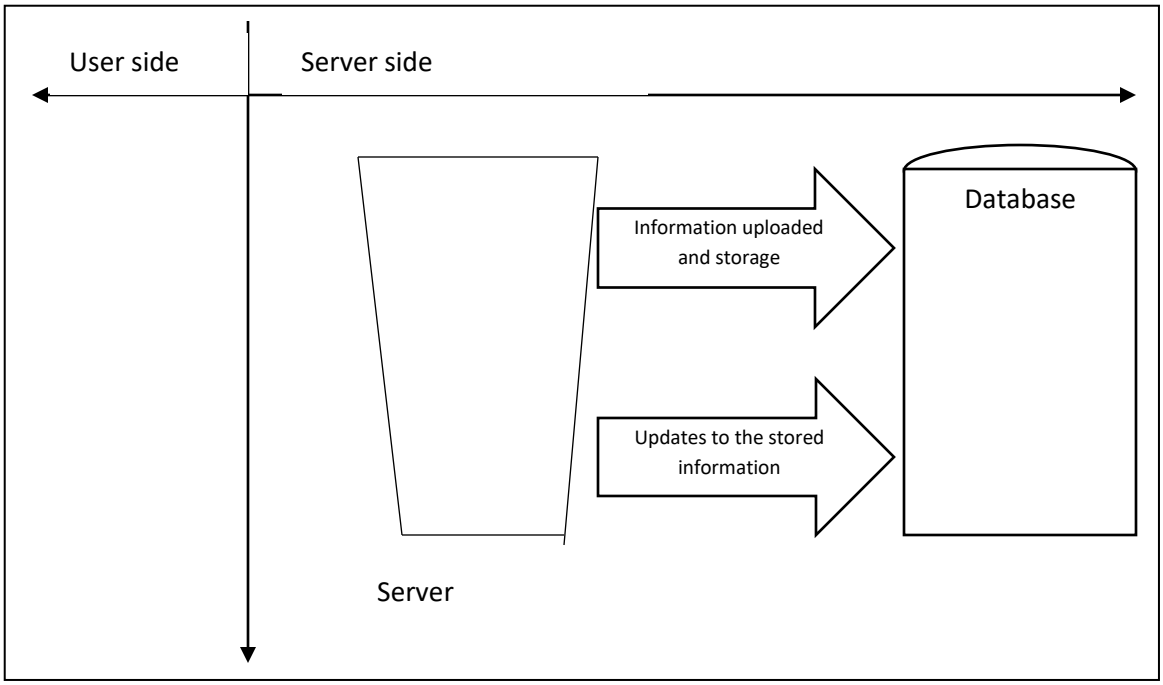

Figure 4.3: Architectural design

4.4 Physical Design

According to Lonnie et al (2013), physical design is concerned with designing how the suggested system's hardware and software components will be laid out and how they will interact. In this physical model, which is the procedures under account, the real procedures of the scheme are processes of input and output. The main focus will be to check how data is captured until it is produced as output. The required hardware and software have been met and available as previously stated in the feasibility study above, meaning that we should use the required hardware and software without incurring additional costs for the proposed system to work well. The physical layout of the scheme suggested on the next page:

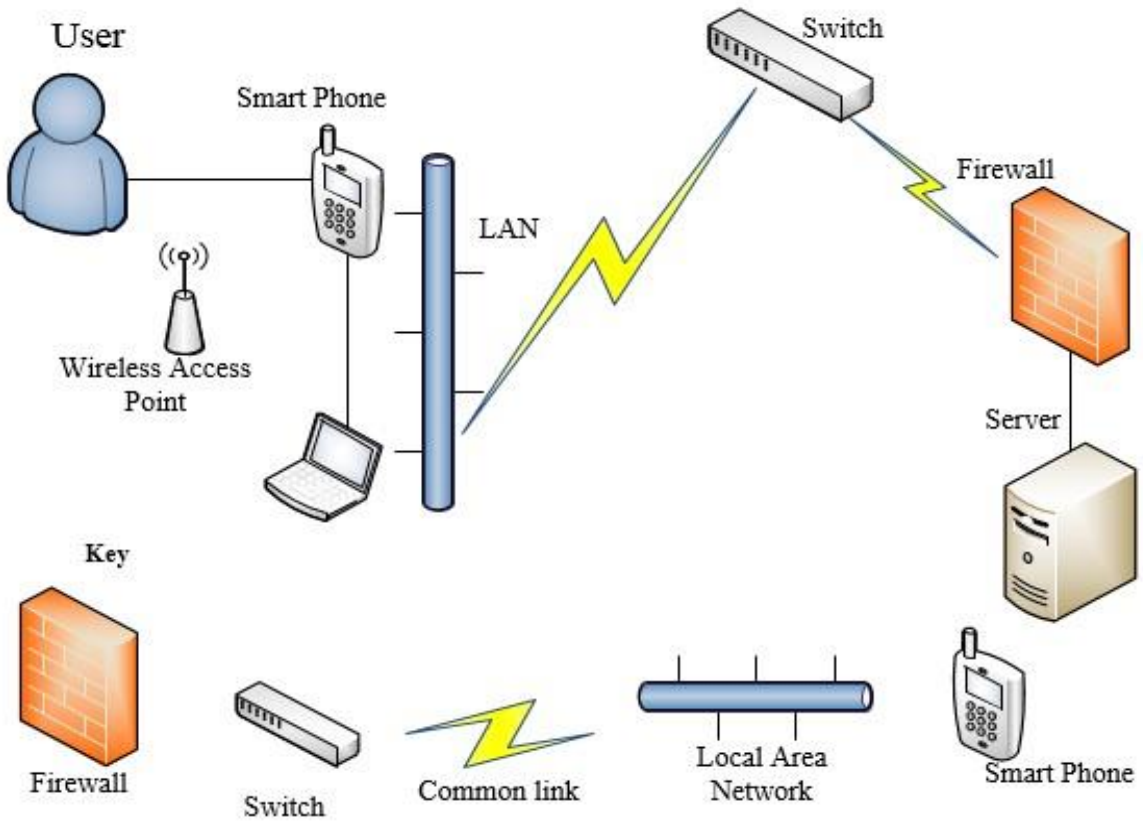

Figure 4.4 Proposed physical design

4.5 Database Design

This was a technique of creating a complete data model or a whole database system of a database. This involved the logical data model that had all needed designs ranges such as physical and logical.

External Level

A given database generally had many external schemas each corresponded to the way in which a specific application program viewed the database. An external schema corresponded directly to a user view. A user view existed in the form of a chart drawn on paper.

Conceptual level

A conceptual level is described all the different types of data elements that were stored in the database and the relationships among them. All the external schemas were derivable from the conceptual schema. In effect the conceptual schema was a computerized representation of a logical data model

Internal Level

This defines the actual data that was stored in the database. It was a computerized representation of the physical data structures that were used to implement a conceptual schema. Computerized descriptions of the physical data structures defined the data files that made up the database to both the database software and operating system software. How data was stored was described in this stage.

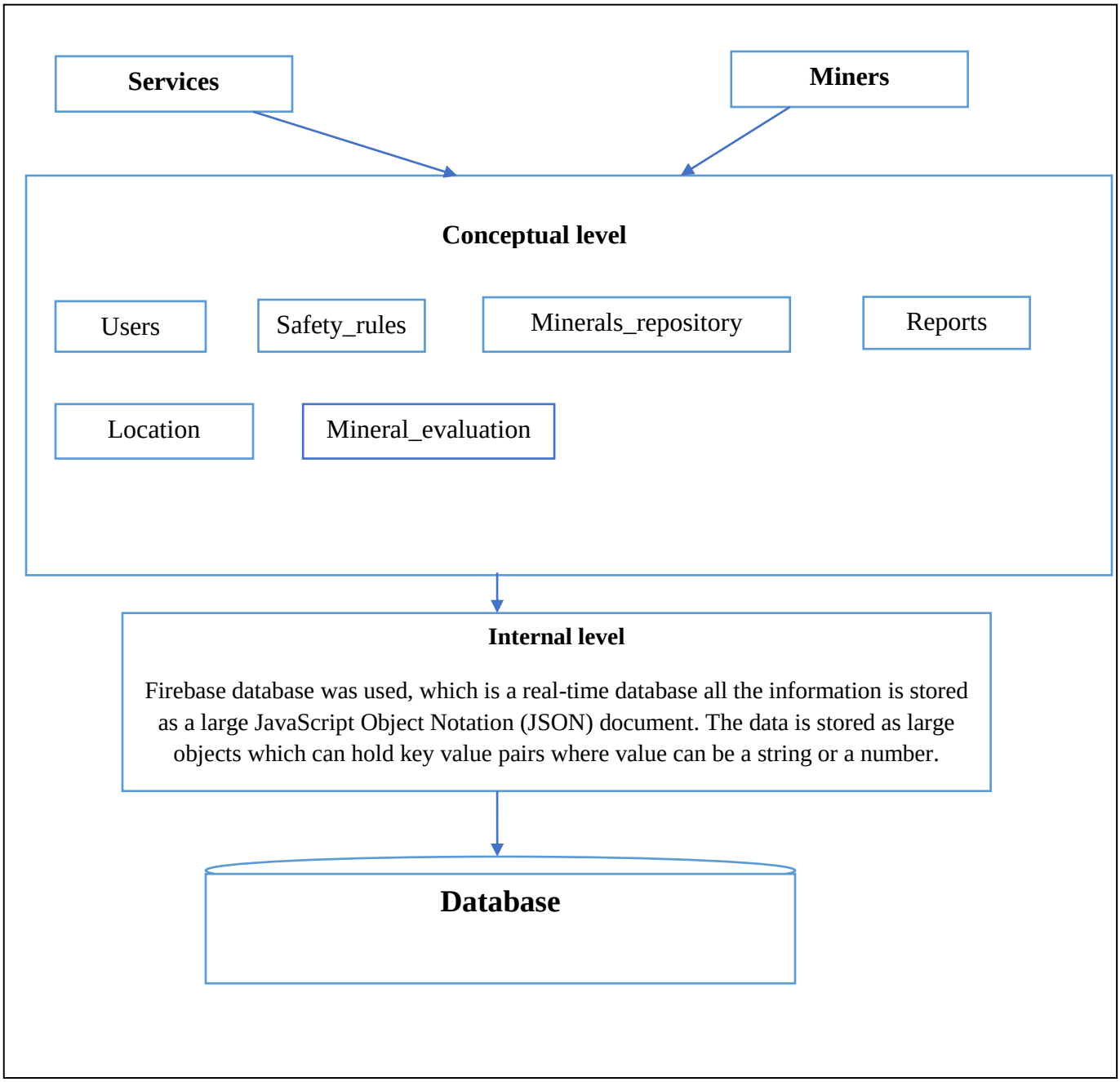

Figure 4.5 System database architecture

4.5.1 Tables of the proposed system representing application database

User registration table

The user registration table mainly kept the information of mine workers who had been registered with safe miner android application.

Title	Length	Datatype
User_id <PK>	15	String
Name	10	String
Surname	10	String
Password	10	Alphanumeric
E-mail	12	Alphanumeric

Table 4.1 user registration table

Minerals repository table

This was designed to store details of the minerals:

Title	Length	Datatype
Mineral_id <PK>	20	Alphanumeric
Name	10	String
Description	10	String
Type	10	String
Colour	10	String

Table 4.2 minerals repository table

Safety rules table

This was designed to store safety rules used in mines and to keep record of the updated rules and the date when an update is made:

Title	Length	Datatype
Rule_id <PK>	10	String
Rule_description	25	String
Date_created	10	Date and time

Table 4.3 safety rules table

Minerals report table

Title	Length	Datatype
Mineral_id <FK>	20	Alphanumeric
Name	10	String
Description	10	String
Type	10	String
Colour	10	String
Report_id <PK>	10	Alphanumeric
Amount_of_minerals	10	Integer
Date_created <FK>	10	Date and time

Table 4.4 minerals report table

User list report table

Title	Length	Datatype
User_id <FK>	15	String
Name	10	String
Surname	10	String
Password	10	Alphanumeric
E-mail	12	Alphanumeric
Report_id <PK>	10	Alphanumeric
Number_of_users	10	Integer
Date_created <FK>	10	Date and time

Table 4.5 user list report table

Mineral evaluation table

This was designed to make miners upload their inputs for online evaluation through the use of pictures over the application.

Title	Length	Datatype
User_id <FK>	15	String
Picture <PK>	10	Picture(img)
Location	15	String
Mineral_type	10	String

Date_created <FK>	10	Date and time

Table 4.6 mineral evaluation table

4.5.2 Enhanced entity relationship diagram

Enhanced entity relationship diagram was a high-level data ideal that joined the extensions to the original entity relation model. It was a diagrammatic technique for displaying the following concepts such as sub class and super class, specialization and the generalization.

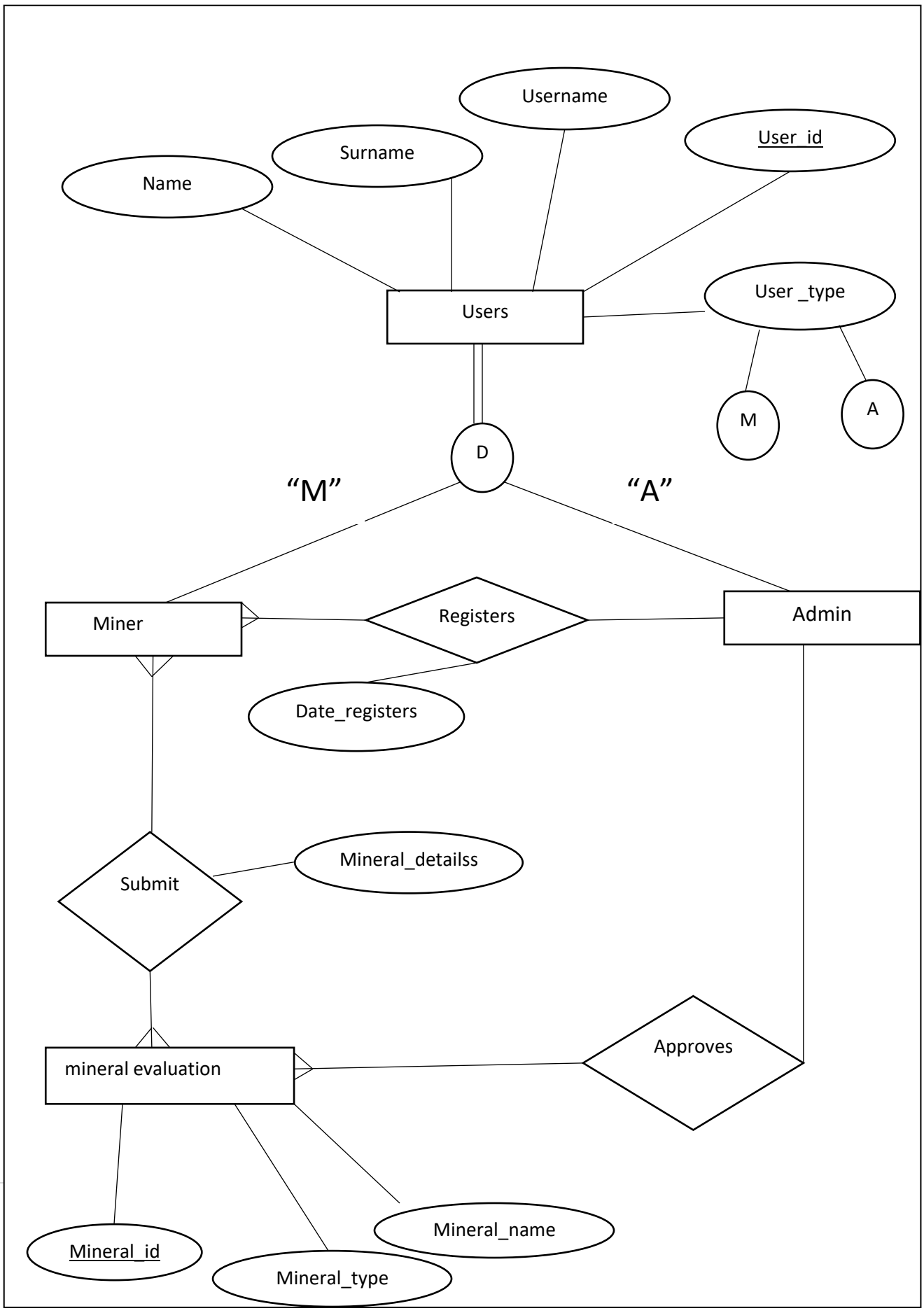
Username
Surname
User_id
Name
Users
User _type
M
A
D
“M”
“A”
Miner
Registers
Admin
Date_registers
Submit
Mineral_detailss
Approves
mineral evaluation
Mineral_name
Mineral_id
Mineral_type

Figure 4.6 Enhanced entity relationship diagram

4.6 Program Design

Ulrich et al (2016) is involved in program designing the classes, functions and modules of the proposed system. The design of modules and classes of the suggested scheme is taken into account in this stage of tasks. A structured methodology is adopted during the design of the scheme. The focus of this methodology is on breaking down the scheme into a subsystem. Three diagrams are used to illustrate the design of the program which is the diagram of the package, the diagram of the class and the sequence.

4.6.1 Package Diagram

Ulrich (2016), defines this as UML structure which shows packages and dependencies between the packages.

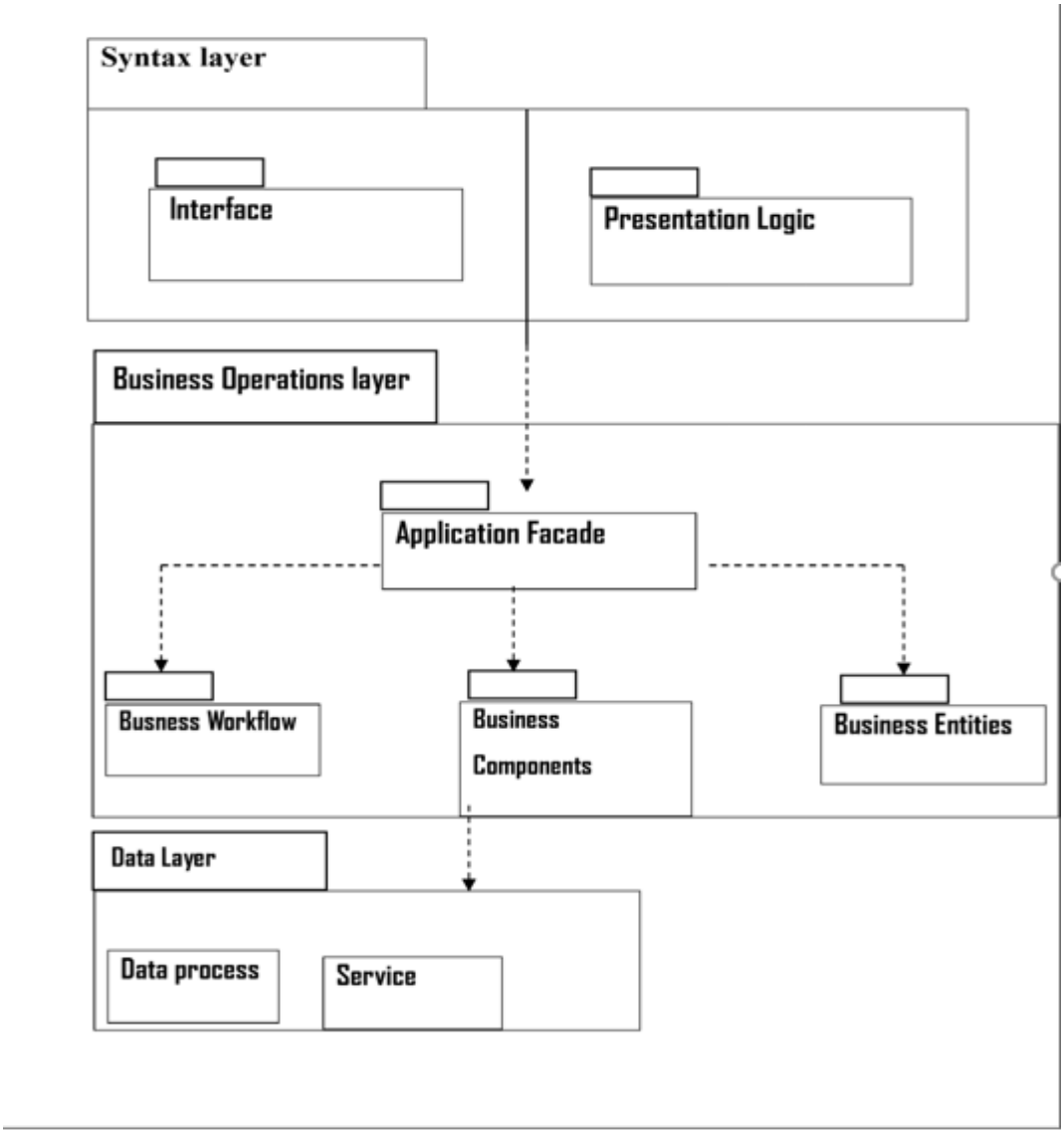

Figure 4.7 Package diagram

4.6.2 Class Diagram

According to Beynon (2014), class diagrams refer to a type of static structure diagram that describes the structure of the system by displaying system classes, attributes, and class relationships. Class consists of two primary relationships that are association and inheritance that can occur between them. An association that is a member of a second class is used by one class to represent the relationship cases of each class. Generalizations is another word used for inheritance that defines the significant super-class and sub-class connection. Class diagram

demonstrates the interaction of proposed system classes that is in terms of its behaviour and expected states this can be illustrated as show in figure below:

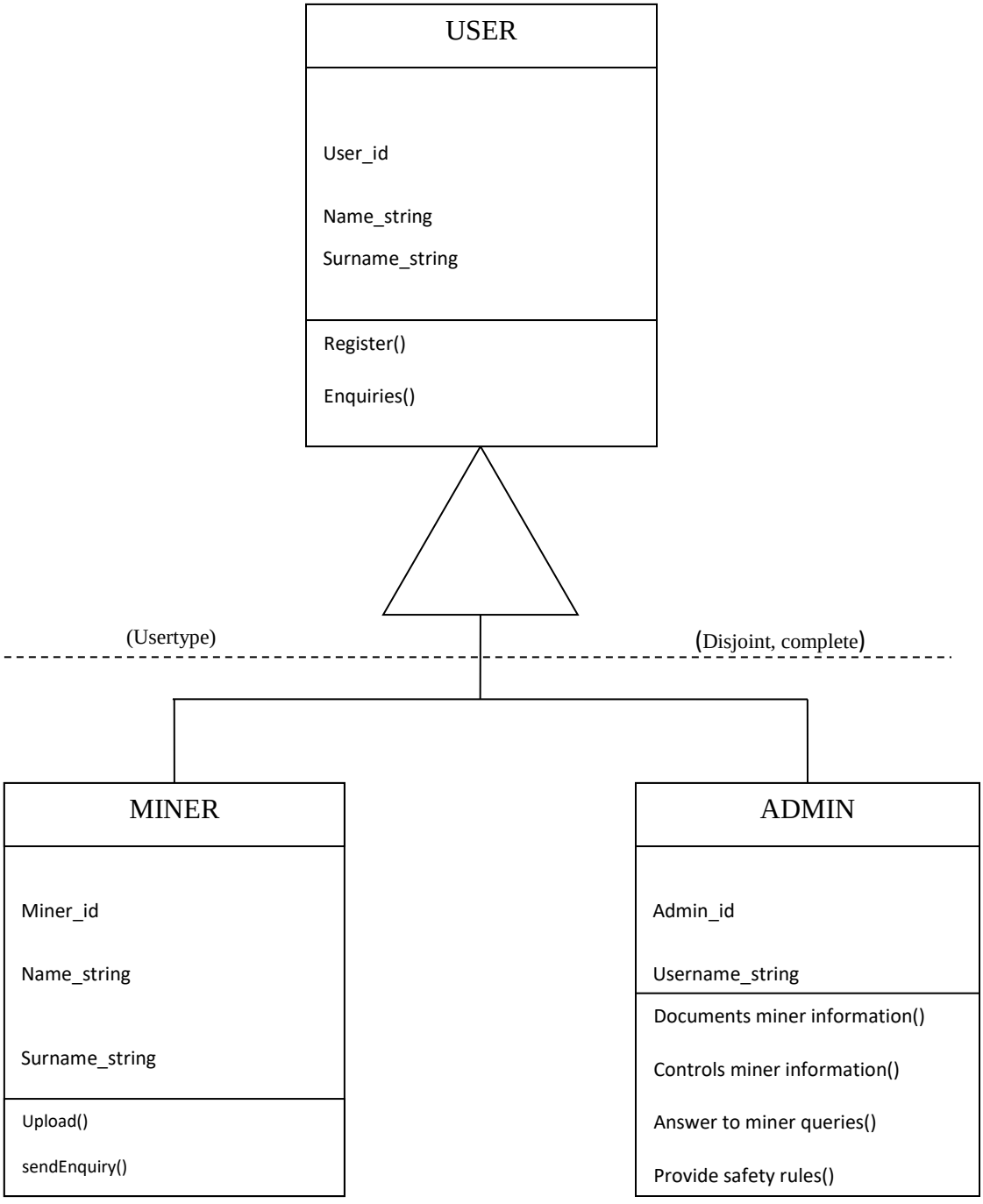

Figure 4.8 Class diagram

4.6.3 Sequence Diagram

Beynon (2014), defined sequence diagram as a model of the flow of system logic in a visual manner which will enable one to validate and document logic. Analysis and design phases commonly use the sequence diagram. The sequence diagram of the proposed system is shown in the figure 4.9 on the next page:

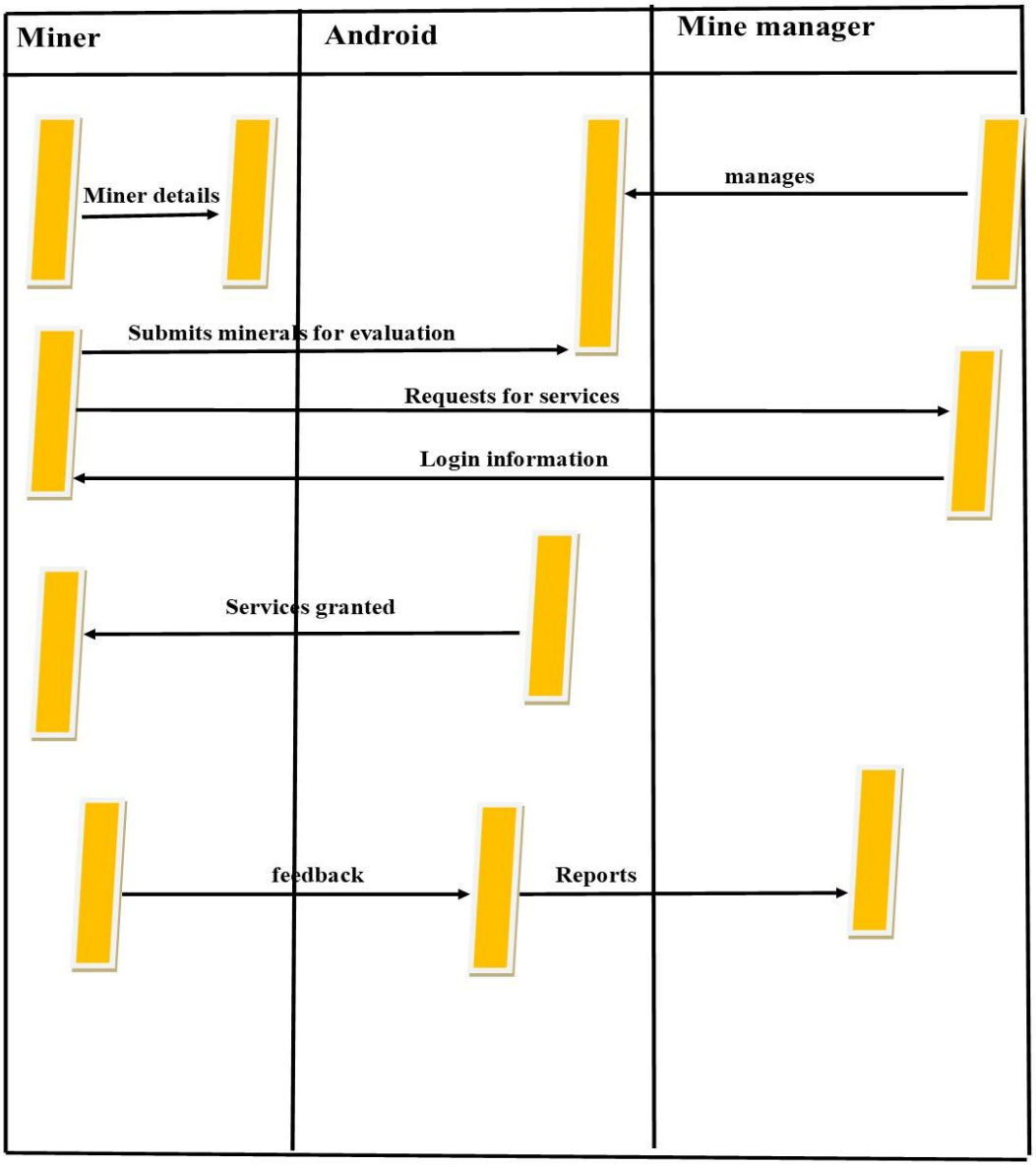

Figure 4.9 Sequence diagram

4.7 Interface Design

Lauren (2014), described interface design as user interaction and experience-focused computer designs, computers, software apps, websites and mobile communication devices. This is where forms and menus for information input into the scheme are made for the interfaces design secure miner implementation. In this situation, this interface design outlines the input and output structure.

4.7.1 Menu Design

Safe miner android application menu consists of user login interface in which the user should input the credentials to access the system. When the user credentials are verified the user will be redirected to a page where he or she proceed in doing his or her businesses and other activities.

4.7.1.1 Main Menu

Safe miner android application main menu comprises of the menu of mining activities which are offered in the mines and the navigation bars of the application.

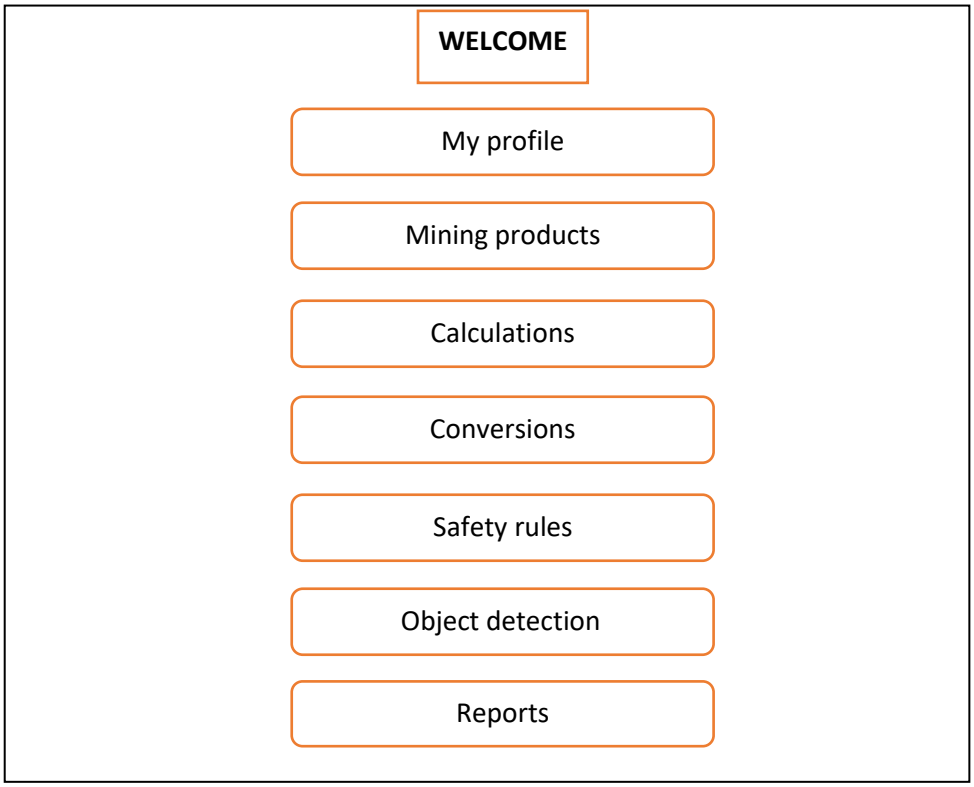

Figure 4.10 Main menu design

4.7.1.2 Sub-Menus

This refers to secondary menu that appears while one navigates to another menu.

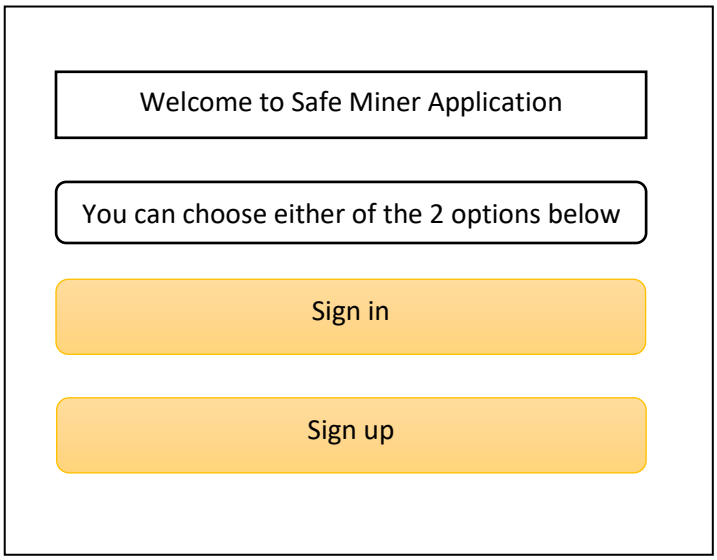

Figure 4.11 safety issues sub-menu

4.7.2 Input Design

According to Lauren (2014), input design refers to the conversion process of a user-oriented description of input into a system. Validation of inputs, error avoidance and making the process simple is the major concern of the input design. The more the quality the system input have is the more the quality of system output. The major goal of the input design is creating input forms that are easy to fill in details and easy to follow. Shown below in figure 4.12 is a form that shows an input of creating a new user.

User registration form

Below is the form for user registration form:

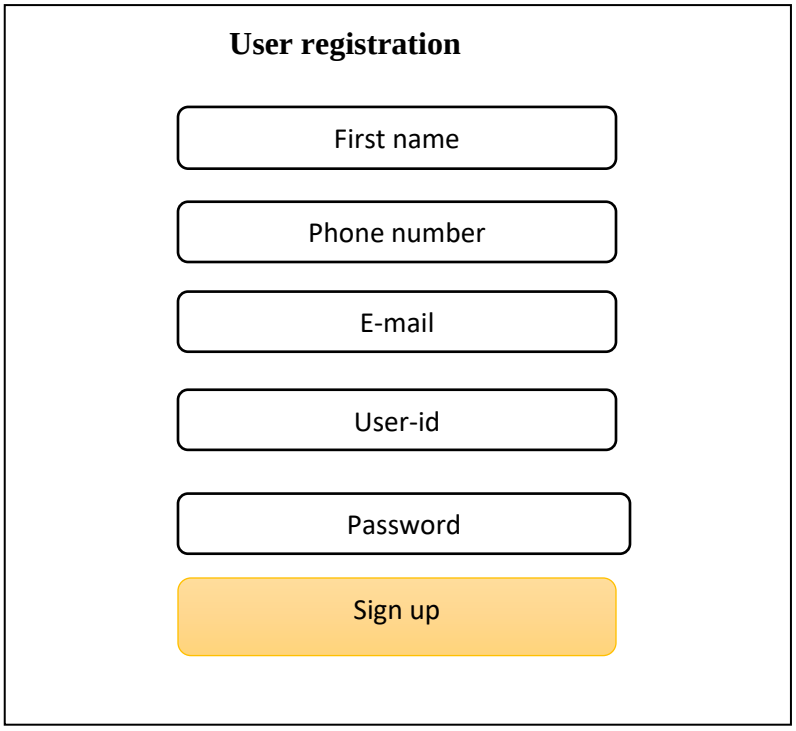

Figure 4.12 user registration form

User sign in form

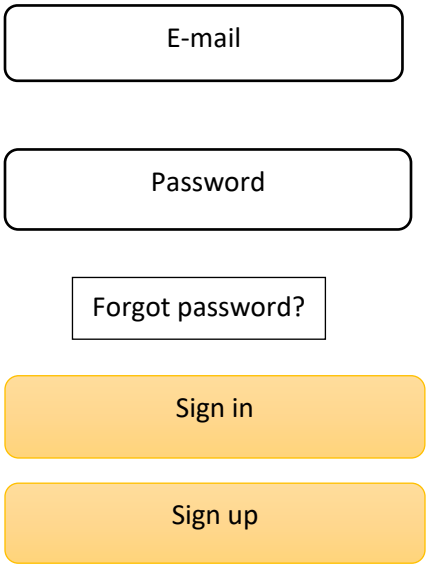

Figure 4.13 user sign in form

Checking platform

The form will be filled by the user given details specifying the type of soil or stones he or she wants to mine.

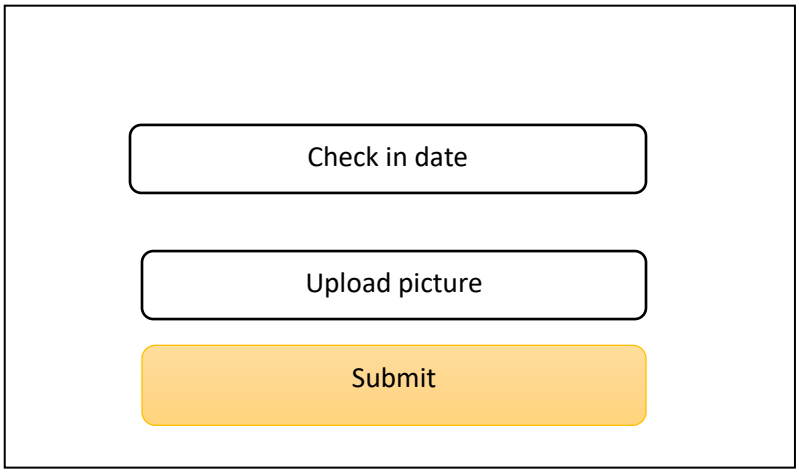

Figure 4.14 checking platform

Conversions and calculations

The form will be used to input data for calculations by a miner.

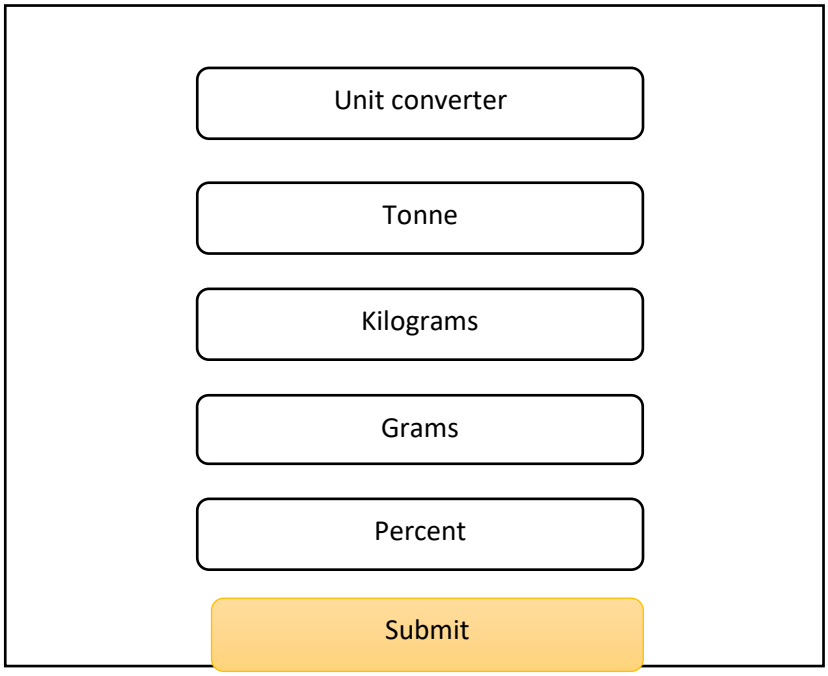

Figure 4.15 conversions and calculations form

4.7.3 Output Design

In order to satisfy the demands of end users, information should be provided clearly, Lauren (2014), considered output to be the significant source of user information. A clear and smart output design enables managers and customers to make decisions. Output design focuses heavily on how to display the data and how to produce the hard copy of the output. In real time, reports are updated as per user input.

Mining products

The form will display a list of minerals.

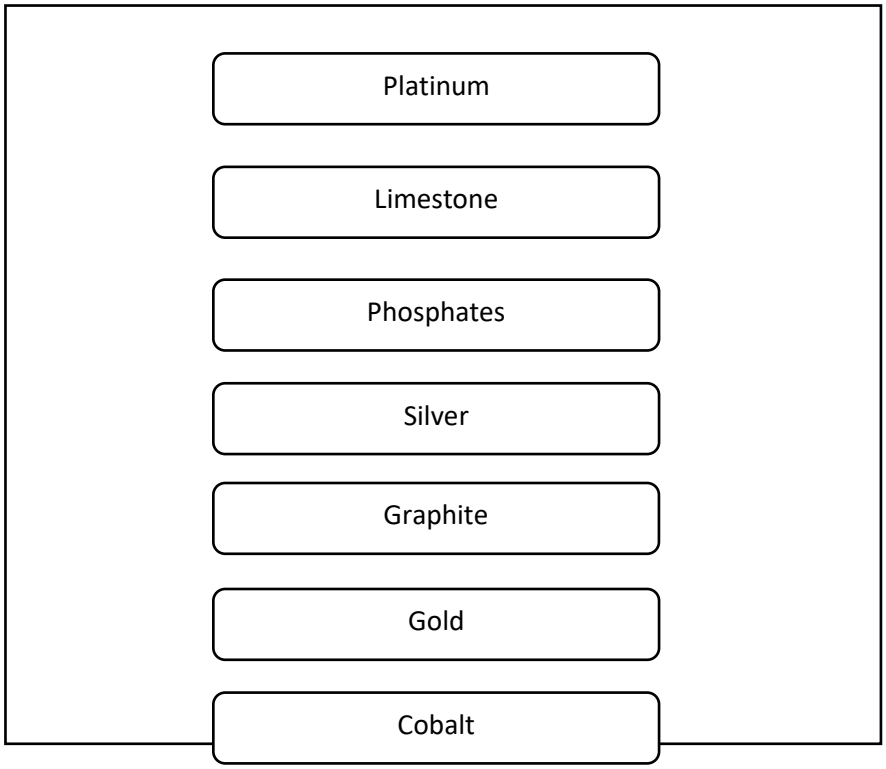

Figure 4.16 list of mining products

Mineral evaluation form

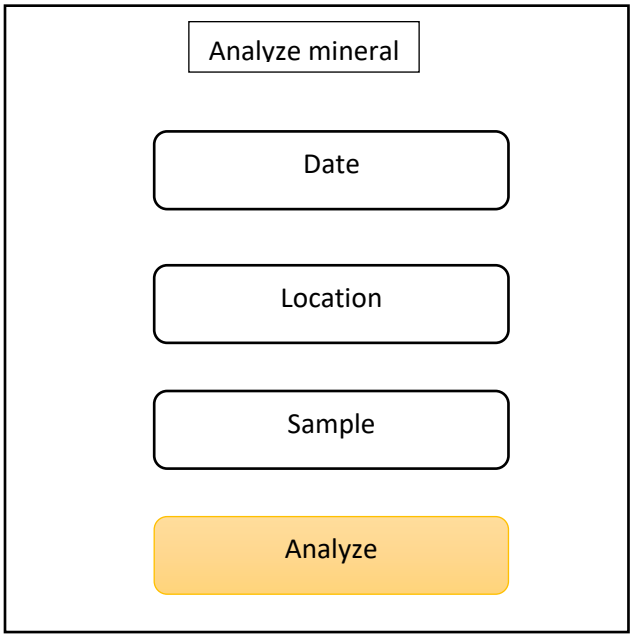

Figure 4.17 mineral evaluation form

Reports

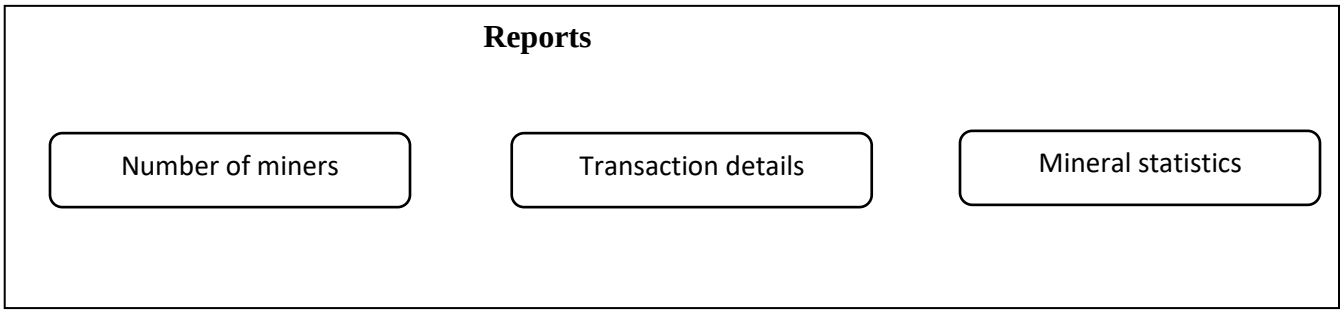

Figure 4.18 Report Interface

4.8 Pseudo Code

Stephen et al (2013) defined pseudo code as a description of a computer programming algorithm using programming language structural conventions but omitting detailed subroutines or language-specific syntax and the code cannot be compiled into an executable program. This is a rough code draft that needs to be inserted and transformed to a true scheme using a particular programming language. The main aim of this program is to make it easy for individuals to comprehend the processes that will be conducted to develop a true system code.

4.8.1 User Login

Sign Up New User

Begin:

Open safe Miner android app

Input username and password

Adding New User Phone Number

{ Function **Capture** New User Phone Number

{ Capture new User Phone Number;

Verify if phone number is a valid phone number;

If Yes

Then **accept** phone number and **Store** data in user table

Else

Enter new phone number;

Validate new user phone number

Store data in user table

Display confirmation details verify; end

} // close capture details function

}

Function Capture New User Information

{

Capture New Mine, Name, Location;

Store data in user table end

} // close capture details function

Accessing the main menu

{ Route User to the main menu

Accept selection made on menu options end

} // close main menu function

Issuing safety rules

{

If

user is registered

then

view rules //select rules from rules table

}

Report Generation

Click on reports

Values get validated

Then

Get result

Return 0;

}

4.9 Security design

Security development is the concept of software engineering so that under malicious assault it continues to operate properly. Most technologists recognize the significance of this undertaking, but they need some assistance in overcoming it. The investigator will use the username and passwords to avoid anyone from accessing the system at any moment and moment. Each computer that accesses the system and a camera function to take snapshots of system users also has mac address logging.

4.9.1 Physical Security

According to Field (2014), on physical security it defines physical security as the measures that an organization takes to make sure that no unauthorized access to system facilities, resources and hardware are granted through the use of physical barriers

4.9.2 Network security

It was the way to take visible and coding dissuasive measures to safeguard the fundamental application from unauthorized access, abuse, failure, alter or destruction, thus creating a controlled platform for pcs, customers and users to carry out their basic operations in a secure environment.

4.9.3 Operational security

It was a significant element in the creation of a safety system for protecting sensitive information and maintaining vital secrecy. IT consisted of five procedures beginning with the identification of critical data and implementing the suitable operational safety at the last point. All the procedures would go through the designed scheme. This is shown in the following figure below.

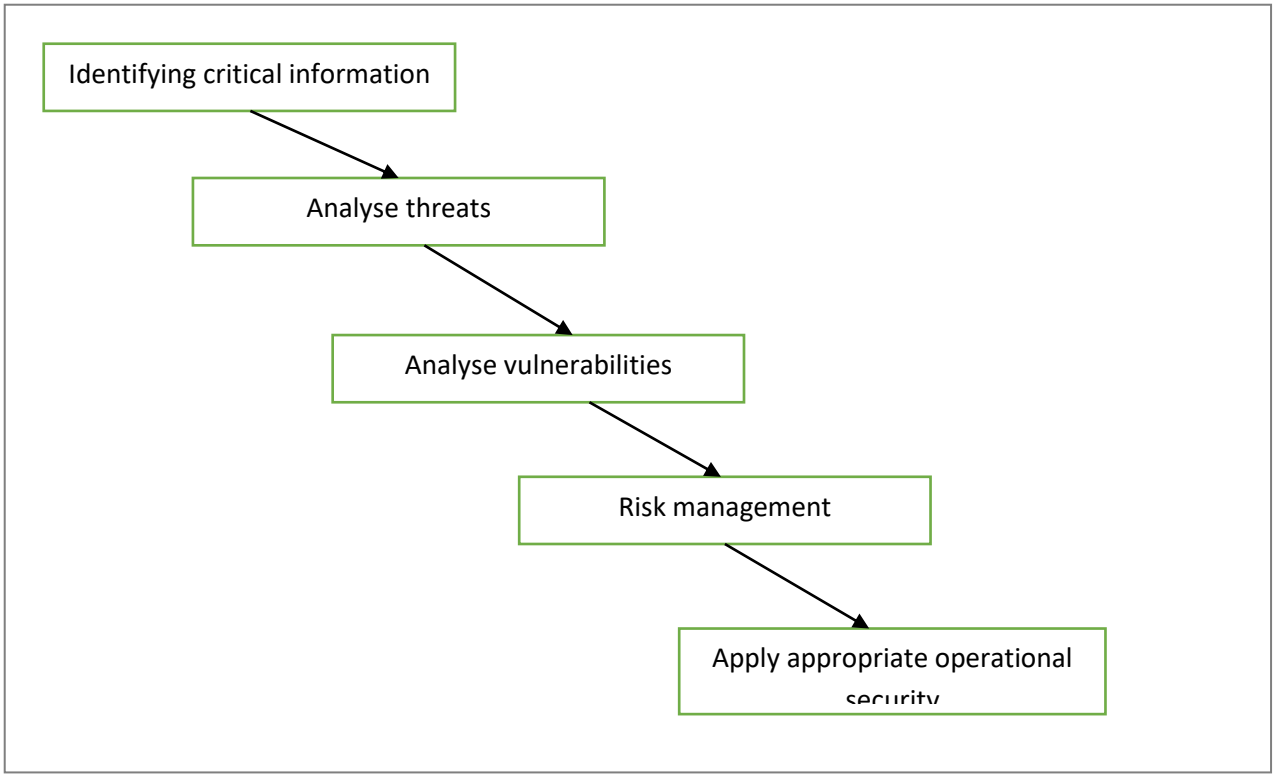

Figure 4.19 Operational security

4.10 Conclusion

The design stage showed the method the new application to be created, configured and installed and also highlighted how the application would function in a real environment. The design stage helped in the creation of user-friendly application which operators find simple to comprehend and work with.

Chapter 5: Implementation Phase

5.1 Introduction

In this phase the main focus is at the implementation of the safe miner android system, this phase encompasses the functionalities of the system, code snippets, snap shots of system testing, maintenance of the system, recommendations for further development as well as the implementation plans and the maintenance strategy to use. In this phase much attention is on system modules. It is a stage a deliverable is realized; a system is made up of units that are integrated to bring about a fully functional system. All units are tested as a separate entity and combined for a test of a single unit system. The system will be tested for user requirements to assess if it meets the specified needs.

5.2 Coding

According to Marcus et al (2018), coding describes the steps of a program with resolute syntax depictions, it is an expansion of what a system has to do. Coding part was the foundation of the application since every operations and functionalities of the segments are dictated by the program. The blend of the application components and connection to database was done via code.

5.3 System Testing

Testing is an essential part of the validation process, system testing is the method of practicing or assessing a system or system element by manual or automated means to check that it meets defined criteria or to detect gaps between anticipated and actual outcomes, validation is the software evaluation method to guarantee compliance with software requirements at the end of the software development phase, (Gao 2016). In addition, it is assessing the system ability to deliver what is intended to produce, system is measured with its objectives. The diagram below shows steps that are followed in testing:

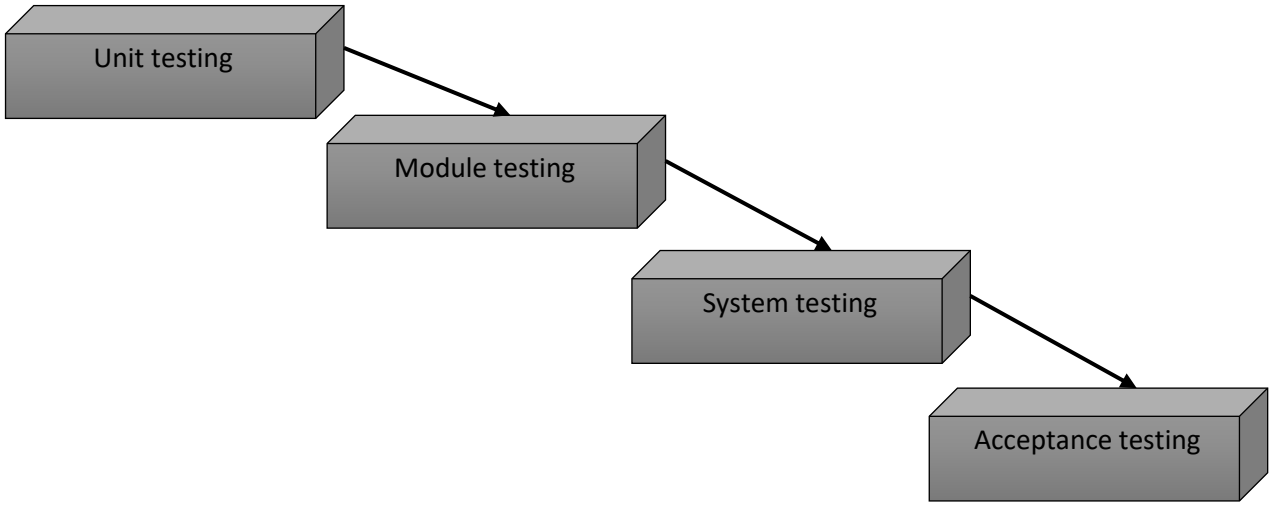

Figure 5.1 System testing flow process

5.3.1 Unit testing

According to Stair (2014), unit testing is unit testing is a product advancement process in which the littlest testable parts of an application, called units, are exclusively and autonomously investigated for appropriate operation. Unit testing should be possible physically yet was frequently automated. In addition, it is when individual component of a system is tested to uncover errors that might not have been recognised during desk checking, all possible situations should be tested for and the unit should contain correct data. There are two categories used for unit testing which are white box or logical testing and black box or functional testing. An example is that the system should verify the user email, as in screenshot below:

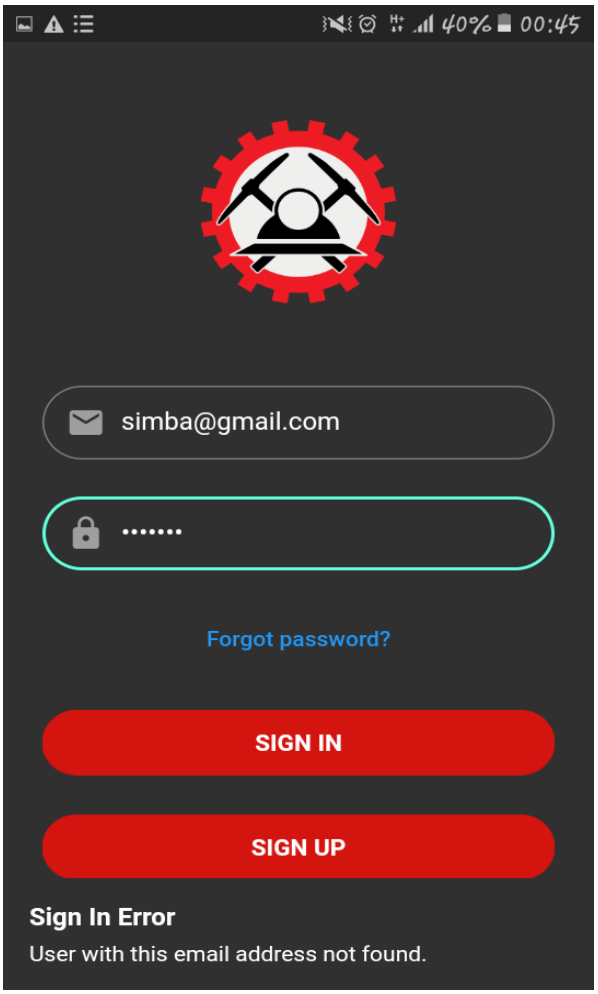

Figure 5.2 Screenshot for user email validation

5.3.1.1 White box testing or Logical testing

According to Eppinger (2017), white box testing is a testing strategy that analyzes the program structure and gets test information from the program rationale/code. It is a test of the code to verify if it works the intended task, it looks at the internal components or mechanisms of the program. This test is carried out by an individual who have explicit knowledge about the code and test to examine the output of the code. It tests internal parts of the system which maybe testing unit or the integrated system, if the code is declared clear it means the output produced will meet the specified known needs of the system.

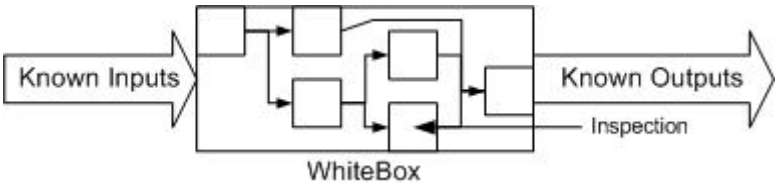

Figure 5.3 White box testing

5.3.1.2 Black box testing or Functional testing

It is not concerned with the source code; the test focuses on the functional aspects of the system without looking into the internal structure of the system, the people who performs the test do not have access and control of the code, it uncovers errors such as missing functions, errors found in data structures, as well as errors in interfaces.

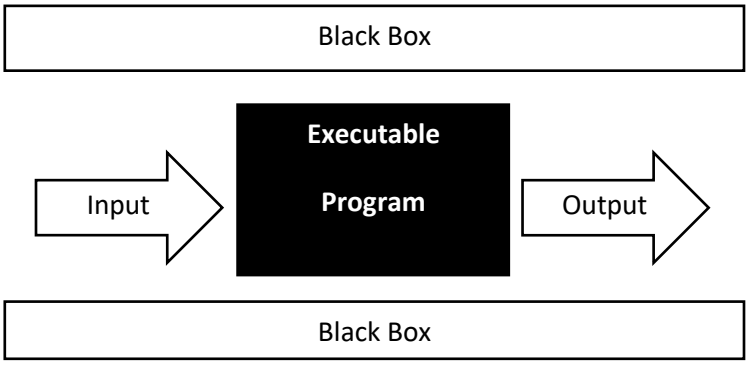

Figure 5.4 Black box testing

5.3.2 Module testing

It is the testing of dependent component of the system, testing can be done on a single component without other components, testing is done according to the desired outcome of the module. It is a very important test as it tests the interfacing modules, module testing was used to term testing done on fully assembled component as a single system. It was anticipated that defective components could not be isolated during module test and that as result no rework could be performed based on failure during module test, (Gao 2016).

5.3.3 System testing

According to Gao (2016), system testing focuses on the whole system ability to meet the specified functions, it involves the coordination and the interaction of all the elements of the

system. The integrated components will now be tested for errors as a single unit. Major functionalities are security and ability to produce desired output. Also, the compatibility of the software on the available hardware will be tested and possible threats are looked at with software ability to adapt to threats.

5.3.4 Acceptance testing

Stair (2014), describes acceptance testing as the process when the actual system is delivered to the actual users of the system who test it on the hardware that it is supposed to run on and the actual data that will be dealt with during the entire life of the software. It is the last stage of testing and once it is successful the system will be ready for deployment for full operational use. The system will be tested with data that will be entered by the miners to make sure that the system is working as required by the specifications. The actual users will review errors and difficulties in the system. Acceptance testing comprise of alpha and beta testing. Alpha testing is a sort of testing that is done to distinguish every one possible issue before distributing the application to general users, it takes place at the developer's site by the internal teams before release to external users. Beta testing is designed to safeguard that the product is ready for release by distributing it into the real world and getting response, (Gao 2016). It was done by mine workers of the application system in a real situation and could be well-thought-out as a kind of external user acknowledgment testing. It decreased application dissatisfaction dangers and gave expanded nature of the application through mine workers approval. Screenshot below shows the application’s dashboard after user log in:

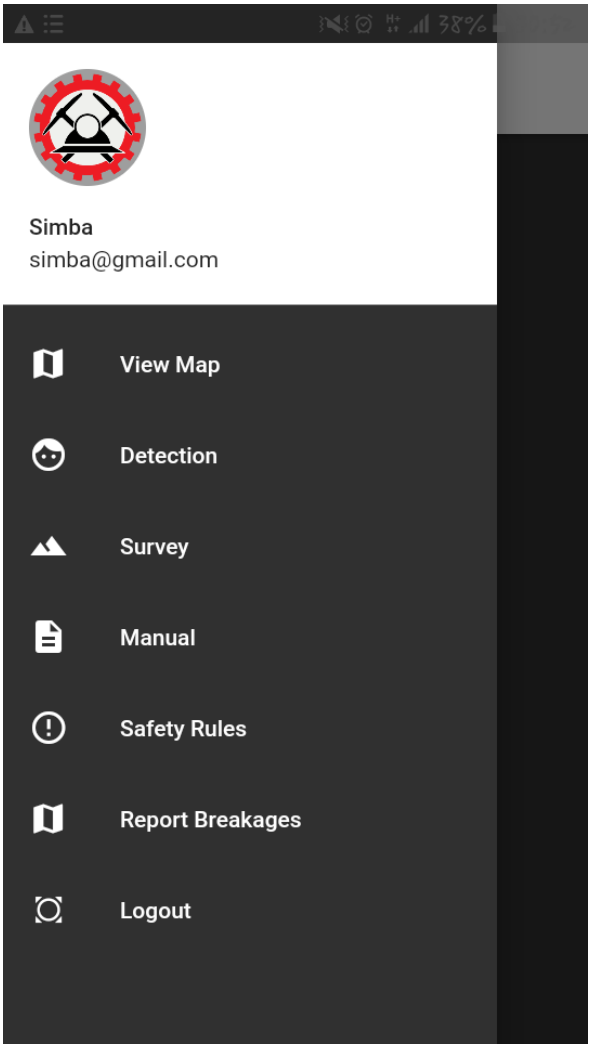

Figure 5.5 screenshot of application dashboard

5.3.5 Testing strategies

A testing procedure was a general way to deal with the testing processes as opposed to a technique for formulating specific application or part tests. Distinctive testing techniques might be embraced depending on the kind of application to be tried and the improvement procedure utilized. The strategies used are:

5.3.5.1 Validation

Gao (2016), states that the main objective of validation is to check if we are developing the right system which solves the intended problem; it is tested through the data that is entered and the output. It is for ensuring that the correct and desired data is entered in order to produce desired

output. Validation basically checks the entered data in the text box to see if it is correct to the specified field type. This form was tested for validation of the user email and password:

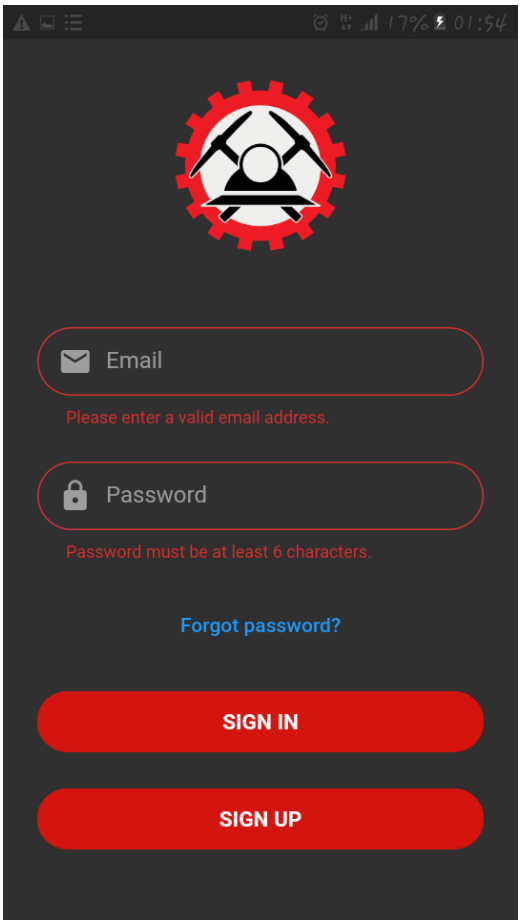

Figure 5.6 screenshot for sign in validation

5.3.5.2 Verification

It is reviewing, inspecting and testing for establishment and documenting the product. It is ensuring that the system meets technical and regulatory standards or whether the system was built conforming to required standards. It strives to answer the question as to whether the system is meeting its functional requirements. In conclusion verification reveals that the system was validated correctly and meets specific objectives. For example, screenshot of logout dialog box as below:

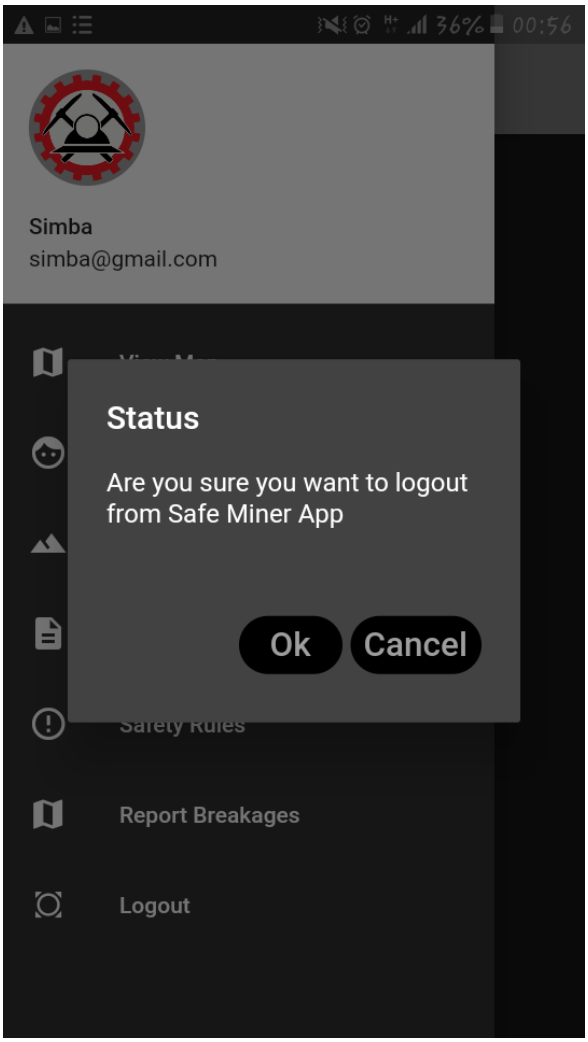

Figure 5.7 screenshot of logout dialog box

5.4 Installation

Alexander (2014), ascertain that it is the procedure of linking, setting and creating the application ready for implementation. The procedure of alignment and installation was engaged with sub activities to it. These activities included user training manuals, and reference as in where it will be placed such that it could be retrieved by all the mine workers. The android application was to be placed on google play store where all mine workers can access it.

5.4.1 Installation procedure of the android application

Steps to be taken

- First make sure your android version is 5.0 and above
- Download application from play store
- Click on the application
- Select install and after installation
- Click finish
- Open the application and sign up first to start using it.

5.5 Maintenance

Due to the dynamic world of business a system needs to be reviewed and updated to ensure that the system continues to cope up with changes. Maintenance is carried out after the system is delivered, periodically usually monthly to make sure that the changes in demand are met by the system. Sommerville (2015), points out that maintenance is the fact of assuring that the system is acting admirably, distinguishing requirement for alterations regarding working there might be recognized adjustments that may be seen during the maintenance procedure. They are four types of maintenance which are perfective, adaptive, preventive and corrective.

5.5.1 Perfective maintenance

Krugman (2016), stated that perfective maintenance involves improving performance in processing of the system hence adding the desire to use the system. It is more like development of a new software because some features will not be necessarily needed. It is concerned with add-ons to the system to add extra value and efficiency giving room for improvements. Perfective maintenance will be done after every six months and some features would have upgraded.

5.5.2 Adaptive maintenance

Adaptive maintenance is carried out so that the application adjusts to changes that are to transpire in its process. Due to technological changes, the system should be capable to adjust to any alterations, (Sommerville 2015). The need for adaptive maintenance can only be identified by controlling the environment. Adaptive maintenance is to be carried out every time the application changes the environment. Mostly changes in hardware and operating system results in adaptive maintenance.

5.5.3 Preventive Maintenance

According to Krugman (2016) preventive maintenance are activities that involve application alterations leading to better functional aspects of the software. It will be implemented to improve performance, accessibility and other features of an application. Preventive maintenance will be done every week to make sure the application is continuously meeting the requirements of users.

5.5.4 Corrective Maintenance

Valacich (2014), stated that corrective maintenance encompasses changing a software system to eliminate errors. The major causes of maintenance are design errors, coding errors and logic errors which were encountered during the system design and is done unpredictably because there is no knowledge when the system is going to fail. Corrective maintenance is done in three steps: diagnosing the problem, repairs and replacements of faulty component and verification of the repair action.

5.5.5 Recommendation on maintenance strategy

Preventive maintenance has ended up being convincing from the researcher's point of view because it deters the software from breaking down by performing maintenance regularly instead of conducting maintenance when failure has occurred. It is used to maximise an assets useful lifetime and minimise costs, its purpose is to avoid unscheduled or unplanned breakdowns. There is less risk factor because software will be checked regularly therefore creating a safer system for the workers. It keeps the software up and running for a long period of time and long-term repair costs are usually significantly lower however, preventive maintenance may be too costly when initially starting it than it would be if there is breakdown.

5.6 Recommendations for future/further development

The system is not perfect as it allows room for improvement like any other system would, so as for recommendations, it is important to state that the system before full implementation or use by the mine workers should allow for corrective maintenance to allow a higher range of accuracy. For further development the system should allow biometric identification that is use of a finger print to log in or sign on instead of typing credentials and a signature capture feature which is integrated signature capturing technology which makes it easy to sign a document through a device with the signature then stored alongside a date and time stamp for superiors, also, have tracking devices that work in hand with GPS to allow tracking of each mine worker as they go deep down in the mines and while planning a blast to assist with various environmental predictors. Add on content in different medium like videos, manuals, quizzes for training user at the mine site. Configure an emergency alert button to call the response team in case of emergency and track of medical reports which contain medical history of employees at a mine site.

5.7 Conclusion

The safe miner android application in overall if implemented and tested for a prolonged period can allow for improvement in the general Zimbabwean mining industry as a whole. It is a work under constant development that can allow safety and health hazardous mining sites which is both low cost and effective. The system has passed the testing phase and implementation was successful.

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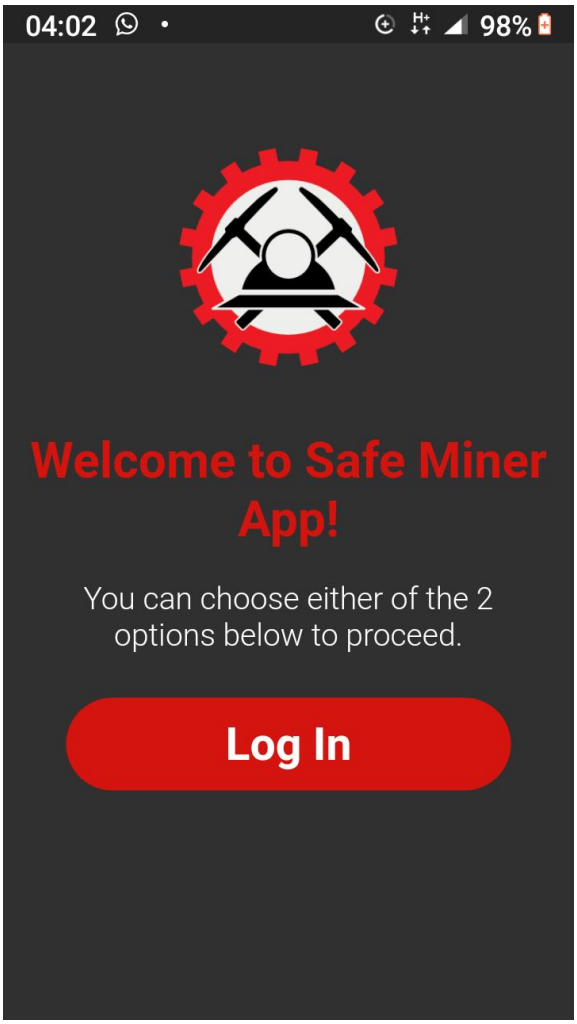
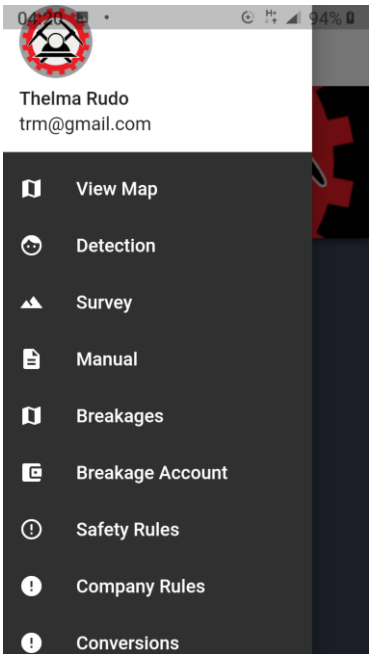
APPENDIX A: USER MANUAL

The user manual will help the users of the newly developed system in using it, thus it will be containing close to all the controls and meanings of the controls and instructions on how to use them. For every system to be effectively used it needs to have a very informative user manual to assist users on the system's functionality which is an important area of concern in software operation. The user manual is also used as a training tool which is used by trainers when they train users on how to use a system, it makes it easy for the trainers and also the new users as they will have somewhere to refer to in the event that they need a certain directive. The screenshots below will assist in navigation of the application.

Homepage

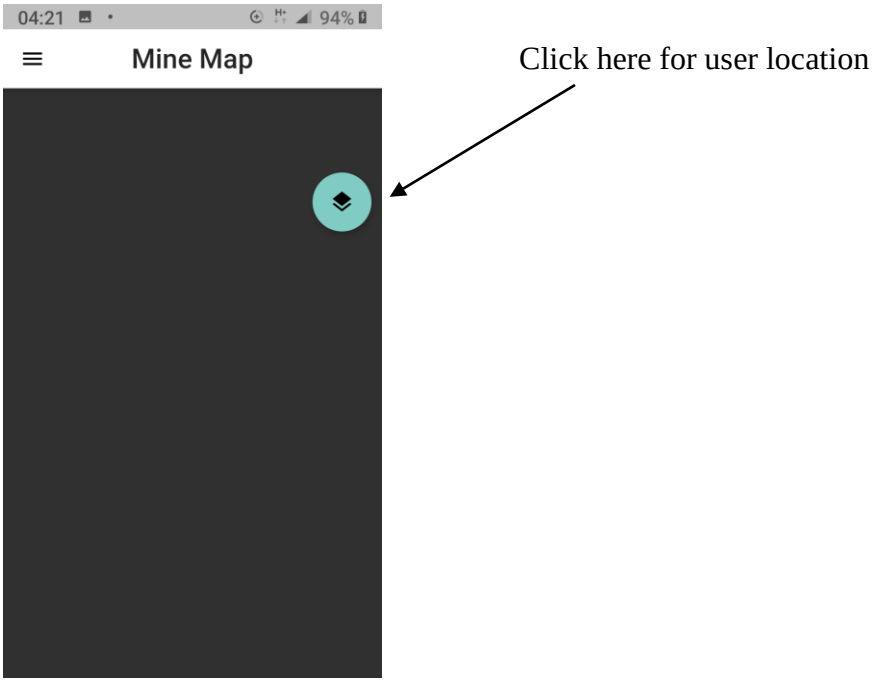


Application navigation drawer

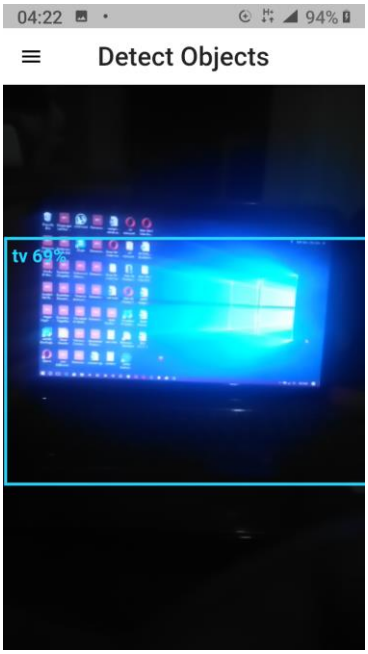


After login the user is directed to the application's navigation drawer where they is the application's menu.

Map view



Object detection



the application is detecting a laptop, it is 69% definite.

Conversions

APPENDIX B: INTERVIEW QUESTIONS

Interview Transcript

The following is an extract of the questions that were asked during the interviews conducted During data gathering activity.

MINE WORKERS

Q1. Do you enjoy the current system?

……

……

……

Q2. How do you take the idea of making an android application that will aid your safety during work?

……

……

……

Q3. How is mining carried out?

…….

…….

……..

Q4. Do you think a mobile application will be of great importance to how your is done?

…….

……..

……

Q5. Are you satisfied with the current system?

……

……

Date……. **Time**……...

Signature…….

Thank you!!!

APPENDIX C: QUESTIONNAIRES

My name is Thelma R Machakaire and I am from Midlands State University and pursuing a degree in Information Systems. I designed this questionnaire for mine workers to find out how they feel about the current system and also asking about how they will feel about an introduction of a new mobile application to use during their operations. I kindly ask for your help to answer the questions by just placing a tick in a box. Your response will be greatly appreciated.

Just place a tick in the box

Q1. What is your rating of the current system of doing things?

- Excellent
- Good
- Fair
- Poor

Q2. Do you vote for the mobile application for this purpose?

- Excellent
- Good
- Fair
- Poor

Q3. Do you worry about the costs of using the mobile application?

- Excellent
- Good
- Fair

Poor

Q4. Do you think a mobile application should be produced to cater for mining operations?

Excellent

Good

Fair

Poor

What other views do you have concerning the current system that you would like to be known?

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Thank you!!!

APPENDIX D: OBSERVATION

OBSERVATION SCORE SHEET

Date……... **Observer**……...

Time……...

Observation

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Conclusion

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Signed by observer……

Date……...