ZIMBABWE OPEN UNIVERSITY

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"TANK FARM MONITORING SYSTEM"

BY

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Approval form

The undersigned certify that they have supervised the student **P1970141R** dissertation and project entitled **Tank Farm Monitoring System** submitted in Partial fulfilment of the requirements for the Bachelor of Software Engineering Honour's Degree of Zimbabwe Open University.

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Dedications

You are the pillars of my life, the guiding stars that have illuminated my path and shaped me into the person I am today. Dad, your unwavering belief in my abilities has given me the courage to reach for the stars. Mama, your wisdom and nurturing nature have instilled in me the values of compassion and resilience. Kudakwashe, your innocence and pure love have reminded me of the beauty and purity in this world. Nyaradzai, your unwavering love and unwavering support have given me the strength to pursue my dreams fearlessly, and Mazvitazvenyuishe, your infectious laughter and boundless curiosity have reminded me to find joy in every moment.

This project is dedicated to each one of you, for your unconditional love, encouragement, and sacrifices. You have stood by my side through thick and thin, offering your unwavering support and cheering me on even when doubt crept in. Your belief in me has been my guiding light, propelling me forward when the road seemed treacherous.

Thank you for being my rock, my inspiration, and my biggest fans. This is a testament to the profound impact you have had on my life, and I am eternally grateful for the love and strength you have given me.

With immense love and gratitude,

Darlington Azram Shoniwa

Abstract

Tank farms are critical infrastructures used for the storage and distribution of various liquid products such as petroleum, chemicals, and gases. Ensuring the safe and efficient operation of tank farms is of utmost importance to prevent accidents, minimize environmental risks, and optimize resource utilization.

This abstract presents a tank farm monitoring system designed to enhance the overall management and safety of tank farm operations. The system utilizes advanced technologies such as Internet of Things (IoT), sensor networks, and data analytics to provide real-time monitoring, control, and decision support.

The tank farm monitoring system consists of several components. Firstly, a network of sensors is deployed throughout the tank farm to capture critical parameters such as liquid levels, temperatures, pressures, and gas concentrations. These sensors continuously collect data and transmit it to a centralized data acquisition system.

The collected sensor data is processed and analysed using advanced algorithms and machine learning techniques. The system employs anomaly detection algorithms to identify abnormal conditions such as leaks, overflows, or equipment malfunctions. Additionally, predictive analytics models are utilized to forecast future states and behaviours of the tank farm, enabling proactive maintenance and optimization.

The monitoring system provides a user-friendly interface that allows operators and managers to visualize real-time data, receive alerts and notifications, and access historical trends and reports. It facilitates remote monitoring and control of the tank farm, enabling operators to make informed decisions and take prompt actions when necessary.

By implementing the tank farm monitoring system, operators can improve safety by early detection of potential hazards, optimize operational efficiency by identifying bottlenecks and inefficiencies, and reduce maintenance costs through proactive maintenance practices. The system also supports compliance with regulatory standards and facilitates data-driven decision-making for long-term planning and optimization.

In conclusion, the tank farm monitoring system presented in this abstract offers a comprehensive solution for enhancing the safety, efficiency, and management of tank farm operations. By leveraging advanced technologies, the system empowers operators and managers with real-time insights, enabling them to mitigate risks, optimize resources, and ensure the smooth functioning of tank farm facilities.

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CHAPTER 1: PROBLEM IDENTIFICATION

1.0 Introduction

Raspberry Pi is a small, single-board computer that was developed with the intention of promoting computer science education and providing an affordable platform for experimentation and project development. It was first introduced by the Raspberry Pi Foundation in 2012 and has since gained popularity among hobbyists, students, and professionals alike.

Here are some key features and characteristics of Raspberry Pi:

1. Size and form factor: Raspberry Pi boards are compact and credit card-sized, making them easily portable and suitable for various applications.

2. Hardware: Raspberry Pi boards feature a processor, RAM, graphics processing unit (GPU), input/output (I/O) ports, and storage options (typically via microSD card). Different models of Raspberry Pi offer varying specifications and capabilities.

3. Operating System: Raspberry Pi can run a variety of operating systems, including the Raspberry Pi Foundation's official operating system called "Raspberry Pi OS" (formerly known as Raspbian), as well as other Linux distributions and even Windows 10 IoT Core.

4. GPIO Pins: Raspberry Pi boards are equipped with General-Purpose Input/Output (GPIO) pins, which allow for interfacing with various electronic components and peripherals, such as sensors, actuators, displays, and more. This makes it a popular choice for projects involving physical computing and Internet of Things (IoT) applications.

5. Programming: Raspberry Pi supports multiple programming languages, including Python, C/C++, Java, and others. Its versatility and accessibility make it an excellent platform for learning programming and electronics.

6. Community and Resources: Raspberry Pi has a vast and active community of enthusiasts, developers, and educators. There are numerous online resources, tutorials, forums, and projects available, making it easier to get started and seek assistance when needed.

Raspberry Pi can be used for a wide range of projects, such as home automation, robotics, media centers, retro gaming consoles, weather stations, and much more. Its affordability, versatility, and vast community support have contributed to its popularity as a powerful tool for learning, prototyping, and building innovative projects.

1.2 Background

Zimgold Oil Industries was incorporated in Zimbabwe in 2012 initially as a joint venture between ETG/Vamara & Parrogate Zimbabwe. The first commercial production started in 2013. The business is now an established processor of edible oil primarily soya bean, cotton, palm, sunflower, and canola oil with the leading brand being "ZIMGOLD". The company crushes soya beans, cotton seeds and sunflower seeds and extracts oil that is furnished into different brands as mentioned above. However, Zimgold cannot sustain the cooking oil demands of the nation via extracting oil through only seed crushing but also imports crude oil which is then refined to the finest and favored audible oil.

When crude oil is received at the organization it is stored in storage tanks waiting for processing. This place has a collection of different tanks for storage of crude oil and is named the Tank farm. These tanks store processed oil and that is ready for market which is Palm Olen and Zimgold cooking oil which is transferred to the Bottling Plant for packaging into different sizes that is 750 ml, 2 liters, 5 liters, and 20 liters.

1.3 Problem Statement

There is an issue of oil spillage in the tank farm area, the receiving tanks become full during receiving and end up spilling the oil, resulting in a loss for the organization.

Using a reference conversation to calculate projected tank capacities is insufficiently acceptable in reporting farm quantity because dipping sticks are used to measure the oil content. The organization has challenges that lead to operating inefficiencies, making it impossible to maintain an exact inventory level and ensure the effective use of our tank.

When the tank farm receiving clerk plunges for dip readings on top of the 25 m high tanks, they are falling hence hazard.

Moreover, because the issuing valve is controlled manually, the operators are dispensing more bulk oil than is specified on the order.

Lastly, the tank farm target for theft, sabotage, or other security breaches, we are concerned about its safety.

1.4 Research Aim

To design and implement a Raspberry pi prototype for a tank farm monitoring system for Zimgold Oil Industries.

1.5 Research Objectives

1. To develop a web-based portal to facilitate remote tank farm monitoring and tank operations.
2. To develop a tank farm monitoring prototype utilizing raspberry pi, sensors, pumps etcetera working together.
3. To develop a system that can effectively report real time tank farm status.

4. To develop a system that includes the analysis of sensor data to detect anomalies, predict equipment failures, and optimize tank utilization.

1.6 Research Question

1. What are the current challenges and limitations of existing tank farm systems in terms of safety, efficiency, and economical sustainability?
2. What are the best practices and technologies available for real-time monitoring and detection of leaks, spills, and other hazardous incidents in a tank farm.
3. How will the web-based portal be capable of communication with the Raspberry pi and the other components?
4. What are the key parameters and variables that should be monitored in a tank farm to ensure safe and efficient operations?
5. How can a tank farm monitoring system be integrated with other industrial project control components i.e., Ultrasonic sensors, flowmeters and pumps communicate with each other to enable seamless communication and decision-making?
6. What are the potential economic benefits and return on investment (ROI) associated with implementing an advanced tank farm monitoring system?

1.7 Research Hypothesis

Does a tank farm monitoring system reduce operational costs for oil and storage tanks?

H0: A tank farm monitoring system has no effect on operational costs for oil and chemical storage tanks.

H1: A tank farm monitoring system reduces operational costs for oil and chemical storage tanks.

1.8 Significance of the study

A tank farm monitoring system is a system that uses wireless technology to measure and report the level, temperature, pressure, and other parameters of liquid tanks in remote locations. It can be used for inventory management, overfill prevention, leak detection, safety compliance and automation of tank farms.

Reducing operational costs by eliminating manual measurements, optimizing tank capacity and transfer rates, and minimizing human errors and risks.

Enhancing environmental protection by preventing oil spills, leaks, and losses, and complying with regulatory standards.

Furthermore, the implementation of such a system brings great innovation not only to Zimgold Oil industries but to the country, as many organisations will find this project as a point of reference for implementation of such systems.

1.9 Scope

A tank farm monitoring system is a system that collects and analyses data from various sensors and devices installed in a tank farm, which is a facility that stores crude oil in large tanks. The system aims to provide real-time information on the status and performance of the tanks, such as temperature, pressure, level, flow, leakage, etc. The system also aims to detect and alert any abnormal or hazardous conditions that may affect the safety and efficiency of the tank farm operations. The project scope for a tank farm monitoring system includes the following.

Define the objectives and requirements of the system, such as the types and number of tanks to be monitored, the data to be collected and analysed, the communication protocols and standards to be used, the security and reliability measures to be implemented.

Design the system architecture and purchasing components, such as the sensors and raspberry pi to be installed for managing and control of the prototype, installation of ultrasonic sensors for tank data acquisition and processing, purchase of the network and communication infrastructure.eg ethernet cables and Ethernet port outlet.

Develop a ASP.NETCORE WEBAPI app for management, control monitoring of the prototype and test the system software and hardware, such as the data collection and, the user interface and display functions, the network and communication protocols, the sensor and device calibration and configuration.

Deploy and commission the system in the tank farm, such as installing and connecting the sensors and devices in the tanks, setting up and configuring the data acquisition and processing units, testing, and verifying the system functionality and performance.

1.10 Assumptions of the Research

After the tank farm monitoring system tank is installed, it will give real-time monitoring of all tanks inside the farm. Continuous monitoring of tank contents for example level pressure, and other important metrics would be included like leak detection. The technology would provide remote access to monitoring data, allowing operators to view tank status and receive alarms from any location at any time. Sensors in each tank measure level, temperature, and pressure.

The tank farm monitoring system is simple to deploy, scale, and maintain. Even when operators are not physically present at the tank farm, this would allow for more efficient management and decision-making. Automated Alerts, the system would have automated alert mechanisms that would notify operators of any abnormal conditions or potential issues. These notifications could be delivered via email, alarm, or a dedicated monitoring platform, ensuring a quick response to prevent or mitigate issues.

By decreasing manual gauging, optimising inventory management, minimising spills, and leaks, and improving customer service, the tank farm monitoring system improves the efficiency, safety, and profitability of tank farm operations.

1.11 Limitation

1. Training for the staff to adapt to the complimentary system, depends on their level of computer literacy.
2. Solution depends heavily on the stability of internet connectivity.
3. This resolution is contingent upon availability of electrical power source.

1.12 Definition of terms

Arduino: An open-source electronics platform based on easy-to-use hardware and software. The hardware component of an Arduino board is a programmable circuit board that is also known as a microcontroller. A microcontroller is a small computer with a processor, memory, and other peripherals designed for embedded applications.

Raspberry pi: A small, single-board computer that was developed with the intention of promoting computer science education and providing an affordable platform for experimentation and project development. It was first introduced by the Raspberry Pi Foundation in 2012 and has since gained popularity among hobbyists, students, and professionals alike.

Tank Farm: A tank farm monitoring system is a system that uses wireless technology to measure and report the level, temperature, pressure and other parameters of liquid tanks in remote locations. It can be used for inventory management, overfill prevention, leak detection, safety compliance and automation of tank farms.

Ultrasonic Sensor: is used for non-contact range detection. It makes use of sonar for its working. IR Infrared obstacle avoidance sensor detects objects which are before it and generates a digital signal.

Tank Farm Monitoring System: The project intended to be implemented at Zimgold Oil Industries that will monitor the tank farm area operations from crude oil receiving to Palm Olen offloading.

Ethernet shield: Is a device that connects an Arduino to the internet. The Arduino Ethernet Shield connects an Arduino to the internet in mere minutes. Just plug this module onto your Arduino Board, connect it to your network with an RJ45 cable and follow a few simple steps to start controlling your world through the internet**.**

Crude Oil: a dark oil consisting of many hydrocarbons that can be further refined into plenty types of oils.

MQTT: Message Queuing Telemetry Transport. It is a publish/subscribe, extremely simple and lightweight messaging protocol, designed for constrained devices and low-bandwidth, high-latency or unreliable networks. The design principles are to minimize network bandwidth and device resource requirements whilst also attempting to ensure reliability and some degree of assurance of delivery.

MongoDB: MongoDB is a NoSQL document database that allows us to save documents with different schemas in one collection. MongoDB is our data persistence layer. This kind of database is well suited for dealing with sensor data from various devices, as the data structure or the parameters vary from solution to solution. To know more about MongoDB, refer to https://www.mongodb.com.

Palm Olen: is an edible vegetable oil derived from the mesocarp (reddish pulp) of the fruit of the oil palms. The oil is used in food manufacturing, in beauty products, and as biofuel.

Zimgold Oil industries: A fast-moving consumer goods company located at 72 Lytton Road Workington Harare where the proposed system is to be implemented.

Single Page Application: A web app implementation that loads only a single web document, and then updates the body content of that single document via JavaScript APIs such as HTTP Request and Fetch when different content is to be shown.

Vuejs: Is a progressive JavaScript framework for building user interfaces. It is an open-source framework that was developed by Evan You in 2014. Vue.js is designed to be easy to use and understand, while still being powerful and flexible enough to build complex applications.

Node-red: Node-RED is a flow-based programming tool for the Internet of Things (IoT). It was developed by IBM Emerging Technology and was released as an open-source project in 2013. Node-RED provides a browser-based flow editor that allows users to create and deploy complex flows using a visual programming interface.

IOT: Stands for Internet of things which is a network of physical devices, appliances, and other items that are embedded with sensors, software, and connectivity, enabling them to connect and exchange data with each other and with the internet. IoT devices can be anything from a simple sensor to a complex machine, and they can communicate with each other and with humans in real-time.

API Engine: An API engine is a web server application, written on Node.js, Express with persistence layer as MongoDB. This engine is responsible for communicating with Mosca as a MQTT client, persisting data into MongoDB as well as to expose APIs using Express. These APIs are then consumed by the apps to display the data.

Angular: Angular is a web development framework that lets you create scalable and secure web apps with confidence. It is written in TypeScript and is free and open-source. Angular implements core and optional functionality as a set of TypeScript libraries that you import into your applications.

.NET: .NET is a free, open-source, cross-platform framework for building modern apps and powerful cloud services. It supports building web apps and services for macOS, Windows, Linux, and Docker. You can use a single codebase to build native apps for Windows, macOS, iOS, and Android.

CHAPTER 2: LITERATURE REVIEW

2.0 General Overview

Tank farms are critical infrastructures used for storing large quantities of liquids, such as petroleum products, chemicals, and gases. The monitoring and management of tank farms are essential to ensure safe operations, prevent environmental hazards, and optimize resource utilization. In recent years, the development of advanced monitoring systems has significantly enhanced the safety and efficiency of tank farm operations.

Tank farm monitoring systems are designed to provide real-time monitoring and control of tank farm operations. These systems can collect data from various sensors and devices installed in the tank farm, such as level sensors, temperature sensors, pressure sensors, and flow meters. This data is then processed and analyzed to provide insights into the performance of the tank farm and to identify any potential issues that may arise.

This literature review aims to explore the existing research and technologies related to tank farm monitoring systems.

2.1 Tank Farm Monitoring System Components

Sensors and Instrumentation

Sensors play a crucial role in tank farm monitoring systems by collecting data on various parameters such as temperature, pressure, level, and composition. Different types of sensors, including ultrasonic, radar, and capacitance sensors, are utilized to accurately measure liquid levels and detect leaks.

Communication Infrastructure

Efficient communication systems are essential for real-time monitoring and control of tank farms. Wireless technologies, such as Wi-Fi, ethernet, Zigbee, and cellular networks, enable seamless data transmission between sensors, control units, and central monitoring stations.

Data Management and Analysis

The collected data from tank farm monitoring systems can be vast and complex. Effective data management and analysis techniques are required to process the data and extract actionable insights. Data storage, retrieval, and visualization techniques, along with advanced analytics tools like machine learning algorithms, can aid in identifying patterns, anomalies, and predictive maintenance opportunities.

2.2 Applications of Tank Farm Monitoring Systems

Safety and Security
Monitoring systems provide real-time information on tank conditions, enabling operators to identify potential safety hazards, such as leaks, overflows, or abnormal pressure levels. Early detection of such incidents allows for prompt response actions, minimizing the risk of accidents and environmental contamination. Integration with security systems, such as access control and surveillance cameras, enhances overall security.

Operational Efficiency and Resource Optimization

Tank farm monitoring systems contribute to optimizing resource utilization and operational efficiency. Accurate measurement of liquid levels helps in managing inventory and scheduling deliveries. Real-time monitoring of temperature and pressure enables operators to optimize processes and reduce energy consumption. Predictive maintenance algorithms can identify potential equipment failures, reducing downtime and maintenance costs.

Regulatory Compliance

Tank farms are subject to various regulations and standards imposed by environmental agencies and safety organizations. Monitoring systems facilitate compliance by providing accurate and reliable data on tank conditions, emissions, and leak detection. Automated reporting capabilities streamline regulatory reporting processes and ensure transparency.

Challenges and Future Directions
Despite the advancements in tank farm monitoring systems, several challenges remain. These include the integration of legacy systems, cybersecurity threats, and the need for interoperability standards. Future research should focus on developing advanced analytics techniques, such as artificial intelligence and big data analytics, to improve anomaly detection, predictive maintenance, and risk assessment capabilities.

Conclusion
Tank farm monitoring systems have evolved significantly, providing enhanced safety, operational efficiency, and regulatory compliance. The integration of sensors, communication infrastructure, and data management techniques enables real-time monitoring, predictive maintenance, and intelligent decision-making. Further research and development efforts should be directed towards addressing the challenges and exploring emerging technologies to ensure the continuous improvement of tank farm monitoring systems.

2.3 Recent Developments in Tank Farm Monitoring Systems

Recent developments in tank farm monitoring systems have focused on addressing some of the challenges associated with their implementation and improving their functionality and efficiency. One such development is the use of wireless communication devices. Traditionally, tank farm monitoring systems have used wired communication devices, which can be expensive and time-consuming to install. Wireless communication devices offer several advantages over wired devices, including lower installation costs, increased flexibility, and reduced maintenance requirements.

Another recent development in tank farm monitoring systems is the use of cloud-based software. Cloud-based software offers several advantages over traditional on-premises software, including increased scalability, flexibility, and accessibility. With cloud-based software, tank farm operators can access their monitoring system from anywhere with an internet connection, making it easier to manage and analyze data remotely.

Recent developments in technology, such as wireless communication devices, cloud-based software, AI and ML algorithms, and improved data visualization capabilities, have improved the functionality and efficiency of these systems. The implementation of these systems offers several benefits to tank farm operators, including improved safety, increased efficiency, and cost savings. However, there are also several challenges associated with the implementation of these systems, including the complexity of the systems, the integration of the components, and the management of the data generated by the systems. Successful implementation requires careful planning, coordination, and management to ensure that the system meets the specific needs and requirements of the tank farm.

Finally, there has been a focus on improving the user interface and data visualization capabilities of tank farm monitoring systems. This includes the use of dashboards and graphical interfaces that provide real-time data visualization and alerts, making it easier for operators to monitor the performance of the tank farm and quickly identify any potential issues.

2.4 Case Studies

Several case studies have demonstrated the benefits of implementing tank farm monitoring systems and vindicated the importance of such facilities for example in Zimbabwe. These facilities are used to store a variety of materials, including petroleum products, chemicals, and other hazardous materials. A tank farm monitoring system can help to improve safety and efficiency, and here is a case study of a tank farm monitoring system in Zimbabwe:

Background:

Zimbabwe Petroleum Company (ZPC) operates a tank farm in the outskirts of Harare, which is the largest city in Zimbabwe. The tank farm has over 30 tanks of different sizes, ranging from 5,000 to 50,000 litters, and stores various types of petroleum products, including gasoline, diesel, and jet fuel. ZPC is responsible for ensuring the safety and reliability of its tank farm operations, and therefore decided to implement a tank farm monitoring system.

Solution:

ZPC worked with a vendor to develop a tank farm monitoring system that could monitor the level, temperature, and pressure of each tank in real-time. The system included sensors installed on each tank that could transmit data wirelessly to a central monitoring station.

The monitoring station was equipped with software that could display the data from each tank in real-time, allowing operators to quickly identify any issues or abnormalities. The software also included alarms and notifications that would alert operators if a tank was approaching capacity, if the temperature or pressure exceeded safe levels, or if there was a leak or other issue.

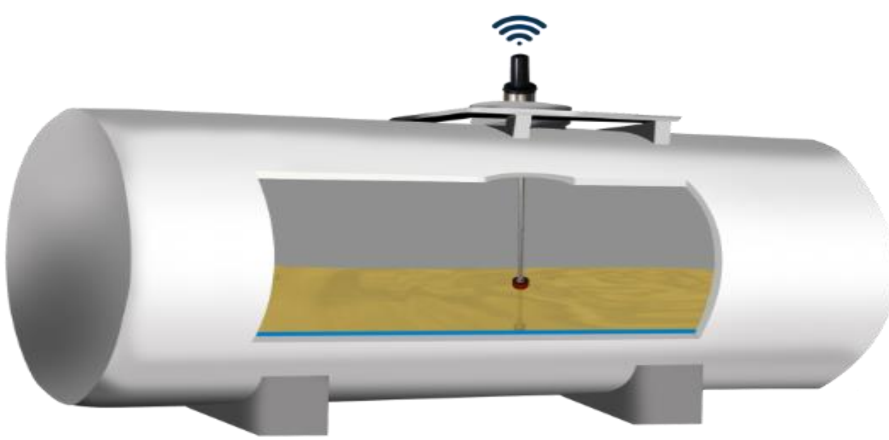
ZPC also implemented a comprehensive maintenance program to ensure that the sensors and other equipment were functioning properly. The maintenance program included regular inspections, calibration of sensors, and replacement of any faulty equipment.

Results:

The tank farm monitoring system has been in operation for over a year, and ZPC has seen significant improvements in safety and efficiency. The system has helped to prevent incidents by providing early warning of potential problems, allowing operators to take corrective action before a hazardous situation can develop. The system has also improved efficiency by enabling ZPC to optimize tank utilization, reducing the need for unnecessary tank transfers and minimizing downtime for maintenance.

The tank farm monitoring system has also helped ZPC to comply with local regulations governing the storage and handling of hazardous materials. The system provides real-time data that can be used to demonstrate compliance with these regulations, which has helped to improve ZPC's reputation and relationships with regulatory agencies.

Overall, the tank farm monitoring system has been a valuable investment for ZPC, providing a reliable and effective way to ensure the safe and efficient operation of their tank farm.



A tank with installed liquid level sensor and transmitter for communication on top

2.5 Project Name: Tank Farm Monitoring System

A typical tank farm monitoring system consists of several components, including sensors, controllers, communication devices, and software. The sensors are used to collect data from various points in the tank farm, such as the tanks, pipelines, and valves. This data is then transmitted to the controllers, which process and analyze the data to provide real-time feedback on the performance of the tank farm.

Communication devices are used to transmit data from the sensors to the controllers and from the controllers to the central control room. These devices can include wired or wireless networks, depending on the size and complexity of the tank farm.

Webpages are used to manage and analyze the data collected by the system. This software can provide various functionalities, such as data visualization, reporting, and alarm management. Node-RED is a powerful tool to build the Internet of Things (IoT) applications that use predefined blocks of code, called nodes, to perform tasks. It uses a visual programming approach, which enables developers to link code blocks together. This solution is convenient as an intermediate to link devices of different types to one another or to an automation system such as DBMS or cloud etc. Node-RED runs on Node.js and it has been designed to operate on low performance systems such as **Raspberry pi, Arduino, Docker, and Android**

Business Case: A tank farm monitoring system provides significant benefits to businesses that store liquids in large tanks, such as oil, chemical, food and beverage industries.
Safety, a tank farm monitoring system can help ensure the safety of personnel and the environment by detecting leaks, spills, or other hazards in real-time. It can also provide early warning of potential issues, allowing for quick response and mitigation.

Efficiency, with a tank farm monitoring system, businesses can optimize their inventory management by tracking the level, temperature, and pressure of their tanks. This can help reduce the risk of stockouts or overstocks and minimize waste or spoilage.

Problem: Zimgold Oil Industries has been facing several problems that gave birth to the idea of implementing a tank farm monitoring system, these problems include:

1. Safety hazards, there are the risk of accidents, fires, leaks, and spills in a tank farm, which has posed as a serious safety hazard to workers and the environment. A monitoring system can help detect these hazards in real-time, allowing for quick response and mitigation.
2. Operational inefficiencies without an accurate and up-to-date inventory of tanks and their contents, it can be difficult to manage inventory levels and ensure that tanks are being used efficiently. A monitoring system can help optimize inventory management and reduce waste or spoilage.
3. Maintenance issues without proper maintenance, tanks can develop issues such as corrosion, leaks, or other defects that can compromise their integrity. A monitoring system can help detect these issues early on and enable proactive maintenance and repair.
4. Security concerns: Tank farms can be vulnerable to theft, sabotage, or other security breaches. A monitoring system can help detect and prevent unauthorized access and ensure the security of the tank farm.

Deliverables: Below is the task expected to be completed through the implementation of this project

1. Real-time monitoring and control of the tank farm, the system should provide real-time monitoring of oil tank levels, temperature, and other critical parameters. The system should also allow for remote control of tank valves, pumps, and other equipment.
2. Data acquisition and storage the tank farm monitoring system should collect and store data from sensors and other monitoring devices, allowing for historical analysis and trend monitoring. This data can be used to optimize tank farm operations, reduce downtime, and improve safety.
3. Alarm and event management the tank farm monitoring system should provide alarms and notifications when critical parameters exceed pre-set limits or when other events occur that require attention. The system should also allow for the management of these alarms and events to ensure they are addressed in a timely and effective manner.
4. Reporting and analysis the tank farm monitoring system should provide reports and analysis of tank farm operations, including inventory levels, flow rates, and equipment performance. This information can be used to optimize operations and improve decision-making.
5. Access control, the tank farm monitoring system should provide appropriate security measures, such as firewalls, authentication, and regular vulnerability assessments, to protect the system from cyber threats.
6. Training and support of the operators. The tank farm monitoring system should include training and support for operators and maintenance personnel to ensure that they can use and maintain the system effectively.

2.6 Benefits of the Proposed System

The implementation of tank farm monitoring systems offers several benefits to tank farm operators. One of the key benefits is improved safety. Tank farms can be hazardous environments, with the potential for leaks, spills, and fires. By providing real-time monitoring and control of tank farm operations, monitoring systems can help to identify and address potential safety issues before they escalate into major incidents.

A tank farm monitoring system can provide numerous other benefits to businesses that operate storage facilities for liquids, such as petroleum products, chemicals, and gases. The proposed system can provide the following benefits:

1. Improved Safety: The tank farm monitoring system can help to identify and address potential safety issues before they escalate into major incidents. By providing real-time monitoring and control of tank farm operations, the system can help to prevent accidents and reduce the risk of harm to employees, the environment, and the surrounding community.

2. Increased Efficiency: The tank farm monitoring system can provide insights into the performance of the tank farm, such as the levels of inventory, the flow rates of liquids and gases, and the temperatures and pressures of the tanks. By using this information, operators can optimize the use of resources, such as the scheduling of deliveries and the use of storage tanks. This can result in increased efficiency and reduced costs.

3. Cost Savings: The tank farm monitoring system can help to identify inefficiencies and areas for improvement. This can lead to cost savings through the optimization of resources and the reduction of waste. The system can also help to avoid costly shutdowns due to equipment failures, as potential issues can be identified and addressed before they cause significant damage.

4. Real-time Data Access: The tank farm monitoring system can provide real-time access to critical data for operators, managers, and other stakeholders. This can enable quick decision-making, increased collaboration, and faster response times to issues and emergencies.

5. Competitive Advantage: The tank farm monitoring system can provide businesses with a competitive advantage by improving the safety and efficiency of their operations. This can lead to higher customer satisfaction, increased market share, and improved profitability.

Challenges of Tank Farm Monitoring Systems

Despite the benefits of tank farm monitoring systems, there are also several challenges associated with their implementation. One of the key challenges is the complexity of these systems. Tank farms can be large and complex, with multiple tanks, pipelines, and valves. Implementing a monitoring system that can effectively collect and analyze data from all these points can be a significant challenge.

Another challenge is the integration of the various components of the monitoring system. The sensors, controllers, communication devices, and software all need to work together seamlessly to provide an effective monitoring system. Achieving this level of integration can be challenging, particularly when using components from different vendors.

Conclusively, there is the challenge of data management. Tank farms generate a large amount of data, and effectively managing this data can be a significant challenge. This can include issues such as data storage, data analysis, and data security.

2.7 The Proposed System

A tank farm monitoring system is a technology that provides real-time monitoring and control of tank farm operations by collecting data from various sensors and devices installed in the tank farm, such as level sensors, pressure sensors, and flow meters. The proposed system will have a web application interface that will be used to control, monitor, and operate the tank farm remotely. The web app user interface will provide utilities to

1. Login and log out.
2. New user registration
3. Live tank farm monitoring through graphs.
4. Generate reports.
5. Loading operation facility.
6. Offloading operation facility.

While the prototype will comprise of:

1. Plastic bottles imitating tanks.
2. Raspberry pi
3. 8 channel relays for power distribution
4. Ultrasonic sensor
5. Pressure sensor
6. Submissible pump
7. Arduino Buzzer
8. Flow meter
9. pipes

The tank farm prototype will be made on a wooden project board for the placement of nicely cut 2 litter containers to imitate the tanks in the tank farm in these containers ultrasonic sensor and pressure sensor will be mounted inside for tank level monitoring procedure. Straws will imitate the pipes place in the tank farm area. A switch for electrical power supply for all components on the project board which will involve raspberry pi, 8 channel relay, submissible water pump. solenoid valves for automatic valve control. A flow meter for precise measurement of the oil passing through the pipeline in each period. Buzzers for alarms in event of system detecting tank leaks.

2.8 Chapter Summary

In this chapter the proposed system and its benefits were laid out and discussed in detail to show its benefits to the tank farm operators and the contemporary organisation. The successful implementation of a tank farm monitoring system and all its benefits have been clearly laid out.

The system user interface and how it will be facilitating its services and the general layout of the system components and how they are connected have been demonstrated.

CHAPTER 3: METHODOLOGY

3.0 Introduction

There are different methodologies that can be used for developing a tank farm monitoring system. One of the most common methodologies is the Agile methodology which is an iterative approach that emphasizes flexibility and customer satisfaction. The purpose of a tank farm monitoring system is to provide accurate and reliable information on the status and contents of storage tanks. This system is used for inventory management of oil at Zimgold Oil Industries. Radio telemetry and is used for monitoring oil in the tanks. The system can be used to automatically access, record, and transmit data from remote storage tanks using wireless hardware and sensors linked to a computer database via wifi network.

With the aid of diagrams, I will illustrate how the system functions, from how the user operates the system, how real time data is displayed, how sensors collect data in the tanks and store it, The operator panel on the web application. I will illustrate how information is processed and services dispatched.

3.1 System Development Model

Agile development methodology is an iterative and incremental approach to software development that emphasizes flexibility, collaboration, and customer satisfaction. It was first formalized in the Agile Manifesto, which was written and signed by a group of software developers in 2001.

Agile development is based on the principles of adaptive planning, evolutionary development, early delivery, continuous improvement, and rapid and flexible response to change. Agile teams work in short cycles or iterations, typically lasting 1-4 weeks, and deliver working software at the end of each iteration. This allows for frequent feedback and testing, which helps to ensure that the software meets the needs of the customer.

Agile development also emphasizes collaboration and communication between team members and with the customer. The team is typically self-organizing and cross-functional, with members from different disciplines working together to deliver the software. The customer is an integral part of the team, providing feedback and guidance throughout the development process.

This division of the entire project into smaller parts helps to minimise the project risk and to reduce the overall project delivery time requirements.

There are several different agile methodologies, including Scrum, Kanban, and Extreme Programming (XP), each with its own set of practices and processes. However, all agile methodologies share the same core values and principles and are designed to help teams deliver high-quality software quickly and efficiently.

3.2 Research Design

Designing a tank farm monitoring system involves several steps, including research, planning, design, and implementation. Here are some general steps that can be followed to design a tank farm monitoring system:

1. Research: Conduct research to understand the requirements and constraints of the tank farm monitoring system. This may involve studying existing systems and technologies, reviewing industry standards and regulations, and identifying the specific needs of the tank farm.

2. Planning: Based on the research, create a plan for the tank farm monitoring system. This plan should include the scope, goals, and objectives of the system, as well as the specific features and requirements that need to be included.

3. Design: Develop a detailed design for the tank farm monitoring system. This may involve creating a system architecture, designing hardware and software components, and selecting appropriate sensors and communication protocols.

4. Implementation: Build and test the tank farm monitoring system. This may involve procuring hardware and software components, integrating sensors and communication systems, and testing the system to ensure that it meets the requirements and functions correctly.

5. Deployment: Once the system has been tested and validated, deploy it in the tank farm. This may involve installing sensors and communication systems, configuring the software, and training personnel to use the system effectively.

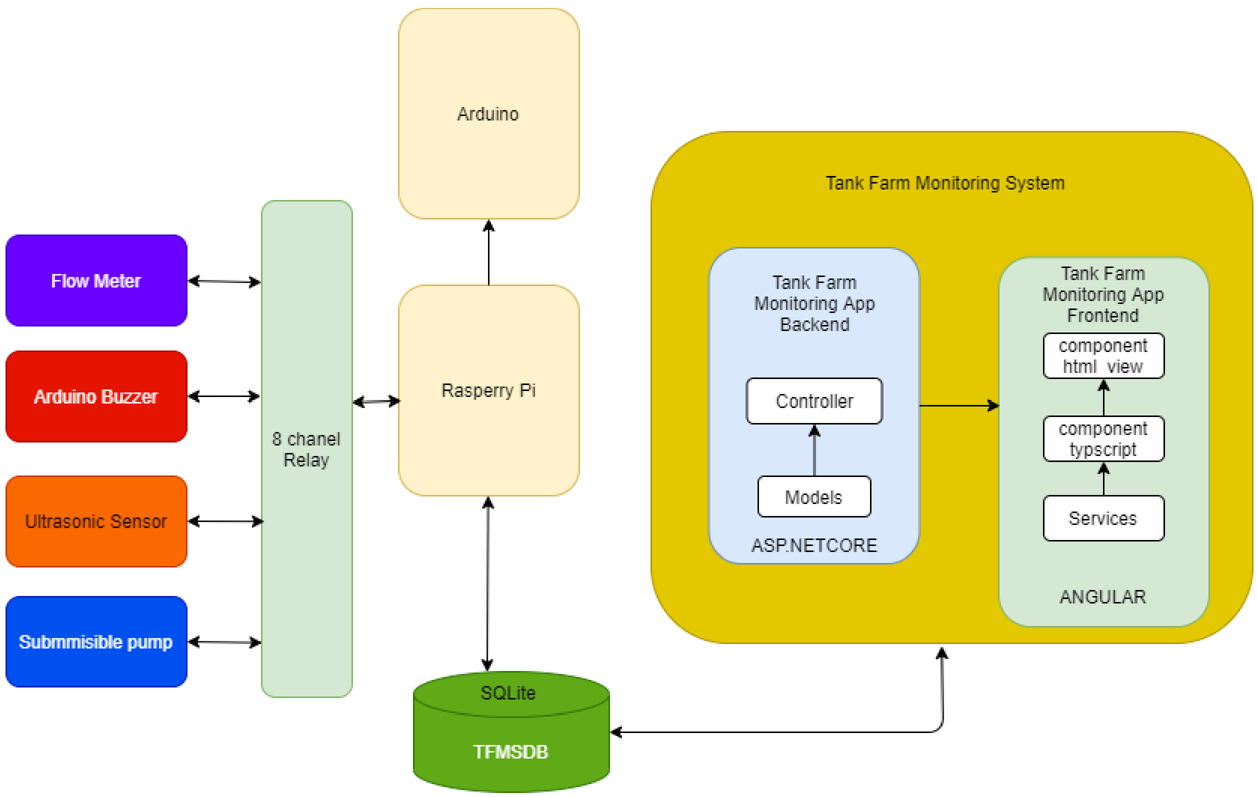
3.3 Design Methods

Research methodology, according to Babbie (2016), involves a thorough investigation of the study fields. The actions taken to analyse a research topic and the explanation for the application of methodologies used to locate, pick, process, and interpret information used to comprehend the problem are referred to as "methodology."

Additionally, Cohen (2017) defines quantitative research as social research that makes use of empirical methodologies and assertions.

A statement that reflects what "is" the situation in the "real world," as opposed to what "ought to be the situation," is what he refers to as an empirical assertion.
Applying empirical evaluations is another part of quantitative research. Empirical statements are typically expressed in numerical terms.
An empirical evaluation is a procedure that determines how closely or loosely a particular program or policy complies to a particular standard or norm.

3.3.1 System Architecture



System architecture of the Tank Farm Monitoring System

3.3.2 Software Description

The tank farm monitoring system software is a powerful solution designed to provide real-time monitoring and management of storage tanks in industrial settings. This software offers a range of features and functionalities to ensure efficient and secure operations within the tank farm.

One of the key features of this software is its ability to provide real-time tank level monitoring. It continuously collects data on oil levels in each tank and presents this information on a user-friendly interface. This allows operators to determine the current levels and make informed decisions regarding refilling or optimizing the distribution process quickly and easily.

In addition to tank level monitoring, this software also offers comprehensive alarm management capabilities. It can set customizable thresholds for each tank and alert operators via notifications or visual alarms when these thresholds are breached. This helps prevent costly and potentially dangerous overfill or underfill situations, ensuring optimal storage capacity utilization and minimizing the risk of spills or leaks.

Moreover, the tank farm monitoring system software offers advanced reporting and analytics features. It can generate detailed reports on tank usage, inventory levels, and consumption patterns, allowing operators to identify trends and make data-driven decisions for operational improvement.

Integration with other software systems, such as inventory management or enterprise resource planning (ERP) systems, is also possible, enabling seamless data exchange and enhanced overall efficiency. Another advantage of this software is its remote monitoring and control capabilities. It can be accessed via web-based or mobile applications, allowing operators to monitor and manage tank farm operations from anywhere at any time. This flexibility not only improves operational efficiency but also enhances safety and reduces the need for on-site personnel. To ensure data security and integrity, the tank farm monitoring system software employs robust authentication and encryption protocols.

User access can be restricted based on roles and permissions, preventing unauthorized individuals from tampering with sensitive information or making critical changes to the system.

In summary, the tank farm monitoring system software offers a comprehensive solution for the efficient management and monitoring of storage tanks. With its real-time monitoring, alarm management, reporting, and remote access capabilities, it enables operators to optimize tank usage, mitigate risks, and make informed decisions for improved operational efficiency and safety.

3.4 Functional Requirements

Tank farm monitoring systems are designed to ensure the safe and efficient storage and handling of liquids in tank farms. Such a system plays a critical role in preventing accidents, mitigating risks, and ensuring compliance with safety regulations. The functional requirements of a tank farm monitoring system are below:

1. Real-time monitoring, the system should provide real-time monitoring of all aspects of the tank farm, including tank levels, temperatures, pressure, and flow rates. This allows operators to quickly identify any anomalies or deviations and take appropriate actions.
2. Alarm and alert system, the system should be able to generate alarms and alerts in case of abnormal conditions, such as high or low tank levels, leakages, or pressure surges. These alarms should be communicated to the operators through visual and audible indicators for immediate response.
3. Remote monitoring and control, the system should support remote monitoring and control, allowing operators to access and control the tank farm from a central control

room or even remotely through mobile devices. This enables operators to respond quickly to any issues or emergencies, regardless of their location.

4. Data logging and reporting, the system should record and store data from various sensors and devices in the tank farm. This data can be used for historical analysis, trend monitoring, and reporting purposes. The system should also be capable of generating customizable reports on tank statuses, incidents, maintenance activities, and compliance with regulations.
5. Integration with other systems, the tank farm monitoring system should seamlessly integrate with other systems within the facility, such as fire suppression systems, emergency shutdown systems, and security systems. This ensures coordinated responses to critical events and minimizes the risk of accidents.
6. Tank inventory management, the system should have the capability to track and manage tank inventory, including quantities received, delivered, and stored. This helps optimize inventory levels, prevent overfilling or underfilling, and facilitate efficient logistical operations.
7. Maintenance and diagnostics, the system should provide maintenance and diagnostics features to detect and predict potential equipment failures, enabling proactive maintenance activities. This helps reduce downtime, extend equipment lifespan, and optimize maintenance costs.
8. Security and access control, the system should ensure proper security measures, including user authentication, access control, and audit trails. This prevents unauthorized access to the system and data, protecting the tank farm from potential security threats.
9. Scalability and flexibility, the system should be scalable to accommodate future expansion or modification of the tank farm. It should also offer flexibility in terms of configuring and customizing monitoring parameters, notification preferences, and reporting formats.
10. Compliance with regulations, the tank farm monitoring system should adhere to relevant safety and environmental regulations, such as OSHA, API, and NFPA standards. It should provide necessary data and reports to demonstrate compliance and facilitate regulatory inspections. By meeting these functional requirements, tank farm monitoring systems can help operators ensure the safety, efficiency, and regulatory compliance of their tank farms.

3.5 Non-Functional Requirements

Non-functional requirements for a tank farm monitoring system typically focus on the system's performance, reliability, security, and usability. Here are some non-functional requirements that the tank farm monitoring system will provide.

1. Performance:

- Response Time: The system should provide real-time or near-real-time monitoring of tank levels and other parameters.
- Scalability: The system should be able to handle a large number of tanks and sensors without significant degradation in performance.

- Throughput: The system should be capable of processing a high volume of data from multiple tanks simultaneously.

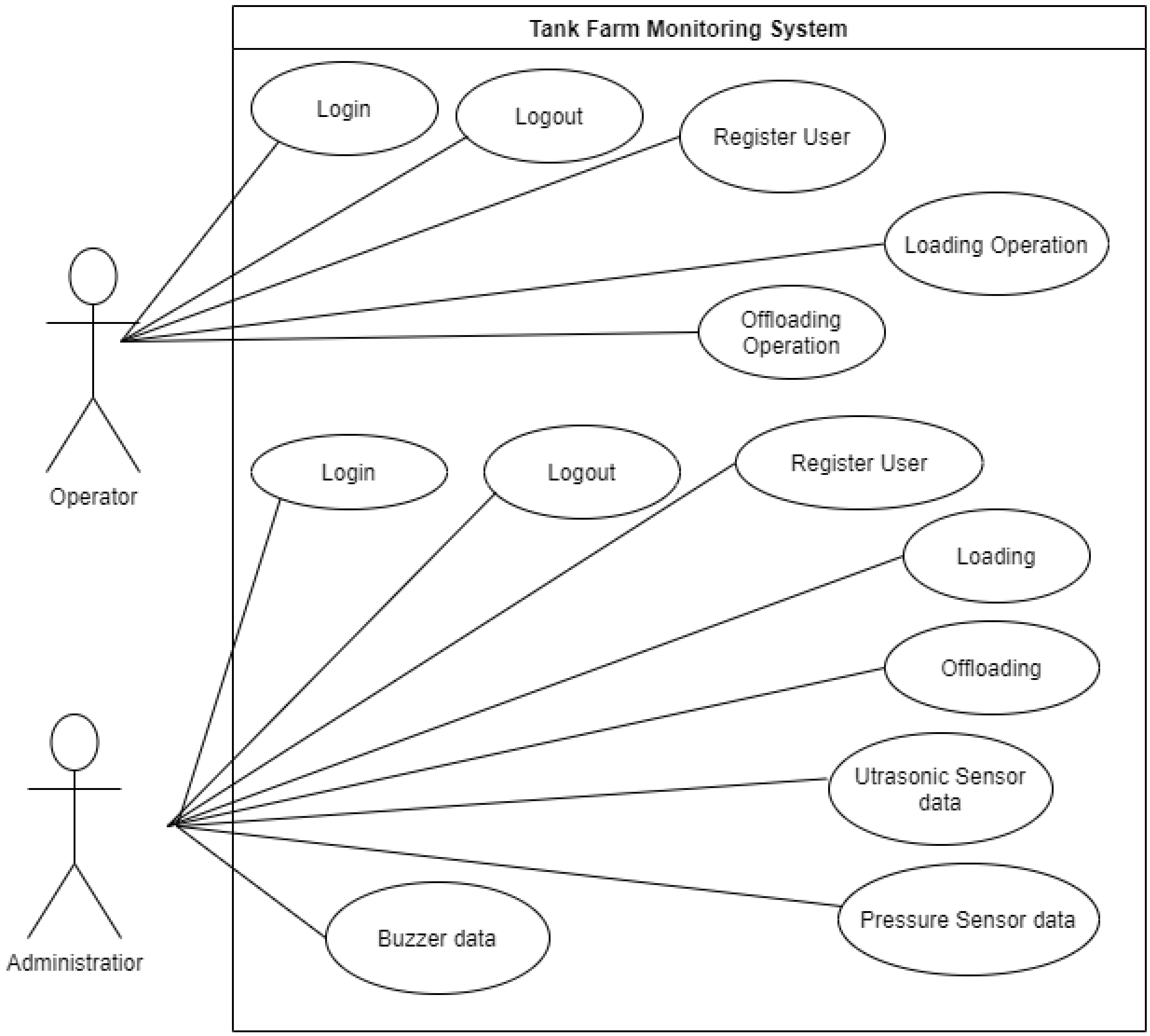
2. Reliability:
    - Availability: The system should be available and accessible to authorized users at all times, with minimal downtime.
    - Fault Tolerance: The system should be able to handle hardware or software failures without significant disruptions in monitoring or data collection.
    - Disaster Recovery: The system should have backup and recovery mechanisms in place to ensure data integrity in the event of a system failure or disaster.

3. Security:
    - Data Protection: The system should employ robust encryption and access controls to protect sensitive tank data from unauthorized access or tampering.
    - Authentication and Authorization: The system should require users to authenticate themselves before accessing the monitoring system and restrict access based on user roles and privileges.
    - Auditability: The system should maintain logs of user activities and system events for auditing and forensic purposes.

4. Usability:
    - User Interface: The system should have an intuitive and user-friendly interface that allows users to easily navigate and interpret tank data.
    - Configurability: The system should allow users to configure alarm thresholds, notification preferences, and other system settings according to their specific requirements.
    - Compatibility: The system should be compatible with various devices and platforms to enable access from different locations and devices.

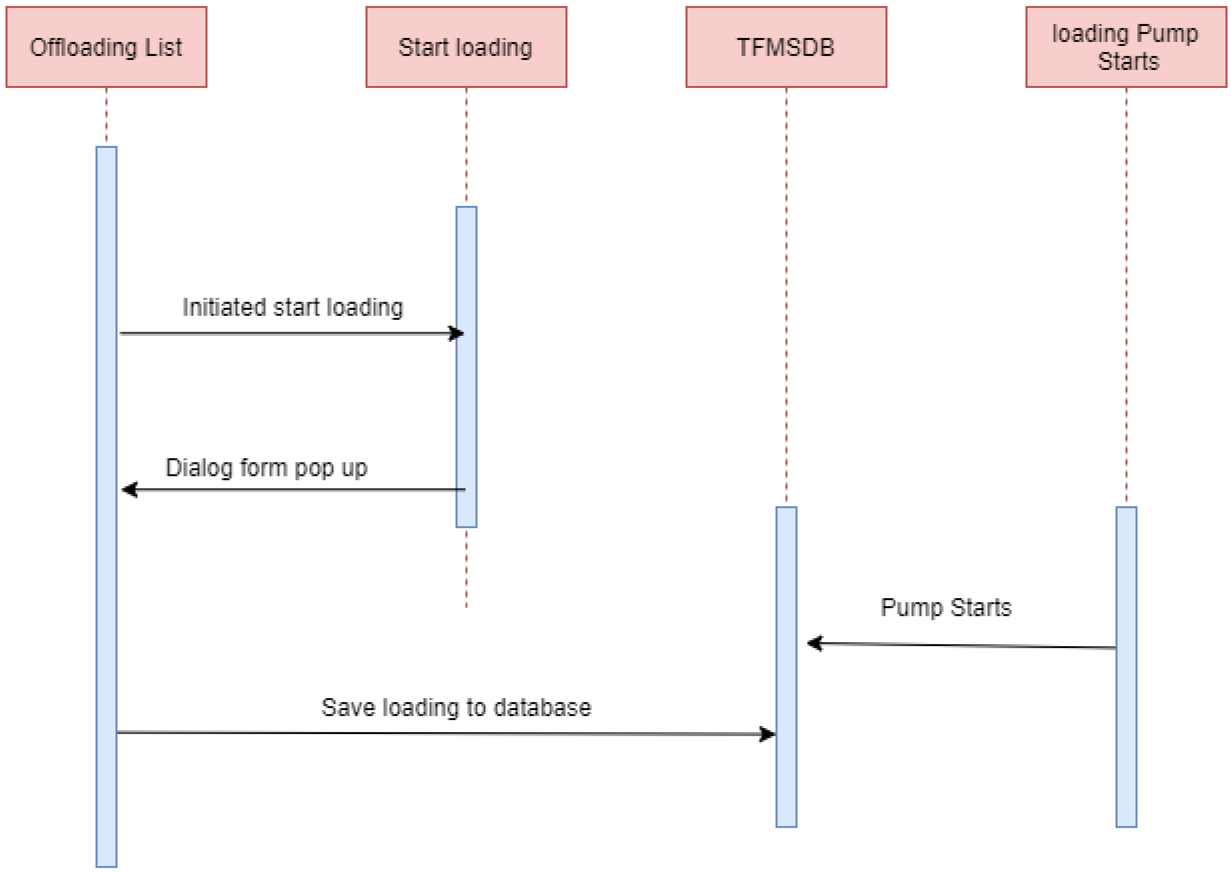
5. Integration:
    - Compatibility with Existing Infrastructure: The system should be able to integrate with the tank farm's existing sensors, control systems, and data storage infrastructure.
    - Data Exchange: The system should support standard data exchange protocols and formats to facilitate interoperability with other systems, such as SCADA (Supervisory Control and Data Acquisition) systems.

3.6Use Case Diagram



Tank Farm Monitoring System
Login
Logout
Register User
Loading Operation
Offloading Operation
Operator
Login
Logout
Register User
Loading
Offloading
Utrasonic Sensor data
Pressure Sensor data
Buzzer data
Administratior

3.7 Sequency Diagram



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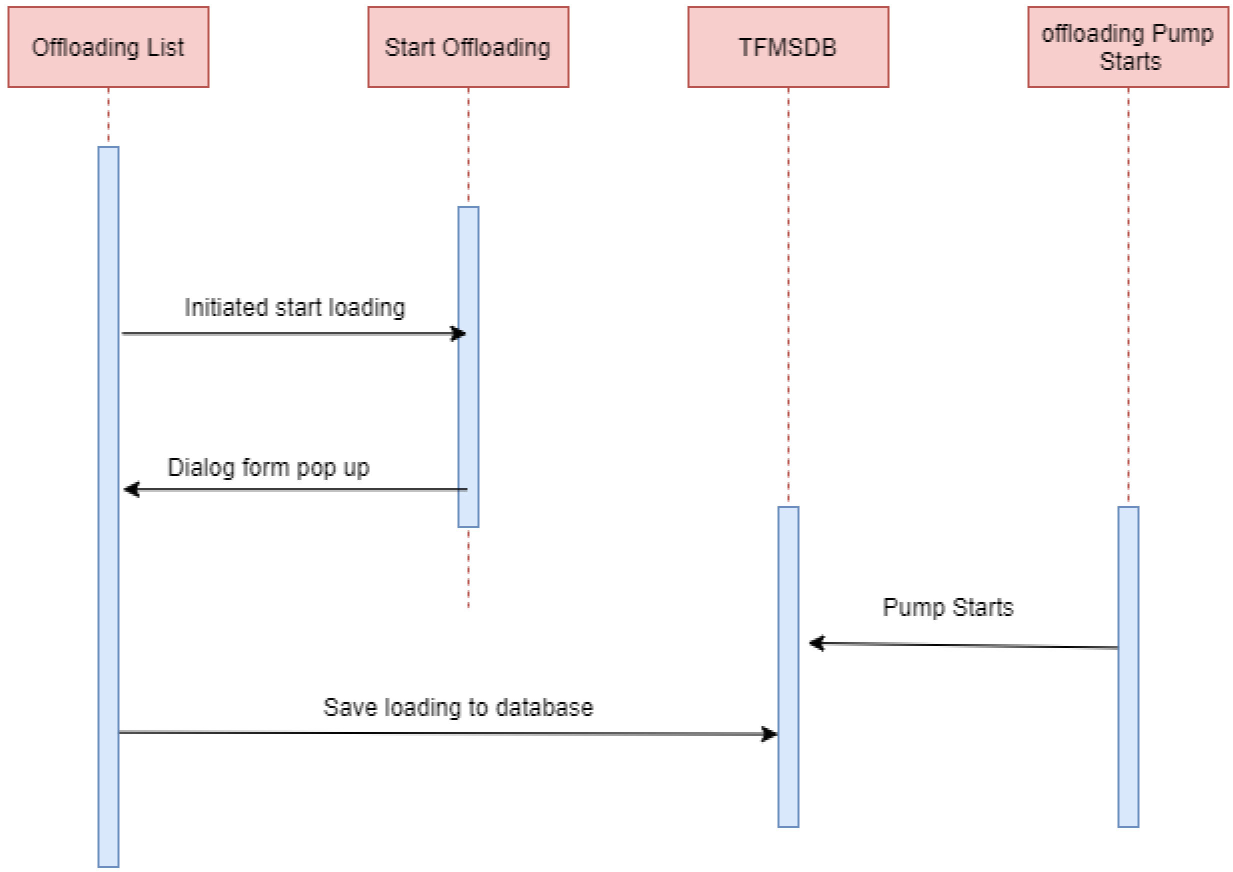
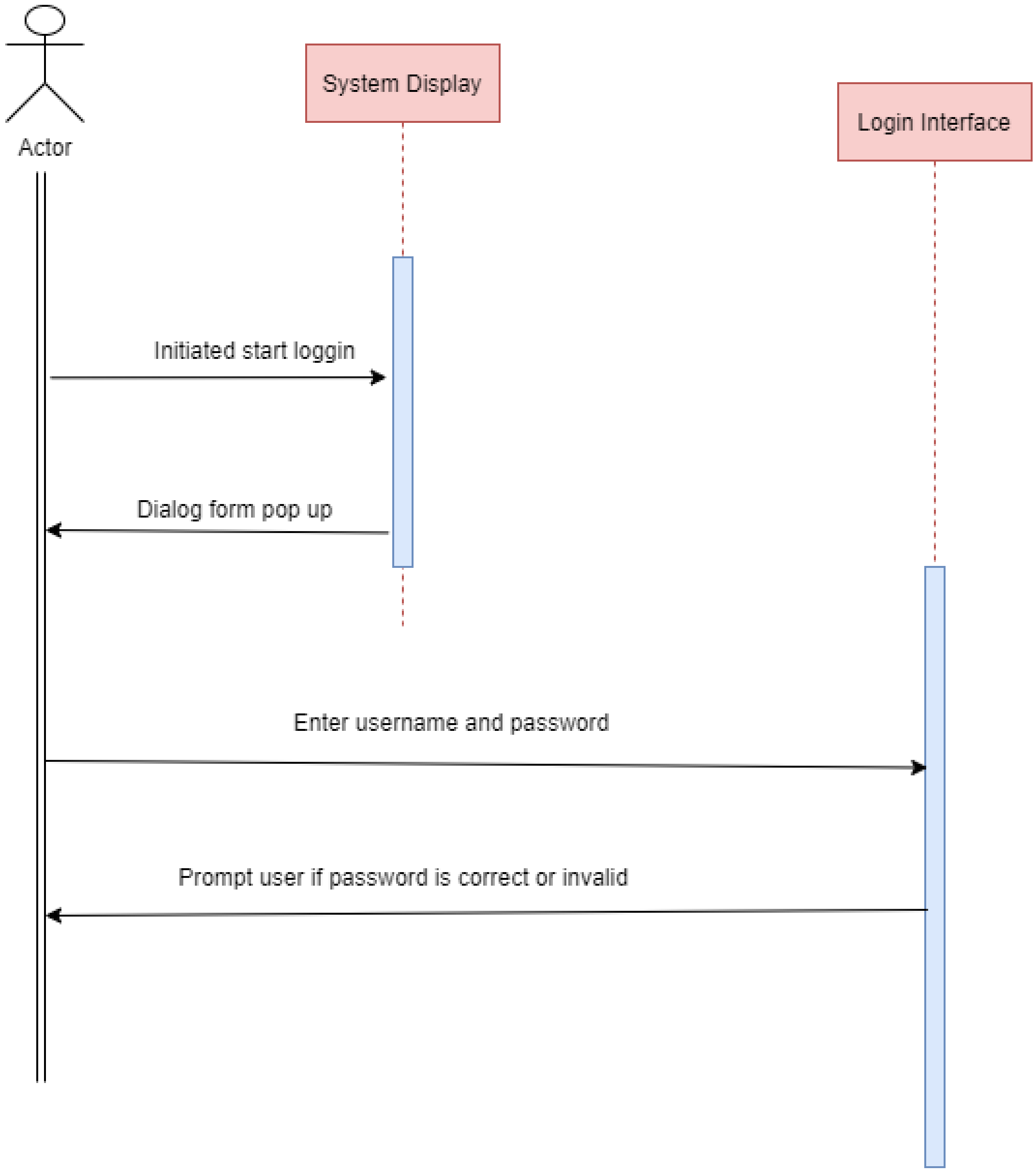
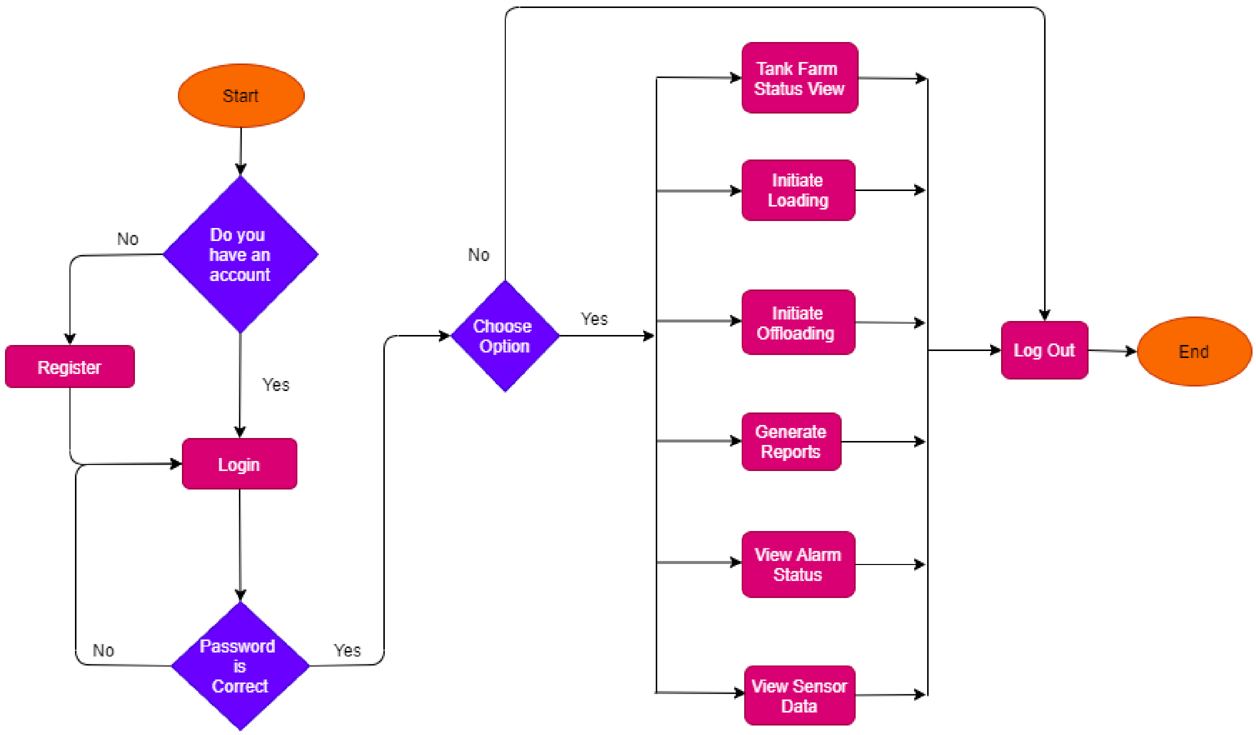


Offloading Sequency Diagram



Login sequency diagram

3.8 Flow Chart



3.9 Conclusion

In conclusion, this chapter has presented a comprehensive overview of the methodology employed for the development of the tank farm monitoring system. The methodology followed a systematic and iterative approach to ensure the successful implementation of the system.

The chapter began by outlining the importance of understanding the requirements and objectives of the tank farm monitoring system. Through research and engagement with stakeholders, the specific needs and functionalities of the system were identified, providing a clear direction for the project.

The design phase of the methodology focused on selecting appropriate hardware components and designing the system architecture. This involved careful consideration of factors such as sensor selection, communication protocols, power requirements, and data storage. By having a well-defined design, the development process was streamlined and efficient.

The subsequent development phase involved implementing the hardware and software components of the tank farm monitoring system. This included integrating sensors, microcontrollers, communication modules, and developing the necessary software algorithms for data collection, analysis, and visualization. Throughout the development process, regular testing and validation were conducted to ensure the functionality and reliability of the system.

Additionally, the methodology emphasized the importance of iterative improvements and user feedback. By incorporating user perspectives and continuously refining the system based on their input, the tank farm monitoring system was tailored to meet the specific needs of the end-users, enhancing usability and effectiveness.

Overall, the methodology adopted for the tank farm monitoring system encompassed crucial steps, including requirements analysis, design, development, testing, and iterative improvements. By following this systematic approach, the development team ensured the successful implementation of the system, meeting the objectives and expectations of the project. The methodology provided a solid foundation for the subsequent chapters, where the system's performance, results, and analysis will be presented and discussed in detail.

In conclusion, the resulting prototype will demonstrate the feasibility and practicality of the proposed solution, providing valuable insights and potential for real-world implementation in tank farm monitoring systems.

CHAPTER 4

4.0 Discussion of Results

The company under research currently monitors the Tank farm manually using employees who manner around takes dips to calculate the quantities via a dip chart.

Offload crude oil from tankers into the tank farm facility, as well as conduct thorough cleaning of the area. Moreover, the staff reports daily activities to the Warehouse Coordinator. The company is failing to meet the offloading demand as trucks are queuing at the company the large number of trucks has caused massive delays in the turnaround of the area.

The outcomes of this project have provided insight into the operations within the motor vehicle insurance sector. The difference has been greatly noticed in terms of customer care and customer service provision. The project has brought about the much-needed changes in the sector, that are in line with the technological changes taking place globally.

However, the results should be interpreted with caution due to the limitations of the current research. This prototype is merely a reflection of the research process and ends with several recommendations for future research.

CHAPTER 5: RECOMENDATIONS

5.0 Introduction

Tank farm monitoring systems are used to monitor and control the storage and distribution of products in a tank farm. They are designed to provide accurate and reliable information about the inventory levels, temperature, pressure, and other parameters of the tanks. The systems can be used to monitor a single tank or multiple tanks in a tank farm. They can also be used to monitor the loading and unloading of products from the tanks. The systems can be customized to meet the specific needs of the tank farm. Some of the features of a tank farm monitoring system include real-time monitoring, remote access, automatic alerts, and data logging. The system can be integrated with other systems such as SCADA and DCS to provide a comprehensive solution for tank farm management.

5.1 Aim and Objectives realisations.

The primary aim was to design and implement a Raspberry pi prototype for a tank farm monitoring system for Zimgold Oil Industries. That would ensure the safe, efficient, and reliable operation of storage tanks in a tank farm.

Objectives

1. **Safety:** The system is designed to maintain the highest levels of safety for employees, the plant, and the environment.
2. **Efficiency:** It aims to increase productivity by reducing inventory costs and providing complete inventory visibility 24/71.
3. **Regulatory Compliance:** The system helps to comply with regulations by providing pre-certified solutions that streamline the plant certification process.
4. **Accuracy**: The system provides highly accurate tank measurements with level, temperature, and pressure instruments.
5. **Remote Monitoring:** The system allows for remote tracking of tank fill levels to maximize efficiency and minimize downtime.
6. **Inventory Management:** The system improves inventory management by providing accurate wireless level monitoring.
7. **Integration:** The system can be integrated with other systems such as SCADA and DCS to provide a comprehensive solution for tank farm management.

5.2 Challenges Faced

Implementing a tank farm monitoring system using a Raspberry Pi prototype presented several challenges:

1. Purchasing The protype components proved too difficult as they are exorbitant since you must import them from China.

2. Power Supply: Ensuring a consistent and reliable power supply for the Raspberry Pi and connecting sensors was challenging, especially in remote or outdoor locations.
3. Connectivity: The Raspberry Pi needs to be connected to a network to transmit the collected data. Ensuring reliable network connectivity.
4. Data Management: The system may generate a large amount of data that needs to be stored, processed, and presented in a user-friendly manner. Managing this data proved to be a stumbling block.
5. System Integration: The Raspberry Pi-based system needed to be integrated with existing database like Microsoft Sql Server, which I failed and ended up using a different database because of compatibility issues.
6. Security: As with any IoT device, the Raspberry Pi is susceptible to cyber-attacks. Therefore, appropriate security measures need to be implemented to protect the system.

5.3 Future Recommendations

1. **Accuracy**: Use industry-leading field instrumentation to ensure the highest reliability and accuracy in processes.
2. **Productivity:** Reduce inventory costs and increase productivity with complete inventory visibility.
3. **Integration:** Integrate the system with other platforms and technologies.
4. **Digital Transformation:** Embrace the digital transformation of tank farm automation for oil movement and storage.
5. **Wireless Monitoring:** Implement wireless tank monitors for accurate level monitoring and alerts.

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