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COURSE CODE	**IT414**
COURSE NAME	**RESEARCH PROJECT**

Application of Markov Decision Algorithm for the Allocation of Computer Maintenance.

APPROVAL FORM

The undersigned certify that they have supervised the student Success Mugwagwa's dissertation entitled, "Application of Markov Decision Algorithm for the Allocation of Computer Maintenance" submitted in partial fulfillment of the requirements for a Bachelor of Information and Technology Honors Degree at Bindura University of Science Education.

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Abstract

No matter how good a computer is and how much RAM it has, if it does not have proper maintenance it will end up accumulating more and more programs, many of which are unnecessary, and it will end up making the RAM work harder (which, among other things, will mean a great slowdown in your system).

Dedication

This paper is dedicated to my father Mr. J. Z HASSAN and my mother Primrose Mugwagwa for they raised and nurtured and supported me from the beginning of my time up to this moment. Patience, endurance, and passion are fundamentals they gave which have been taking me to different levels in life. My right doings are all rooted in these two special persons, I am proud to be your son.

Acknowledgements

All the credit goes to the Almighty God who guided me through my final year dissertation. Mr. Ndumiyana my supervisor I extend my sincere gratitude for the time and patience he invested in me as I worked through my research project, I value your time and contribution, sir. I also want to thank the Bindura University of Science Education for all the infrastructural support and all the academic provisions that led to the completion of this study. Not forgetting my family and fellow colleagues who played a supporting contribution positively to my welfare.

Table of Contents

CHAPTER 1: INTRODUCTION

1.1 Introduction

Jena Mines is a fast-growing mining company located in Nkayi under the banner of Kwekwe City. It's a Member of Kuvimba mining house and has around 1000 employees. It has a vast of computers and servers which run to speed up the mining operations. Maintenance of those machines has become a challenge since some might be not serviced as they go on day-to-day operation. This has caused some hiccups and slowdowns in the course of operating. IT problems could even be occurring in the business operations every day without the knowledge of the organization.

One of the best ways to plan for the future of your business is to learn about the current struggles your company and employees face on a day-to-day basis. This knowledge brings the power of change and better ways to implement strategies for growth and success.

Computer maintenance means all those activities that run on a computer (both its software and hardware) to ensure that its operation is optimal. Depending on our needs and our possibilities, you could leave computer maintenance to the experts. When your computer maintenance is not in the right hands, it is possible that, over time, some problems arise. Let's see some of the most frequent ones.

1.2 Background of the Study

Decision-making plays a very important role on individual, organizational, societal, and governmental levels. In this study, the decision maker (vendor), after considering all surrounding circumstances, has to go through the core process before an action is taken among several alternatives. The kind of decision taken by the vendor today affects its future either positively or negatively. The fundamental decision faced by the organization is how to optimally allocate its resources at each decision epoch during a time horizon on a machine required for maintenance to optimize its performance. From a control point of view, the organization as the controller must optimize its allocation function at each decision epoch by selecting appropriate action(s) from its action space. The optimal policy that maps action to a given state was also studied. The main objective of the study is to apply the Markov decision process to portfolio allocation problems under an organization-managed inventory

environment to obtain the expected reward for each decision and the optimal policy that maps an action to a given state.

Inventory management is very important in most companies as well as commercial sectors because it helps the company or the vendor to respond quickly to customers' demands, which is an important element in competitive markets. An inventory is a collection of people, equipment, and procedure that function to keep account of the quality of items in inventory and determine which item to purchase or what quantity to produce.

1.3 Statement of the Problem

Do the computers in your office roar like lions and burn like embers in the underworld? Have your computers taken over the kitchen? Have your computers spent the morning drinking coffee and playing darts? What did you expect? Just like any other electronic device (from a car to a dishwasher), to function properly, computers need maintenance.

In fact, due to its importance and complexity, computer equipment maintenance requires special attention.

When approaching the different types of IT maintenance, two aspects must be considered:

- The maintenance includes both hardware and software of the computer. Both are very important and will decisively influence the operation of the system.
- The various types of maintenance can work simultaneously. In the case of corrective maintenance, it will act if the predictive maintenance or preventive maintenance is not able to anticipate the problem at hand affecting the Jena Mining Company.

1.4 Research Objectives
1. To design and develop a Resource Allocation System for Computer maintenance.
2. To evaluate the efficiency of the resource allocation system.
3. To evaluate the Markov Decision Process algorithm used for resource allocation.

1.5 Overall Aim
The study aims to design and develop a Resource Allocation System for Computer maintenance to be used at Jena Mines

1.6 Research Questions

1. How is the Markov Decision Algorithm used in computer maintenance?

2. Why do we decide to use the Markov Decision Algorithm for computer maintenance system resource allocation?

3. What problems do users experience when using the Markov Decision Process Algorithm for resource allocation?

1.7 Justification or significance of the research

No matter how good a computer is and how much RAM it has, if it does not have proper maintenance it will end up accumulating more and more programs, many of which are unnecessary, and it will end up making the RAM work harder (which, among other things, will mean a great slowdown in your system).

1.8 RESEARCH LIMITATION.

More time to devise mathematical algorithms and training

1.11 Definition of Terms

- **Resource Allocation-** is the process of assigning and managing assets in a manner that supports an organization's strategic planning goals
- **Markov Algorithm-** string rewriting system that uses grammar-like rules to operate on strings of symbols for decision making
- **Computer Maintenance-** keeping your computers and laptops in good condition through regular cleanings, hard drive updates, and virus prevention
- **RAM-** a computer's short-term memory, where the data that the processor is currently using is stored

1.12 Summary

This script serves the different aspects of the objectives of the study that brought out the main objectives and research questions which also helps to formulate the problem statement. A detailed overview of the study to be carried out is outlined in this chapter.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The previous chapter discussed about problem statement and the research framework however this chapter discusses the review of what has been done in the past. Bloomsburg University of Pennsylvania Library defined literature review as a comprehensive summary of previous research on a topic, which surveys scholarly articles, books, and other sources relevant to a particular area of research. In line with the definition of literature review this chapter serves to provide information on how others managed to implement computer maintenance strategic plans

2.2 Computer Maintenance

Kent D. Stuckey (2016) Computer maintenance involves keeping a computer in a good state of repair and physical health. Meaning, it's set of maintenance tasks and procedures that help to keep the computer software and hardware updated and operational.

What is Computer Maintenance Plan?

Acosta, Jeremy (2019) Computer Maintenance Plan is a list of predefined procedures and tasks needed to keep a computer in good condition. There are thorough maintenance checks needed on a computer to avoid unnecessary downtime and failure.

Your computer is a key component of your digital communication and network, its hardware and software must be custom tailored to your office computing needs. Your computer network must also be properly maintained to function properly and avoid system downtime or loss of computer data.

Maintenance Tasks and Procedures

Palma Majorca (2017) Computer maintenance tasks include reviewing the computer's performance, ensuring that automated system monitoring utilities are properly installed and configured, identifying potential security risks and backing up data at regular intervals. The maintenance procedure is part of a wider policy which defines what, how, and when the required changes can occur. The procedure also defines step by step low-level actions.

Maintenance Plan

(Corey Sandler 2019) tables a detailed stages on maintenance plan.

1. A solid computer maintenance plan generally requires several steps, including:
2. Checking computer log files

3. Assessing hard disk space

4. Examining computer folder permissions

5. Monitoring computer temperature

6. Ensuring adequate redundancy of computer systems

7. Examining security features

8. Examining [computer cleaning](#)

9. Installing security software patches

10. Reading computer logs for security alerts or evidence of computer hacking attempts

11. Updating antivirus software on all computers on the network

12. Updating critical service packs and software updates

13. Performing regular comprehensive back-ups to ensure that vital data can be retrieved from storage in the event of a system failure.

Maintenance Engineers

(https://www.ukdatacentercleaning.co.uk/ 2022) Computer maintenance engineer is a skilled technician with a good engineering background and relevant experience in preventative maintenance, troubleshooting and repair and the installation and/or modification of computer machinery. They liaise closely with the Maintenance Manager and operations staff in all respects to ensure efficient and effective planned and reactive maintenance at all times.

The maintenance technicians usually perform tasks such as; preparing parts orders for dispatch, assembly of new machines, servicing machines that have been returned with faults, going to customers for repairs, maintenance and installation of our machines, providing remote assistance either online or over the phone to customers.

Scope of Maintenance

All Computer types including Blade; Rack; and Tower options. Computer Maintenance includes all internal computer components, i.e., Processor, Memory, hard-drives and any internal cards. Operating System: (including Windows, Unix, Linux and Solaris) – Maintenance service relates to the operational readiness and security of the system which includes Operating System re-installation and application of Security Patches and Service Releases et al Bradley Mitchel (2017).

Maintenance Checklist

(Norman Lieberman 2009) This checklist will help you to do a quick self-evaluation to see how safe your computer systems are from hackers. Our trusted technology professionals can provide

a complimentary consultation to make sure you are protected from the numerous security threats that are lurking. Meanwhile, we'll stay in touch via our newsletter, which provides timely alerts and useful tips to help keep your organisation's technology running smoothly.

Computer Security

Chris Woodford 2016 suggests thar security and application functionality should also be examined. If required, security patches should be installed on individual computers within the network to ensure that data is secure. The review should also include reading computer logs for evidence of computer hacking attempts or security alerts. In addition, the administrator should ensure that antivirus software is updated on all of the computers in the network.

Maintenance Window

Andy Rathbone 2019 explains that during server maintenance, any essential service packs and software updates should be installed on the network computers. Typically, this work can be done after working hours so that network user activity is not disturbed. When necessary, a system correction, system restoration, or hardware component replacement may also need to be made.

Backup Plan

Phil Zanderbergen 2018 explains that a comprehensive backup plan should also be included. In the event of a system failure, the backup data will be vital in helping the network users retrieve their stored information. Depending on what kind of data is stored on a computer, it may need to be backed up daily, weekly, bi-monthly, or monthly. A good backup plan should always be tested regularly to ensure that it will meet data recovery requirements.

2.3 Markov Decision Process

Warren, et al (2003) suggests that the Markov decision processes (mdps) model decision making in discrete, stochastic, sequential environments is dormant. The essence of the model is that a decision maker, or agent, inhabits an environment, which changes state randomly in response to action choices made by the decision maker. The state of the environment affects the immediate reward obtained by the agent, as well as the probabilities of future state transitions. The agent's objective is to select actions to maximize a long-term measure of total reward. Efficient algorithms for mdps based on dynamic programming and linear programming, and more recently on compact representations, enable large planning problems from artificial intelligence, operations research, economics, robotics, and the behavioral sciences to be modelled and solved.

Markov decision process problems (MDPs) assume a finite number of states and actions. At each time the agent observes a state and executes an action, which incurs intermediate costs to be minimized (or, in the inverse scenario, rewards to be maximized). The cost and the successor state depend only on the current state and the chosen action. Successor generation may be probabilistic, based on the uncertainty we have on the environment in which the search takes place. For example, an action might sometimes fail to result in the desired target state, instead staying in the current state with a small probability.

2.4 Emotion model based on Markov decision process

Md.Noor and John (2010) studies the Markov decision process (MDP) is a mathematical model of sequential decisions and a dynamic optimization method. A MDP consists of the following five elements:

$$\{T, S, A, p, r\}$$

Where:

1.T is all decision time sets.

2.S is a set of countable nonempty states, which is a set of all possible states of the system.

3.A is a set of all possible decision-making behaviors when the system is in a given state.

4.p indicates the probability of moving to state j when the system is in state i∈S and the decision-making behavior a ∈A(i) is taken.

$$\sum_{j \in S} p(j|i, a) = 1$$

5.r=r (i, a) is called a reward function, which represents the expected reward obtained when the system is in a state i∈S at any time and adopts a decision-making behavior a ∈A(i).

The strategy π expresses that, in every state, we should adopt a certain action. In the Markov decision-making process, the transition probability and reward only depend on the current state and the action chosen by the decision maker but have nothing to do with past situations.

2.5 Markov decision process algorithm for allocation of computer maintenance

Michelle Desalvo 2019 explains the optimal routing of a computer in need of maintenance is formulated as a Markov Decision Process (MDP) problem to account for long-term profit over the full working period. The state is defined by the node at which a computer in need of maintenance is located, and action is the link to take out of the node. State transition probabilities depend on computers in need of maintenance matching probabilities and priority probabilities. The probability that a computer in need of maintenance is matched with a priority probability during the traversal of a link is calculated based on temporal Poisson need for computers to maintained at a given time and spatial Poisson distributions of competing priority machines. Priority matching probabilities are calculated directly using observed fractions of computers in need of maintenance from a given origin. The MDP problem is solved by value iteration resulting in an optimal routing policy, and the computational efficiency is improved by utilizing parallelized matrix operations.

2.6 Previous Studies on Computer Maintenance and Markov Decision Algorithm

Archie Nel De jesus 2019 study aims to provide a CHSM Trainer or Computer Hardware Servicing and Maintenance Trainer for the College of Information and Communication Technology (CICT). The purpose of this study is to enhance the troubleshooting, system configuration and computer hardware skills of the CICT Information Technology students. The said project was constructed using different computer peripheral parts. The CHSM Trainer has a dual core motherboard which has a built-in video card and a 512 RAM. The CHSM Trainer was evaluated by the BSIT students using the following projects criteria: (a) functionality; (b) user-friendliness; (c) portability; and (d) reliability. The result of the respondent's evaluation was interpreted as follows: Excellent, Very Satisfactory, Satisfactory, Fair and Poor. Overall, the project got 4.33 mean rating with a verbal description of "Very Satisfactory" The conclusions of this study were drawn as follows: (1) The proponents included several peripheral parts for construction of the CHSM Trainer (2) This project is for the students which can help them in troubleshooting, system configuration interfacing technique and computer assembling; (3) The CICT has a growing population of students and many of the students must be familiar with the peripheral parts of a computer. Generally, the CHSM Trainer can lessen the time consumed in practicing interfacing and troubleshooting inside the classroom. Lastly, the recommendations of this study were drawn as follows: (1) The CICT must provide troubleshooting practicing equipment like CHSM Trainer for the information and technology students as it is part and parcel of their skills development; (2) Improve the functionality of the

CHSM Trainer; (3) If the CHSM Trainer is for hardware, they must develop a computer trainer for software like Computer Aided Instruction with the topic in troubleshooting and assembling. The researchers also used hard disk drive, DVD-Rom drive, power supply and a flat LCD monitor which makes the project functional. However, the researchers make it more compact by customizing its casing.

John I. S. Hsu 2018 writes this paper that reports the findings of the study of maintenance policies for the IBM 1620 system installed at the university's computing center. Three Maintenance policies were investigated by studying the operating characteristics of the system's two functional units, IBM 1620 Processor and IBM 1622 Card-Punch, covering the period of twenty-nine months. Cost minimization approach is used to determine the optimum policy among three alternatives. These three alternatives are: 1) re- pairs only; 2) scheduled maintenance at a time interval of t hours of operation without failure; 3) performing maintenance procedures at t, 2t, 3t, regardless of intervenr- ing repairs. The problems of gathering information and the condition of optimum for the al- ternative 2 and 3 are discussed. The empirical result of this study is in favor of al- ternative 1 for servicing both functional units, 1622 and 1620.

Fauzan Asrin, Saide Saide &Silvia Ratna 2013 studies on analyzing a large amount of data that often appears to create a knowledge base that can be utilized by firm to enhance their decision support system. The authors used the association rules with rapid miner software, data mining approach, and predictive analysis that contains various data exploration scenarios. The study provides important evidence for adopting data mining methods in the industrial sector and their advantages and disadvantages. Chevron Pacific Indonesia (CPI) has a type of computer maintenance activity. Currently, numerous errors often occur due to the accuracy in computer maintenance which has a major impact on production results. Therefore, this study focuses on association rules using growth patterns that often appear on variables that have been determined into the algorithm (FP-growth) which results in knowledge with a 100% confidence value and a 97% support value. The value results of this study has support and trust are expected to become knowledge for top management in deciding evergreen IT-business

Bukie Paul Tawo March 2018 in an article Adopting Effective Computer Maintenance and Troubleshooting Cultures for Sustainable Development of IT-Driven Sectors of the Third World Countries explains that a computer is an electronic device with mechanical components requiring adequate care and maintenance due to the system's fragile nature. Today, computers

have become an integral part of global communications. Computers are built to be reliable and serve as professional machines; however, they are frequently disposed to develop problems such as malfunction and system failure in the process. The personal computer (PC) often displays error messages, hang up, and in the worse conditions, stop working completely. This article explicitly examines effective measures for PC maintenance, configuration, updating and troubleshooting to protect against system malfunction, recognizing that computer application program is the steering wheel of growth and development in most segments of our society. The paper highlights most reliable techniques to troubleshoot, fix bugs, and repair, and further recommends computer maintenance, effective utilization and development, especially in developing countries.

Mimica MILOSHEVICH & Aybeyan SELIM September 2016 in this paper, explained how they will develop model for troubleshooting procedures and creating computer maintenance programs. The aim of this paper is to provide a model that allows students to be motivated and educated to detect and eliminate errors and apply the acquired knowledge. This model is a starting point to help students develop their preventive maintenance and troubleshooting skills. Troubleshooting is the systematic process used to locate the cause of a fault in a computer system and correct the relevant hardware and software issues. This paper offers general model of working with students within workshop. Proposed model includes the development of the general working process with IT students, in solving problems and repairing computers, as well as a mutual communication. As IT professional, students will troubleshoot and fix computers, and they'll frequently communicate with others.

Wahyu Nur Hidayat 2022 suggests that practical learning on computer maintenance for vocational students during the COVID-19 pandemic cannot be implemented optimally. Hardware access problems that are difficult to reach by students cause the learning barriers in this subject to be even greater. Therefore, through this research, a mobile-based learning media was developed to visualize computer component devices with AR technology and 3D animation. The research method used is the ADDIE model. The research begins by diagnosing the problem, describing needs, and finding appropriate solutions for computer maintenance learning. Next, the product design process and user journey are carried out and then develop applications with 3D animation assets and learning materials. Implementation activities go through an evaluation process to media and content experts to determine the validity of the application. The media and content validation instrument consists of 4 aspects with 46 items. This media is equipped with 3D objects that can be used to help students observe computer

hardware. Media validation got a value of 79.49% and was included in the valid criteria so that it could be used in learning. Content validation is in the valid category with a value of 80.2%. Several improvements were made to increase the usability and attractiveness of the media so that students' interest in using the media increased. In the future this media can be applied in learning so that it can be seen the impact, both on learning outcomes, student interest and critical thinking on computer troubleshooting.

Many related research works have been carried out. Dror and Ball (1987) considered the application of integrated inventory and transportation problem. They investigated the problem of distributing heating oil among customers using a fleet of vehicles. Their objective was to minimize the annual delivery stockout costs using both deterministic and stochastic demands. The allocation of human and physical resources over time as a fundamental problem that is central to management science was carried out by Warren, et al (2003). They reviewed a mathematical model of dynamic resource allocation that is motivated by problems in transportation and logistics using an algorithm developed by Warren.

They showed how problems in Computer Maintenance can be solved through dynamic programming to select a policy that maximizes the expected reward over the time horizon. Transaction costs and resampling are two important issues that need great attention in every portfolio investment planning, Dror and Trudean , 1996; Christophette et al (2004) considered a risky asset whose instantaneous rate of return takes two different values and changes from one to the other one at random times which are neither known or directly observable. They studied the optimal strategy of traders who, in the presence of cost transaction, invest on this risky asset, or on a nonrisky asset according to their belief on the current state of the instantaneous rate of return and finally applied dynamic programming.

In Application of Markov Decision Process to a Simplified Model of Robot Fire Fighter studied by Kwame (2009), he provided a review of Markov decision process and investigated their suitability for the problem of designing autonomous intelligent agent for forest fire fighting. He formulated the problem in the frame work of Markov decision process and implemented a fast value iteration algorithm to obtain the optimal policy. Arseal (2009) studied the Graphic Processing Unit (GPU)-Bases Markov Decision Process. He used Markov decision process to provide a mathematical frame work for modeling decision making in situation where outcomes are partly random and partly under the control of the decision maker and finally applied value

iteration to obtain the optimal policy. Md.Noor and John (2010) studied stochastic investment decision with dynamic programming. In their research, proper investment decision making is key to success for every investor in their efforts to keep pace with the competitive business environment. The mitigation of exposure to risk plays a vital role, since investors are now directly exposed to the uncertain decision environment. They opined that the expected reward on investment of a decision often carries high degree of uncertainty and their objective was to formulate a dynamic programming model for the investment incorporating the uncertainty in a probabilistic manner in order to find a policy that maximizes the expected gain.

Kobbane et al (2012) discussed the approach of using MDPs for dynamically optimizing the network operations to fit the physical conditions. They observed that the MDP model allows a balanced design of different objectives, for example, minimizing energy consumption and maximizing sensing coverage. Mohammad, et al (2015) applied Markov decision process in wireless sensor network. They opined that wireless sensor networks (WSNs) operate as stochastic system because of randomness in the monitored environments.

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2.7 Chapter Summary

This chapter serves to outline the previous researches that have been done by various authors. The author serves to explain the much-needed information to prove the feasibility of the system with respect to other researches that has paved a way. Henceforth in addition the author explains in detail how the author is going to tackle the problem at hand with technological practical solutions.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

The chapter aims to define the strategies and tools used to achieve the proposed objectives of research and system. With the help of the information attained in the previous chapter the researcher will formulate the necessary methods to build a solution and be able to make choices among competing strategies to achieve the expected results of the research.

Decision making plays a very important role on individual, organizational, societal and governmental levels. In this study, the decision maker (Technician), after considering all surrounding circumstances, has to go through the allocation process before an action is taken among several alternatives. The kind of decision taken by the Technician today affects its future either positively or negatively. The fundamental decision faced by the Technicians is how to optimally allocate its resources at each decision epoch during a time horizon on an uncertain environment in order to optimize its reward. From control point of view, the Technician as the controller must optimize its reward function at each decision epoch by selecting appropriate action(s) from its action space.

3.1 RESEARCH DESIGN

Research design should be a reflexive process operation through every stage of a project. The design stage involves coming up with the different modules of the system and their intended functionality. The core objective of this stage is to ensure that an operative, proficient, sustainable and reliable system is designed. Thus, there should be a designed application by the researcher that will be used to demonstrate the author's research topic.

3.2 REQUIREMENTS ANALYSIS

Requirements analysis is critical to the failure or success of a project and the formulated requirements need to be realistic, documented, testable, actionable, traceable, measurable, related to identified business needs and detailed enough to facilitate the system design (Abram Moore, Bourque, & Dupuis 2004).

At this point, it is thus essential to record all the functional and non-functional specifications of the required system. It is advisable to structure all the incoming data, asses it as well as

considering all the limitations which may arise on the consumer's side and come up with a ready to follow specification which may arise on the consumer's needs. The researcher also took into consideration all the limitations that may arise such as budget restrictions that may impede the design method.

3.2.1 FUNCTIONAL REQUIREMENTS

Defines the functions of a system or its modules, whereby the function is typically a specification of the interaction between inputs and outputs (Fulton & Vandermolen, 2017). Thus, functional requirements outline the system service provided on completion of certain tasks at hand by how the system respond to the set of inputs, the behaviour and output.

The proposed system must be able to meet the following requirements.

- ➢ Admin Technician should register his/her details
- ➢ Admin Technician should register all computers into the system.
- ➢ The system requires the Technician to enter all Computer users
- ➢ The system should be able to manage all computer
- ➢ A cron job is created using Markov Decision Algorithm to alert the Technician if the computer is in need of maintenance
- ➢ Notification is sent to the admin if the maintenance is done

3.2.2 NON-FUNCTIONAL REQUIREMENTS

They are often referred to as quality requirements and used to judge the performance of a system rather than its intended behavior. The proposed system must be able to meet the following:

- ➢ System should have very relatively small response time and decision time
- ➢ The system should be easy to assemble

3.3 TOOLS USED (Hardware and Software)
- ➢ PHP v 7.2

- ➢ Laravel
- ➢ JavaScript
- ➢ Markov Algorithm
- ➢ PHP cron Jobs

3.4 SYSTEM DEVELOPMENT

This describes the overview of the system and how it was developed so as to produce the results. Thus, it specifies all the software tools and models used in the development of the system.

3.4.1 SYSTEM DEVELOPMENT TOOLS

The researcher is using php and JavaScript as a programming language to develop an application to be used for testing. This application serves as a tool to test for results. The Markov Decision algorithm is used by the researcher for allocation of resources. Henceforth the research is based on the Technician to enter the computers and being able to track them if there is need for maintenance. Therefore, the Markov Algorithm will enhance its abilities on coming up with a possible decision, thus if there is a computer in need of maintenance will definitely be alerted to the Technician.

3.3.2 BUILD METHODOLOGY

- • Prototyping Development- Evolutionary prototyping

Prototype Model

Requirement Analysis → Feasibility Study → Software Design → Customer Evaluation → Coding → Software Testing → Software Maintenance

Prototyping — Customer Reviews and Updation
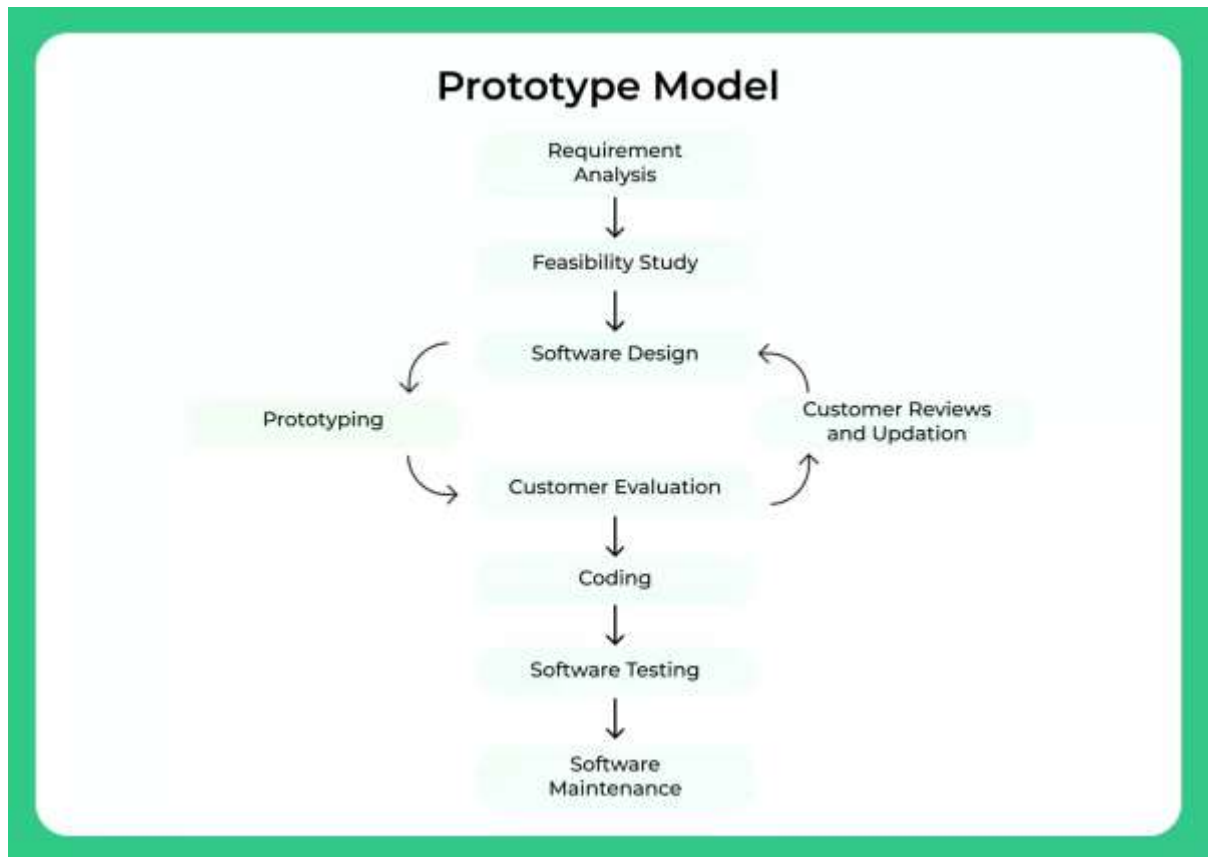
3.3.3 PROTOTYPE

The prototype are usually not complete systems and many of the details are not built in. The goal is to provide a system with overall functionality.

3.3.4 ADVANTAGES OF PROTOTYPE MODEL

During the development of the product phase a user has exploited some of the advantages of using the prototype model for system analysis and design of the Computer Resource Allocation System. Since this type of model works hand in hand between the developers and the users (Jena Mine employees). It allows users to have a better understanding of the system. Henceforth errors are quickly detected as developers quickly receive feedback, thus improve the solution to be developed, helping the author in finding the missing functionalities. The functionality of adding a cron job and an email was advised by the users. Taking back also the model had a one-to-one relationship for technician to computer. But with thorough feedback from the users the author discovered that there was need for one-to-many relationship. Therefore, this quickly traverse the need to urgently address confusing functions, requirements validation and implementation of incomplete but functional application.

- Users are actively involved in the development

- Since in this methodology a working model of the system is provided, the users get a better understanding of the system being developed.

- Errors can be detected much earlier.

- Quicker user feedback is available leading to better solutions.

- Missing functionality can be identified easily

- Confusing or difficult functions can be identified

- Requirements validation, Quick implementation of, incomplete, but functional, application.

3.3.5 DISADVANTAGES OF PROTOTYPE

With a lot of advantages to both the users and the developers in quickly determining the faults of the system. The methodology tends to complicate the system at large. The system was as simple as possible, but with engagement with users. More load of information was added. As well as database relationships. There was an issue of using the cron job or use of a button to attend the issue or resolve the issue. Thus, the whole system tends to be complicated. Although the system was not yet done for production phase the users were in a motion to use it as a final system.

- Leads to implementing and then repairing way of building systems.
- Practically, this methodology increases the complexity of the system as scope of the system may expand beyond original plans.
- Incomplete application may cause application not to be used as the full system was designed

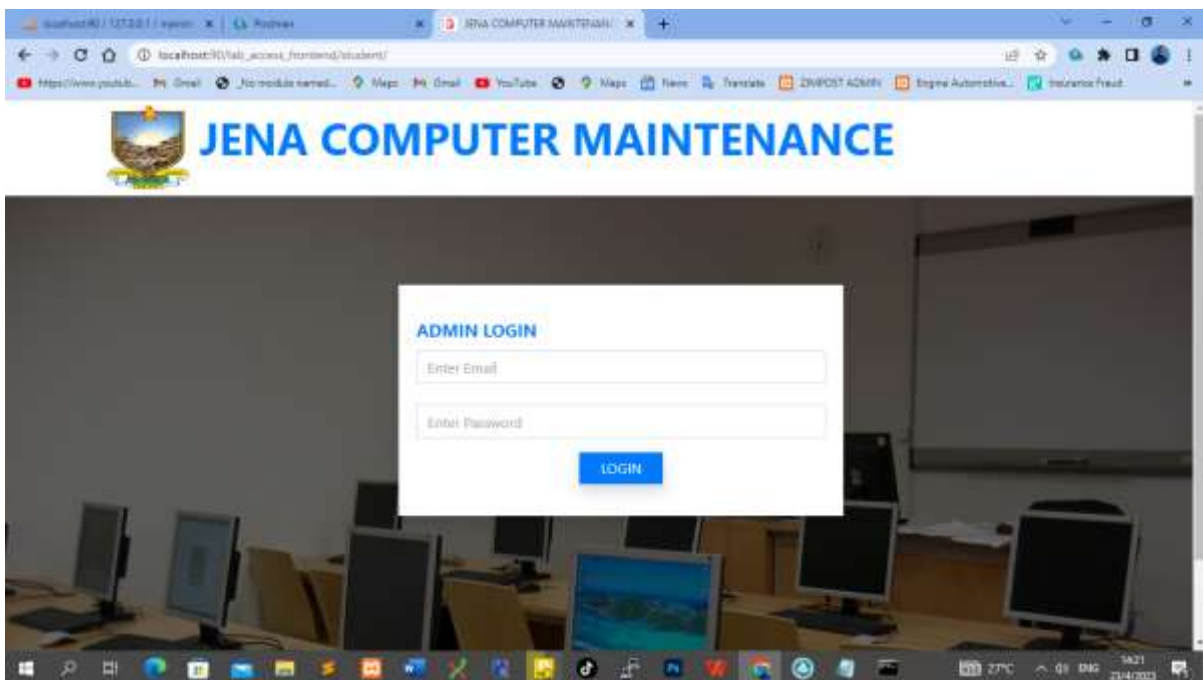### 3.4 ALGORITHMS USED

- Hidden Markov Algorithm (HMA)

Hidden Markov Decision

The optimal routing of a computer in need of maintenance is formulated as a Markov Decision Process (MDP) problem to account for long-term profit over the full working

period. The state is defined by the node at which a computer in need of maintenance is located, and action is the link to take out of the node. State transition probabilities depend on priority matching probabilities and computer in need of maintenance probabilities. The probability that a priority is matched with a technician during the traversal of a link is calculated based on temporal Poisson computer in need of maintenance and spatial Poisson distributions of competing priorities. Priority probabilities are calculated directly using observed fractions of computer in need of maintenance from a given origin. The MDP problem is solved by value iteration resulting in an optimal routing policy, and the computational efficiency is improved by utilizing parallelized matrix operations.

3.5 GENERAL OVERVIEW OF RESOURCE ALLOCATION FOR COMPUTER MAINTENANCE SYSTEM

JENA COMPUTER MAINTENANCE

ALLOCATE A COMPUTER

BEAST GAMING MACHINE

ASUS

CORE I5 11TH GENERATION 32 GIG RAM 1 TERABYTE SSD

--Select Technician--
Liberty Mashonganyika
Shalom Mashonganyika

Revelation Mudoti

ALLOCATE

JENA COMPUTER MAINTENANCE ACCESS CONTROL

Search for PC

All Computers

Report

CSV

Model	Make	Specs	Serial Number	Status
DUAL CORE	HP	CORE I 5 10TH GENERATION	43-TREBENDH234M	good
Chromebook	HP	Dual Core 4 gig RAM	53v3gvndndn4	bad
MAC	MACBOOK	CORE I3 8 GIG RAM	HDHDHDEU3738	good
COMPAQ	HP	DUAL CORE 4 GIG RAM 1 TERABYTE	HJCEHKDCH767BDH	bad
BEAST MACHINE	ASUS	CORE I7 8 GIG RAM 2 TERABYTE	474GDHDBDBD4	good
BEAST GAMING MACHINE	ASUS	CORE I5 11TH GENERATION 32 GIG RAM 1 TERABYTE SSD	54VVDH7HDKDHD	good

Logged in as

Screenshot 1: All Technicians

JENA COMPUTER MAINTENANCE ACCESS CONTROL

Search for PC

Sidebar:
- Dashboard
- Allocate Computer
- Add Technician
- View Technicians

All Technicians

Report

⬇ CSV

Fullname	Email	Idnumber	PhoneNumber
Success Mugwagwa	libertymashonganyika@gmail.com	59-188107 Y 47	0779475766
Shalom Makandigona	chido@gmail.com	59-188107 Y 47	0779475766
Revelation Mudoti	rev@gmail.com	67-234654 N 56	0875736565
Success Mugwagwa	success@gmail.com	45-474844N65	0776543654

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Screenshot 2: All Functional Computers

JENA COMPUTER MAINTENANCE ACCESS CONTROL

Search for PC

Sidebar:
- Dashboard
- Allocate Computer
- Add Technician
- View Technicians

All Functional Computers

Report

⬇ CSV

Model	Make	Specs	Serial Number	Status
DUAL CORE	HP	CORE I 5 10TH GENERATION	43-TRE8ENDH234M	good
MAC	MACBOOK	CORE I3 8 GIG RAM	HDHDHDEU3738	good
BEAST MACHINE	ASUS	CORE I7 8 GIG RAM 2 TERABYTE	474GDHDBDBD4	good
BEAST GAMING MACHINE	ASUS	CORE I5 11TH GENERATION 32 GIG RAM 1 TERABYTE SSD	54VVDH7HDKDHD	good

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JENA COMPUTER MAINTENANCE ACCESS CONTROL

All Non Functional Computers

Report

⬇ CSV

Model	Make	Specs	Serial Number	Status
Chromebook	HP	Dual Core 4 gig RAM	53v3gvndndn4	bad
COMPAQ	HP	DUAL-CORE 4 GIG RAM 1 TERABYTE	HJCEHKDCH767BDH	bad

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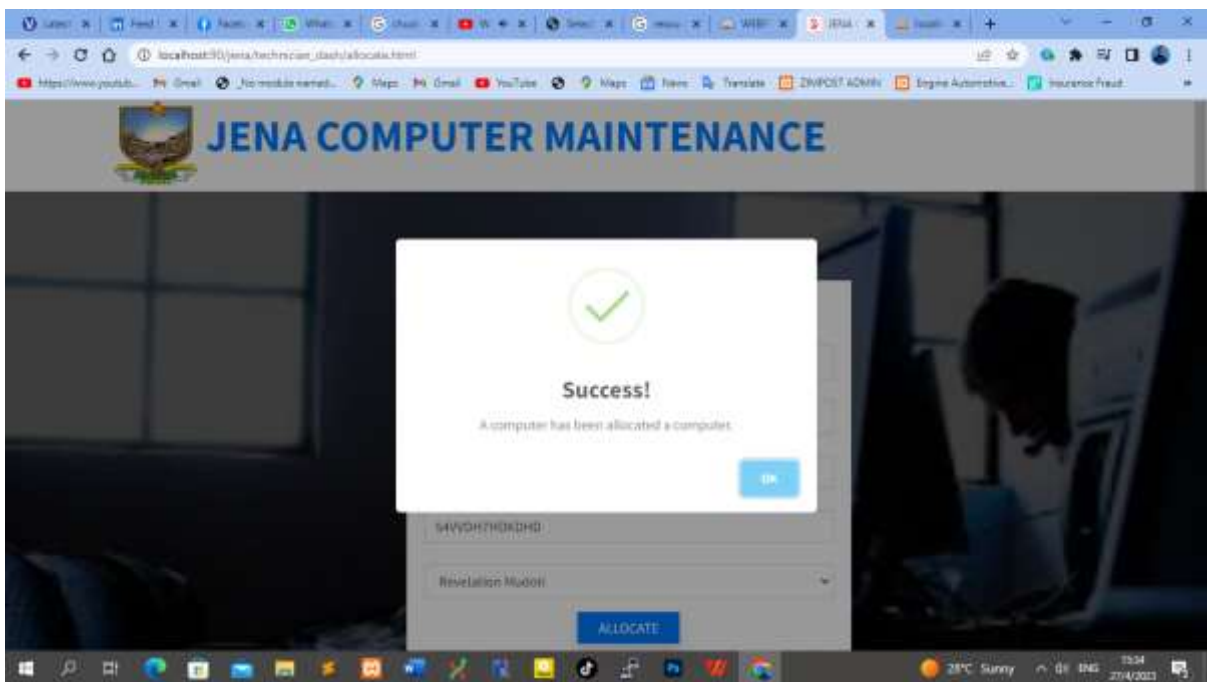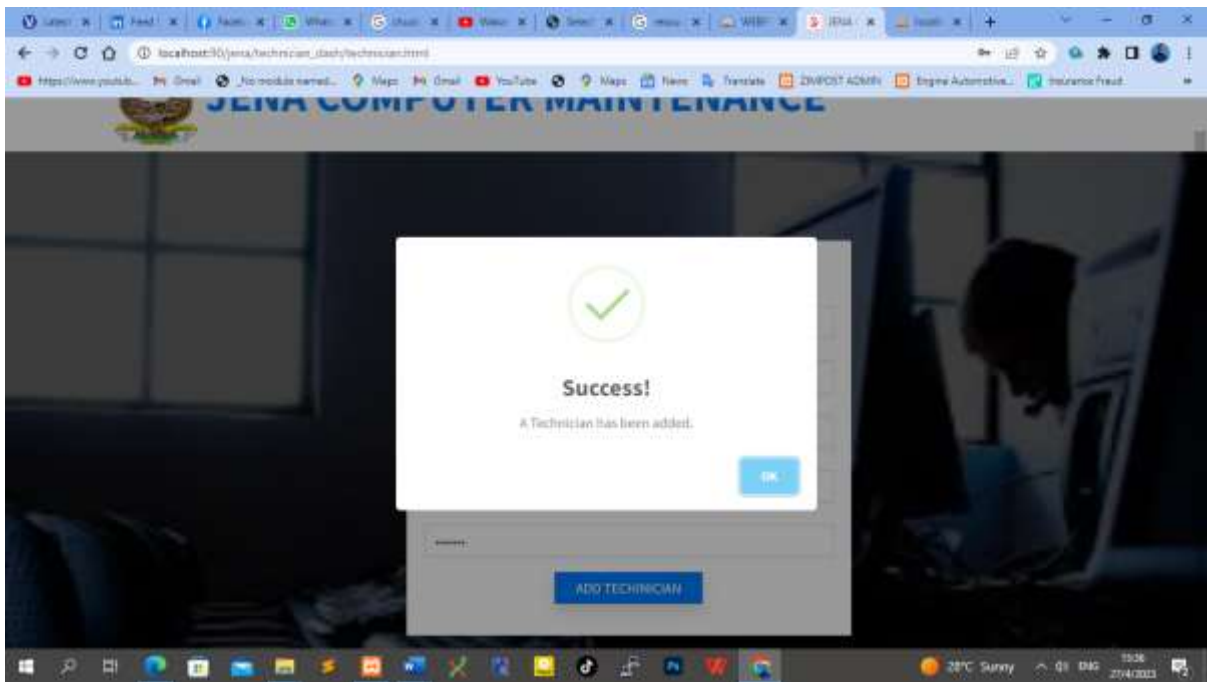## JENA COMPUTER MAINTENANCE

ADD TECHINICIAN

Success Mugwagwa

success@gmail.com

45-474844N65

0778543654

••••••

ADD TECHINICIAN

3.6 SYSTEM DETAILING

This segment serves to give a full detail about the research project, system implementation and its operations. Therefore, the author will slice the detail of the research system into various segments.

3.6.1 System Database Overview

The system uses MySQL database for storing information as well as admins, Technicians and computers. The database has four (4) tables. There is a one-to-many relationship for a technician has many computers. The database consists of only one super admin to control whole system.

3.6.1 Admin Operations

The admin is required to enter the correct credentials in order to access the system. When the admin enters correct credentials, he/she will be directed to the dashboard of the whole system. The dashboard consists of various options including adding technician, allocating computers to technicians, view available technicians, view all computers (functional & non-functional). The admin also can alert the technician by clicking an attend button operation. This button allows the admin to alert the technician that the computer he/she is allocated to is need of maintenance. Immediately an email will be directed to the responsible technician. If the technician fully services the computer the admin will press a resolve button and the computer will be restored to a good state.

3.6.1 Team involved for the system development

The Jena Mine management team approves the research project to be performed at their organization. The IT Director act as an admin. Five computer technicians were involved in the development and testing of the system. The IT Director allows the system to register 20 computers for maintenance. The system was tested and developed using the prototype methodology.

3.6 PROPOSED SYSTEM FLOWCHART
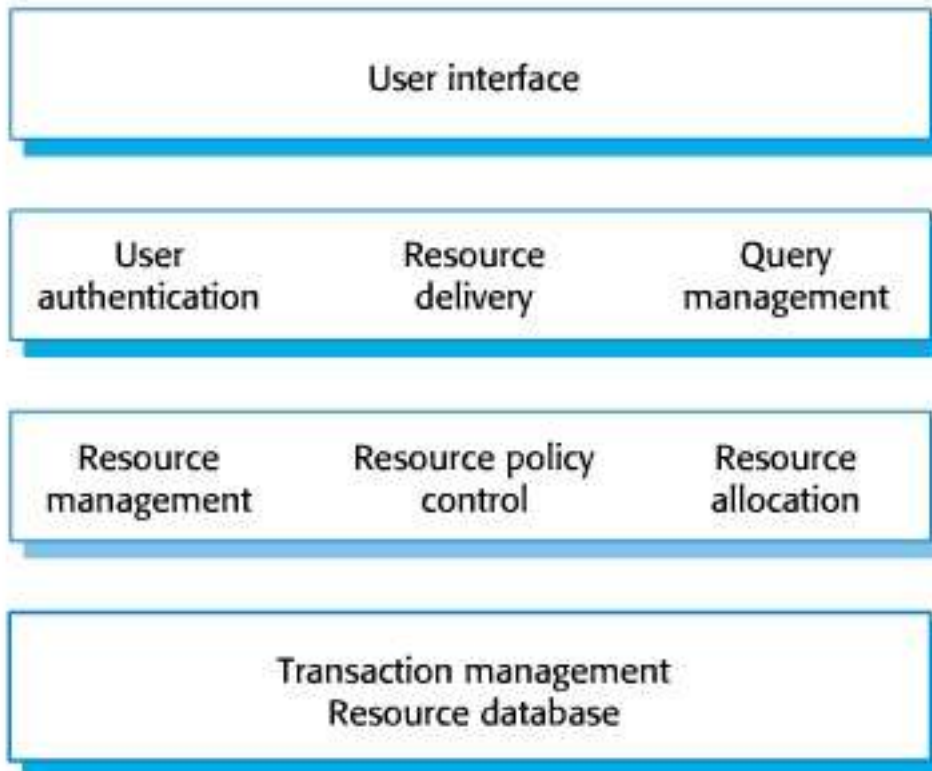
3.7 IMPLEMENTATION OF THE MARKOV ALGORITHM

```php
<?php

declare(strict_types = 1);

namespace MarkovChain;

use MarkovChain\Tokenizer\TokenizerInterface;

/**
 * Class MarkovChain
 *
 * @author Patrick Schur <patrick_schur@outlook.de>
 * @package MarkovChain
 */
class MarkovChain
{
    /**
     * @var array
     */
    protected $result = [];

    /**
     * @var TokenizerInterface|null
     */
    protected $tokenizer = null;

    /**
     * MarkovChain constructor.
     *
     * @param TokenizerInterface $tokenizer
     */
    public function __construct(TokenizerInterface $tokenizer)
    {
        $this->tokenizer = $tokenizer;
    }
```



```php
    public function learn(array $input)
    {
        $matrix = [];

        foreach ($input as $value)
        {
            $array = $this->tokenizer->tokenize($value);

            for ($pos = 1, $length = count($array); $pos < $length; $pos++, $counter++)
            {
                $counter = &$matrix[ $array[$pos - 1] ][ $array[$pos] ];
            }
        }

        foreach ($matrix as $prev => $array)
        {
            $total = array_sum($array);

            foreach ($array as $next => $count)
            {
                $this->result[$prev][$next] = ($count / $total);
            }
        }
    }

    /**
     * @param string $subject
     * @return array|null
     */
    public function classify(string $subject)
    {
        if (!isset($this->result[$subject])) {
            return null;
        }
```

File Edit Selection Find View Goto Tools Project Preferences Help

```php
        $array = $this->tokenizer->tokenize($value);

        for ($pos = 1, $length = count($array); $pos < $length; $pos++, $counter--)
        {
            $counter = &$matrix[ $array[$pos - 1] ][ $array[$pos] ];
        }
    }

    foreach ($matrix as $prev => $array)
    {
        $total = array_sum($array);

        foreach ($array as $next => $count)
        {
            $this->result[$prev][$next] = ($count / $total);
        }
    }
}

/**
 * @param string $subject
 * @return array|null
 */
public function classify(string $subject)
{
    if (!isset($this->result[$subject])) {
        return null;
    }

    arsort($this->result[$subject]);

    return $this->result[$subject];
}
```

File Edit Selection Find View Goto Tools Project Preferences Help

```php
    */
   public function handle()
   {
       $quotes = [
           'Computers Needs Checking' => 'The computer is down .Go and check as soon as
               possible.',
       ];

       $key = array_rand($quotes);
       $data = $quotes[$key];

       $users = Technician::all();
       foreach ($users as $user) {

           Mail::raw("{$key} -> {$data}", function ($mail) use ($user) {
               $mail->from('successmsgwague@gmail.com');
               $mail->to($user->email)
                   ->subject('COMPUTER MAINTENACE ALERT!');
           });
           // }
       }

       $this->info('Successfully sent alert to all Technicians.');
   }
   protected function schedule(Schedule $schedule)
   {
       $schedule->command('quote:daily')
           ->everyMinute();
   }
}
```
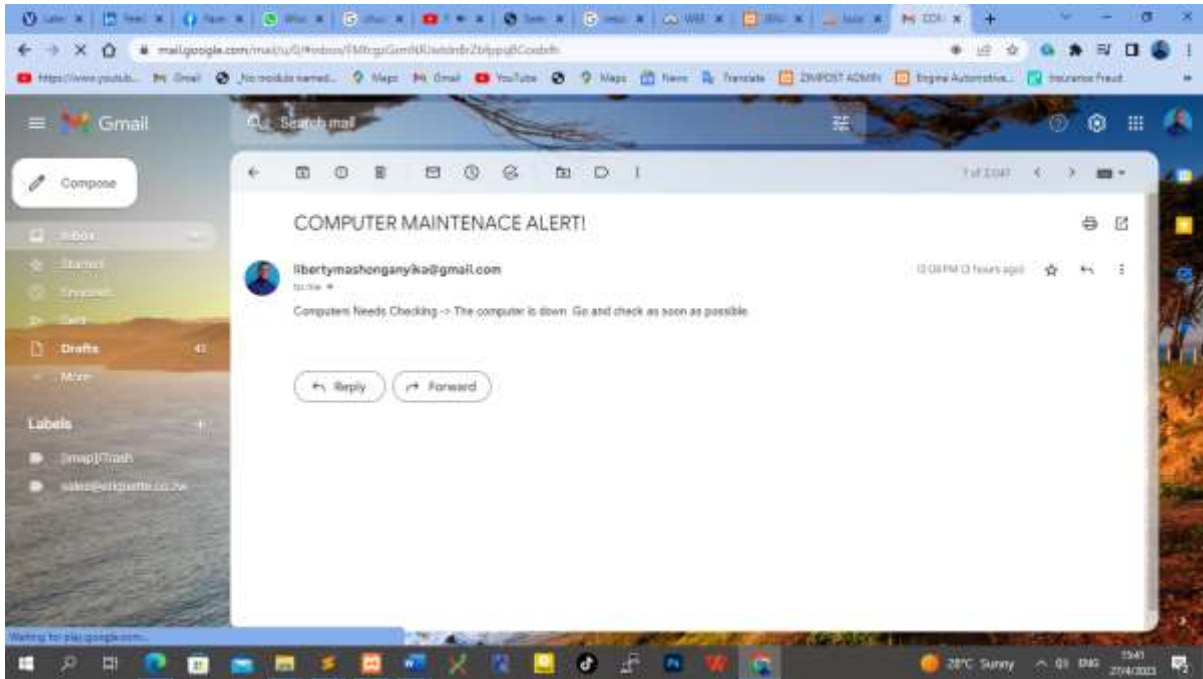
This section implicates setting the system into action thus coordination and directing the resources elaborated in the previous chapter to meet the objectives of the research plan. Thus, all the documentation from all previous chapters is being finalized to align it in order to deliver the system.

The application is required to have a specified data for Technicians and Computers allocated to each specified user if the computers are not working or in bad shape. Therefore, the system is required to have accurate email addresses which will enhance easy alert to the users.

3.8 CHAPTER SUMMARY

This chapter mainly focused on the methodology used in the development of the system and how it was designed as well as implemented. Different techniques were used to come up with the system, also different tools like the android 3.0 and different Markov algorithms made it possible to come up with the proposed system.

CHAPTER 4: RESULTS AND ANALYSIS

4.0 INTRODUCTION

After the author had successfully implemented the system there arose the need to analyze the efficiency of the developed solution. Accuracy, performance and response time were the matrices used to determine the efficiency and effectiveness of the developed solution. The developed solution's behavior was also well observed under the different times and the outcome was presented in a table format.

4.1 TESTING

Testing is a vital part of the development process and this chapter shows the tests that were undertaken and the result they produced. The testing is thus measured against the functional and non-functional requirements as outline in the previous chapter.

4.1.1 BLACK BOX TESTING

Black box testing enables a user without the knowledge of the internal structure of the system to test it against the functional and sometimes the non-functional requirements of the system. It mainly focused on reminding the Technician for computer maintenance through continuous email sending. Thus, the main purpose of black box testing was to test if the system worked as per expected in requirement document.

4.1.1.1 FUZZY TESTING

Fuzzy testing is a black box testing technique which the researcher used on the Resource Allocation Maintenance application to check if the system is accurately responding and giving the correct results as per given enough data.

4.2 EVALUATION MEASURES AND RESULTS

An evaluation metric measures the performance of a classifier (Hossin & Sulaiman, 2015). Moreover, according to Hossin & Sulaiman (2015), model evaluation metrics can be grouped into three types namely threshold, probability and ranking.

4.2.1 Measuring System Performance

The performance of the system is ranked according to its ability to give a real time feedback as per given user's location.

4.2.1 Measuring System Performance

The performance of the system is ranked according to its ability to give a real time feedback as per given dataset.

Machine 1(8 gig Ram, Core i3 1Terrabytes)

Test Runs	1	2	3	4	5
Time(s)	150	145	151	164	149

Mean Value for the performance of the system on machine 1

150+145+151+164+149=759/5

=151.8 seconds

Machine 2(8 gig Ram, Core i3 1terabyte)

Test Runs	1	2	3	4	5
Time(s)	69	78	76	67	80

Mean Value for the performance of the system on machine 1

69+78+76+67+80=370/5 =74 seconds

Measuring Supervised Machine Learning to previous algorithms

| Algorithms	Markov Decision Algorithm	Decision Tree	Random Forest
Accuracy	0.99	0.98	0.99

Table 1 Confusion Matric

Type	Bad Resource Allocation Decision	Accurate Resource Allocation Decision
Bad Resource Allocation Decision	True Positive	False Negative
Accurate Resource Allocation Decision	False Positive	True Negative

Three scenes and test environment were created for observation of the system. On each scene the system was observer on 40 occasions ,20 occasions were performed on bad resource allocation and 20 occasions were performed on good resource allocation and the behavior of the system was observed. All the analysis on the scenes was carried out to test for the solution's accuracy and elimination of false prediction. The tables below show the observed results from the tests carried out.

Table 2 Accurate Resource Allocation

Test cases	Accurate Resource Allocation	Number of occasions	Correct readings	False Readings	Classification
1	Yes	20	16	4	True positive
2	No	20	18	2	True negative

Accurate Resource Allocation

Accurate Resource Allocation
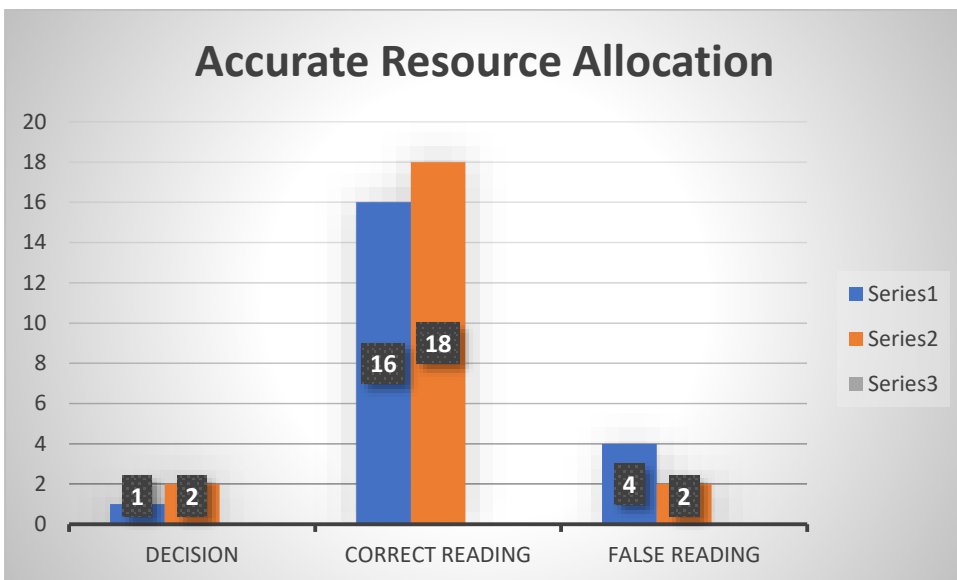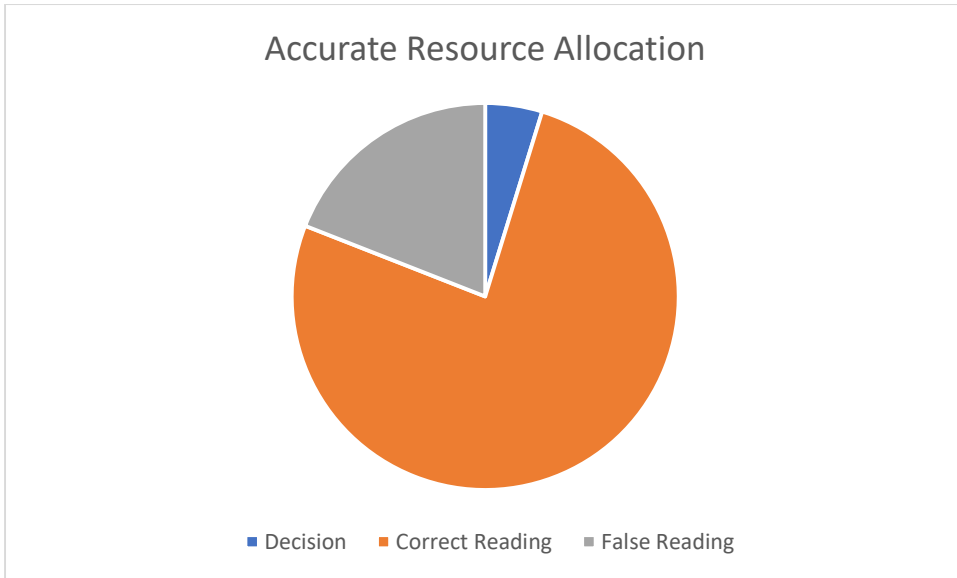
Table 3 Bad Resource Allocation

Test cases	Bad Resource Allocation	Number of occasions	Correct readings	False Readings	Classification
1	Yes	20	14	6	True positive
2	No	20	17	3	True negative

Bad Resource Allocation

Decision   Correct Reading   False Reading

Bad Resource Allocation

Decision   Correct Reading   False Reading

Series1   Series2
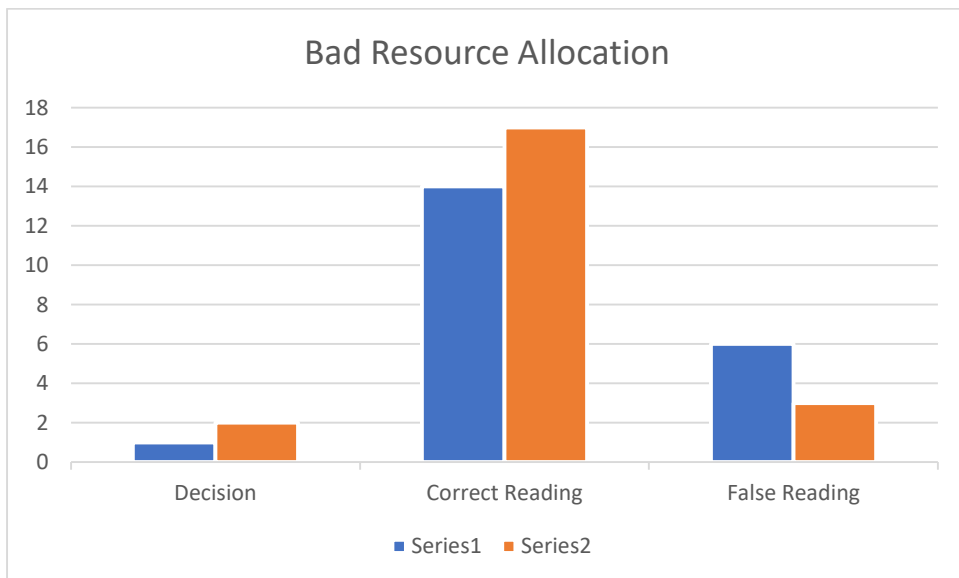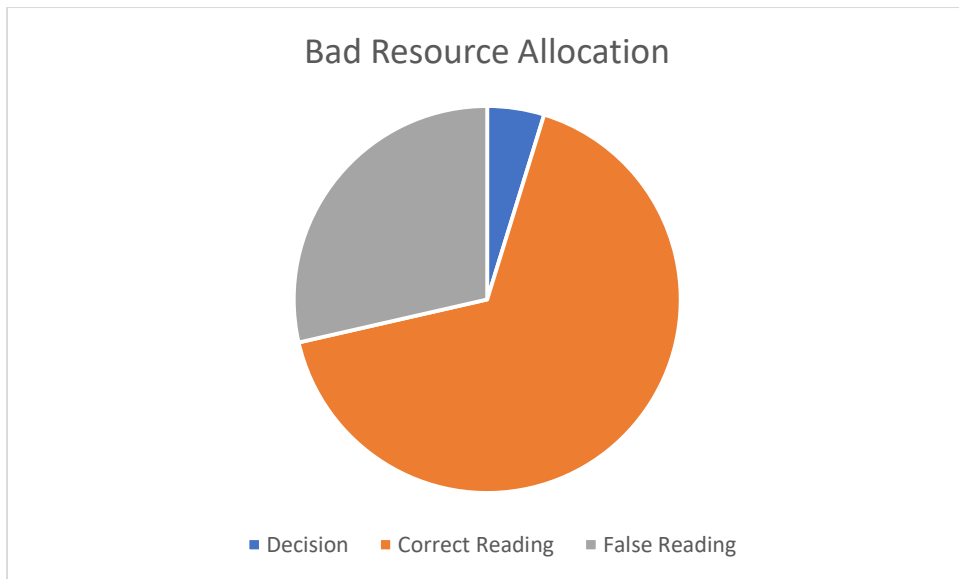
4.2.1 Accuracy

Accuracy is the number of right predictions divided by the total number of network decision in each category. It is then multiplied by 100 to get the percentage of correctness. It is calculated using the equation below:

Equation 1: Accuracy calculation as adopted from Karl Pearson (1904)

$$\text{Accuracy} = (TP+TN)/ (TP+TN+FP+FN)*100$$

Accuracy on Good Road Network = (16+18)/ (20+20+0+0)

$$=0.85$$

$$=0.85*100= 85\%$$

Accuracy on Bad Road Network = (14+17)/(14+17+3+6) *100

$$= 76\%$$

Average Accuracy rate = Accuracy at (good + bad) /2

$$= (85+88)/2 *100 = 173/2 *100$$

$$=86.5\%$$

4.3 Conclusion

The test results indicated the solution had a high level of accuracy since in 2 scenes it produced an 85% and 76% rate of accuracy respectively which was a result of the analysis of the confusion matrix. However, the solution had eighty-five (85%) percent accuracy during the accurate resource allocation this was due to the high levels of traffic, poor resource allocation and insufficient Technicians to traverse for the data and proper environment exposure. The high levels of accuracy of the system indicate a reduction of false prediction on resource allocation.

CHAPTER 5: RECOMMENDATIONS AND FUTURE WORK

5.1 Introduction

In the previous chapter, the researcher focused on presentation and analysis of obtained data. This chapter covers the research and development of the solution in line with the set objectives. This chapter will also examine the difficulties encountered by the researcher in designing and carrying out this study.

5.2 Aims and Objectives Realization

Decision-making plays a very important role on individual, organizational, societal, and governmental levels. In this study, the decision maker (vendor), after considering all surrounding circumstances, has to go through the core process before an action is taken among several alternatives. The kind of decision taken by the vendor today affects its future either positively or negatively. The fundamental decision faced by the organization is how to optimally allocate its resources at each decision epoch during a time horizon on a machine required for maintenance to optimize its performance. From a control point of view, the organization as the controller must optimize its allocation function at each decision epoch by selecting appropriate action(s) from its action space.

5.3 Conclusion

Since the aim of Artificial Intelligence is to get closer to human behavior therefore with this researcher, the author concludes that several developments being done so far is quite promising of the future to come.

5.4 Recommendations

There is need for greater adjustments in terms of imitating the human decision making mindset .Firstly the machine learning models have to be more developed in such a way that they can be able to imitate real natural human mindset on decision making.

5.5 Future Work

The researcher didn't manage to completely develop a system which can make decision for available technicians. This was due to lack of resources and time. Therefore, the researcher uses less dataset. The package is bundled with the project. There is need for a 2 gig NVidia graphics card.

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