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Abstract

In companies where heavy equipment like XCMG machines, compressors, generators, and HDD drilling systems must function continually efficient maintenance is crucial to lowering costs, increasing equipment lifespan, and avoiding downtime. Many small and medium-sized companies still depend on manual maintenance procedures, including running sheets, paper base documentation that can be prone to inefficiencies, missed service schedules, and mistakes by employees.

A web-based machinery maintenance management system called MachniX is offered in this project. It was created for a real-life company to automate and optimize its maintenance processes. The system offers a consolidated platform for inventory employees, technicians, and supervisors to efficiently manage services, track service history, and plan maintenance tasks. Although technicians can update meter readings, submit service records, and document repair charges, supervisors can allocate equipment as well as set up service schedules. Inventory staff may additionally maintain track on stock levels and respond to material requests.

Using real-time inventory tracking, MachniX confirms material availability, automated alerts for preventive maintenance, and produces helpful documents to aid in improved decision-making. Using contemporary technologies like React, Next.js, MongoDB, and Firebase and the Agile methodology, the system was built with role-based dashboards and a notification system that includes email alerts to enhance operational efficiency and transparency. A scalable and efficient digital solution for enhancing machinery maintenance in companies is provided by this project.

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1. Introduction

1.1 Industrial machinery

The definition of "**Industrial Machinery**" describes large, powerful equipment and machinery used for production, manufacturing, building, and other industrial processes. These machineries are created to efficiently and large-scale complete out specific tasks, sometimes with minimal support from human beings.

Industrial machinery is a wide range of equipment and mechanical systems used in mining, manufacturing, construction, and agriculture, among other industries, to improve accuracy, productivity, and efficiency. These equipment aid in process automation, labour cost reduction, and manufacturing quality improvement. Precision-driven CNC machines in manufacturing and heavy-duty construction equipment like excavators and cranes are examples of industrial machinery made to do complex tasks with little assistance from humans.

The long lifespan of industrial machinery is a result of its approach enabling it to survive extended, heavy function without breaking down. Every machine is designed specifically, which means it was created especially to carry out a certain industrial activity like cutting, melding, assembling, or moving materials — effectively. Furthermore, this equipment provides high-capacity skills, which enable them to reliably and quickly process substantial amounts of materials or products crucial features for large companies.

The improvement of industrial machinery significantly promoted both economic expansion and industrial progress. Today's machinery is safer, more efficient, and capable of predictive maintenance because of technologies like automation, web/mobile apps, robots, and IOT connectivity. Maintaining the machinery properly is necessary to save delays, prevent unplanned malfunctions, and improve the lifespan of the equipment.

Industrial machinery categories:

1. **Construction Machinery -** used to construct buildings, bridges, and other infrastructures.
   Example - Road rollers, concrete mixers, trenchers, cranes, loaders, excavators, and bulldozers.

2. **Manufacturing Machinery -** Operates at factories that process raw materials into completed products.
   Example- Welding machines, CNC machines, lathes, milling machines, drilling machines, hydraulic and mechanical presses, and injection molding machines.

3. **Agricultural Machinery -** Assists the actions of farming, growing, and producing food.

   Example - Plows, seed drills, irrigation systems, ballers, tractors, and combine harvesters.

4. **Mining Machinery -** Helps with the resources' and minerals' extraction and processing.

Example- Draglines, continuous the miners, loaders and haulers, conveyors, and drilling rigs.

5. **Power Generation & Energy Machinery -** Used for generating and distributing electricity in power plants and other energy facilities.
   Example- Transformers, boilers, turbines, and generators.

6. **Material Handling Equipment -** Allows things to be moved, lifted, and stored inside buildings.
   Example- Automated guided vehicles (AGVs), winches, hoists, conveyor belts, and forklifts.

7. **Food Processing Machinery -** Used to ensure efficiency and hygienic conditions in food processing and packing.
   Example- Pasteurizers, food extruders, mixers, blenders, and packaging machines.

8. **Textile Machinery -** Used to produce and cure fabrics in the textile industry.
   Example- machines for spinning, weaving, and dying.

9. **Printing & Packaging Machinery -** Created for product packaging, labelling, and bulk printing.
   Example- Labelling and wrapping machines, offset printers, flexographic printers, and 3D printers.

   (Osha.gov, 2025) (Lisa, 2024) (Freddy, 2024) (Writer, 2024) (AZoM - Industries Classifications, 2025) (Batool et al., 2023) (Osman, 2025)

1.2 Machinery Maintenance

The systematic approach of **Machinery Maintenance** provides that industrial machinery and equipment continue functioning dependably, effectively, and securely. Many activities are included in this process, such as routine inspections, equipment replacement or repair as needed, cleaning, lubrication, testing, and service. Manufacturing, construction, energy, transportation, and agriculture are just a few of the industries that depend on mechanical systems for maintenance.

The primary objective of machinery maintenance is to avoid unplanned equipment breakdowns, which can result in expensive delays in production, reduced product quality, or even hazards to safety. Businesses can improve overall equipment effectiveness (OEE), decrease unexpected delays, and improve the operational lifespan of costly assets by maintaining machinery in good condition.

Maintenance of machinery also helps ensure conformity to safety requirements, industry regulations, and product agreements. It also makes it possible for companies to schedule workers, arrange for projections of finances, and purchase equipment. A successful maintenance program can eventually result in significant cost savings and enhanced operational performance, especially combined with modern technology like automation, sensors, and maintenance management software.

Types of Machinery Maintenance:

1. **Preventive Maintenance (PM) -** The strategy aims to stop equipment failures using scheduled maintenance processes, such as checks and part replacements, performed at scheduled periods. PM aims to identify possible problems while taking solutions before they become significant issues.

2. **Predictive Maintenance (PdM) -** Equipment failures can be predicted by PdM using condition-monitoring technologies (such as vibration analysis and thermal imaging) and real-time data. To avoid unplanned breaks down, maintenance can be performed just in time by assessing the real condition of the equipment.

3. **Corrective (Reactive) Maintenance –** This method includes repairing or changing out parts after a problem has happened. While it could be cost-effective in the moment, depending only on corrective maintenance can result in more delay and greater long-term expenses.

4. **Condition-Based Maintenance (CBM) -** CBM includes maintaining a check on specific machinery performance indicators (such as temperature and pressure) to identify when maintenance is necessary. Resource use is optimized by only doing maintenance when specific thresholds are surpassed.

5. **Reactive Maintenance (Breakdown Maintenance) -** repairing machinery only after it malfunctions. often leads to unscheduled downtime and costly maintenance.

6. **Autonomous Maintenance -** The approach encourages an awareness of duty and makes it possible to identify any problems early by giving machine operators the responsibility to perform simple maintenance tasks like cleaning and lubrication.

(UTI Corporate, 2023) (eMaint, 2021) (Mullins, 2025) (Appvizer, 2024) (Sensemore, 2023) (Immerman, 2020) (onupkeep, n.d.)

Importance of Machinery Maintenance:

Enhance Equipment Performance and Reliability - Regular maintenance reduces the possibility of unplanned breakdowns by ensuring that machinery operates at maximum efficiency. Effectively managing breakdowns helps companies complete their company objectives and maintain consistent production quality.

Reduces Downtimes in Operations - Preventive and predictive maintenance techniques reduce unscheduled downtime and ensure that equipment is ready for use when required. Achieving production deadlines and maintaining customer satisfaction depend on this reliability.

Improves the Lifespan of Equipment - Regular maintenance methods extend the life of machinery by identifying and fixing small problems before they become more serious. This expansion reduces the frequency of capital expenditures for new machinery.

Provides Safety and Integrity - Regular maintenance inspections must be carried out to ensure that the equipment performs properly and protects employees from hazards. Commitment to maintenance procedures additionally assists companies in following company standards and requirements.

Reduces Operational Costs - While upkeep duties are expensive, they are usually less expensive than those related to breakdowns in equipment, reduced productivity, and urgent replacements. Cost reductions are a result of efficient maintenance techniques.

(Siva, 2023) (Eitutis, 2023) (supplychainbrain, n.d.) (Warren CAT, 2019) (The CMM Group, 2018) (Primesource, 2019) (Facilio Blog, 2023)

1.3 Preventive Maintenance

Preventive maintenance (PM) is a proactive approach to maintenance that includes usual scheduled inspections of equipment and service that extend asset lifespan while minimizing unplanned breakdowns. It is an important part of excellent property management, allowing the company to decrease the costs and inefficiencies that come with unplanned breakdowns and equipment downtime.

PM contains several different duties, such as lubrication, cleaning, adjustments, repairs, and part replacements. These tasks are usually planned based on utilization of metrics (such as production cycles or operational hours) or time intervals (such as weekly or monthly). By executing a preventative maintenance plan, companies can identify and fix issues before they develop into serious ones, which reduces unscheduled downtime and improves productivity.

Several advantages that improve operational performance, safety, and cost-effectiveness are provided by preventive maintenance. Companies can ensure constant output by minimizing unplanned equipment failures and ensuing downtime by planning regular checks, service, and part replacements. This method delays the life of machinery by treating wear and tears before it causes significant damage. It also improves worker safety by maintaining equipment in top shape, which lowers the chance of incidents. Preventive maintenance reduces the need for expensive emergency repairs and unplanned shutdowns, which saves money over time. Better planning is also made possible by the ability to schedule maintenance tasks at off-peak times to reduce operational disturbance.

(IBM, 2021) (Aptien.com, 2025) (www.twi-global.com, n.d.) (www.reliableplant.com, n.d.) (Aptien.com, 2025) (Group, 2024) (GeeksforGeeks, 2024)

2. Project Background

2.1 Problem Definition

Maintenance of heavy machinery and equipment is an essential part of any company's procedures, and it's particularly significant for companies that rely on the ongoing functioning of heavy machinery like XCMG machines, generators, horizontal directional drilling (HDD) machines, and other industrial equipment. The efficiency of tasks depends on ensuring sure that every equipment is operating effectively, receiving preventative maintenance on time, and avoiding failures.

The maintenance process is still done manually at my selected company, as though, utilizing running sheet - documentation used to keep track of improvements and preventative maintenance schedules for each component of equipment. Working with warehouse employees, machine operators, Mechanical supervisors/Engineers, technicians and other staff members, a mechanical supervisor or engineer keeps track of the records, scheduling necessary maintenance, documenting working hours, and collecting meter readings. Although there are several apps available for tracking maintenance of vehicles, there are relatively very few applications made specifically for industrial equipment maintenance. Vehicle maintenance applications are widely used in sectors such as vehicle management, where digital solutions make it easy to track mileage, service history, maintenance schedules, and part replacements. Nevertheless, there aren't many specialized programs designed for heavy machinery maintenance, especially for companies which maintain multiple types of equipment with different maintenance requirements. As a result, a lot of companies who rely on machinery still plan and carry out maintenance manually.

An equipment maintenance system is required since the company's current manual approach is ineffective. Because running sheets, paperwork are prone to human mistakes, incomplete information, and missed maintenance schedules, they increase the possibility of equipment breakdowns and costly repairs. The company finds it challenging to monitor equipment usage, manage preventative machinery maintenance, and maintain enough materials and spare parts without an organized structure. A digital maintenance system would simplify processes, reduce delays, and improve resource allocation to ensure that the company's equipment operates efficiently and reliably to satisfy its functional requirements.

2.2 Challenges

Historical maintenance records are difficult to retrieve for review with the manual approach. This limits the company's capacity to successfully predict future equipment requirements, plan, and evaluate trends.

Inaccurate or missing maintenance logs may result from the prone to mistakes nature of manual data entry. This increases the possibility of unplanned breakdowns, missed services, and increased repairs.

Manually organizing maintenance tasks commonly results in delays. Workflow may be delayed if crucial changes, such as planned services or meter readings, are not provided on time.

Tracking stock levels in real time is challenging when maintenance items are managed manually. This may result in delays or shortages in the purchase of necessary parts, which may delay maintenance.

2.3 Project Description

The main objective of this initiative is to develop **MachniX**, a web application that will enhance the company's equipment maintenance strategy. This strategy aims to simplify methods and reduce delays while also improving the company's capacity for performing out preventative maintenance on each of its inventory equipment. The project provides an effective efficient maintenance procedure while handling fundamental functional challenges by changing to a manual, risk approach to a requested, organized digital platform.

The application will manage the entire machine maintenance process. It will manage scheduling by providing maintenance schedules based on machine usage, service schedules, or other operational requirements. It becomes feasible to track daily consumption data, including meter readings, in real time because of the digitization of data gathering. Additionally, inventory management will be digitalized to provide real-time tracking of spare parts and the creation of purchase plans, preventing delays or shortages of materials. The system will also provide thorough information on the state of the equipment, its service history, and upcoming maintenance to support proactive management and well-informed decision-making.

MachniX's main functions include meter reading recording to track performance in real-time, service alerts to inform technicians and management of upcoming maintenance services, and daily machine registration for maintaining current records of equipment usage and condition. Additionally, the system will maintain an established record of service history for efficiency and evaluations, schedule preventative maintenance to reduce delays, and maintain a check on material inventories to ensure the availability of the resources required.

This complete strategy improves the lifespan of machinery and reduces maintenance, ensuring that the company's equipment is functional. At the same time, automation will reduce human error by providing accurate data entry and consistent documentation. By simplifying planning and inventory management, **MachniX** enhances resource utilization by enabling more effective staffing and supplies distribution. Because alerts and notifications ensure that no maintenance tasks are missed, they protect the company from expensive replacements or equipment breakdowns.

MachniX is a complete equipment maintenance solution, not simply a part of machinery. It has innovative features that simplify and improve maintenance management while maintaining accuracy, success, and dependability. The company will be able maintain with maintenance, maintain the equipment's condition, and function effectively for an extended period with this strategy.

2.4 Features

1. **Registering Machines and Creating Databases –**
   Allows the registration of equipment with a unique ID, brand, and model; all associated data, including service history and meter readings, are stored in a centralized database.

2. **Meter Reading and Monitoring of Working Hours –**
   Daily meter readings are entered into by supervisors to monitor equipment consumption and facilitate fast preventative maintenance.

3. **Notifications of Services and Scheduling –**
   Schedule-based or usage-based automated alerts ensure that maintenance is not missed or delayed.

4. **Task Monitoring & Allocation of Manpower –**
   Technicians are given tasks by supervisors with effective communication and real-time information.

5. **Purchasing Plans & Material Management –**
   Maintains track of the materials used for services and alerts inventory employees when products require reorder to avoid shortages.

6. **Logging and updating services –**
   Provides a complete maintenance history by documenting service information (repairs, replacements) following each task.

7. **Analyzing Historical Data and Reports –**
   Generate reports for managers for maintaining track on patterns, assess the state of the machines, and efficiently schedule maintenance in the future.

8. Objectives

3.1 Project Objectives

Preventive maintenance suspension analysis helps in identifying hazards such as an increase in failures and expensive repairs brought on by inconsistent maintenance. By automating PM, mistakes made by humans in data entry are reduced, proper maintaining records are ensured, and schedules stay dependable and organized.

Preventive maintenance techniques can be improved by identifying frequent issues and inefficiencies by the analysis of historical maintenance reports. These reports help inform decisions based on data and direct targeted investments and improvements.

Using real-time data to optimize resource allocation provides effective scheduling, prevents staff overburden, and provides equipment availability, all of which increases maintenance efficiency and reduces delays.

Planning and maintaining an eye on inventory and materials ensures parts availability on time, avoids delays, and coordinates purchase with maintenance requirements, reducing downtime and supporting productivity.

Through a reduction of missed services, the avoidance of failures, the improvement of equipment dependability and accountability, and the alerting of staff of impending duties, the implementation of a dependable warning system ensures timely maintenance.

3.2 Business Objectives

Making the change from manual data input to a digital system would reduce human error and mistakes while increasing the accuracy and dependability of maintenance records.

Technology reduces equipment downtime and delays by optimizing the scheduling process, which provides timely machinery service.

This application assists in reducing shortages and supports the maintenance and inventory team by facilitating efficient tracking of material consumption and assisting in the planning of purchases based on impending maintenance requirements.

Implementing the move to a digital platform reduces the amount of paper used and the expenses related to printing, storing, and maintaining physical documents.

It will be easy to obtain historical data for analysis, checks, or planning when long-term maintenance records are archived in a centralized database.

The system supports proactive maintenance by using information-driven decisions and timely notifications, which helps extend equipment life and prevent unplanned breakdowns.

The system increases performance, reduces redundancy, and improves collaboration by organizing all maintenance-related tasks into a single platform.

In addition to saving money, reduced paper use supports environmentally friendly procedures and creates a more sustainable workplace.

3.3 Project Deliverables

Supervisors, technicians, and inventory employees may digitally supervise and maintain an eye on machinery repairs using this useful on the web application.

To make sure that users can only carry out tasks relevant to their roles, the system will include separate dashboards and entry levels for supervisors, technicians, and inventory employees.

The features will include the ability to User Authentication, register machines, Track repair history, Schedule preventative maintenance, and record daily meter readings.

Users will be reminded of upcoming maintenance, low material supplies, and other important alerts through emails.

The platform would have an inventory system for processing orders and usage, monitoring stock levels, and managing maintenance supplies.

Users will have access to reports on monthly activities, material use, maintenance history, and cost of service.

All system data will be maintained in a centralized database, which will also have automated backup capabilities to ensure data recovery.

Reactive web technologies, such as Next.js, typescript, Tailwind CSS, will be used in the application's design to ensure usability across a variety of displays and devices.

For easy deployment and user onboarding, thorough documentation will be supplied, including system architecture, setup guidelines, and user manuals.

9. Literature Review

1. **Implementation of an Integrated Monitoring Platform for Preventive Maintenance of Industrial Machines.**

   The authors created an integrated monitoring platform that gathers and analyses data from industrial machinery by utilizing external sensor devices. Without requiring a large IT infrastructure or expert staff, this technology is intended to help SMEs execute preventative maintenance plans.

   To reduce communication weight, the article suggests an integrated monitoring platform for industrial machine preventative maintenance that uses sensor devices for the edge processing to extract pertinent information prior to data transmission. For effective data transfer, it uses Low Power Wide Area (LPWA) connectivity, most especially LoRa. A Django-based web application that provides real-time machine status updates that are available through ordinary web browsers is used to visualize the system's performance. When examining average dispersion over 20 cycles, the platform's remarkable 99.999% detection accuracy was achieved during experimental validation on a screw ball mechanism to identify bolt loosening.

   SMEs may benefit from the platform's cost-effective installation, which eliminates the requirement for costly infrastructure and specialized knowledge. Additionally, it has a high detection accuracy, as seen by its remarkable precision in identifying mechanical problems such bolt loosening. The system's user-friendly web interface facilitates easy, real-time viewing of machine conditions, enabling maintenance staff to make quick options. Its scalable design also makes it simple to integrate and expand across different machines.

   There are certain disadvantages, though. Due to their short 8-hour backup duration, the sensor devices might not be able to sustain continuous monitoring without regular recharging. In addition, manual involvement is necessary during the first gathering of information phase, which can be time-consuming, particularly in large-scale operations. Sensor device firmware upgrades necessitate technical know-how, which presents difficulties for SMEs without a dedicated IT workforce. Finally, because operators need to physically engage with each unit to gather data, data gathering can be laborious, leading to inefficiencies in facilities with many devices. (Kamiya et al., 2024)

2. **Concept and Development of IoT-Based E-Maintenance Platform for Demonstrated System.**

   The development of an Internet of Things (IoT)-based e-maintenance platform that combines real-time monitoring and machine learning to improve predictive maintenance in manufacturing is covered in the article. Machine learning techniques are used for predictive maintenance and problem detection, while Arduino UNO boards and ESP32 modules are used for real-time data collecting and transmission. To improve decision-making and avoid unplanned failures, it also makes use of Blynk's dashboard for live monitoring, which enables operators to track machine data in real-time. To ensure optimal machine performance, the platform keeps an eye on six crucial machine parameters: conveyor speed, coolant level, tool holder temperature, spindle speed, vibration, and control cabinet temperature.

   Effective signal monitoring and data capture are made possible using the Arduino IDE for data processing, which uses C-based code. The modular architecture of this system makes it simple to scale, allowing it to grow and adjust to various production configurations. Because it uses open-source platforms, it may be customized and upgraded in the future. Real-time insights from the platform enable ongoing monitoring, guaranteeing early detection of possible problems and enabling proactive maintenance. Additionally, small and medium-sized businesses may use predictive maintenance without having to make large financial commitments thanks to its affordability.

There are certain restrictions to consider, though. Continuous and adequate data collection and analysis are critical to predictive maintenance's efficacy, although they can be difficult in some settings. Additionally, the system needs a certain amount of technical know-how to be implemented and maintained, which may be a problem for firms with little technological experience. Furthermore, there can be difficulties connecting the system with the current industrial infrastructure, especially legacy systems, which must be resolved for seamless operation. For those who can use it, the system provides substantial advantages despite these difficulties. (Worapong Sawangsri and Peerapol Prasithmett, 2023).

3. **IoT-Based Predictive Maintenance System for Industrial Machinery**

   The Industrial Machinery IoT-Based Predictive Maintenance System presents a thorough framework for proactive maintenance and ongoing monitoring. With edge computing utilized to perform initial data processing to reduce latency, it incorporates sensors for real-time data collecting on characteristics like temperature, vibration, and pressure. Predictive maintenance has a strong basis thanks to cloud technology, which supports scalable data storage and advanced analytics.

   To identify irregularities and anticipate errors before they happen, machine learning models like Random Forest, SVM, and LSTM are utilized. A user-friendly dashboard that provides maintenance scheduling and predictive alerts is another element of the system that improves decision-making. Moreover, the system may grow with the addition of more sensors or machines thanks to scalable and secure communication protocols that guarantee data integrity. This makes it appropriate for expanding industrial settings.

The system has several disadvantages in spite of its benefits. A strong data infrastructure is necessary to handle and process enormous volumes of sensor data. Some SMEs may find it difficult to install and maintain since it requires a moderate to high level of technical skill. Furthermore, it may be difficult to integrate this new system with existing industrial infrastructure; this may call for hardware upgrades or specialized solutions. (www.ijrpr.com, n.d.)

4. Exploring Predictive Maintenance Applications in Industry

The study identifies a few crucial elements that are necessary for predictive maintenance (PdM) to be applied successfully. These include determining the best trigger to start PdM initiatives, picking efficient data gathering methods, picking suitable maintenance approaches, and putting in place a methodical framework for decision-making. By examining the ways in which these elements are used in various sectors, the study shows that successful PdM implementation frequently requires a customized strategy rather than a one-size-fits-all paradigm.

This strategy's emphasis on adaptability and customization is one of its advantages as it enables businesses to mix and match various approaches according to their own operating requirements. Additionally, it promotes data-driven decision-making, which lowers unplanned equipment failures and boosts overall maintenance effectiveness. When PdM is backed by well-integrated data gathering and analysis systems, organizations may benefit from increased machine lifespans, less operational downtime, and improved equipment dependability.

But the report also identifies several Disadvantages. Due to their lack of a defined framework for PdM adoption and heavy reliance on experience, many businesses continue to provide uneven results. Without the right direction, choosing and integrating the appropriate data and approaches may be extremely difficult. Adoption may also be slowed down by the absence of industry-wide best practices and the requirement for cross-functional cooperation, particularly in businesses with little organizational preparedness or technical resources for digital transformation. (Tiddens, Braaksma and Tinga, 2020)

4.1 Existing Systems

1. IBM Maximo Manage

An enterprise asset management (EAM) system called IBM Maximo Manage was created in 1985 and purchased by IBM in 2006. It is extensively utilized in a variety of sectors, including industry, energy, utilities, transportation, and healthcare. The platform improves asset reliability and lowers operating costs by moving companies from reactive to predictive maintenance using AI, IoT, and real-time data.

Maximo makes it possible to schedule and track maintenance operations automatically, monitor assets in real time, and use predictive analytics to find problems before they become problems. Additionally, it oversees procurement and inventory, using automatic reordering to guarantee part availability. The system interfaces with ERP and financial systems like SAP and Oracle and offers cloud deployment for scalability as well as mobile access for technicians. (Ibm.com, 2025)

2. SAP Plant Maintenance (SAP PM)

SAP Plant Maintenance (SAP PM) is an advanced maintenance management module of SAP's Enterprise Resource Planning (ERP) system. It is specifically designed for businesses who need to manage work orders, perform preventative maintenance, and closely monitor assets to boost equipment productivity and dependability.
One of the main features of SAP's ERP system, SAP Plant Maintenance (SAP PM) is made to handle equipment maintenance, minimize downtime, and maximize operational effectiveness. It helps companies to streamline work orders, carry out preventive maintenance, and keep an eye on assets in real time. It is widely utilized in sectors like manufacturing, energy, and transportation. (Top, 2025)

The system extends asset life and helps identify problems early by using AI and IoT technologies for predictive maintenance. Automated work scheduling, integration of inventory and procurement, technician mobile access, and cloud-based deployment for scalability are all supported. Additionally, SAP PM provides compliance monitoring, real-time dashboards, and smooth connectivity with other SAP and ERP systems. (Top, 2025)

3. UpKeep Mobile-first CMMS

UpKeep is a computerized maintenance management system (CMMS) designed for small and medium-sized businesses (SMEs) that prioritize mobile devices to optimize maintenance processes. Especially for field-based teams, its user-friendly interface and mobile accessibility allow technicians and managers to carry out maintenance chores straight from their smartphones or tablets, boosting flexibility and efficiency. (onupkeep, n.d.)

The platform has significant features including scheduling preventive maintenance, tracking assets and parts, and managing repair orders in real time. To reduce downtime, the system helps manage spare parts inventory and monitor equipment performance. Users can also simply create, assign, and track maintenance assignments. The lifespan of assets is increased, and the risk of equipment failure is further decreased with scheduled maintenance depending on consumption or time.

Also, UpKeep has integrated analytics and reporting capabilities that offer useful information about asset health, technician productivity, and operational performance. It is the perfect option for companies looking for an affordable, simple-to-implement maintenance solution without the overhead of conventional enterprise systems because of its contemporary, scalable design. (onupkeep, n.d.)

4. Fiix by Rockwell Automation

To help industrial businesses with asset monitoring, work order tracking, predictive maintenance, and maintenance operations optimization, Rockwell Automation developed Fiix, a cloud-based Computerized Maintenance Management System (CMMS). With Fiix, businesses can transition from reactive to proactive maintenance, which decreases downtime, boosts asset dependability, and saves maintenance costs. Fiix is designed for industries such as utilities, manufacturing, energy, transportation, and food and beverage. Fiix is a cloud-native solution that gives maintenance teams flexibility by facilitating mobile work order administration, remote data access, and integration with IoT and AI-driven analytics. (Fiix, n.d.)

Predictive maintenance using AI and IoT data, real-time asset tracking, and remote order management are all made possible by the cloud-based maintenance management system. By planning maintenance according to consumption trends and sensor alerts, it helps avoid equipment failures.
The system integrates with procurement systems to automate inventory monitoring and guarantee the availability of spare parts. Without the need for on-premises installation, its mobile access enables offline data entry and real-time notifications.
Fiix provides insights into equipment performance, maintenance trends, and compliance through dashboards and analytics driven by AI. Its smooth integration with ERP systems, such as SAP and Oracle, improves operational efficiency and automation.

5. eMaint CMMS (by Fluke)

Fluke Corporation created eMaint CMMS, a cloud-based computerized maintenance management system that streamlines maintenance operations in sectors like manufacturing, energy, oil & gas, and facilities management while lowering downtime and improving asset reliability. It offers real-time insights into asset health by integrating with IoT sensors, EAM systems, and predictive maintenance tools.
The platform centralizes asset data, such as service histories and part replacements, automates work order development and tracking, and facilitates scheduling preventative maintenance based on time, usage, or asset condition. Part tracking and spare part availability are enhanced by features including automated inventory management, procurement integration, and QR/barcode scanning. IoT-based condition monitoring facilitates the identification of performance problems and initiates predictive maintenance work orders automatically.

eMaint provides global accessibility, offline capability, and real-time warnings through mobile and cloud-based access. While REST API connection facilitates interaction with ERP systems and third-party platforms, simplifying remote operations and inventory control, customizable dashboards provide insights into compliance, asset performance, and maintenance costs. (eMaint CMMS Software, n.d.)

6. Limble CMMS

A cloud-based maintenance management system called Limble CMMS was created to assist small and mid-sized businesses in increasing productivity, decreasing equipment downtime, and better managing their assets. Widely used in sectors like manufacturing, healthcare, logistics, and facilities management, it is renowned for its user-friendly interface.

Work order management, asset tracking, and scheduling preventive maintenance are all made easier by the system. It reduces unplanned breakdowns by using AI and IoT sensor data to forecast equipment failures and initiate preventative maintenance. Automating, prioritizing, and monitoring work orders is simple, and professionals may take advantage of offline features, smartphone access, QR code scanning, and real-time field updates.

Limble additionally maintains track of depreciation, performance, and asset lifetime costs to help with planning and budgeting. For companies looking to improve operational control and reliability, its sophisticated reporting and KPI dashboards provide real-time insights into asset health, technician efficiency, and overall maintenance performance. This makes it a scalable and affordable solution.

7. MPulse Maintenance Software

MPulse Maintenance Software is a complete CMMS system made to assist businesses in managing assets effectively, cutting down on equipment downtime, and streamlining maintenance procedures. With strong automation capabilities, it enables both predictive and preventative maintenance techniques and is widely utilized in industries like manufacturing, fleet management, healthcare, utilities, and government. (MPulse Software, 2024)

The software optimizes service intervals and detects any problems before they lead to failures by automating maintenance scheduling based on historical trends and real-time IoT sensor data. By automating reordering and maintaining ideal spare part stock levels, MPulse also improves inventory management by integrating with purchasing systems, avoiding shortages and overstock.

The system is perfect for field use because technicians can retrieve work orders, scan assets using barcodes or QR codes, and use the system even in offline conditions. Real-time insights into important performance measures, such as asset uptime, maintenance expenses, technician productivity, and compliance data, are offered by custom dashboards. MPulse is scalable for companies of all sizes and contributes to increased asset life, enhanced productivity, and data-driven decision-making. (MPulse Software, 2024)

4.2 Drawback of the existing systems

IBM Maximo Manage - High complexity and cost; better suited for large businesses, it is less suitable for SMEs because of its costly deployment and steep learning curve.

SAP Plant Maintenance (SAP PM) – Complex to set up and manage; highly dependent on the larger SAP ERP ecosystem, which could lead to a lengthy and expensive deployment process.

UpKeep Mobile-first CMMS - Less choices for customization and scalability than enterprise-level systems; some advanced functions may require more expensive categories.

Fiix by Rockwell Automation - It can be difficult to integrate with outdated or non-standard systems; some functionalities might not work properly without third-party add-ons.

eMaint CMMS (by Fluke) - Because of the depth of functionality, there is a steeper learning curve for novice users; performance may lag with sophisticated configurations or very large information volumes.

Limble CMMS - Lacks several enterprise-grade capabilities that are necessary for very big operations; higher-tier plans may be needed for custom processes and comprehensive reporting.

MPulse Maintenance Software - Some clients could suspect that the interface is out of date; without vendor support, customization may be limited; and upgrades might not occur as frequently as with cloud-native solutions

4.3 Disparities between MechniX and Existing systems

MechniX offers an affordable, cost-effective, and user-friendly solution designed especially for small to larger organizations, in contrast to the enterprise-focused, intricate, and expensive platforms of existing systems like IBM Maximo, SAP PM, and Fiix. MechniX concentrates on functional requirements like meter-based preventive scheduling, internal material tracking, role-specific dashboards, and email/in-app notifications, without requiring complex infrastructure or third-party integrations, whereas most current systems offer comprehensive features like IoT integration, ERP connectivity, and AI-based predictive maintenance. For teams. that require an effective maintenance system without the cost of conventional corporate products, its easy design and deployment make it perfect.

5. Method of Approach

5.1 Functional Requirements

Functional Requirements Roles of users:

1. **Supervisor (admin)**
Supervisors are responsible for monitoring equipment, assigning tasks, and ensuring that maintenance schedules are followed to.

Machine Registration and Database Creation –

You may add new machinery by entering its brand, model, and unique ID.
ability to manage and store service information, maintenance records, and meter readings.
able to change or delete machine-related information as necessary.

Meter readings monitoring –

Every day, machine meter values may be checked and tracked.
able to manually change meter readings as needed.
can enhance scheduling by tracking machine operation hours in real time.

Notifications of Services and Scheduling -
Receives service notices automatically based on schedules or meter readings.
the capacity to develop routine maintenance schedules for every unit of equipment.
ability to modify maintenance schedules based on equipment usage.

Monitoring of Manpower and Task Allocation -
can delegate maintenance or repair tasks to professionals.

Managing the procurement of supplies and managing inventory -
able to view the current inventory of maintenance materials.
They may ask for more supplies when their current supply runs low.
able to approve or reject requests for parts from technicians or inventory employees.

Updates and Service Documentation -
permission to view and approve service logs produced by technicians.
can review and get records of previous maintenance.

Reporting and Analysing Historical Information -
It is possible to create reports on the health of the equipment, maintenance costs, and servicing frequency.
used to analyse trends in machine breakdowns and optimize maintenance planning.

2. **Technician**

   Technicians are in the role of performing maintenance tasks and reporting machine issues.

   Getting Assignments
   Get alerts when repairs or maintenance are assigned.

   Meter readings and working hour tracking
   After service, update the machine's operating hours and meter readings.

   Notifications and Alerts
   gets a reminder to complete the required tasks.

3. **Inventory Employee**

   Inventory workers respond to purchase orders and manage the stock levels of maintenance materials.

   Verifying Stock Levels
   can maintain an eye on the availability of oil, spare parts, and other maintenance materials.

   Handling Material Requests
   Capable of receiving and reviewing material requests from technicians and supervisors.

   Processing Purchase Orders

   Able to generate purchase orders for out-of-stock items.

4. **All users (Supervisor, Technician, Inventory Employee)**

   User registration and authentication -
   Any user with a proper position can sign up for the system.
   When logging in, users must utilize secure authentication.
   Passwords are securely stored and encrypted.

5.2 Non-Functional Requirements

1. **Performance**
   The system requires to react to user inputs quickly and be responsive. It should be no delays in the display of real-time meter reading updates, service alerts, and job progress.

2. **Scalability**
   The system must be flexible so that additional equipment, technicians, and data may be added without affecting system performance. As the company grows, the system should be able to efficiently handle increasing requirements for traffic and data storage, guaranteeing uninterrupted performance even as the workload increases.

3. **Usability**
   Supervisors, technicians, and inventory employees should all be able simply navigate the user interface. To ensure smooth experience across all platforms, the app needs to be available on desktop and mobile devices, with mobile optimization created especially to support employees working directly.

4. **Security**
   Data Encryption: Encrypt sensitive data such as machine information and maintenance logs, both during transmission and storage.

5. **Reliability**
   The system's high level of reliability and low downtime should always ensure access. Backup systems must be developed to guard from loss of information, and periodic application updates and maintenance checks should be scheduled to ensure optimum system reliability and efficiency.

6. **Compatibility**
   The system should work with a variety of mobile platforms (iOS and Android) and operating systems, such as Windows and macOS. To provide notifications and warnings and guarantee efficient workflow and communication, it must also easily interact with additional applications, such as email services like Nodemailer.

5.3 Hardware / Software Requirements

Mobile devices - Android or IOS

Computers - For developer work.

Internet Access - Required for android studio, firebase and cloud services

6. Method of Approach

The MachniX Machinery Maintenance Web Application is being developed using an organized and progressive method to ensure that business needs are satisfied effectively, and that the final product is secure, scalable, and easy to use. The project will be divided into several stages, such as design, development, testing, deployment, maintenance, and planning.

6.1 Development Methodology

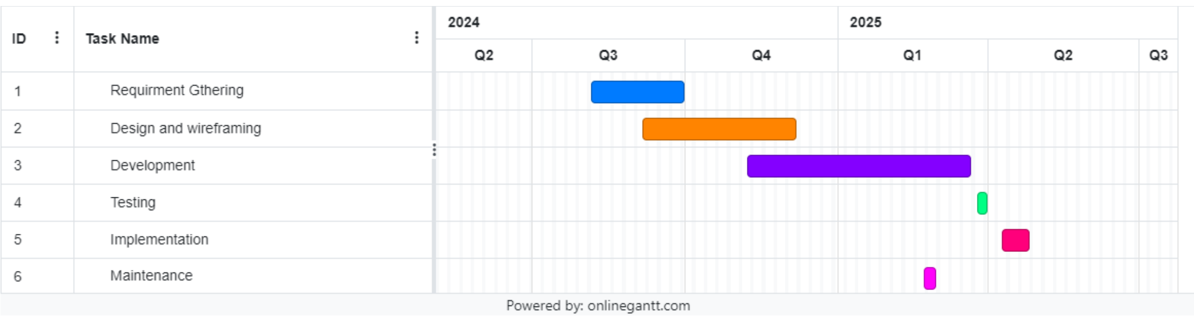
The Agile methodology will be applied to the project, focusing iterative development and ongoing feedback. Each sprint will offer a functional increment of the system, and the work will be divided into brief intervals of two to three weeks in length. Agile offers several advantages, including:

The ability to respond to changing requirements.

Regular input from stakeholders.

Regular releases are necessary for testing and validation.

focus on improvements and user-cantered design.



6.2 Programming Languages and Tools

Frontend: Next.js

The Next.js features such as server-side rendering (SSR) and static site generation (SSG) guarantee fast performance.

Field technicians need Tailwind CSS responsive user interface design that is optimized for mobile devices.

Backend - Firebase (Cloud function)

Serverless design lowers the need for infrastructure management.

controls event triggers, including maintenance warnings, in real-time.

guarantees efficient operation by automatically scaling in response to demand.

Database -Firebase Realtime Database

NoSQL, real-time syncing.

Great for mobile/web apps but limited querying.

Firebase Firestore -Improved version of Firebase DB.

Real-time updates, better querying, scalable for larger apps.

Authentication - Firebase Authentication

Supports OAuth, email/password, and multi-factor authentication.

Depending on needs, administrators, technicians, and supervisors can readily control access.

Notification - Nodemailer + Firebase Cloud Messaging

Real-time maintenance alerts are provided using FCM push notifications.

Nodemailer's email notifications confirm that users receive critical notifications.

GitHub version control -

Allows branches and pull requests for cooperative development.

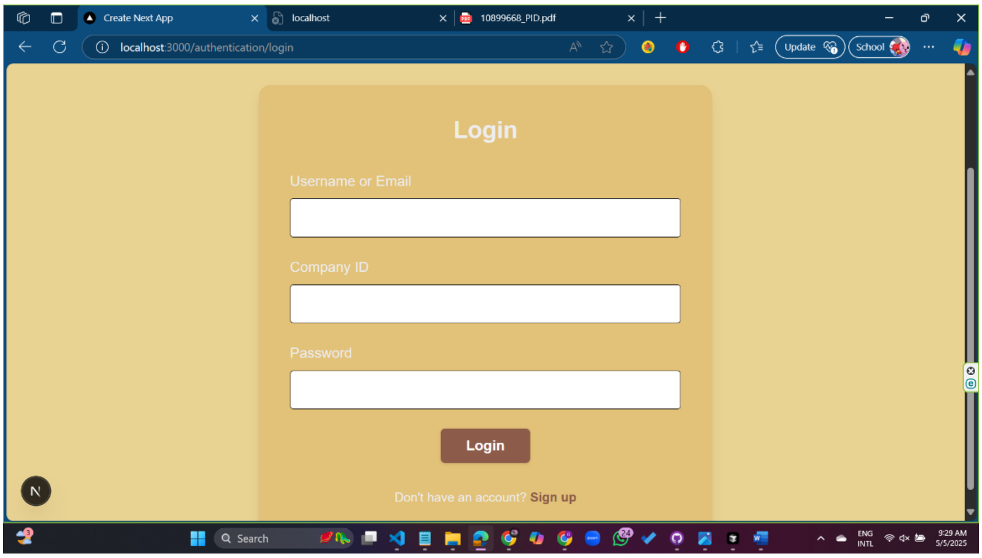
Uses GitHub Actions to facilitate automated testing and deployment.

7. User interfaces

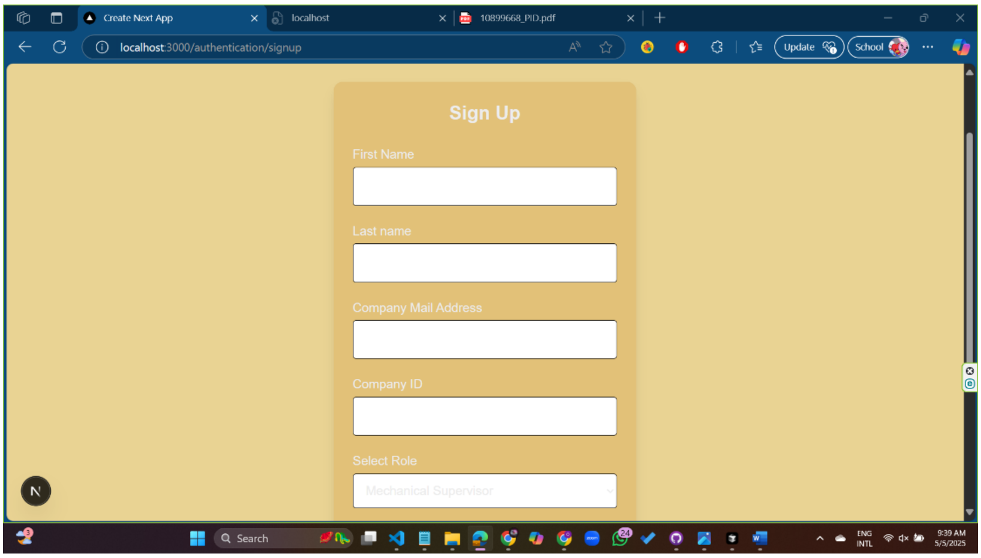
Loading page

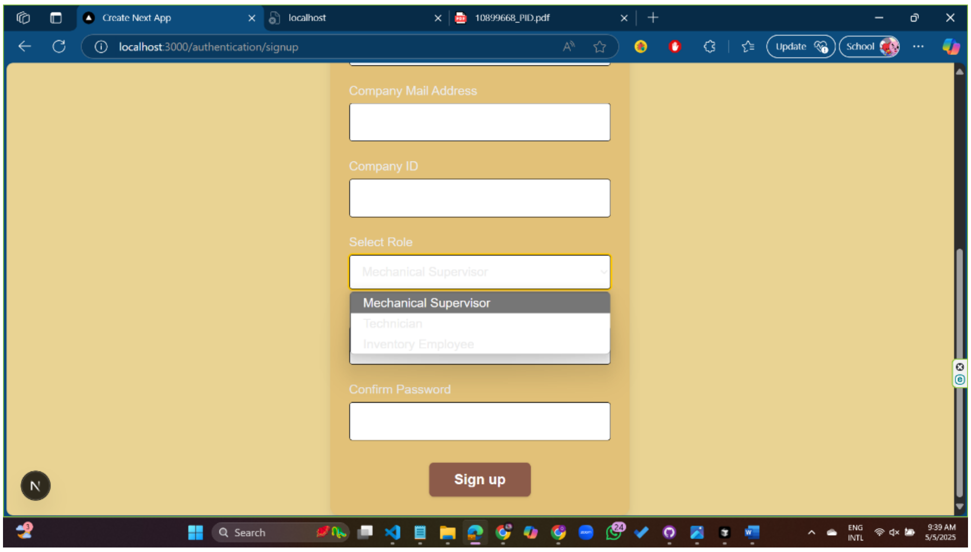
User Authentication

1. Login page

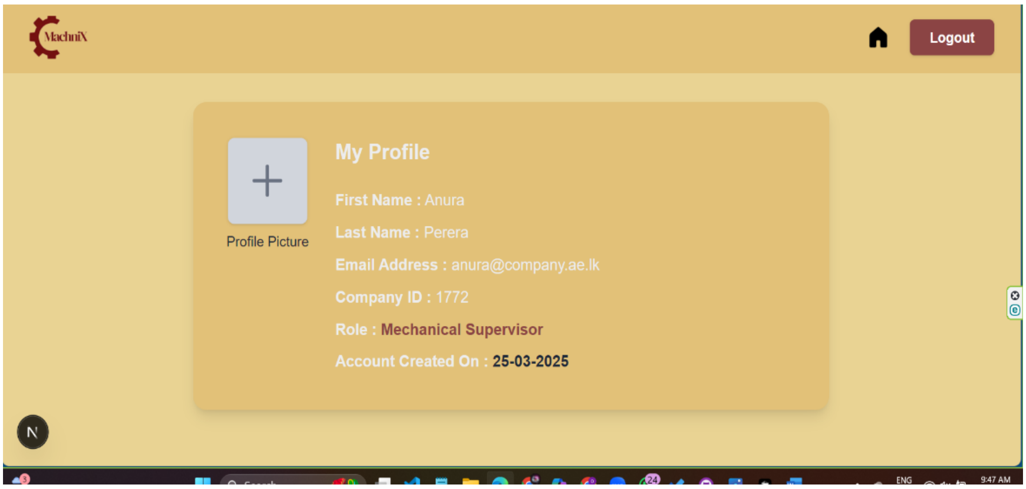


2. Sign up


Create Next App
localhost
10899668_PID.pdf
localhost:3000/authentication/signup
Sign Up
First Name
Last name
Company Mail Address
Company ID
Select Role
Mechanical Supervisor

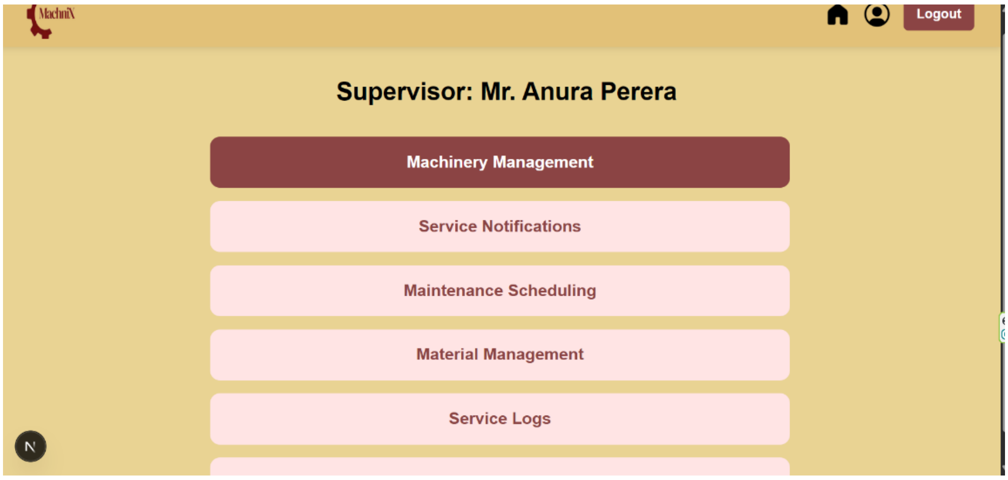

Create Next App
localhost
10899668_PID.pdf
localhost:3000/authentication/signup
Company Mail Address
Company ID
Select Role
Mechanical Supervisor
Mechanical Supervisor
Technician
Inventory Employee
Confirm Password
Sign up

3. User profile

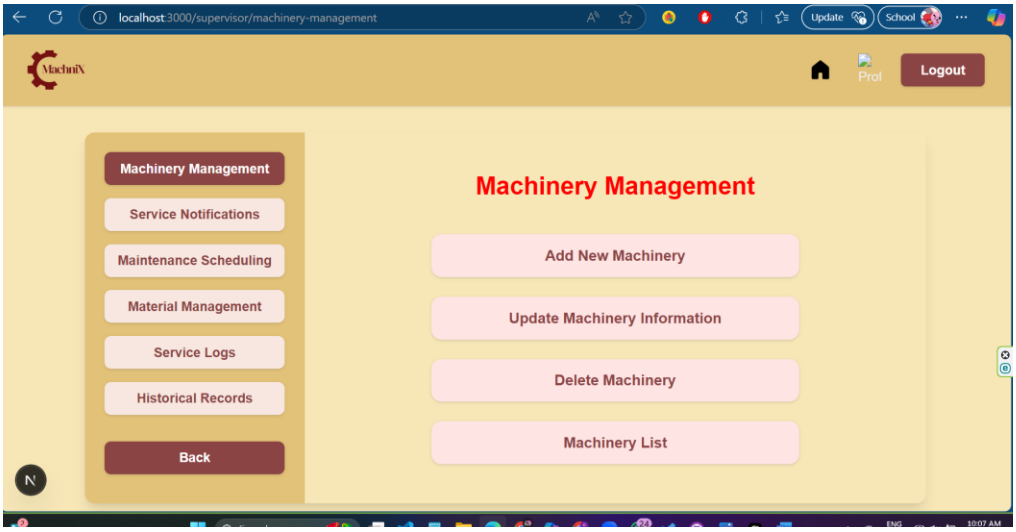


Supervisor pages

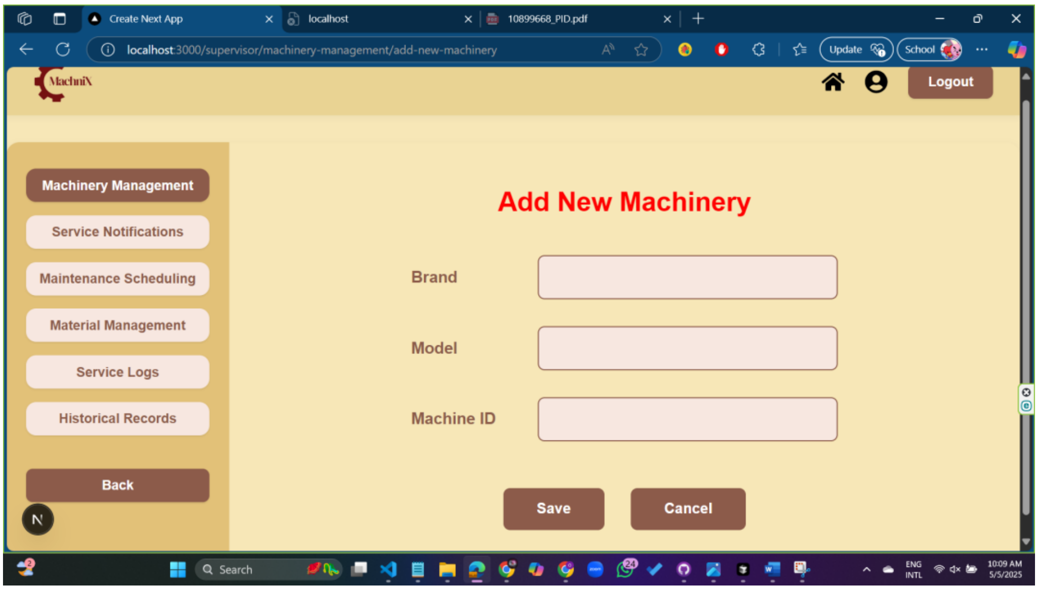
1. Supervisor dashboard



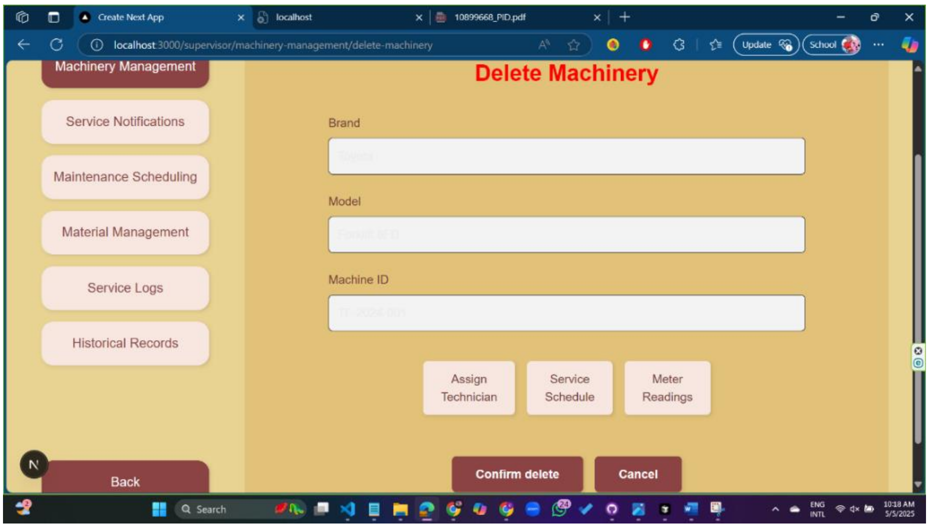
2. Machinery Management Dashboard



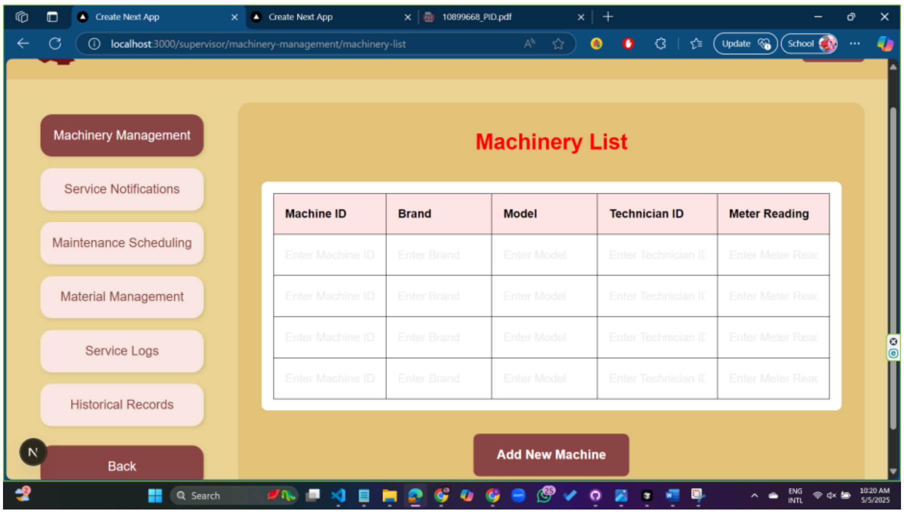
3. Add new Machinery page



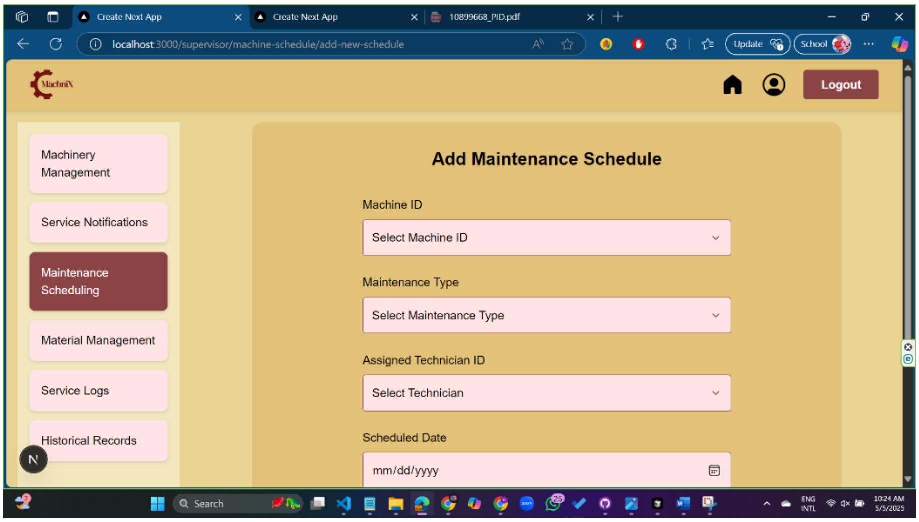
4. Delete machinery

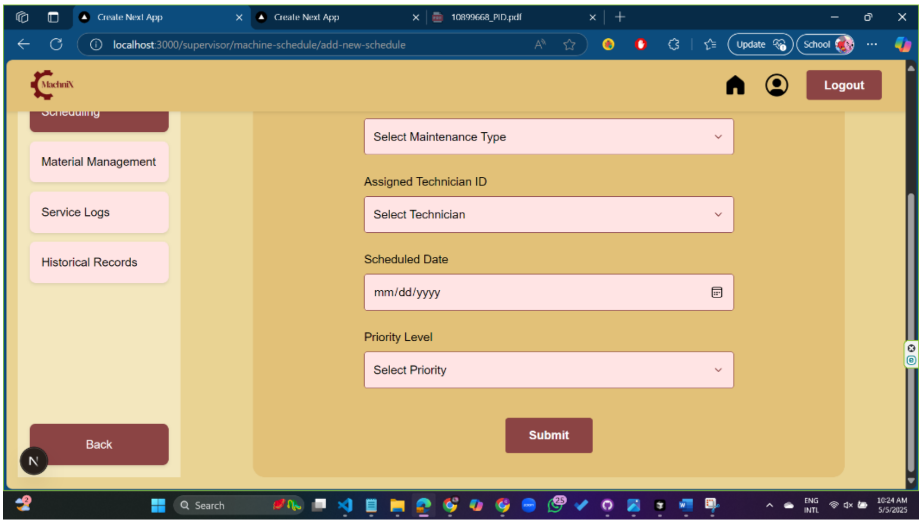


5. Machinery List

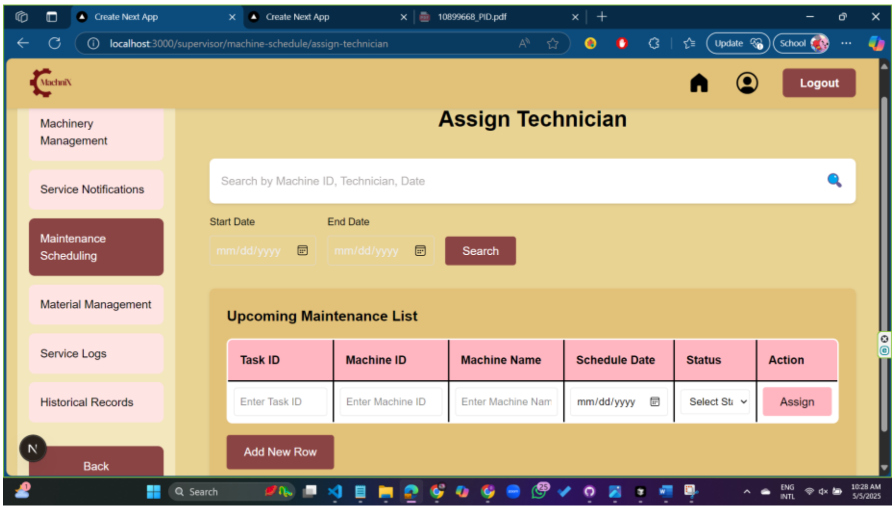


6. Maintenance Schedule Dashboard

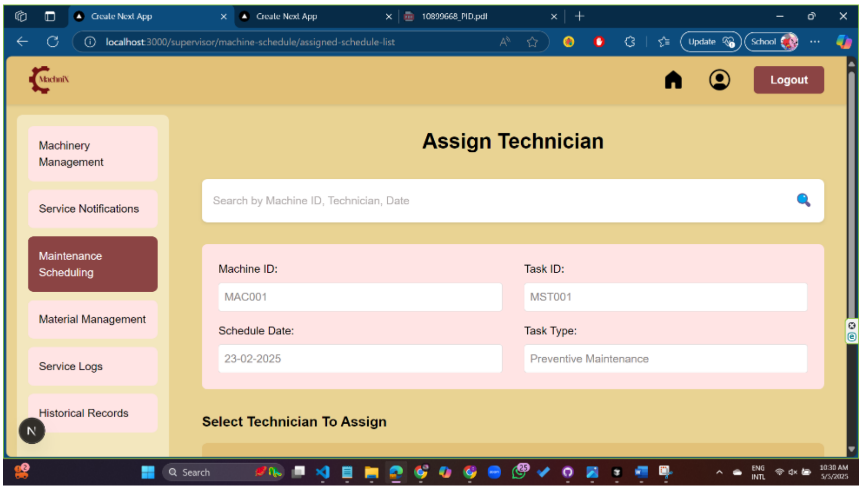


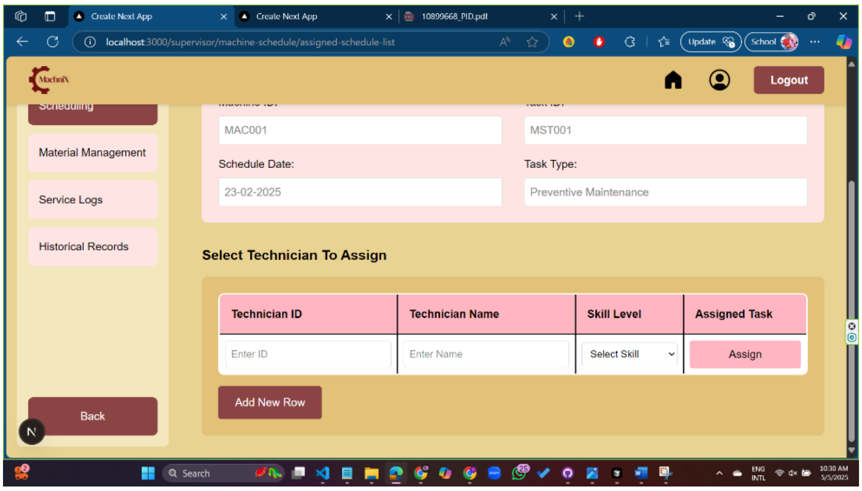


7. Assign technician page

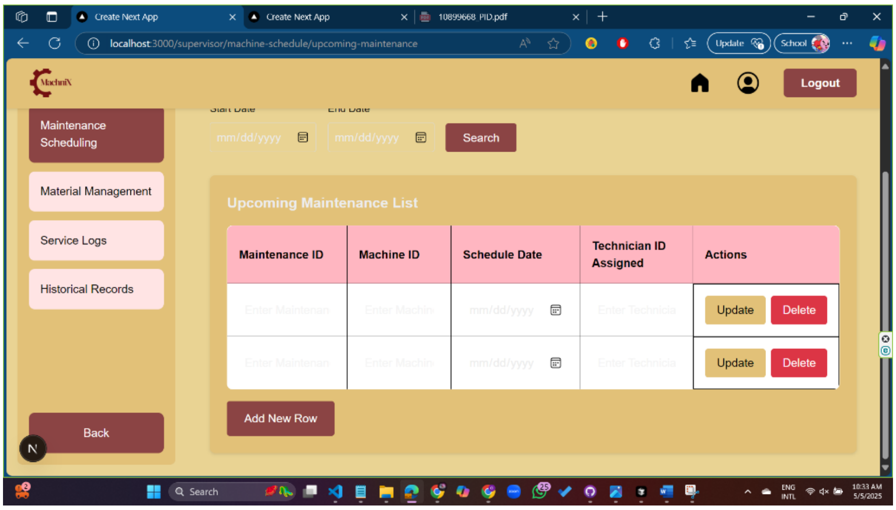


8. Assigned Schedule List



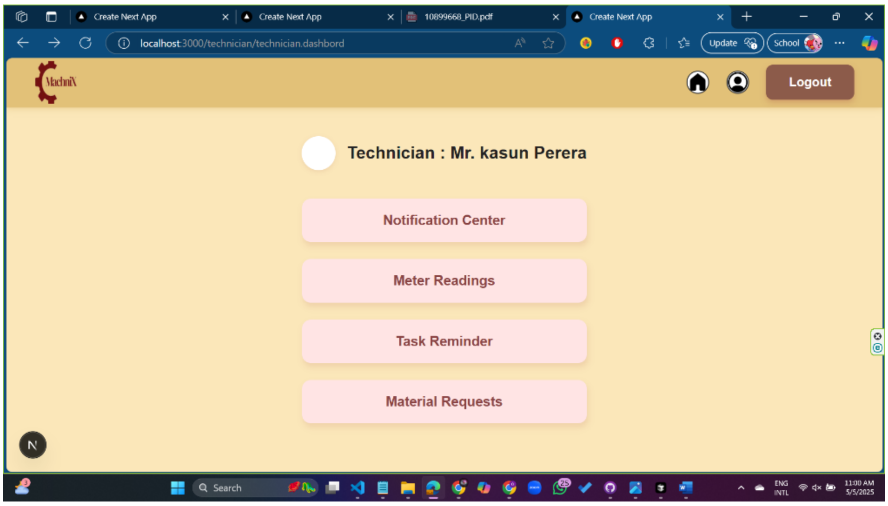


9. Upcoming Maintenance

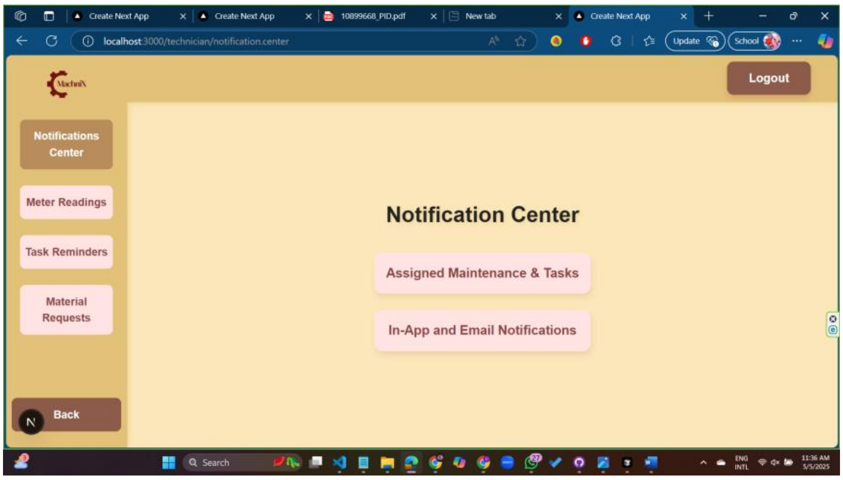


Technician pages

1. Technician dashboard



2. Notification Canter



8. End Project Report

Project summery

The MachniX web application was created as a solution for a private company in the real world that specialized in managing heavy equipment including generators, compressors, and HDD drilling systems. In the past, the company tracked meter readings, scheduled services, and managed material supply using manual running sheets, an approach that was prone to mistakes, delays, and inaccurate information.

With MachniX, supervisors, technicians, and inventory employees may effectively manage their tasks by replacing this manual technique with a centralized, web-based platform. A few notable accomplishments are email-based notifications, inventory management, real-time meter reading updates, automated preventive maintenance scheduling, and service history reporting. The application was developed utilizing the Agile development technique and cutting-edge technologies like React, Next.js, MongoDB, and Firebase. It is scalable for adding more features in the future, responsive, and role-based for users.

Project Objectives and Critical Evaluation

With the objective of lowering mistakes made by humans, increasing accuracy, and enhancing operational efficiency, the MachniX project was created to replace the company's manual machinery maintenance procedure with a digital platform. Real-time meter reading tracking, automated reminders for preventative maintenance, and consolidated service history storage for improved data access and planning are some of the significant achievements. By analyzing usage of materials and assisting with purchase planning to prevent shortages, the system also helps with inventory management. It helps environmentally friendly initiatives and reduces printing and storage expenses by eliminating paper-based procedures. Proactive maintenance is also encouraged via timely notifications and historical data analysis, which helps extend the life of machines and reduce unscheduled breakdowns. While all the primary objectives have been achieved, maintenance performance analytics and procurement system integration could be added in the future to further improve company performance.

Changings during the project

The project's main change was the frontend framework's switch from React.js to Next.js. The decision was taken to take advantage of Next.js benefits in server-side rendering, routing, and performance enhancement. For a system that needs faster load times and improved SEO for possible public-facing modules, these characteristics offered a more scalable and effective solution.

The user role structure was refined as another modification. The system had general user roles at first, but as development went on, the roles were explicitly separated into three categories: Inventory Employee, Technician, and Supervisor. This facilitated processes for every user type, improved task management, and provided better access control.

The inventory management feature was also improved in response to early feedback and real-world issues. To better support maintenance planning and prevent shortages, real-time material tracking functions were enhanced. This modification improved the system's capacity for preventative maintenance and brought it closer to real operational requirements.

9. Project Post-Mortem

Product Specifications

MachniX, the outcome, is a web-based equipment maintenance management system designed to provide a consolidated digital platform in place of manual tracking. It has modules for managing material inventories, scheduling preventive maintenance, updating meter readings, and providing role-based dashboards for technicians, supervisors, and inventory employees. In addition to gathering and reporting historical data, the system provides real-time notifications through email and in-app alerts.

Client-Relationship

In the project, the client's company and the relationship remained positive and helpful. Frequent discussions and updates make sure that client requirements were considered as the product developed. Features including material requests and service alerts were designed with input from the client, who offered helpful details about everyday tasks.

Development Process Evaluation

Short sprints of iterative work were made possible by the Agile development methodology. As the project progressed, this aided in work management, feedback incorporation, and priority adjustments. Mid-project updates and refinements, such as shifting frameworks and modifying inventory logic, caused some delays, but the adaptable development methodology allowed for the adjustments to be made without causing major problems.

Technology Evaluation

Developing a scalable and modern web application was made easy with the support of the technology stack, which included Next.js (which replaced React.js), Firebase Authentication, Firebase Realtime Database, Firebase Firestore, and Tailwind CSS. Better routing and server-side rendering made the switch to Next.js possible. A safe and simple user login method was made available via Firebase Authentication. Firebase Realtime Database and Firestore were both utilized for the database layer. Realtime Database allowed for real-time data syncing and was best suited for basic structured data, while Firestore offered more sophisticated querying, scalability, and superior support for intricate data structures. The result enabled the rapidity and adaptability required for future scalability and real-time updates. Tailwind CSS's responsive design and uniform styling made UI design easy.

Personal Performance

Project planning, problem-solving, and full-stack development skills were all able to advance because of the project. Setting priorities for fundamental capabilities enabled balancing the time management challenges that arose during the complex feature development phases. During the project, there was significant progress in communication, documentation, and response to feedback.

Client Feedback

Initial client feedback was positive, especially about the accessibility of accessing previous service records, the automation of reminders, and simplifying of inventory maintaining. They valued the dashboards' organized visibility and the decrease in challenging paperwork. A few usability changes were proposed and quickly fixed.

Lessons Learned

Rework during development can be reduced with early and comprehensive domain knowledge.

A accurate base product can be ensured by giving priority to fundamental functions before upgrades.

Early testing with actual users benefits in the early identification of usability problems.

Performance and scalability can be significantly improved by being adaptable to technological changes, such as the move to Next.js.

In order to effectively manage changing requirements, version control and clear documentation are essential.

10. Conclusion

A significant development in updating maintenance processes for small to mid-sized industrial companies has been taken with the creation and deployment of the MachniX machinery maintenance web application. Major challenges like human mistakes, missed services, inventory shortages, and a lack of documentation were effectively handled by the project by switching from manual, paper-based processes to a centralized digital platform. The solution improves decision-making, accountability, and operational efficiency with role-based dashboards, automatic service notifications, and real-time data management. Regular enhancement has been rendered possible by the Agile methodology, which allowed for changes to make during the project changes like switching to Next.js and improving inventory logic without causing delays. Technology like Next.js for performance and Firebase for database and authentication worked very well to accomplish the project's objectives.

All things considered, MachniX offers a scalable, user-friendly solution that fits the feasible requirements of heavy machinery-dependent sectors and offers long-term advantages in the areas of productivity, equipment dependability, and cost reduction.

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eMaint CMMS Software. (n.d.),MPulse Software. (2024)

12. Appendices

PUSL3190 Computing Individual Project
Student Progression Report
[Student Copy]

01. Student Name P. A. D. N. L. Premathilaka.
02. Plymouth Index Number 10899668
03. Degree Program Bsc (Hons) Software Engineering
04. Supervisor Name Miss. Dulanjali Wijesekara.
05. Project Title ~~Vehicle~~ Maintenance Application.
Machinary

Meeting Number	Meeting 01	Meeting 02	Meeting 03	Meeting 04	Meeting 05	Meeting 06	Meeting 07
Date	15/10/24	09/11/24	22/11/24	24/03/25	28/04/25		
Student Signature	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
Supervisor Signature	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		

Meeting Number	Meeting 08	Meeting 09	Meeting 10	Meeting 11	Meeting 12	Meeting 13	Meeting 14
Date							
Student Signature							
Supervisor Signature							

UNIVERSITY OF PLYMOUTH

NSBM GREEN UNIVERSITY TOWN

PUSL3190 Computing Individual Project
Student Progression Report
[Student Copy]

01. Student Name P. A. D. N. L. Premathilaka.
02. Plymouth Index Number 10899668
03. Degree Program Bsc (Hons) Software Engineering
04. Supervisor Name Miss. Dulanjali Wijesekara.
05. Project Title ~~Vehicle~~ Machinary Maintenance Application.

Meeting Number	Meeting 01	Meeting 02	Meeting 03	Meeting 04	Meeting 05	Meeting 06	Meeting 07
Date	15/10/24	09/11/24	22/11/24	24/03/25	28/04/25		
Student Signature	Nesandi	Nesandi	Nesandi	Nesandi	Nesandi		
Supervisor Signature	[signature]	[signature]	[signature]	[signature]	[signature]		

Meeting Number	Meeting 08	Meeting 09	Meeting 10	Meeting 11	Meeting 12	Meeting 13	Meeting 14
Date							
Student Signature							
Supervisor Signature							

UNIVERSITY OF PLYMOUTH | NSBM GREEN UNIVERSITY TOWN

Final Year Project – Supervisory meeting minutes

Meeting No:

Date : 11/09/2024

Project Title : Vehicle Maintenance Application.

Name of the Student : D.N.L. Premathilaka.

Students ID : 10899668

Name of the Supervisor : Miss Dulanjali Wijesekara .

Items discussed:

Select the project.

Items to be completed before the next supervisory meeting:

1. Requirement hathering;
   ↳ To find the problem

9/11/2024.

Supervisor (Signature & Date)

Instructions to the supervisor: **Do not sign** if the above boxes are blank.

UNIVERSITY OF PLYMOUTH | NSBM GREEN UNIVERSITY TOWN

Final Year Project – Supervisory meeting minutes

Meeting No:

Date : 15/10/2024.

Project Title : Machinary Maintanance Application for a company

Name of the Student : P.A.D.N.L. Premathilaka.

Students ID : 10899668

Name of the Supervisor : Miss Dulanjali Wijesekara.

Items discussed:

*Change the project idea.

Items to be completed before the next supervisory meeting:

Machinary Maintanance.

Existing solution	Features	Pros & cons

[signature] 15/10/2024

Supervisor (Signature & Date)

Instructions to the supervisor: **Do not sign** if the above boxes are blank.

UNIVERSITY OF PLYMOUTH | NSBM GREEN UNIVERSITY TOWN

Final Year Project – Supervisory meeting minutes

Meeting No: 03

Date : 22/11/2024.

Project Title : Machinary Maintanance Application.

Name of the Student : P A D N L Premathilaka.

Students ID : 10899668.

Name of the Supervisor : Ms. Dulanjali Wijesekara.

Items discussed:

Discussed on developing part of the project,
That is miss told that change the predecide
mobile application to web application.

Items to be completed before the next supervisory meeting:

complete the PID

22/11/24

Supervisor (Signature & Date)

Instructions to the supervisor: **Do not sign** if the above boxes are blank.

UNIVERSITY OF PLYMOUTH | NSBM GREEN UNIVERSITY TOWN

Final Year Project – Supervisory meeting minutes

Meeting No: 04

Date : 24/09/25.

Project Title : Machinary Maintenance Application.

Name of the Student : DNL Premathilaka.

Students ID : 10899668.

Name of the Supervisor : Ms. Dulanjali

Items discussed:

Interim Report Precentation.

Items to be completed before the next supervisory meeting:

Change the objective patterns in writing.

Design.

3/24/2025

Supervisor (Signature & Date)

Instructions to the supervisor: **Do not sign** if the above boxes are blank.

Final Year Project – Supervisory meeting minutes

Meeting No: 05

Date : 26/04/2025 .

Project Title : Machinery Maintenance web Application.

Name of the Student : P. A. D. N. L. Premathilaka.

Students ID : 10899668 .

Name of the Supervisor : Miss. Dulanjali Wijesekara .

Items discussed:

Check The front-end developing.

Items to be completed before the next supervisory meeting:

Focus on the dev.

4/28/2025

Supervisor (Signature & Date)

Instructions to the supervisor: **Do not sign if the above boxes are blank.**

PUSL3190 Computing Individual Project

Project Initiation Document

MechniX -

Machinery Maintenance Web Application

Supervisor: Ms. Dulanjali Wijesekara

Name: Panadura A Premathilaka

Plymouth Index Number: 10899668

Degree Program: BSc (Hons) Software Engineering

Abstract

Companies operating with equipment need to ensure diligent service of heavy machinery such as rated HDD machines or generators. Currently, however, the methodology of service employed within these companies, utilizing running sheets to delineate services, could result in inefficiencies, missed schedules and inadequate inventory. These inefficiencies are bound to cause machinery failures, expense repair cycles and subsequent delays in operations. MachniX is a web application set to enable optimization of the processes pertaining to maintenance of machinery through digitization. The system will monitor maintenance and servicing schedules and avert delays through tasks such as coordinating wire meter readings and machine usage. The application would also collect data to facilitate proper service history of the machines and issue reminders for efficient execution of tasks.

MachniX will further enhance the management of the inventory processes through monitoring of spare parts and materials stock levels while minimizing the generation of purchase plans. Equipped with the understanding of machines' conditions and the timing of the necessary maintenance, the platform will aid in efficient decision making and resource distribution.

1. Introduction

1.1 Machinery Maintenance

Machinery maintenance is the process of ensuring that machinery and equipment are operating at their most efficient speed with routine inspections, repairs, and part replacements to increase their service lives and avoid failures. To ensure that machinery works safely, effectively, and reliably, this includes both preventive and repairs.

The maintenance of machinery has grown from reactive to predictive approaches. Maintenance was primarily reactive at first, fixing equipment problems only after they happened, which resulted in unscheduled downtime and increased expenses. With a focus on routine, planned service to avoid malfunctions, preventive maintenance first appeared in the second half of the 20th century. Reliability-Centered Maintenance (RCM), which focuses on maintaining system operations and giving priority to essential components to improve reliability, was developed as another stage of this strategy. The use of real-time data and condition monitoring to detect problems before they occur has made predictive maintenance solutions feasible, which optimize maintenance schedules and resource allocation. (Sondalini, 2021). Today, the concept of Smart Maintenance, which enables accurate projections and automated decision-making processes—was born out of the combination of Artificial Intelligence (AI) and the Industrial Internet of Things (IIoT). (Zheng, Paiva and Gurciullo, 2020). This progression shows how industrial maintenance procedures are becoming more economical and efficient.

There are several types of machinery maintenance.

- Preventive maintenance (PM): regular planned maintenance to avoid unexpected failures.
- Corrective maintenance: As an issue or failure is found, repairs or replacements are carried out.
- Predictive Maintenance: Use technology and data to predict when a machine is going to break.
- Maintenance Based on Conditions (CBM): Maintenance is defined by monitoring and diagnostics that identify the machinery's correct state.
- Emergency Maintenance: Unplanned maintenance to fix unexpected failures.

1.2 Preventive Maintenance (PM)

Preventive maintenance (PM) is a concept used for the scheduled, planned repair of machinery and equipment to optimize performance, reduce unscheduled downtime, and increase operational lifetime. PM focuses on observing and solving possible issues before they become failures, as versus reactive maintenance, which deals with problems after they arise. This entails planned maintenance, inspections, and part replacements carried out on a regular basis or in accordance with certain use metrics, such production cycles or operational hours. Organizations may reduce unplanned disruptions and guarantee ongoing production by following these plans.

Frequent inspections, maintenance, and repairs are necessary to avoid equipment problems before they occur. Because unexpected failures can result in large production losses, safety risks, and increased operating expenses, this preventive plan is essential in workplaces. (Chan, 2023).

Optimizing equipment accuracy is one of the fundamental goals of preventative maintenance. Frequent maintenance lowers the chance of wear and tears and ensures that machinery runs at its best. Examples of this maintenance include cleaning, lubricating, and fastening parts. Because early interventions stop small concerns from growing into big, irreversible damages, PM also delays the lifespan of assets. For instance, early cleaning of air filters or replacement of worn-out belts may save expensive repairs and ensure operating efficiency. (MicroMain, 2022).

Cost reduction is a crucial advantage of preventative maintenance. Without the initial time and resource commitment, PM reduces the need for emergency repairs, which are frequently more costly because of manpower, unplanned downtime, and quicker part replacements. Additionally, by reducing the dangers of equipment failures, it enhances workplace safety by protecting both workers and operations.

(ServiceChannel, 2023).

Preventive maintenance is frequently used in various industries. It ensures that production lines in manufacturing operate efficiently, reducing delay and increasing productivity. PM has a direct influence on patient care in the healthcare industry by ensuring that vital medical devices continue to work. In the transportation and construction industries, routine maintenance of large machinery and automobiles guarantees efficiency and safety on the road and on building sites. A well-structured preventive maintenance plan may help firms maximize asset performance, save expenses, and ensure safety regulations are followed. (developer, 2024).

1.3 Introduction to Industrial Machinery.

The definition of "Industrial Machinery" covers many kinds of equipment used in the construction, manufacturing, agricultural, and other areas. When it's accurate production or heavy lifting and transporting, these machines are built to perform certain tasks. They are essential for increasing manufacturing efficiency, enhancing safety, and reducing labor costs. There are several categories of industrial machinery.

- Manufacturing Machinery: This category includes robotic arms, CNC machines, presses, lathes, and mills.
- Construction Machinery: This category includes huge pieces of equipment including bulldozers, excavators, cranes, and concrete mixers that are utilized in infrastructure and construction projects.
- Agricultural machinery: Includes agricultural equipment such as tractors, harvesters, plows, and irrigation systems.
- Material handling equipment: Includes material-transporting devices including automated guided vehicles (AGVs), forklifts, and conveyors.
- Energy and Power Machinery: It includes equipment used in mining, oil extraction, and power generation, such as compressors, pumps, turbines, and generators.

Energy and power machinery as well as construction machinery are the main topics of discussion in this project.

1.4 Problem Definition

Heavy machinery and equipment maintenance is a key component of any of the company's operations, specifically for companies that depend on the constant functioning of significant machines like Generators, HDD (Horizontal Directional Drilling) machines, and other industrial equipment. The efficiency of operations depends on ensuring that all the machines are working properly, getting timely preventative maintenance, and preventing failures.

However, the maintenance procedure is still carried out manually at my specified company using a running sheet, which is a record used for maintaining records of upgrades and preventative maintenance programs for each component of equipment. A mechanical supervisor or engineer maintains the records, working with warehouse employees, machine operators, and other employees to schedule required services, record working hours, and gather meter readings. While there are plenty of applications available for monitoring the maintenance of vehicles, applications designed especially for the maintenance of industrial machines are significantly underutilized. Applications for vehicle maintenance are frequently utilized in industries like vehicle management, where digital solutions facilitate the tracking of service history, mileage, maintenance plans, and part replacements. However, there aren't many specialist applications developed for maintaining heavy machinery, specifically for companies which run multiple types of equipment with various maintenance requirements. Because of this, many companies that depend on machinery continue to schedule and perform maintenance using manual techniques.

The company's present manual procedure is ineffective, hence requires a machinery maintenance system. Equipment failures and expensive repairs are more likely when running sheets are used for maintenance tracking because they are prone to human error, insufficient data, and missed maintenance schedules. Without a well-organized system, the business finds it difficult to track equipment utilization, manage preventive machinery maintenance, and have a sufficient stock of materials and spare parts. To ensure that the company's machinery runs effectively and reliably to fulfill its operational requirements, a digital maintenance system would optimize operations, decrease delay, and enhance resource allocation.

The company needed to improve the efficiency of its current maintenance system, which is what inspired this project. The manual method of data management and recording has resulted in ongoing issues including expensive repairs, missed maintenance schedules, and inventory shortages.

[redacted]	Telecommunication Projects Division	Document Code	PMDII/TPD/EMS/08
		Issue/Revision	01/01
	Overall Maintainance Schedule - Compressor	Date	24/02/2016
		Page	1 of 1
Project Name :-			

Service	Maintenance Interval-Service hours			
	Daily	500 Hours / 12 Months	2000 Hours / 24 Months	As required
Check engine oil and coolant level	×			
Check fuel filter/Water bowl	×			
Check Air cleaner Dust Unloader Valve & Restriction indicator gauge	×			
Visual Walk Around inspection	×			
Service Battery		×		
Check Manual belt Tensioner and belt wear		×		
Change engine oil and replace oil filter		×		
Clean crank case vent tube		×		
Check air intake hoses,connections & system		×		
Replace fuel filter elements -Bleed fuel system		×		
Check belt tensioner and belt wear		×		
check engine elictrical ground connection		×		
Check cooling system		×		
Pressure test cooling system		×		
Flush Cooling system			×	
Test Thermostat			×	
Check and adjust engine valve clearance			×	
Add coolent				×
Replace air cleaner eliments				×
Replace poly - vee belt				×

[redacted]	Telecommunication Projects Division	Document Code	PMDII/TPD/EMS/02-B
		Issue/Revision	01/01
	Weekly Inspection Sheet (HDD Vermeer)	Issued Date	24/02/2016
		Page	1 of 1
Project Name:			

Year : 2019

Machinery No : HDD - 01 (PMHDD - 01) Vermeer

Operator : Milinda.

Location : Bgm machinery pool.

Month	November - 2019				December - 2019				January - 2020				February - 2020				March - 2020				May - 2020			
Week	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Control levers linkage-check/oil	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Shutdown For Corona pandemic	Re Start after Covid 19 on 11/05/2020	✓	✓	✓
Track Planetary gearbox oil level -check	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
Rack Frame pivot -grease	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
Rack frame pivot cylinders -grease	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
Rack carriage float -grease	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
Drilling fluid pump crankcase oil level-check	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
Rear Stabilizer -grease	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
Power vise cylinder- grease	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
Power vise - grease	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
Front roller Guides -grease	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
Rotation gearbox -grease	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
Meter Reading	04/11 5259	07/11 5259	16/11 5259	23/11 5259	02/12 5259	10/12 5259	21/12 5259	28/12 5259	02/01/2020 5259	11/01/20 5259	16/01/20 5259	25/01/20 5259	01/02/20 5259	08/02/20 5259	15/02 5259	28/02 5259	07/03/20 5259	14/03/20 5259	20/03/20 5260			12/05/20	19/05/20	26/05/20
Supervisor Name (Mechanical In Charge)	Owen	Owen	Owen	Owen	Owen	Owen	Owen	Owen	Owen	Owen	Owen	Owen	Owen	Owen	Owen	Owen	Owen	Owen	Owen			Owen	Owen	Owen
Signature																								
Supervised by	Name														Signature									

Note: The machine place in the Bgm machinery pool. * 07/11/2019 - Battery Weak. Recharge the Battery, Start and check the machine.
* 12/05/2020 - Battery dead. Need to be re-charge the battery * 15/05/2020 - Re charge the battery and Start the engine and checked the machine.
* 19/05/2020 - cleaned the machine and covered by Polythene.

Manual data entering – Running charts

1.5 **Project** Description

The main objective of this project is to develop MachniX, a web-based application that will improve the way the business will its machinery service. In addition to improving the company's capacity to carry out preventative maintenance on all its machinery inventory, this solution is intended to simplify processes and get away from inefficiencies. To provide a smooth and dependable repair procedure, the project tackles important operational difficulties by switching from a manual, hazardous system to an organized structured digital platform.

The application will automate the whole period of machinery maintenance. It will manage scheduling by creating maintenance schedules according to machine usage, service schedules, or specific operational requirements. The digitization of data gathering will enable real-time tracking of daily consumption information, including readings of meters. Additionally, inventory management will be automated, allowing for real-time tracking of the spare components and the creation of purchase plans to prevent delays or shortages of materials. In addition, the system will provide complete information on the condition of the equipment, its service history, and its impending maintenance requirements, allowing proactive management and well-informed decision-making.

MachniX's main functions include meter reading recording to measure performance in real-time, service alerts to inform technicians and management of upcoming maintenance services, and daily machine registration to keep accurate records of equipment usage and condition. Additionally, the system will monitor material inventory to ensure the availability of necessary components, plan preventative maintenance to reduce delays, and maintain a central repository of service history for easy use and reviews.

By reducing maintenance and enhancing equipment duration, this all-encompassing strategy guarantees that the business's gear stays in operation. Additionally, automation will reduce human mistakes by ensuring consistent record-keeping and precise data entry. MachniX enhances resource use by simplifying inventory management and planning, which enables more effective personnel and material allocation. By ensuring that no maintenance activity is missed, alerts and notifications keep the company from costly replacements or equipment failures.

MachniX is a full-featured equipment repair solution, not simply a piece of equipment. It combines innovative features to simplify and improve maintenance management while maintaining accuracy, success, and dependability. With this approach, the company will be able maintain up with maintenance requirements, maintain the condition of its equipment, and perform effectively over a long period of time.

1.6 Objectives:

- Creating a complete maintenance management system:
  every element of machinery maintenance, including scheduling, data gathering, inventory management, and reporting, must be automated and integrated through the design and implementation of an intuitive online application.

- Scheduling of Preventive Maintenance Centralized:
  Reduce depends on manually entered information and reduce missing information or mistakes that are by centralized and automated the preventive maintenance process. As a result, the maintenance tasks will get more organized, with proper records and frequent alerts.

- Completed Reports and Maintenance History:
  Identify maintenance requirements and improve machine accuracy by providing an understandable overview of maintenance history and generating reports that help with preventative planning and analysis.

- Effective Allocation of Resources:
  Enhance employment and supply scheduling using real-time data, enabling management to efficiently allocate resources and schedule servicing tasks with appropriate employees and required materials available.

- Material and Inventory Management:
  Monitoring material use while developing a strategy for purchases based on future maintenance dates. For both the maintenance and store teams, this application will facilitate an improved process and help prevent late shortages.

- A preventive system that provides notifications and alerts:

Ensure the maintenance workforce is always informed about machine status and planned services by automating alerts for upcoming maintenance activities and material requirements.

1.7 Features

- **Registering a machine and creating the database:**
  Database creation and machine registration are made possible by this feature, which will store the required information in a single database and allows each machine to be registered by brand, model, and unique ID. Each machine's meter readings, repair type, and service history may be tracked by mechanical supervisors/engineers; the information will be saved and accessed for use in future maintenance scheduling.

- **Checking meters and recording working hours:**
  The mechanical supervisor will record the amount of hours each unit runs and submit daily meter readings. The system will be automatically updated with this data, enabling the supervisor to monitor machine utilization in real time and ensure appropriate preventative maintenance.

- **Notifications of Services and Scheduling:**
  The app will use established schedules or meter readings to automatically alert supervisors of impending servicing dates. This feature reduces the possibility of services being missed or delayed by ensuring that the maintenance service is informed of each machine's repair requirements.

- **Allocating Manpower and Monitoring Tasks:**
  Supervisors may assign specific tasks to current technicians, allowing for effective resource allocation. The app's ability to quickly inform selected users facilitates easy communication and real-time task tracking.

- **Plans for Purchasing and Material Management:**
  Based on service schedules, the program will enable purchase planning and track the materials—such as oil, filters, and other parts—used for each service. Employees at the stores will be notified when supplies need to be ordered ahead of time, preventing delays brought on by shortages.

- **Recording service and updates:**
  Supervisors and engineers can document service information, including components changed, repairs created, and additional tasks performed, following each maintenance task. A thorough service history will be created from this document, which will help with future maintenance scheduling and provide an accurate evaluation of each machine's state.

- **Creating reports and analyzing historical data:**
  The app will provide historical reports that provide an overview of the maintenance tasks completed on every unit. Supervisors will be able to analyze machine health trends, manage

maintenance plans, and make well-informed decisions for the future with the use of this based on data knowledge.

2. Business Case

2.1 Business Needs

The machinery maintenance system currently handled by a manual system in the company I pick, which is nearly capable of mistakes and delays. The company's ability to maintain operational efficiency and cost management is limited by several problems caused by its dependence on outdated systems. In addition to being helpful, addressing these problems with a digital solution is crucial for the company's ongoing expansion and ability to compete in the industrial sector.

Challenges with Manual Maintenance Processes for Machinery:

- **Human Mistakes:**

  Human mistakes are typical in manual data entry and tracking. Inaccurate records resulting from mistakes in meter readings, maintenance plans, or inventory levels may enable maintenance cycles to be delayed and result in missed service or incorrect equipment purchases. In time, these mistakes compound and affect the overall efficiency of maintenance procedures.

- **Delays in Repairs and Maintenance:**

  In manual systems, identifying and fixing maintenance problems frequently takes more than needed. Defining objectives and assigning resources are challenging when there is no centralized tracking system in place. Equipment breakdowns, longer delays, and production schedule delays can all be caused by maintenance delays.

- **Finding Technicians Is Difficult:**

Another major problem is organizing technicians for repairs. Finding and allocating available staff at the appropriate moment may result in delays and inefficiencies in the absence of a well-organized system, which makes operational difficulties much worse.

- **Lack of materials and delayed purchasing:**

Proper purchasing of spare parts or materials is essential for efficient machinery maintenance. Real-time inventory tracking is frequently missing from manual operations, which makes it challenging to project shortages or effectively manage purchases. Delays, higher expenses, and possible delays are the consequences of that.

- **High Cost of Paper-Based Processes:**

Paper, printing, and storage costs are only a few of the significant expenses related to maintaining a dependence on physical records. In addition to being costly, paper-based methods take a lot of time and are not safe for the environment.

- **Challenge Collecting Historical Maintenance Information:**

Planning, checks, and decision-making all depend on the timely collection of historical maintenance information, which is difficult with manual systems. The organization's capacity to apply preventative maintenance techniques or take experiences from previous problems has been limited by a lack of readily available historical data.

Uniqueness of Maintenance Solutions for Machinery
For vehicle maintenance, there are many online and mobile applications accessible, but there aren't many comparable options for machinery maintenance. This market sector gives a chance to create a solution specifically for the company that takes advantage of its specific requirements and challenges.

The suggested maintenance of machinery web application provides a thorough, digital answer to these problems. By automating important maintenance tasks, the application will give the company real-time data, improved resource management, and faster processes.

2.2 Business Objectives

The web-based application for machinery maintenance aims to accomplish the following specific, measurable objectives:

- **Reduce on Human Mistakes:**

  To increase data accuracy and dependability, move from manual entry of data to an electronic system.

- **Enhance the Efficacy of Maintenance:**

  Simplify the process of scheduling maintenance to ensure quick servicing and avoid delays.

- **Material and Inventory Management:**

  Monitoring material use while developing a strategy for purchases based on future maintenance dates. For both the maintenance and store teams, this application will facilitate an improved process and help prevent late shortages.

- **Reduction of Paper-Based Works:**

  To save money on printing and storage, switch to a digital system from paper records.

- **Facilitate Historical Data Access:**

Develop a single database to store and retrieve maintenance records from previous decades.

- **Improve the Reliability of the Equipment:**

  Use analysis of data and alerts to support proactive maintenance techniques.

- **Increase the Overall Effectiveness of Processes:**

  To increase efficiency and cooperation, combine all maintenance tasks into a single platform.

- **Support the Sustainability of the Environment:**

  Reduce the amount of paper used in maintenance procedures to promote sustainability.

2.3 Reliability with Business Strategy

The company's overall productivity, efficiency at work, and sustainability will all be significantly improved if the stated goals are achieved. The company could reduce its environmental effect by changing from manual operations to a completely digital machinery maintenance system, which would remove paper-based records and improve the utilization of resources. Reducing breakdowns and preventing expensive repairs through automated scheduling, real-time data availability, and proactive maintenance planning would immediately minimize operating costs and increase machinery dependability. These improvements not only ensure more efficient daily operations but also prolong the life of machinery, which improves returns on investment and delays investment costs for new machinery.

The development indicates a change in strategy for the company in addition to the immediate operational improvements. The company is better prepared to handle upcoming difficulties, expand operations, and keep a competitive advantage in the market by adopting a merged data-driven platform. In addition to addressing present inefficiencies, this project provides a solid basis for future expansion, operational stability, and financial sustainability.

3. Objectives

- **Analyse Suspension of PM:**

Critically assess the potential advantages of automating centralized preventive maintenance procedures over targeting the reduction of manually keyed data and those errors that occur. Schedule and structure planned maintenance activities ensure that there are adequate paper trails, and that maintenance is performed at suggested intervals.

- **Interpret Maintenance Reports:**

The assessment of maintenance activities should be broad, extensive and more thorough. It should determine what has been done in the past and what has to be done in order to ensure optimum machine performance and predictive preventive maintenance strategies. Reports should be prepared in a manner suitable for making informed business decisions that are backed up by data.

- **Optimize Allocation of Resources:**

Determine and control the distribution of resources in employing real time and adjusted data to deploy staff and materials needed to complete the servicing tasks. Scheduling should also be optimized to allow for the availability of resources when required.

- **Monitor & Plan Material Management and Inventory Management:**

Assess the consumption of materials to develop a forecast for anticipated use and then come up with a strategic buying scheme. There should be better interactions between the maintenance and the store team to avoid the undesirable scenario of material sparseness slowing down operations.

- **Design an Alerting System:**

Design a system that automatically informs the machine maintenance squad about the status of the machine so that they do not forget to service it enabling smooth operations in service departments.

4. Literature Review

4.1 What is Machinery Maintenance?

Maintaining machinery includes the following measures to maintain it working at maximum capacity, extend its service life and reduce delays. Both proactive (preventive and predictive maintenance) and reaction (repairing after failure) maintenance are included. (Pooja et al., 2018). analyzed the challenges that companies face while using manual tracking methods, including lack of communication and waste of resources. These issues have a direct effect on overall efficiency and machine reliability.

(ZHANG et al., 2023) pointed out similar problems in the agricultural industry, where a lack of appropriate maintenance schedules lead to frequent delays and failures. Since physical records frequently fall below modern industrial settings' needs, centralized solutions are essential for managing equipment data.

4.2 Industrial Machinery Maintenance

The objective of preventive maintenance is to avoid unexpected breakdowns in machinery by taking preventative measures. Methods include planned maintenance, regular checks, and machine history recording. (Repin Sergey, Evtiulov Sergey and Rajczyk Jaroslav, 2016) noted the fact that manual techniques frequently lead to ignoring servicing requirements and recommended organized schedules to ensure timely service.

(Walia, Huria and Cordero, 2010) emphasized how important it is to maintain track of previous information to spot trends and identify future maintenance requirements. However, reliable data analysis is difficult to offer via manual systems, which results in inefficient planning. A digital solution can provide proactive updates and real-time monitoring.

4.3 Techniques, Possibilities, and Methods for Machinery Preventive Maintenance

For basic cleaning and oil to more involved procedures like mechanical modifications and part replacements, preventive maintenance can take various forms. Simple inspections of the installation of advanced sensor-based systems that provide predictive analytics are just a few examples of the techniques used

(Repin Sergey, Evtiulov Sergey and Rajczyk Jaroslav, 2016).

Because missed or delayed maintenance can result in expensive failures and shorter equipment life, scheduling and job classification are crucial to the efficiency of preventative maintenance (Guzman, 2023).

The application of preventive maintenance systems, which use sensor data and advanced analysis to determine when a failure might occur and enable intervention before failures occur, is a developing trend in this field (Walia, Huria and Cordero, 2010). However, a lot of systems continue to use outdated preventive maintenance plans without making use of recently developed technologies that facilitate data-driven decision-making.

4.4 Existing Systems

Large-scale operations are the focus of current equipment maintenance systems, which frequently include modern technologies like IoT and predictive analytics. (Guzman, 2023) comprehensive enterprise-level technologies intended to automate maintenance scheduling and track the condition of machines. However, smaller firms are unable to afford these solutions due to their high cost and technical competence requirements.

(Lopes et al., 2017) discussed how current systems for small and medium-sized businesses (SMEs) lack scalability and customization. Furthermore, a lot of systems fall short in meeting the fundamental requirements of sectors moving from manual to digital processes, such work delegation and record-keeping.

4.5 My Opinion

Significant gaps exist in give machinery maintenance procedures, especially in businesses that rely on manual techniques like physical sheets, according to the studied literature. Significant findings include:

1. Challenges with Manual Systems: Ineffective tracking of inventory, missing maintenance plans, and keeping records mistakes are frequent problems.

2. The requirement for cost methods: small and medium-sized enterprises (SMEs) cannot use the current systems because they are either too costly or too complicated.

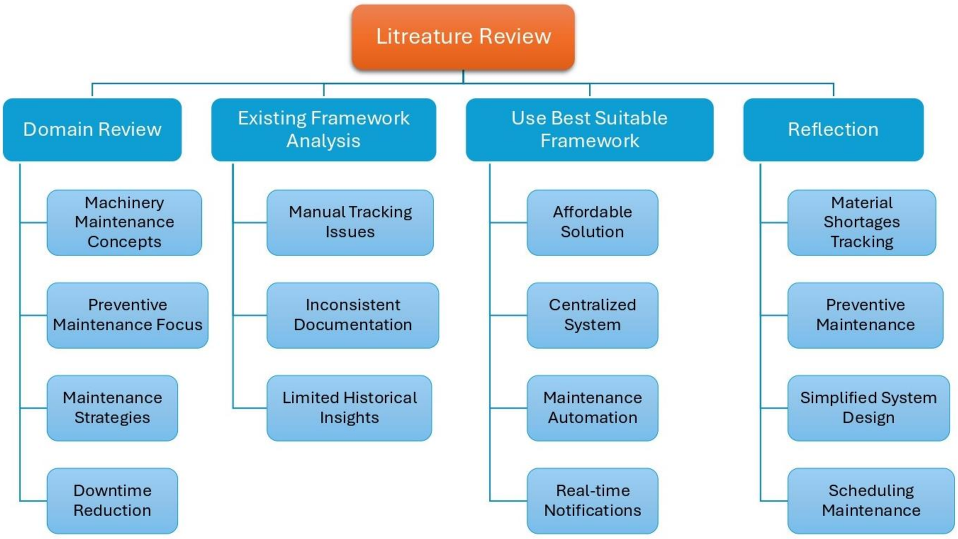
3. The Benefits of Preventive Maintenance: Operations inefficiencies have been caused by the absence of organized and easily accessible tools for monitoring preventive maintenance.

By creating a web-based platform to take the role of manual procedures, this project aims to address these gaps. The suggested system would prioritize accessibility, affordability, and simplicity in contrast to current business systems, which makes it perfect for sectors moving away from physical records. Technology will reduce mistakes made by humans and increase operational efficiency by centralizing data management, automating work allocations, and sending out timely reminders. This strategy helps companies optimize their operations by ensuring that maintenance schedules are fulfilled, inventory shortages are prevented, and machinery dependability is increased.

This project aims at filling the gaps in research and creating foundations for the scalable growth of machinery maintenance management. Start with a system that automates manual procedures, the solution may develop over time to include more sophisticated capabilities like analytics for resource optimization, real-time inventory updates through supplier network connection, and intuitive dashboards for insights that can be use. Ease of adoption is ensured by the emphasis on clarity, specifically for businesses where employees may lack technical competence.

Additionally, by centralizing all maintenance records, the platform will improve transparency and accountability across teams, reducing the possibility of jobs being ignored because of oversight or misunderstanding. Because maintenance schedules and history are readily accessible and transparent, this method also makes it easier to comply with legal requirements. By facilitating improved decision-making and eliminating unexpected delays brought on by postponed maintenance or material shortages, the initiative has the potential to drastically save long-term costs in addition to increasing operational efficiency.

In final analysis, this solution not only covers the gap between manual methods and complex business tools, but it also creates a fresh standard for how heavy machinery-dependent companies may upgrade and plan. The project meets the urgent demands of SMEs by emphasizing scalability, cost-effectiveness, and real-world usage while providing a roadmap for incremental technical improvement.



Conceptual Diagram

5. Method of Approach

5.1 Agile Methodology for Machinery Maintenance System

The Agile methodology aims to break down my web application system for maintenance purposes since it offers a flexible, iterative approach that keeps up with the project's complexity and changing requirements. The application may be enhanced over sprints and has several interdependent functions, including inventory management, maintenance scheduling, machine registration, and reporting. Continuous input from stakeholders is made possible by Agile, ensure that the system satisfies real-world demands and may be modified according to new or changing requirements as they develop. Furthermore, Agile focuses on frequent testing and early delivery reduces risk and ensures quality at every step.

- **Phase 1: Plan and Gather Requirements**

  Analyze the requirements of the business fully and collect specifications for features like reporting, inventory management, and machine monitoring.

  Complete the tech stack and make a thorough project plan.

- **Phase 2: Design**

  Design user interface models and diagrams.

  Design data models.

- **Phase 3: Development**

  Sprint 1: Develop user interface using React.js.

  Sprint 2: Integrate role-based dashboards and user authentication into place.

  Sprint 3: Develop machine registration, Invoice and cost submission and maintenance schedule features.

  Sprint 4: Implement inventory management, including material requests and updates.

  Sprint 5: Set up notification systems (email and in-app) using Nodemailer and cron jobs.

  Sprint 6: Develop reporting features and ensure monthly report generation.

  Sprint 7: Conduct extensive testing and debugging.

- **Phase 4: Testing and Quality Assurance:**

  Perform end-to-end testing, integration testing, and unit testing.

  Use tools such as Postman for API testing and Jest for React.

- **Phase 5: Implementation**

  With the correct load balancing and auto-scaling settings, deploy the application to AWS EC2.

  To improve security, set up AWS Firewall or Cloudflare.

- **Phase 6: Maintenance and Repeating**

  For ongoing enhancements, track application performance and collect user input.

  Add new functionality to the system on a regular basis in response to user requests.

  Use GitHub for version controlling continues integration and continues deployment.

5.2 Tools and Frameworks

- **Frontend (UI/UX Layer):**

  Frameworks: that create responsive and interactive user interfaces include React.js and Next.js.

  Tools: Tailwind CSS or Material-UI for producing modern, approachable designs.

  Dashboards: To ensure user-centric functioning, employ role-specific dashboards (Admin, Supervisor, Operator).

- **Backend (Business Logic Layer and API):**

  Frameworks for server-side rendering and API routes include Next.js and Node.js.

For safe user authentication, utilize Clerk or NextAuth.

Security: Cloudflare/AWS Firewall for defense against malicious traffic and bcryptjs for password hashing.

Task Scheduling: Node-cron is used to automate operations such as creating reports and sending notifications.

- **Database:**

Database Layer:

MongoDB is a versatile document-based database for storing data.

ORM: Prisma for organized and effective database communication.

Users, machines, maintenance logs, inventory, and notifications are important collections.

- **Infrastructure Layer:**

Hosting: The application will be hosted on a VPS using AWS EC2.

Backup: AWS Backup for disaster recovery of databases and applications.

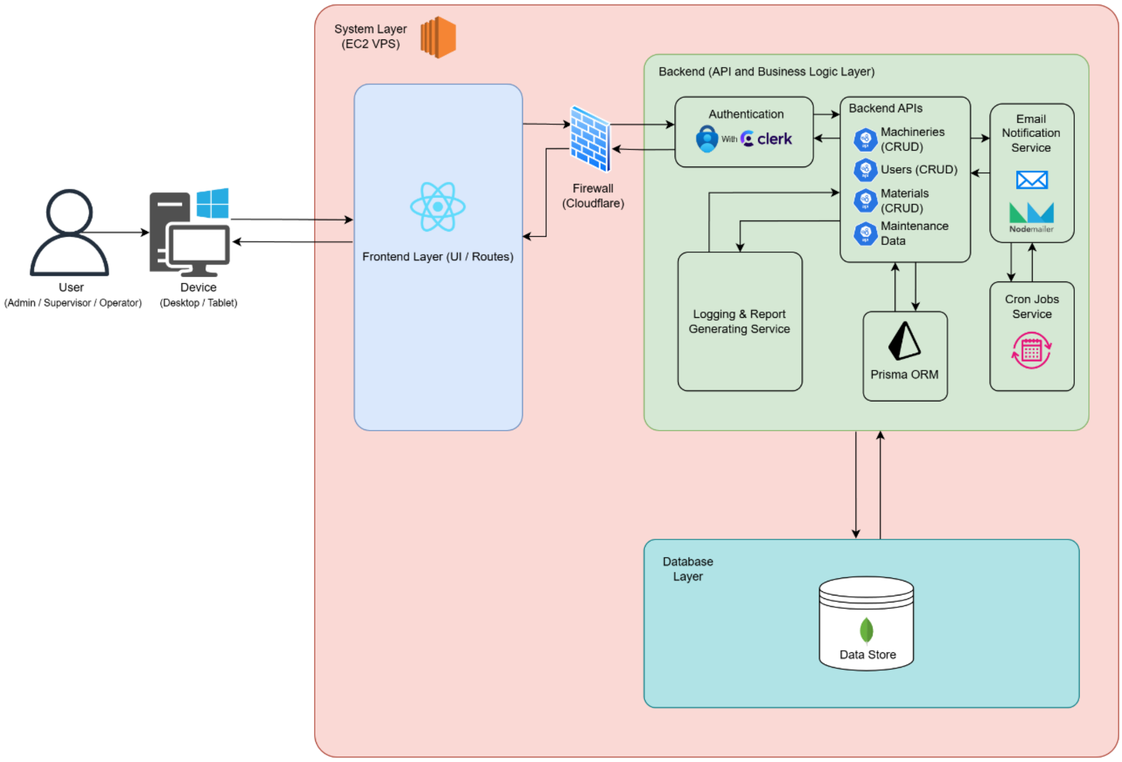
- **Notification System:**

Email Alerts: Use Nodemailer to send emails on inventory levels, late tasks, and maintenance schedules.

In-app Notifications: Real-time update alerts provided within the app.

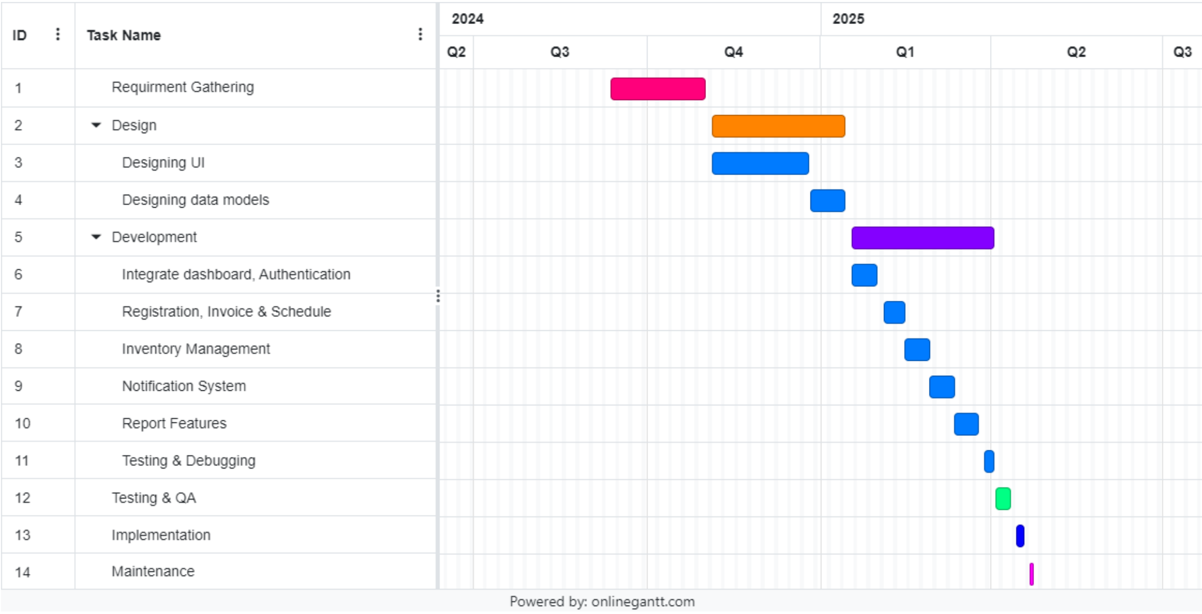
5.3 Benefits of the Approach

- Agile Adaptability: Provides small modifications and continuous input.
- Robust Infrastructure: Reliability is ensured via AWS-based deployment with backup and scalability.
- User-Centric Design: Usability is improved by role-specific dashboards and transparent procedures.
- Data-Driven Decisions: Analytics and reporting facilitate well-informed choices.



High – Level Architecture Diagram

6. Initial Project Plan



Gantt Chart

7. Risk Analysis

- **Financial Restraints:**

Risk: Not having sufficient funds for costs for development, hosting, or maintenance.

Possibility: Medium

Impact: Maximum

Reduce Methods:

When developing anything for the first time, choose free or inexpensive alternatives.

Track AWS or hosting costs by putting cost monitoring tools into action.

- **Technical Problems:**

Risk: Unexpected technological difficulties that arise during development

Possibility: Medium
Impact: Maximum

Reduce Methods:
When developing, carry out complete testing.
Keep thorough records to aid in troubleshooting and problem solving.

- **Cron Job Failures:**

Risk: Server problems or incorrect setups might cause scheduled tasks to fail.

Possibility: Medium

Effect: Medium

Reduce Methods:
Use alerting and logging systems to keep monitors on cron jobs.
Put in place fallbacks and retries for unsuccessful jobs.

- **Adoption and Usability by End Users:**

Risk: Users could find the system complicated or may be difficult to move from the manual to the digital approach.

Possibility: Medium

Impact: Minimum

Reduce Methods:

To make sure the system is easy to use, test it with users as it is being developed. Provide supervisors and operators with documentation and training sessions.

- **Recovery from Disasters and Backup:**

Risk: Data loss because of database corruption or server outages.

Possibility: Minimum
Effect: Maximum

Reduce Methods: Use AWS Backup or comparable products to set up routine automatic backups.

To make sure data recovery is ready, test backup restoration processes frequently.

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PUSL3190 Computing Individual Project

Project Interim Report

Machinery Maintenance Web Application

Supervisor: Ms. Dulanjali Wijesekara

Name: Panadura A Premathilaka
Plymouth Index Number: 10899668
Degree Program: BSc (Hons) Software Engineering

Chapter 01 - Introduction

1.1 Introduction

Industrial machinery

Industrial machinery is a wide range of equipment and mechanical systems used to enhance accuracy, efficiency, and production in a range of sectors, including mining, manufacturing, construction, and agriculture. Automating processes, reducing labor costs, and improving quality of production are all made possible by these devices. Heavy-duty construction equipment like excavators and cranes, as well as precision-driven CNC machines in manufacturing, are examples of industrial machinery that is designed to perform complicated tasks with minimal human intervention.

Industrial development and growth in economy was significantly helped by the development of industrial machinery. Automation, web/mobile applications, robotics, and IOT integration are some of the technologies that have made modern machinery more secure, more efficient, and capable of predictive maintenance. To avoid unexpected breaks down, minimize delays, and improve the machinery's existence, proper maintenance is required.

Industrial machinery may be divided into categories according to its application, industry, and function.

- **Construction Machinery:**

Used in the construction of roads, buildings, and infrastructure.
Excavators, Bulldozers, Loaders, Cranes, Road Rollers, Concrete Mixers, Trenchers.

- **Manufacturing Machinery**

Used in factories for production and processing of materials.
CNC Machines (Computer Numerical Control), Lathes, Milling Machines, Drilling Machines, Press Machines (Hydraulic, Mechanical), Injection Molding Machines, Welding Machines.

Agricultural Machinery

Used in farming and food production.
Tractors, Combine Harvesters, Plows, Seed Drills, Irrigation, Systems, Ballers **Mining Machinery**

Used for extraction of minerals and natural resources.
Drilling Rigs, Conveyors, Loaders and Haulers, Crushers, Continuous Miners, Draglines.

Power Generation & Energy Machinery

Used in electricity generation and power distribution.
Generators, Turbines, Boilers, Transformers

Material Handling Equipment

Used for transporting and handling goods.
Forklifts, Conveyor Belts, Hoists and Winches, Automated Guided Vehicles

Food Processing Machinery

Used in food production, packaging, and processing.
Mixers and Blenders, Food Extruders, Pasteurizers, Packaging Machines

Textile Machinery

Used in the textile and garment industry.
Spinning Machines, Weaving Machines, Dyeing Machines

Printing & Packaging Machinery

Used in mass printing and product packaging.
Offset Printing Machines, Flexographic Printers, 3D Printers, Labeling and Wrapping Machines.

5

Machinery Maintenance

Machinery maintenance is the process of inspecting, fixing, maintaining, and controlling industrial machinery to improve performance, reduce delays, and improve a long lifespan. Maintaining machinery to proper operating order and preventing unplanned breakdowns requires regular checks, preventative maintenance, and repairs.

Heavy machinery-dependent businesses including manufacturing, construction, agriculture, mining, and transportation depend on efficient maintenance. Good maintenance plans save operating costs, improve security, improve productivity, and avoid breakdowns that may delay production

Types of Machinery Maintenance

- **Preventive maintenance (PM)** Maintenance to avoid failures.

Includes system checks, lubrication, and part replacements.

- **Predictive Maintenance (PdM)**

Use data analytics and sensors to anticipate errors before they develop. Uses AI, machine learning, and IoT to provide real-time monitoring.

- **Corrective Maintenance (CM)**

Repairing machinery once it breaks down.
Used when preventative maintenance is insufficient or not done at all.

- **Condition-Based Maintenance (CBM)**

Real-time equipment condition monitoring helps identify when maintenance is required.
include oil analysis, vibration analysis, and thermal analysis.

- **Reactive Maintenance (Breakdown Maintenance)**

Repairing equipment only after it breaks down.
Frequently results in expensive repairs and unplanned downtime.

Importance of machinery maintenance

Increases Equipment Lifespan: Machines that require regular service will have a longer lifespan.

Reduces Downtime: Avoids unexpected failures preventing output.

Reduce Costs: Preventive maintenance reduces the requirement for costly emergencies.

Provides Safety: Properly maintained equipment reduces incidents and hazards.

Increases Productivity: Provides that machines perform as efficiently as possible.

Preventive Maintenance (PM)

Preventive maintenance (PM) is a systematic approach to repairing machinery and equipment to optimize performance, reduce downtime, and increase operational lifetime. It involves regular inspections, part replacements, and regular maintenance, aiming to detect and resolve potential issues before they become failures. This approach helps organizations reduce unplanned disruptions and ensures ongoing production, especially in workplaces where unexpected failures can lead to significant damage. (Chan, 2023).

Preventative maintenance aims to optimize equipment accuracy by reducing wear and tears, ensuring optimal machinery performance, and preventing irreversible damage. It includes cleaning, lubricating, and fastening parts. Early interventions, like cleaning air filters or replacing worn belts, can save costs and improve efficiency. (MicroMain, 2022).

Preventative maintenance (PM) offers cost reduction by reducing emergency repairs, which are often more costly due to manpower, unplanned downtime, and quicker part replacements. PM also enhances workplace safety by reducing equipment failure risks. (ServiceChannel, 2023).
Preventive maintenance is crucial in various industries, ensuring efficient production lines, reducing delays, and increasing productivity. It directly impacts patient care, transportation, and construction, ensuring safety, asset performance, and cost savings through well-structured plans. (developer, 2024).

1.2 Problem Definition

Heavy machinery and equipment maintenance is a key component of any company's operations, specifically for companies that depend on the constant functioning of significant machines like Generators, HDD (Horizontal
Directional Drilling) machines, and other industrial equipment. The efficiency of operations depends on ensuring that all the machines are working properly, getting timely preventative maintenance and preventing failures.

However, the maintenance procedure is still carried out manually at my specified company using a running sheet, which is a record used for maintaining records of upgrades and preventative maintenance programs for each component of equipment. A mechanical supervisor or engineer maintains the records, working with warehouse employees, machine operators, and other employees to schedule required services, record working hours, and gather meter readings. While there are plenty of applications available for monitoring the maintenance of vehicles, applications designed especially for the maintenance of industrial machines are significantly underutilized. Applications for vehicle maintenance are frequently utilized in industries like vehicle management, where digital solutions facilitate the tracking of service history, mileage, maintenance plans, and part replacements. However, there aren't many specialist applications developed for maintaining heavy machinery, specifically for companies which run multiple types of equipment with various maintenance requirements. Because of this, many companies that depend on machinery continue to schedule and perform maintenance using manual techniques.

The company's present manual procedure is ineffective, hence requires a machinery maintenance system. Equipment failures and expensive repairs are more likely when running sheets are used for maintenance tracking because they are prone to human error, insufficient data, and missed maintenance schedules. Without a well-organized system, the business finds it difficult to track equipment utilization, manage preventive machinery maintenance, and have a sufficient stock of materials and spare parts. To ensure that the company's machinery runs effectively and reliably to fulfill its operational requirements, a digital maintenance system would optimize operations, decrease delay, and enhance resource allocation.

Project description

The main objective of this project is to develop MachniX, a web application that will improve the company's approach to maintaining its machinery. In addition to enhancing the company's ability to perform preventative maintenance on each of its inventory machines, this approach is designed to simplify systems and avoid inefficiency. In moving from a manual, risk approach to an ordered, structured digital platform, the project addresses significant operational challenges and offers a reliable and fast repair process.

The whole process of maintaining machines will be automated by the application. By providing maintenance schedules based on machine usage, service schedules, or specific requirements for operation, it will handle scheduling. The digitalization of data collection will make it possible to follow daily usage data, including meter readings, in real time. To avoid delays or material shortages, inventory management will also be digitized, providing real-time tracking of spare parts and the development of purchase plans. To facilitate proactive management and informed decision-making, the system will also offer comprehensive information on the equipment's state, service history, and upcoming repairs.
The main features of MachniX include daily machine registration to maintain precise records of equipment usage and condition, service alerts to notify technicians and management of impending maintenance services, and meter reading recording to monitor performance in real-time. The system will also schedule preventative maintenance to reduce delays, maintain a centralized record

of service history for ease of access and reviews, and monitor material inventories to ensure the availability of required materials.

This complete strategy ensures that the company's equipment is functional by reducing maintenance and increasing equipment lifespan. Additionally, by ensuring reliable information entry and regular record-keeping, automation will decrease human error. By making inventory management and planning easier, MachniX improves the use of resources by allowing more efficient staff and material allocation. Alerts and notifications protect the company from cost replacements or breakdowns in machinery by making sure that no maintenance tasks are missed.

MachniX is not just a piece of equipment; it is a comprehensive equipment maintenance solution. It includes innovative functions that maintain accuracy, success, and reliability while simplifying and improving maintenance administration. By using this strategy, the company will be able maintain pace with repairs, maintain the equipment's condition, and operate efficiently for an extended period.

1.3 Objectives

- **Analyze the Suspension of PM (Preventive Maintenance).**

Assess the advantages of automated preventative maintenance to reduce error in human data entry. Ensure that maintenance plans are properly recorded and organized.

- **Analyze and interpret maintenance reports.**

To enhance preventative maintenance, analyze previous maintenance operations. Generate thorough reports that support well-informed company decisions.

- **Optimize Resource Allocation.**

Use real-time data to distribute resources and personnel efficiently. Avoid scheduling issues and ensure that resources are available for maintenance work.

- **Monitoring and Plan the Management of Materials and Inventory**

Monitor material usage and plan future requirements. To avoid shortages, increase contact between the inventory and maintenance staff.

- **Design an Alert System.**

To inform employees working on maintenance of upcoming tasks, put in place a notification system. Ensure regular service to reduce the chance of equipment breakdowns.

Chapter 02 – System analysis

2.1 Facts Gathering Techniques

Getting meetings with the Stakeholders.

I arranged and carried out individual discussions with each group at their place of work to analyze how they work and get firsthand information. I noticed the manual handling of maintenance scheduling, tracking, and material management during these sessions, which takes place in the company's workshop, maintenance area, and inventory storage.

Supervisors (Tasks: Scheduling and Maintenance Management)

I had meetings with mechanical supervisors, who oversee managing repair projects while maintaining updated on maintenance plans.

Challenges discussed –

Manually updating running sheets and other traditional maintenance tracking techniques frequently result in delays and inefficiencies. Unexpected breakdowns are greater when machine usage records are missing or out of date since it is harder to tell when maintenance is necessary.

Furthermore, delays in repairs might result from an inadequate system for tracking the availability of spare parts, which further reduces operating efficiency. These difficulties show how maintenance management must be done in a more efficient and dependable way.

Expectations –

A digital system that tracks all maintenance actions in one place. automated reminders and alerts for impending maintenance. A history of machine services to help in decision-making.

Technicians (Tasks: Reporting problems and doing maintenance)

I had a meeting with the maintenance technicians who work on fixing and maintaining equipment.

Challenges –

With limited access to historical maintenance information, fixing can be challenging since technicians may not have the history they need to identify problems quickly. Frequent issues and repair delays are frequently the result of this. Furthermore, mistakes in teams may cause crucial maintenance tasks to be missed, which might lead to unexpected equipment breakdowns. The inefficiency of manually recording repair information has increased, taking up the time that could be used for actual maintenance. Efficient fixing problems, clear communication, and precise record-keeping require a more simplified, digital approach.

Expectation -

A simple way for digitally recording completed maintenance.
Notifications of planned maintenance.
Service history is easily accessible for improved diagnoses.

Inventory Employees (Tasks: Handling Material Requests & Spare Parts)

I discussed with staff members who deal with requests for materials and replacement parts about the difficulties in inventory management.

Challenges - Manually maintaining track of inventory enhances the possibility of shortages, which might cause delays in maintenance. The availability of essential resources may be compromised in the absence of precise inventory data.
As waiting for spare parts delays equipment delays, slow request and approval procedures further extend maintenance. Productivity and general efficiency are impacted.

Timely replenishment is ensured via a real-time monitoring system that tracks material availability. Operations continue to function smoothly, delays are decreased, and maintenance efficiency is increased.

Expectation -

A real-time inventory updates digital inventory system.
Automated notifications when inventory levels are low to avoid shortages. Faster material request and approval procedure.

Observation: Getting Knowledge about the Current Maintenance Procedure
I studied maintenance staff on-site in their real-world workplace to obtain firsthand knowledge of how maintenance is manually monitored. This made it possible for me to examine their daily operations, spot inefficiencies, and comprehend their problems without having to depend only on surveys or interviews.

2.2 Literature review

Machinery maintenance

In a company, preventive maintenance refers to regularity, planned checks and service on equipment to avoid unexpected breakdowns and expensive repairs. This proactive approach reduces delays, ensures safety, and delays the service life of the machinery. Preventive maintenance services usually include the following for the equipment you mentioned:
HDD Vermeer (, Compressors, Micro Trenching Machines (MTM), and Generators.

Horizontal Directional Drilling Machines (HDD Vermeer)

These machines inspect hydraulic systems to prevent leaks and ensure optimal efficiency.
Air and oil filters should be cleaned and changed for efficient drilling operations.

Oiling moving components reduces apply, such as the drill head and rods. Maintaining the cooling system and checking the batteries will help avoid overheating.

Compressors

To maintain the airflow clean and protect the motor, change the air filter. Compressor oil should be flushed and changed often to prevent damage and improve performance. Belts and hoses are checked for damage and use.
Checking of valves to ensure proper pressure levels.

Micro Trenching Machines

Inspections of the trenching tool or blade to avoid wear and provide clean trench cuttings. Monitoring hoses and hydraulic fluids for leaks or problems with pressure. Inspections of electrical systems are required to ensure their safe and dependable functioning.
Wheels and track checks ensure stability and correct alignment.

** Generators**

Verify start power by inspecting the batteries and charger. To ensure reliability, check and refill the cooling system and oil levels. Monitoring of the fuel system to prevent pollution or blocking. Control panel testing to ensure proper operation of monitoring systems.

Presently, the selected company will manual machinery maintenance using a "running sheet," a document that records all preventative maintenance information. Following this technique, each machine's number, brand, model, location, operating hours, servicing type, and necessary supplies are manually recorded by the mechanical engineer or supervisor. In addition to confirming machine availability and coordinating machine technicians, they additionally require gathering daily meter readings and working hours from machine operators. When materials are required, the supervisor contacts the department in the store to request them. To remind operators when maintenance is necessary, service schedules depend significantly on the supervisor's attention in keeping track of dates and meter readings. However, there is a risk that services will be missing, meter readings will be delayed, and tracking equipment required for repair may be missed while using this manual method. By automating this procedure with a specialized application, the preventive maintenance process would be much more efficient and without any mistakes thanks to more organized tracking, timely reminders, and centralized data management.

Android-Based RCSM Application for Implementation of Preventive Maintenance on CNC Production Machine.

The Android-based "Reminder & Control System Management" (RCSM) software was created to solve scheduling problems and document mistakes in preventive maintenance (PM) procedures, especially in educational settings where PM is in line with the lecture schedule. To help maintenance workers stay on time, the system serves as a reminder, recorder, and controller. In addition to recording maintenance histories for future use, RCSM broadcasts notifications and permits validation and verification that activities are finished as scheduled. The major purpose of RCSM is to avoid human error-related problems in PM scheduling and reporting, such unrecorded maintenance or missing tasks, which may result in PM mismanagement in subsequent cycles. Additionally, it helps to reduce maintenance gaps owing to missing or insufficient documentation by coordinating PM with educational schedules to minimize disturbance and reinforce preventative actions through digital reminders and maintenance record preservation (Fauzi, Yuliadi Erdani and Achmad Sambas, 2023).

- **Pros**

The current "Reminder & Control System Management" (RCSM) program has the advantage of improved scheduling accuracy and maintenance documentation, which helps to avoid human mistakes such as unrecorded service activities or missing maintenance tasks. RCSM reduces the possibility of equipment being ignored by ensuring that PM tasks are finished on time by promptly reminding and notifying technicians. In addition, the app's historical tracking features allow the keeping of exact records of machinery history, enabling more efficient planning for upcoming maintenance requirements.

- **Cons**

However, RCSM's overall efficacy in complete maintenance management is limited by a few limitations. With no maintenance features that may actively detect any problems before they increase, it mainly serves as a notice and documentation tool. In addition, because the program depends on users following their schedules, it may still need human supervision to handle more intricate operations. Its scalability for cross-platform scenarios is further limited by its Android-only platform, which restricts accessibility for teams who depend on other operating systems. These drawbacks show that a more overall PM solution is required, one that goes beyond activity tracking and reminders.

Research Gap

The primary research gap identified in the current "Reminder & Control System Management" (RCSM) application is its focus on scheduling alerts and documentation without using advanced features for complete machinery maintenance management. RCSM effectively reduces beings' error in preventive maintenance (PM) through reminders and activity tracking but lacks functionalities for real-time data tracking, material purchasing planning, and workforce scheduling, which are essential for a reduced maintenance process. My proposed machinery maintenance app aims to address these gaps by integrating features such as material and resource management, predictive maintenance insights, and a cross-platform design for broad accessibility. These additions will provide a more complete PM solution, enhancing both efficiency and operational validity compared to existing solutions like RCSM.

An Android-based Vehicle Maintenance Application.

aims to improve security and efficiency in vehicle operation, the current Androidbased car maintenance application uses GPS tracking, connects users with local service facilities, and provides timely service alerts (Pooja et al., 2018). The system consists of:

Login and registration features for users and facilities.
GPS tracking in real time to find repair facilities and provide support during emergencies. notifications for future maintenance according to the mileage of the car.
Garage staff oversee billing, record-keeping, and service status updates. GPS data mining is used to identify service areas with high demand and enhance user suggestions.
By automating contact and location-based services with an Android application, this method focuses on convenience first and addresses both urgent and regular maintenance requirements (Pooja et al., 2018)

Pros

By automated maintenance notifications, the Android-based vehicle maintenance software simplifies user life and ensures cars in good repair. In the event of a car breakdown, GPS integration enables customers to quickly identify service locations in their area. By studying high-demand regions, methods such as data mining allow for improved service suggestions. This improves efficiency and customization for users and increases cost-effectiveness by promoting prompt maintenance and lowering the need for unplanned repairs.

Cons

The app's scope has been limited still, as it mostly serves to normal vehicle demands and lacks features specifically designed for maintaining industrial machines. Requirements for manual data entry, including mileage, increase the possibility of mistakes, and the system's dependence on GPS may make it less useful in distant locations. The reliability and particular maintenance requirements of various machinery types may also be impacted by its restricted approach to preventative maintenance, which might result in less effective service scheduling.

Research Gap

The limited functionality of the current vehicle maintenance application for industrial equipment, which requires specific maintenance characteristics, presents research requires. In contrast to regular vehicles, equipment such as generators and HDD machines need a thorough materials management system, organized preventative maintenance plans, and daily meter-based tracking. Furthermore, automated paperwork, methodical reminders, and efficient staff allocation for machinery maintenance are absent from the current approach. In order to guarantee total preventative care and lower the possibility of neglected maintenance, these gaps underscore the need for a more reliable application that is suitable to the intricate needs of equipment maintenance.

Application-based support for machine maintenance.

The research paper's current approach for enhancing a company's machinery maintenance procedures is around Total Productive Maintenance (TPM) and its component, Autonomous Maintenance (AM). TPM encourages departmental cooperation for efficient equipment maintenance while optimizing the lifespan and performance of manufacturing equipment. Autonomous maintenance (AM) entails giving machine operators basic maintenance tasks such as periodic checks, oiling, minor repairs, and anomaly detection. By actively including operators in the maintenance process, this strategy aims to reduce maintenance costs, increase productivity, and decrease breakdowns. The research also looks at how an application might help with these maintenance tasks by facilitating effective task management with the use of technological devices, interactive resources, educational films, and simple access to maintenance data.

Pros

Improved efficiency, increased equipment dependability, fewer machine breakdowns, and lower operating costs are just a few benefits of using TPM and AM techniques. By using technology, technicians may more effectively carry out and document maintenance tasks, which promote greater adherence to quality standards and maintenance schedules. This lowers the possibility of human mistake, improves operator skill development, and encourages more interaction with the equipment (Ayele et al., 2017; Kosicka et al., 2018).

Cons

Frequent personnel turnover and the requirement for methodical training present difficulties, but it might take some time for new operators to become acquainted with repairs. Also, even if operators do basic maintenance, major repairs can still call for highly qualified workers, which, if improperly handled, might cause workflow disruptions. If technical help is insufficient, a possible reliance on digital tools for maintenance tasks could result in problems, especially for distant or limited-resource settings (Holik, 2018; Patalas-Maliszewska et al., 2018).

Research Gap

There is limited research on how a custom mobile application may enhance realtime monitoring, automate notifications for impending maintenance tasks, and track past service history in a preventive maintenance system, even if the study article offers a solid basis in TPM and AM. By creating a smartphone application that converts the whole maintenance process from registering machinery information to sending automated notifications for servicing requirements, employment planning, material purchase, and reporting generation, the suggested project seeks to close this gap. In addition to providing organized maintenance for large machinery, this solution offers a methodical approach to operational requirements, monitoring and management, lowering risks and enhancing output in locations where manual procedures are still commonly utilized.

2.3 Existing Systems

IBM Maximo Manage

IBM Maximo Manage is an Enterprise Asset Management software solution developed by Project Software & Development Inc. in 1985. Acquired by IBM in 2006, it is an AI-powered system used across industries like manufacturing, energy, transportation, utilities, and healthcare. It helps organizations monitor, maintain, and optimize their physical assets, reducing operational costs and enhancing asset reliability.

The platform integrates real-time asset monitoring, IoT capabilities, AI-driven analytics, and automation to support predictive maintenance strategies, enabling organizations to transition from reactive to proactive maintenance, ensuring equipment longevity and efficiency. (Ibm.com, 2025)

Features:

The system optimizes asset management by tracking all assets, including machinery, equipment, and facilities, while storing lifecycle details for better oversight. It automates maintenance task creation, assignment, and tracking, enabling field technicians to manage tasks remotely based on urgency and asset condition. AI-powered predictive maintenance, integrated with IoT sensors, monitors asset performance and schedules inspections to extend asset life. Inventory and supply chain management track spare parts, automate reordering, and integrate with procurement systems to prevent shortages. IoT sensors collect real-time asset data, detect anomalies, and trigger maintenance alerts, while AI predicts failures for proactive management. The system provides detailed reports, real-time dashboards, and compliance tracking. Technicians can access asset details and schedules via mobile devices, while cloud-based deployment ensures remote management and scalability. Seamless integration with ERP systems like SAP and Oracle, financial tools, and API-based connectivity enhances interoperability and operational efficiency.

SAP Plant Maintenance (SAP PM)

The Enterprise Resource Planning (ERP) system from SAP has an advanced maintenance management module called SAP Plant Maintenance (SAP PM). It is especially made for companies that require work order administration, preventative maintenance, and thorough monitoring of assets to increase equipment reliability and productivity.

By monitoring equipment, reducing delays, and maximizing maintenance expenses, SAP PM is extensively utilized in the manufacturing, utilities, oil and gas, transportation, and energy sectors to ensure uninterrupted service. (Top, 2025)

Features:

The system streamlines asset management by tracking machinery, equipment, and facilities while storing lifecycle details for efficient oversight. It automates maintenance tasks, enabling field technicians to manage and prioritize them remotely. AI-driven predictive maintenance leverages historical data and IoT sensors to monitor asset performance, schedule inspections, and enhance longevity. Inventory and supply chain management ensure spare parts availability by automating reorders and integrating with procurement systems. IoT sensors collect real-time asset data, detecting anomalies and triggering maintenance alerts, while AI predicts failures for proactive management. The system provides detailed reports, real-time dashboards, and compliance tracking. Technicians access asset details via mobile devices, with cloud-based deployment enabling remote management and scalability. Seamless integration with ERP systems like SAP and Oracle, financial tools, and API-based connectivity enhances interoperability and operational efficiency. (Top, 2025)

Fiix by Rockwell Automation

Rockwell Automation created Fiix, a cloud-based Computerized Maintenance Management System (CMMS), to assist industrial companies with asset monitoring, work order tracking, predictive maintenance, and maintenance operations optimization.

Designed for industries including utilities, manufacturing, energy, transportation, and food and beverage, Fiix helps companies move from reactive to proactive maintenance, which lowers downtime, increases asset dependability, and reduces maintenance costs.

Fiix is a cloud-native solution that provides flexibility by enabling remote data access, mobile work order management, and integration with IoT and AI-driven analytics for maintenance teams. (Fiix, n.d.)

Features:

Fiix provides complete maintenance management by automating assigning tasks, enabling field workers to remotely manage work orders through mobile access, and providing real-time assets and tracking work order. By scheduling maintenance based on usage patterns and data from IoT sensors, its AI-powered predictive and preventive maintenance capabilities set off alarms to avert unplanned malfunctions. By automating reorders, maintaining updated stock levels, and connecting with procurement systems, the system ensures effective inventory and spare parts tracking. Without the need for on-premises installations, a mobile and cloud-based strategy allows for real-time notifications, offline data entry, and remote access.

With AI-driven dashboards for well-informed decision-making, advanced analytics and reporting provide real-time insights into equipment performance, maintenance history, and compliance. Fiix ensures seamless process automation, cost tracking, and improved operational efficiency by integrating with ERP, IoT, and automation systems like SAP and Oracle. (Fiix, n.d.)

eMaint CMMS (by Fluke)

A cloud-based computerized maintenance management system (CMMS) with extensive customization capabilities, eMaint CMMS was created by Fluke Corporation. To decrease downtime, increase asset dependability, and streamline maintenance procedures, it is intended to assist companies in a variety of sectors, including manufacturing, oil and gas, energy, utilities, and facilities management. eMaint provides immediate data into asset health as part of Fluke Reliability by integrating with enterprise asset management (EAM) systems, condition monitoring sensors, and predictive maintenance solutions.

With its IoT-based predictive maintenance, automation features, and mobile accessibility, eMaint is a scalable solution that can be used by both small and big companies.

Features:

Preventive maintenance may be scheduled according to time, usage, or conditionbased triggers with eMaint CMMS, which also automates work order development, assignment, and tracking. Asset tracking is centralized, and maintenance records, part replacements, and service notes are stored. QR and barcode scanning are used for fast identification. Through the automation of reordering, integration with procurement systems, and stock level monitoring, the system improves inventory and components management. IoT sensors used for condition monitoring identify problems in asset performance, which in turn initiate automatic work orders and facilitate predictive maintenance. Real-time data and dashboards that may be customized offer information on compliance tracking, maintenance expenses, and asset outages. Its deployment via mobile and cloud platforms ensures maintenance teams real-time notifications, offline capability, and global access. Through REST APIs, eMaint CMMS easily connects with third-party apps, IoT platforms, and ERP systems like

SAP and Oracle. This allows for remote maintenance operations, decreases downtime, and optimizes inventory.

Limble CMMS

Limble CMMS, or Computerized Maintenance Management System, is a cloud based platform for maintenance management that helps small and mid-sized
Industrial organizations increase operational efficiency, reduce downtime, and streamline asset maintenance.

Preventive maintenance scheduling, asset lifecycle tracking, and work order management are all made simpler for maintenance teams by its user-friendly and straightforward interface. In sectors including manufacturing, healthcare, logistics, and facilities management, Limble CMMS is frequently used due to its AI-powered predictive maintenance, mobile accessibility, and real-time reporting capabilities.

Features:

Limble CMMS analyzes historical data and IoT sensor inputs using AI-powered predictive maintenance to identify possible equipment faults before they occur and save downtime. It allows for configurable priority levels and regular maintenance plans, and it automates the development, assignment, and monitoring of work orders. To support financial planning, the system keeps track of asset lifetime costs, performance, maintenance history, and depreciation. Technicians may see repair orders, quickly identify assets by scanning QR codes, and get real-time updates from any location thanks to complete offline and mobile support. Managers may make data-driven choices with the use of advanced reporting and KPI tracking, which offer real-time insights into asset health, work productivity, and maintenance performance. For companies of all sizes, Limble CMMS provides an easy-to-use, scalable system that lowers maintenance costs, increases equipment longevity, and improves technician productivity.

MPulse Maintenance Software

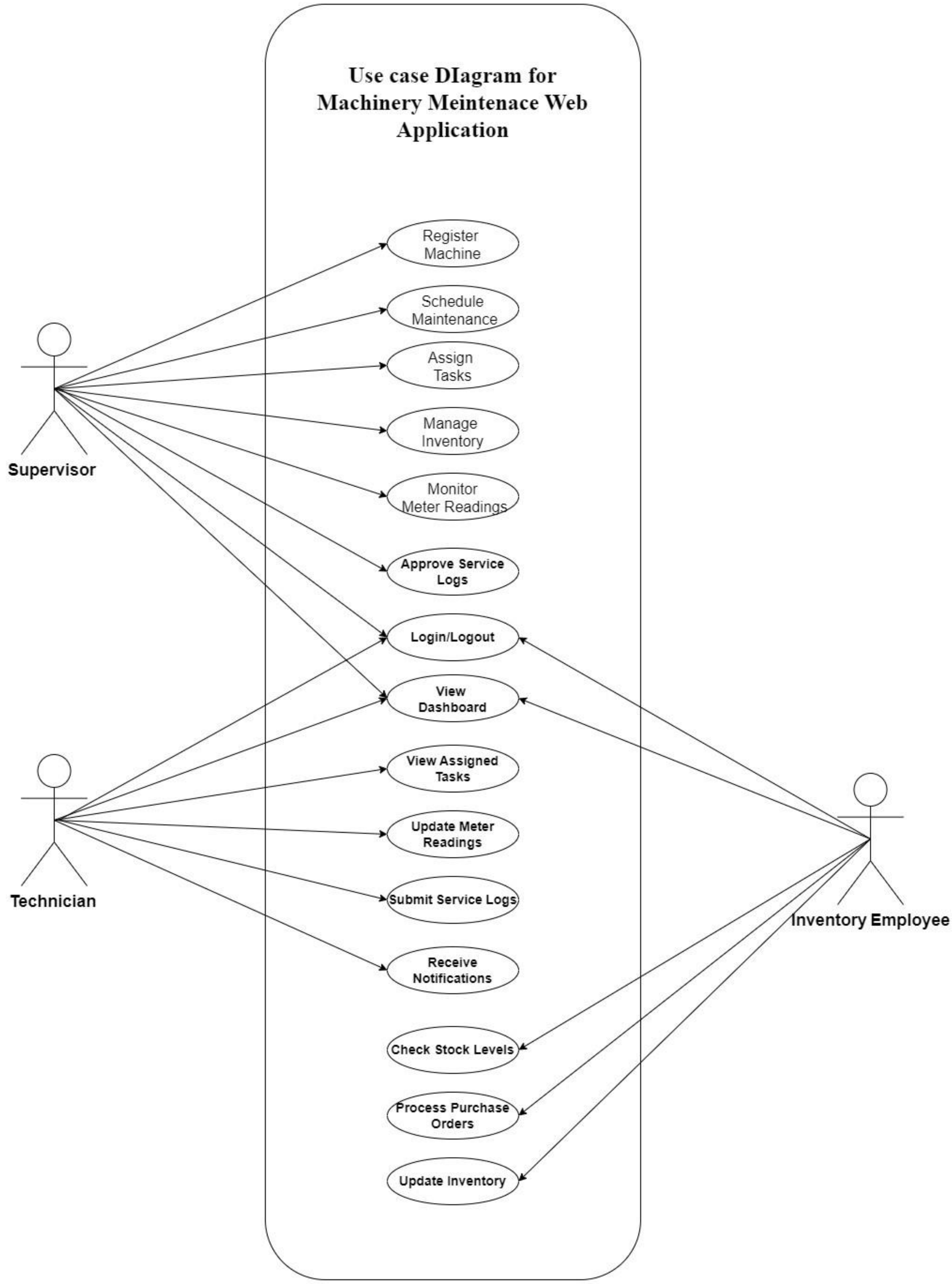
A computerized maintenance management system (CMMS) called MPulse Maintenance Software was created to assist businesses in effectively managing work orders, asset monitoring, and preventative maintenance.

With capabilities to enhance maintenance procedures, minimize downtime, and maximize inventory management, it is extensively utilized in the manufacturing, fleet management, healthcare, utilities, and government sectors. Real-time insights into equipment performance are made possible by MPulse's integration with IoT sensors, mobile applications, and customized dashboards. (MPulse Software, 2024)

Features:

By automating predictive and preventive scheduling and optimizing servicing intervals with sensor inputs and historical data, MPulse Maintenance Software simplifies fleet and equipment maintenance. To avoid shortages and overstocking, its inventory management system interfaces with procurement systems, automate reordering, and monitors the availability of replacement parts. Real-time sensor data is gathered via IoT-enabled asset status monitoring, which then uses anomaly detection to send out predictive maintenance notifications. With barcode/QR scanning for fast asset identification and offline use for remote sites, technicians may effectively handle work orders on mobile devices. Custom dashboards assist budget and compliance choices by offering real-time information into technician productivity, asset up time, and maintenance costs. MPulse is scalable for companies of all sizes since it lowers downtime, increases maintenance effectiveness, delays asset life, reduces inventory costs, and permits data-driven decision-making. (MPulse Software, 2024)

2.4 Use case Diagram



2.5 Drawbacks of the existing system

- High Implementation Costs

Many companies CMMS/EAM systems, such as SAP PM, IBM Maximo, and MPulse, are costly for small and medium-sized companies because to their high license, facilities and customization costs.

- Complexity with a High Learning Curve

Companies who have limited IT skills may find it challenging to deploy advanced systems with AI, IoT, and ERP connections (such as IBM Maximo, SAP PM, and Fiix) since they frequently require specialized training.

- Over-Designed for small companies

Solutions such as Limble CMMS and eMaint CMMS provide a wealth of functionality that small businesses might not need, resulting in underused features and higher maintenance expenses.

- Challenges with Flexibility and Customization

Because of their inflexible designs, most current systems need to be costly customized to meet specific company needs. As compared to this, MechniX is specifically designed for the workflow of its target company.

- Depending on cloud and internet services

Fiix, Limble CMMS, and eMaint are examples of cloud-based systems that rely significantly on internet access, which might cause operational issues if the company has connectivity problems.

- Complex Requirements for Integration

For companies without an established digital platform, integrating SAP PM and IBM Maximo with ERP, procurement, and finance systems can be difficult and resource intensive.

Disparities Between MechniX and Current Systems

The current systems, which integrate AI, IoT, and ERP systems to provide predictive maintenance, asset tracking, and inventory management, are enterprise-level CMMS and EAM solutions intended for large-scale industrial applications. These systems include IBM Maximo, SAP PM, Fiix, eMaint, Limble CMMS, and MPulse. For sectors including manufacturing, energy, and healthcare, these systems focus on automation, analytics, and scalability. On the other hand, MechniX is designed especially for private firm machinery maintenance, providing a more efficient, SME-friendly method. MechniX places more emphasis on role-based access for supervisors and operators, real-time email and in-app message notifications, and easier preventative maintenance monitoring than huge CMMS solutions. While it cannot be integrated with AIdriven analytics, IoT sensors, or ERP systems, it does concentrate on useful, affordable automation for material management, maintenance scheduling, machinery tracking, and service reporting. Because MechniX is a web application, it is easy for the target firm to use, while corporate solutions are frequently more feature-rich and difficult.

Chapter 03 - Requirements Specification

3.1 Functional requirements

Functional Requirements by Roles of Users

Supervisor

Supervisors are in the role of managing equipment, assigning work, and making sure maintenance plans are followed too.

- **Machine Registration and Database Creation -**

Entering the brand, model, and unique ID allows you to add new machinery. able to retain and handle meter readings, maintenance histories, and service information.
Able to change or remove information about machines as needed.

- **Meter readings and work-hour monitoring -**

Can check and monitor machine meter values daily.
Can manually update meter readings as necessary.
can track machine operating hours in real time for improved scheduling.

- **Service Notifications and Scheduling**

Depending on schedules or meter readings, automatically receives service notifications.
Ability to create regular maintenance plans for every equipment. able to alter maintenance plans in response to usage of equipment.

- **Task Allocation and Manpower Monitoring**

Can provide technicians with maintenance or repair assignments.

- **Planning the Purchase of Materials and Handling Stock**

Can see the maintenance material inventory that is currently available.
When supplies run short, they might request additional supplies.
Can accept or deny requests from technicians or inventory staff to acquire materials.

- **Service Documentation & Updates**

Allowed to check and accept technician-submitted service logs. May review and obtain historical maintenance records.

- **Reporting and Analyzing Historical Data**

Reports on machine health, maintenance expenses, and service frequency can be generated.
Used to optimize maintenance planning by analyzing patterns in machine failures.

Technician

Technicians oversee reporting machine problems and carrying out maintenance duties.

- **Getting Tasks Assigned**

Receive notifications when maintenance or repairs are assigned.

- **Readings from Meters and Tracking of Working Hours** Update machine meter readings and working hours after servicing.

- **Alerts and Notifications**

Receives reminders for tasks that have been assigned.

Inventory Employee

Employees in inventory control maintenance material stock levels and respond to purchase requests.

- **Checking Stock Levels**

Can monitor the supply of oils, replacement parts, and other maintenance supplies.

- **Responding to Requests for Materials**

Able to accept and examine requests for materials from supervisors and technicians.

- **Processing Purchase Order Processing**

Able to draft purchase orders for products that aren't in stock.

All Users Share Common Features (Supervisor, Technician, Inventory Employee)

- **Authentication and User Registration**

Any user with the proper position can register in the system.
Users must use secure authentication while logging in.
Passwords are encrypted and saved safely.

3.2 Non-Functional Requirements

- **Performance**

The system requires to react to user inputs quickly and be responsive. It should be no delays in the display of real-time meter reading updates, service alerts, and job progress.

- **Scalability**

The system must be scalable, allowing the addition of more machines, technicians, and data without compromising performance. As the company grows, the system should efficiently handle increased data storage and traffic demands, ensuring seamless operation even as the workload expands.

- **Usability**

The user interface should be intuitive and easy to navigate, catering to supervisors, technicians, and store employees. The app must be accessible on both desktop and mobile devices, with mobile optimization specifically designed to support technicians working on-site, ensuring a seamless experience across all platforms.

- **Security**

Data Encryption: Protect sensitive information by encrypting it both during transfer and storage, including machine information and maintenance records.

- **Reliability**

Access always should be ensured by the system's high availability and low downtime. To ensure optimal system performance and dependability, frequent software upgrades and maintenance checks should be planned, and backup procedures must be put in place to prevent data loss.

- **Compatibility**

The system should be compatible with multiple operating systems, including Windows, macOS, and mobile platforms (iOS and Android). It must also integrate seamlessly with other tools, such as email services like Nodemailer, to send notifications and alerts, ensuring smooth communication and workflow.

3.3 Hardware / Software Requirements

Hardware and devices requirements

Mobile devices - Android or IOS

Computers - For developer work.

Internet Access - Required for android studio, firebase and cloud services

Chapter 04 - Feasibility Study

4.1 Operational feasibility

Benefits & Business Value

The MachniX system delivers significant operational benefits by automating managing stock and machinery maintenance, which enhances productivity and reduces downtime. The main advantages consist of:

Eliminates manual record-keeping - Reduces human errors and ensures accurate maintenance management.

Improves the scheduling of maintenance - Reduces unexpected breakdowns and expensive repairs by ensuring prompt service.

Enhances the management of inventories - maintains records of replacement parts and sends out purchase alerts to avoid material shortages.

Enhances efficiency of tasks - allows managers to keep updated on manpower allocation, service records, and machine usage in real time.

Optimizes the use of resources - ensures that technicians and materials are assigned efficiently, minimizing inefficient expenditures.

Prevents expensive failures - Preventing equipment failures through timely alerts improves asset performance over time.

User-Friendly Interface for Quick Adoption

The system features an intuitive user interface with simple navigation, role-based views, and minimal data entry to enhance usability. Clear menus and dashboards ensure that supervisors, technicians, and inventory staff can easily access relevant features without unnecessary complexity. Automated calculations, pre-filled forms, and dropdown selections streamline data entry, while responsive design ensures seamless access across both desktop and mobile devices. With these userfriendly design principles, most users can quickly adopt the system with minimal training.

4.2 Technical Feasibility

- **Frontend – Next.js**

Static site generation (SSG) and server-side rendering (SSR) are features of Next.js that ensure quick performance.

Field technicians require mobile optimization - Tailwind CSS responsive UI design.

- **Backend – Firebase (Cloud function)**

Infrastructure administration reduces with serverless architecture.

manages event triggers in real time, such as maintenance alerts.

ensures effective performance by auto-scaling according to demand.

- **Database – MongoDB**

NoSQL is perfect for dynamic maintenance records because of its flexibility.

Ensures effective management of expanding data by scaling horizontally.

- **Authentication – Firebase Authentication**

Supports multi-factor authentication, email/password, and OAuth.

Administrators, technicians, and supervisors may easily manage access depending on requirements.

- **Notification – Firebase cloud Messaging + Nodemailer**

FCM push notifications provide real-time maintenance job alerts.

Email notifications from Nodemailer verify that users receive important alerts.

- **Version control – GitHub**

Enables pull requests and branches for collaborative development.

Supports automated testing and deployment using GitHub Actions.

4.3 Budget Outline

- **Frontend**

Next.js (React-based) - Free (Open Source)
Tailwind CSS - Free (Open Source)
React Context API -Free (Open Source)
React Hook Form - Free (Open Source)
Firebase Authentication - Free (with limits)

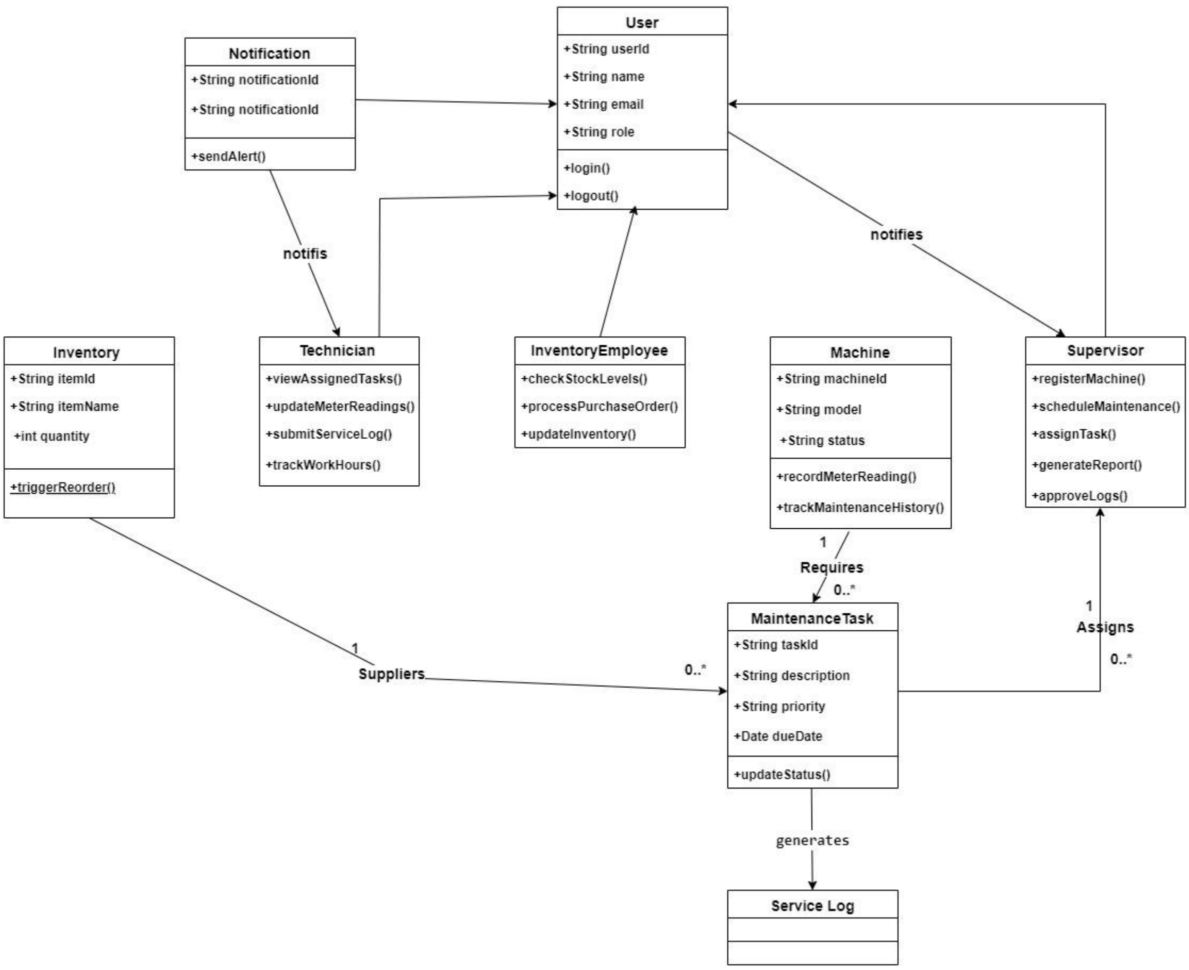
- **Backend**

Node.js (Express.js) - Free (Open Source)

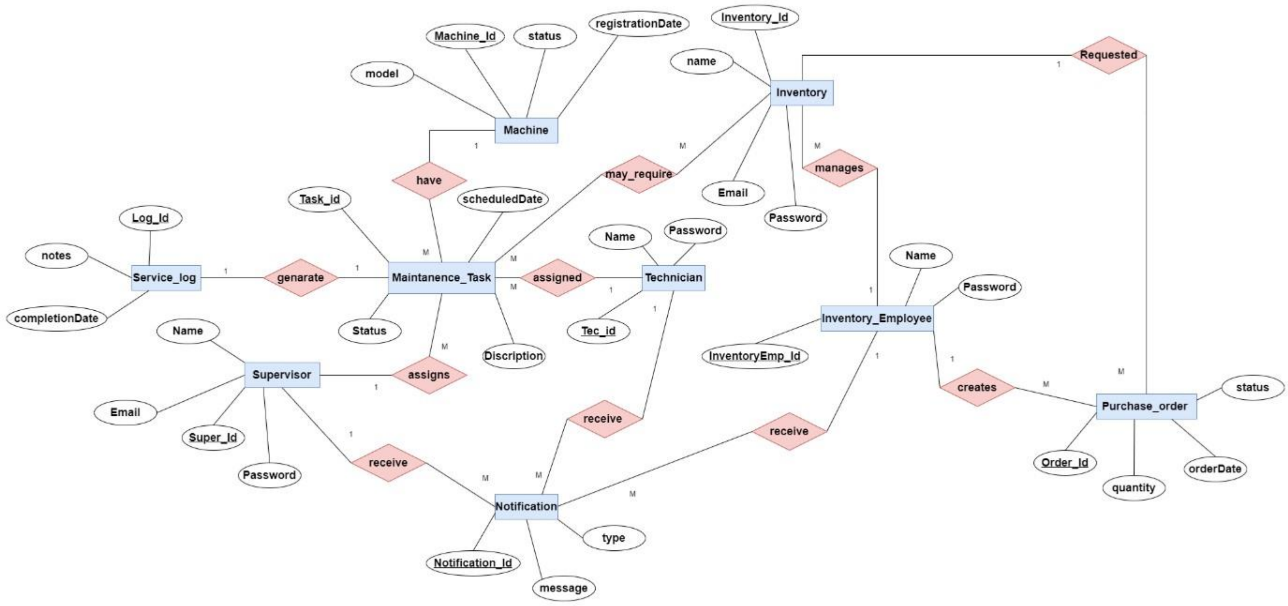
MongoDB Atlas (M0 Free Tier) - Free (5GB storage, shared cluster)
Firebase Cloud Functions -Free ($0.40 per month)
Express.js - Free (Open Source)
Node.js Cron Jobs - Free (Open Source)

Chapter 05 - System Architecture

5.1 Class Diagram of Proposed System



5.2 ER Diagram



Assumptions

Supervisors, technicians, and inventory employees are the three categories of users.

In the system, each function has distinct rights and duties.

A machine's model, status, and registration date are among the details that are entered into the system.

Every maintenance task has a machine associated with it and a technician assigned to it.

Technicians are given maintenance assignments by a supervisor.

There are statuses for maintenance jobs.

After the maintenance job is finished, a service log is created.

Every inventory item has a unique name, quantity, and ID.

Reorder levels for inventory items indicate when new inventory is required.

Multiple inventory items may be needed for a maintenance task, and a maintenance task may use an inventory item (many-to-many relationship).

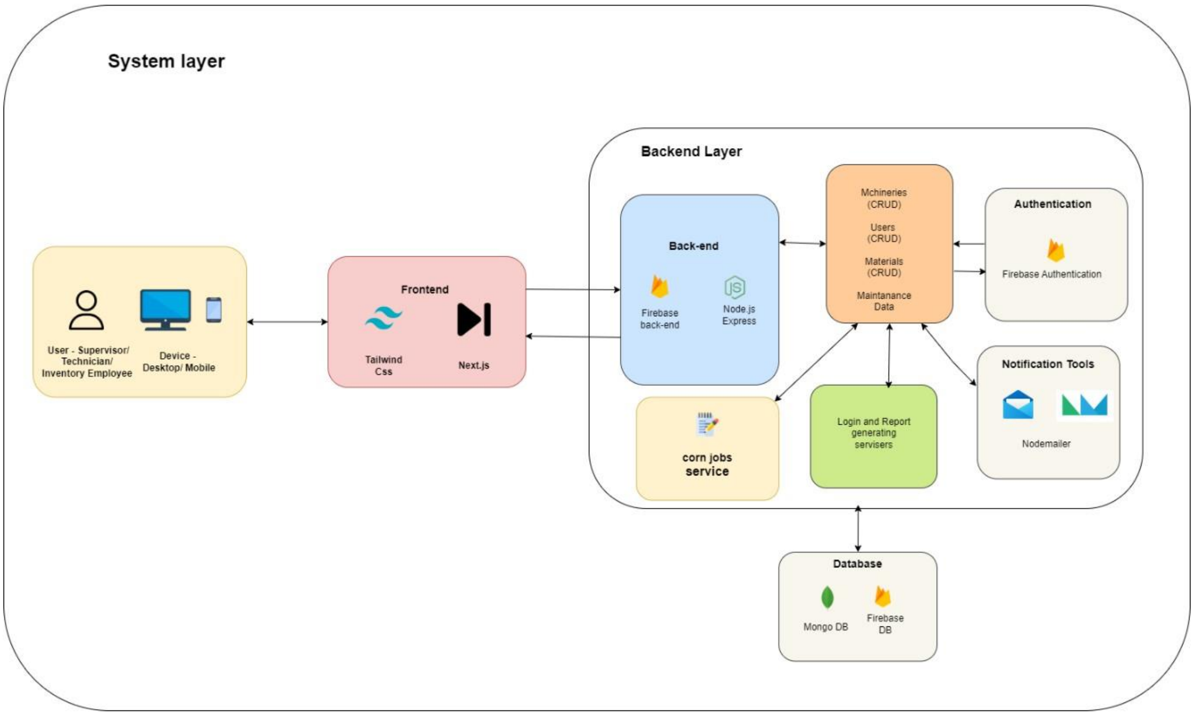
Inventory employees maintain a record of stock levels and issue purchase orders as necessary.

Every purchase order keeps track of the order quantity, date, and status and is connected to an inventory item.
You can request a purchase order for more than one item.

Inventory employees, technicians, and supervisors are informed about relevant tasks (e.g., job assignments, low stock alerts).

A unique source object (such as a maintenance job or purchase order) is associated with each type of notification.

5.3 High-level Architectural Diagram



Chapter 06 - Development Tools and Technologies

6.1 Development Methodology

Agile Development Methodology for Web Application for Machinery Maintenance

This flexible and iterative approach, known as the Agile development Methodology, allows for quick feature development, ongoing feedback, and flexibility. This approach is especially well-suited for the Machinery Maintenance Web Application due to its ongoing system enhancements, changing user requirements, and scalability requirements. The Agile methodology will enable me to:

- Create and develop the system gradually to ensure ongoing progress.
- To improve usability and efficacy, consider input from operators, supervisors, and other stakeholders.
- Improve system performance through iteration in response to user interactions and test findings.
- Make that the system works with real-world expectations, maintenance procedures, and business requirements.

The following stages form the iterative development approach:

- Requirements Gathering and Planning

Identify the main features and user requirements. Describe the restrictions, technological viability, and system goals. To develop key features, get feedback from operators and supervisors.

- Developing and Testing

Use Figma to create wireframes and user interface prototypes.
Give the backend architecture and database schema definitions.
Define access levels, user roles, and system navigation.

- Developing and Testing

Implement features in Firebase (backend services) and Next.js (frontend).
Carry out user, integration, and unit testing.
As going on to the following iteration, identify and fix any problems.

- Implementation and Management

Install the system with security settings on AWS/Vercel.
Keep an eye on error handling, logging, and performance.
Update often in response to comments and new business requirements.

6.2 Programming Languages and Tools

The technology stack is made up of relevant web development technologies that ensure maintainability, scalability, and performance.

Frontend

Framework: Next.js (React-based, supports SSR/SSG)

Programming Language: TypeScript (ensures type safety)

Styling: Tailwind CSS (for a mobile-friendly responsive UI)

State Management: React Context API (or Zustand for lightweight state management)

From Handling: React Hook Form (for managing and validating user inputs)

Backend

Backend Framework: Node.js with Firebase Cloud Functions

Programming Language: TypeScript

Database: MongoDB (NoSQL, flexible schema)

API Development: RESTful APIs with Express.js

Authentication: Firebase Authentication (MFA, OAuth, Email/Password)

Notifications: Firebase Cloud Messaging (FCM) + Nodemailer (for emails) Job Scheduling: Node.js Cron Jobs (for automated maintenance reminders) **Deployment & Hosting**

Frontend Hosting: Vercel (optimized for Next.js)

Backend & Database: Firebase + MongoDB Atlas (cloud-based NoSQL database)

Version Control: GitHub (for collaborative development)

6.3 Third-Party Components and Libraries

Frontend Libraries

next-auth → Authentication handling axios → HTTP client for API requests framer-motion → Smooth UI animations lucide-react → Icons for UI components

shadcn/ui → UI components (modals, forms, tables)

Backend Libraries

express → API routing and middleware firebase-admin → Firebase Cloud Functions and Authentication mongoose → MongoDB ORM for schema management

Nodemailer → Email notifications for maintenance reminders cron → Scheduling maintenance alerts

jsonwebtoken (JWT) → Token-based authentication

Deployment & Security

bcryptjs → Hashing passwords for secure authentication helmet → Security middleware for HTTP headers cors→ Cross-Origin Resource Sharing (CORS) management

6.4 Algorithms

Key algorithms and Logic Implementation.

Algorithm for Preventive Maintenance Scheduling

Input - Last maintenance date, meter readings, predefined service interval.

Logic –

Compare the most recent maintenance reading that was recorded with the current meter reading.

A maintenance notice should be sent out whenever the threshold—for example, 5000 hours—is surpassed.

Set up alerts for impending maintenance duties.

Output - Alerts and reminders for maintenance.

Logic for Machinery Assignment

Input - Supervisor assignment, operator workload, and available machines.

Logic –

Machines can be assigned to different operators by supervisors.

Only allocated machines' readings can be updated by operators.

Output - Equipment assignments that are well managed.

User Role-Based Access Control (RBAC)

Input - Details about user authentication (password, email, OAuth, or multifactor authentication).

Role assigned: Inventory Employee, Technician, or Supervisor.

Logic -

Supervisor (Admin)

Full control and access to the system.

All entities (manpower, equipment, supplies, and maintenance records) may be created, updated, deleted, and managed.

Technicians are assigned to equipment.

schedules and authorizes maintenance work. checks maintenance compliance and checks reports.

Technicians can view and update the machinery that has been allocated to them. refreshes the machine's status and records maintenance activities. requests the maintenance-related materials.

Inventory Employee manages the inventory of supplies and replacement components. updates availability and keeps track of stock levels.

Accepts requests for materials from technicians.

output - User roles provide secure access control, ensure that each user may only carry out tasks relevant to their tasks.

Chapter 07 – Discussion

7.1 Overview of the Interim Report

The interim report focuses on developing MachniX, a web-based tool for equipment maintenance that will replace the company's give manual tracking system. The study discusses the inefficiencies of the current manual method, the significance of maintaining industrial machinery, and the many forms of maintenance.

To improve productivity, reduce human error, and better allocate resources, the project develops an automated maintenance management system. The feasibility study, system architecture, requirements definition, system analysis, and development tools are important parts of the report.

7.2 Summary of the Report

- **Introduction**

explains how industrial machinery is used in many industries. explains the role that preventative maintenance (PM) plays in lowering equipment failure rates.

- **Problem Definition**

Currently, the company uses a running sheet for manual record-keeping, which is error prone.
The lack of real-time tracking causes inefficiencies and delays in maintenance scheduling.

- **Description of the Project**

The goals of MachniX are to automate real-time monitoring, inventory tracking, and maintenance scheduling.
Predictive maintenance, historical data tracking, and service alerts are among the features.

- **Analysis of Systems**

Interviews with stakeholders reveal inefficiencies in inventory control and maintenance tracking. Limitations in the present CMMS (Computerized Maintenance Management Systems) software are found by existing system assessment.

- **Specification of Requirements**

Outlines both functional and non-functional needs, such as system scalability and user roles (supervisor, technician, and inventory staff).

- **Study of Feasibility**

Demonstrates the project's viability from a technical, operational, and financial standpoint.
The cloud-based, economical method guarantees simple implementation and upkeep.

- **System Development and Architecture**

MongoDB is used for data storage, Next.js is used for the front end, and Firebase is used for the back end.
guarantees iterative development by applying the Agile approach.

- **Challenges and Future Plans**

Stakeholder availability and switching from Angular to Next.js for improved performance were the first obstacles.
Finalizing key features, improving UI/UX, and doing thorough testing are the next phases.

7.3 Challenges Faced

Organizing conferences with stakeholders in the requirements-gathering period was one of the main challenges because of their busy schedules. As a result, it takes more time to gather essential feedback and improve the project requirements.

The first frontend framework selection was a further major challenge. Angular was initially utilized for building the project, but I decided to use Next.js because of the intricacies of state management and general development efficiency. Refactoring the current code and adjusting to a new framework took more effort throughout this shift. But in the end, the transition enhanced maintainability and performance.

7.4 Future Plans / Upcoming Work

Completing Up Key Features -

Essential features like inventory control, work monitoring, and maintenance scheduling are available to complete.

Improving User Experience (UX) -
Using Tailwind CSS to create a more user-friendly design and streamlining form processing.

Bug fixing and testing -
Performing full testing to find and fix any security flaws or performance problems.

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PUSL3190 Computing Individual Project

Project Interim Report

Machinery Maintenance Web Application

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Chapter 01 - Introduction

1.1 Introduction

Industrial machinery

Industrial machinery is a wide range of equipment and mechanical systems used to enhance accuracy, efficiency, and production in a range of sectors, including mining, manufacturing, construction, and agriculture. Automating processes, reducing labor costs, and improving quality of production are all made possible by these devices. Heavy-duty construction equipment like excavators and cranes, as well as precision-driven CNC machines in manufacturing, are examples of industrial machinery that is designed to perform complicated tasks with minimal human intervention.

Industrial development and growth in economy was significantly helped by the development of industrial machinery. Automation, web/mobile applications, robotics, and IOT integration are some of the technologies that have made modern machinery more secure, more efficient, and capable of predictive maintenance. To avoid unexpected breaks down, minimize delays, and improve the machinery's existence, proper maintenance is required.

Industrial machinery may be divided into categories according to its application, industry, and function.

Construction Machinery:
Used in the construction of roads, buildings, and infrastructure.
Excavators, Bulldozers, Loaders, Cranes, Road Rollers, Concrete Mixers, Trenchers.

Manufacturing Machinery
Used in factories for production and processing of materials.
CNC Machines (Computer Numerical Control), Lathes, Milling Machines, Drilling Machines, Press Machines (Hydraulic, Mechanical), Injection Molding Machines, Welding Machines.

Agricultural Machinery

Used in farming and food production.
Tractors, Combine Harvesters, Plows, Seed Drills, Irrigation, Systems, Ballers **Mining Machinery**

Used for extraction of minerals and natural resources.
Drilling Rigs, Conveyors, Loaders and Haulers, Crushers, Continuous Miners, Draglines.

Power Generation & Energy Machinery

Used in electricity generation and power distribution.
Generators, Turbines, Boilers, Transformers

Material Handling Equipment

Used for transporting and handling goods.
Forklifts, Conveyor Belts, Hoists and Winches, Automated Guided Vehicles

Food Processing Machinery

Used in food production, packaging, and processing.
Mixers and Blenders, Food Extruders, Pasteurizers, Packaging Machines

Textile Machinery

Used in the textile and garment industry.
Spinning Machines, Weaving Machines, Dyeing Machines

Printing & Packaging Machinery

Used in mass printing and product packaging.
Offset Printing Machines, Flexographic Printers, 3D Printers, Labeling and Wrapping Machines.

5

Machinery Maintenance

Machinery maintenance is the process of inspecting, fixing, maintaining, and controlling industrial machinery to improve performance, reduce delays, and improve a long lifespan. Maintaining machinery to proper operating order and preventing unplanned breakdowns requires regular checks, preventative maintenance, and repairs.
Heavy machinery-dependent businesses including manufacturing, construction, agriculture, mining, and transportation depend on efficient maintenance. Good maintenance plans save operating costs, improve security, improve productivity, and avoid breakdowns that may delay production

Types of Machinery Maintenance

Preventive maintenance (PM) Maintenance to avoid failures.
Includes system checks, lubrication, and part replacements.
Predictive Maintenance (PdM)
Use data analytics and sensors to anticipate errors before they develop. Uses AI, machine learning, and IoT to provide real-time monitoring.
Corrective Maintenance (CM)
Repairing machinery once it breaks down.
Used when preventative maintenance is insufficient or not done at all.
Condition-Based Maintenance (CBM)
Real-time equipment condition monitoring helps identify when maintenance is required.
include oil analysis, vibration analysis, and thermal analysis.
Reactive Maintenance (Breakdown Maintenance)
Repairing equipment only after it breaks down.
Frequently results in expensive repairs and unplanned downtime.

Importance of machinery maintenance

Increases Equipment Lifespan: Machines that require regular service will have a longer lifespan.
Reduces Downtime: Avoids unexpected failures preventing output.
Reduce Costs: Preventive maintenance reduces the requirement for costly emergencies.
Provides Safety: Properly maintained equipment reduces incidents and hazards.
Increases Productivity: Provides that machines perform as efficiently as possible.

Preventive Maintenance (PM)

Preventive maintenance (PM) is a systematic approach to repairing machinery and equipment to optimize performance, reduce downtime, and increase operational lifetime. It involves regular inspections, part replacements, and regular maintenance, aiming to detect and resolve potential issues before they become failures. This approach helps organizations reduce unplanned disruptions and ensures ongoing production, especially in workplaces where unexpected failures can lead to significant damage. (Chan, 2023).

Preventative maintenance aims to optimize equipment accuracy by reducing wear and tears, ensuring optimal machinery performance, and preventing irreversible damage. It includes cleaning, lubricating, and fastening parts. Early interventions, like cleaning air filters or replacing worn belts, can save costs and improve efficiency. (MicroMain, 2022).

Preventative maintenance (PM) offers cost reduction by reducing emergency repairs, which are often more costly due to manpower, unplanned downtime, and quicker part replacements. PM also enhances workplace safety by reducing equipment failure risks. (ServiceChannel, 2023).
Preventive maintenance is crucial in various industries, ensuring efficient production lines, reducing delays, and increasing productivity. It directly impacts patient care, transportation, and construction, ensuring safety, asset performance, and cost savings through well-structured plans. (developer, 2024).

1.2 Problem Definition

Heavy machinery and equipment maintenance is a key component of any company's operations, specifically for companies that depend on the constant functioning of significant machines like Generators, HDD (Horizontal
Directional Drilling) machines, and other industrial equipment. The efficiency of operations depends on ensuring that all the machines are working properly, getting timely preventative maintenance and preventing failures.

companies that depend on machinery continue to schedule and perform maintenance u However, the maintenance procedure is still carried out manually at my specified company using a running sheet, which is a record used for maintaining records of upgrades and preventative maintenance programs for each component of equipment. A mechanical supervisor or engineer maintains the records, working with warehouse employees, machine operators, and other employees to schedule required services, record working hours, and gather meter readings. While there are plenty of applications available for monitoring the maintenance of vehicles, applications designed especially for the maintenance of industrial machines are significantly underutilized. Applications for vehicle maintenance are frequently utilized in industries like vehicle management, where digital solutions facilitate the tracking of service history, mileage, maintenance plans, and part replacements. However, there aren't many specialist applications developed for maintaining heavy machinery, specifically for companies which run multiple types of equipment with various maintenance requirements. Because of this, many sing manual techniques.

The company's present manual procedure is ineffective, hence requires a machinery maintenance system. Equipment failures and expensive repairs are more likely when running sheets are used for maintenance tracking because they are prone to human error, insufficient data, and missed maintenance schedules. Without a well-organized system, the business finds it difficult to track equipment utilization, manage preventive machinery maintenance, and have a sufficient stock of materials and spare parts. To ensure that the company's machinery runs effectively and reliably to fulfill its operational requirements, a digital maintenance system would optimize operations, decrease delay, and enhance resource allocation.

Project description

The main objective of this project is to develop MachniX, a web application that will improve the company's approach to maintaining its machinery. In addition to enhancing the company's ability to perform preventative maintenance on each of its inventory machines, this approach is designed to simplify systems and avoid inefficiency. In moving from a manual, risk approach to an ordered, structured digital platform, the project addresses significant operational challenges and offers a reliable and fast repair process.

The whole process of maintaining machines will be automated by the application. By providing maintenance schedules based on machine usage, service schedules, or specific requirements for operation, it will handle scheduling. The digitalization of data collection will make it possible to follow daily usage data, including meter readings, in real time. To avoid delays or material shortages, inventory management will also be digitized, providing real-time tracking of spare parts and the development of purchase plans. To facilitate proactive management and informed decision-making, the system will also offer comprehensive information on the equipment's state, service history, and upcoming repairs.
The main features of MachniX include daily machine registration to maintain precise records of equipment usage and condition, service alerts to notify technicians and management of impending maintenance services, and meter reading recording to monitor performance in real-time. The system will also schedule preventative maintenance to reduce delays, maintain a centralized record of service history for ease of access and reviews, and monitor material inventories to ensure the availability of required materials.

This complete strategy ensures that the company's equipment is functional by reducing maintenance and increasing equipment lifespan. Additionally, by ensuring reliable information entry and regular record-keeping, automation will decrease human error. By making inventory management and planning easier, MachniX improves the use of resources by allowing more efficient staff and material allocation. Alerts and notifications protect the company from cost replacements or breakdowns in machinery by making sure that no maintenance tasks are missed.

MachniX is not just a piece of equipment; it is a comprehensive equipment maintenance solution. It includes innovative functions that maintain accuracy, success, and reliability while simplifying and improving maintenance administration. By using this strategy, the company will be able maintain pace with repairs, maintain the equipment's condition, and operate efficiently for an extended period.

1.3 Objectives

- **Analyze the Suspension of PM (Preventive Maintenance).**

Assess the advantages of automated preventative maintenance to reduce error in human data entry. Ensure that maintenance plans are properly recorded and organized.

- **Analyze and interpret maintenance reports.**

To enhance preventative maintenance, analyze previous maintenance operations. Generate thorough reports that support well-informed company decisions.

- **Optimize Resource Allocation.**

Use real-time data to distribute resources and personnel efficiently. Avoid scheduling issues and ensure that resources are available for maintenance work.

- **Monitoring and Plan the Management of Materials and Inventory**

Monitor material usage and plan future requirements. To avoid shortages, increase contact between the inventory and maintenance staff.

- **Design an Alert System.**

To inform employees working on maintenance of upcoming tasks, put in place a notification system. Ensure regular service to reduce the chance of equipment breakdowns.

Chapter 02 – System analysis

2.1 Facts Gathering Techniques

Getting meetings with the Stakeholders.

I arranged and carried out individual discussions with each group at their place of work to analyze how they work and get firsthand information. I noticed the manual handling of maintenance scheduling, tracking, and material management during these sessions, which takes place in the company's workshop, maintenance area, and inventory storage.

Supervisors (Tasks: Scheduling and Maintenance Management)

I had meetings with mechanical supervisors, who oversee managing repair projects while maintaining updated on maintenance plans.

Challenges discussed –

Manually updating running sheets and other traditional maintenance tracking techniques frequently result in delays and inefficiencies. Unexpected breakdowns are greater when machine usage records are missing or out of date since it is harder to tell when maintenance is necessary. Furthermore, delays in repairs might result from an inadequate system for tracking the availability of spare parts, which further reduces operating efficiency. These difficulties show how maintenance management must be done in a more efficient and dependable way.

Expectations –

A digital system that tracks all maintenance actions in one place. automated reminders and alerts for impending maintenance. A history of machine services to help in decision-making.

Technicians (Tasks: Reporting problems and doing maintenance)

I had a meeting with the maintenance technicians who work on fixing and maintaining equipment.

Challenges –

With limited access to historical maintenance information, fixing can be challenging since technicians may not have the history they need to identify problems quickly. Frequent issues and repair delays are frequently the result of this. Furthermore, mistakes in teams may cause crucial maintenance tasks to be missed, which might lead to unexpected equipment breakdowns. The inefficiency of manually recording repair information has increased, taking up the time that could be used for actual maintenance. Efficient fixing problems, clear communication, and precise record-keeping require a more simplified, digital approach.

Expectation -

A simple way for digitally recording completed maintenance.
Notifications of planned maintenance.
Service history is easily accessible for improved diagnoses.

Inventory Employees (Tasks: Handling Material Requests & Spare Parts)

I discussed with staff members who deal with requests for materials and replacement parts about the difficulties in inventory management.

Challenges - Manually maintaining track of inventory enhances the possibility of shortages, which might cause delays in maintenance. The availability of essential resources may be compromised in the absence of precise inventory data.
As waiting for spare parts delays equipment delays, slow request and approval procedures further extend maintenance. Productivity and general efficiency are impacted.

Timely replenishment is ensured via a real-time monitoring system that tracks material availability. Operations continue to function smoothly, delays are decreased, and maintenance efficiency is increased.

Expectation -

A real-time inventory updates digital inventory system.
Automated notifications when inventory levels are low to avoid shortages. Faster material request and approval procedure.

Observation: Getting Knowledge about the Current Maintenance Procedure

I studied maintenance staff on-site in their real-world workplace to obtain firsthand knowledge of how maintenance is manually monitored. This made it possible for me to examine their daily operations, spot inefficiencies, and comprehend their problems without having to depend only on surveys or interviews.

2.2 Literature review

Machinery maintenance

In a company, preventive maintenance refers to regularity, planned checks and service on equipment to avoid unexpected breakdowns and expensive repairs. This proactive approach reduces delays, ensures safety, and delays the service life of the machinery. Preventive maintenance services usually include the following for the equipment you mentioned:
HDD Vermeer (, Compressors, Micro Trenching Machines (MTM), and Generators.

Horizontal Directional Drilling Machines (HDD Vermeer)

These machines inspect hydraulic systems to prevent leaks and ensure optimal efficiency.
Air and oil filters should be cleaned and changed for efficient drilling operations.

Oiling moving components reduces apply, such as the drill head and rods. Maintaining the cooling system and checking the batteries will help avoid overheating.

Compressors

To maintain the airflow clean and protect the motor, change the air filter. Compressor oil should be flushed and changed often to prevent damage and improve performance. Belts and hoses are checked for damage and use.
Checking of valves to ensure proper pressure levels.

Micro Trenching Machines

Inspections of the trenching tool or blade to avoid wear and provide clean trench cuttings.
Monitoring hoses and hydraulic fluids for leaks or problems with pressure. Inspections of electrical systems are required to ensure their safe and dependable functioning.
Wheels and track checks ensure stability and correct alignment.

Generators

Verify start power by inspecting the batteries and charger. To ensure reliability, check and refill the cooling system and oil levels. Monitoring of the fuel system to prevent pollution or blocking.
Control panel testing to ensure proper operation of monitoring systems.

Presently, the selected company will manual machinery maintenance using a "running sheet," a document that records all preventative maintenance information. Following this technique, each machine's number, brand, model, location, operating hours, servicing type, and necessary supplies are manually recorded by the mechanical engineer or supervisor. In addition to confirming machine availability and coordinating machine technicians, they additionally require gathering daily meter readings and working hours from machine operators. When materials are required, the supervisor contacts the department in the store to request them. To remind operators when maintenance is necessary, service schedules depend significantly on the supervisor's attention in keeping track of dates and meter readings. However, there is a risk that services will be missing, meter readings will be delayed, and tracking equipment required for repair may be missed while using this manual method. By automating this procedure with a specialized application, the preventive maintenance process would be much more efficient and without any mistakes thanks to more organized tracking, timely reminders, and centralized data management.

Android-Based RCSM Application for Implementation of Preventive Maintenance on CNC Production Machine.

The Android-based "Reminder & Control System Management" (RCSM) software was created to solve scheduling problems and document mistakes in preventive maintenance (PM) procedures, especially in educational settings where PM is in line with the lecture schedule. To help maintenance workers stay on time, the system serves as a reminder, recorder, and controller. In addition to recording maintenance histories for future use, RCSM broadcasts notifications and permits validation and verification that activities are finished as scheduled. The major purpose of RCSM is to avoid human error-related problems in PM scheduling and reporting, such unrecorded maintenance or missing tasks, which may result in PM mismanagement in subsequent cycles. Additionally, it helps to reduce maintenance gaps owing to missing or insufficient documentation by coordinating PM with educational schedules to minimize disturbance and reinforce preventative actions through digital reminders and maintenance record preservation (Fauzi, Yuliadi Erdani and Achmad Sambas, 2023).

Pros

The current "Reminder & Control System Management" (RCSM) program has the advantage of improved scheduling accuracy and maintenance documentation, which helps to avoid human mistakes such as unrecorded service activities or missing maintenance tasks. RCSM reduces the possibility of equipment being ignored by ensuring that PM tasks are finished on time by promptly reminding and notifying technicians. In addition, the app's historical tracking features allow the keeping of exact records of machinery history, enabling more efficient planning for upcoming maintenance requirements.

Cons

However, RCSM's overall efficacy in complete maintenance management is limited by a few limitations. With no maintenance features that may actively detect any problems before they increase, it mainly serves as a notice and documentation tool. In addition, because the program depends on users following their schedules, it may still need human supervision to handle more intricate operations. Its scalability for cross-platform scenarios is further limited by its Android-only platform, which restricts accessibility for teams who depend on other operating systems. These drawbacks show that a more overall PM solution is required, one that goes beyond activity tracking and reminders.

Research Gap

The primary research gap identified in the current "Reminder & Control System Management" (RCSM) application is its focus on scheduling alerts and documentation without using advanced features for complete machinery maintenance management. RCSM effectively reduces beings' error in preventive maintenance (PM) through reminders and activity tracking but lacks functionalities for real-time data tracking, material purchasing planning, and workforce scheduling, which are essential for a reduced maintenance process. My proposed machinery maintenance app aims to address these gaps by integrating features such as material and resource management, predictive maintenance insights, and a cross-platform design for broad accessibility. These additions will provide a more complete PM solution, enhancing both efficiency and operational validity compared to existing solutions like RCSM.

An Android-based Vehicle Maintenance Application.

aims to improve security and efficiency in vehicle operation, the current Androidbased car maintenance application uses GPS tracking, connects users with local service facilities, and provides timely service alerts (Pooja et al., 2018). The system consists of:
Login and registration features for users and facilities.
GPS tracking in real time to find repair facilities and provide support during emergencies. notifications for future maintenance according to the mileage of the car.
Garage staff oversee billing, record-keeping, and service status updates. GPS data mining is used to identify service areas with high demand and enhance user suggestions.
By automating contact and location-based services with an Android application, this method focuses on convenience first and addresses both urgent and regular maintenance requirements (Pooja et al., 2018)

Pros

By automated maintenance notifications, the Android-based vehicle maintenance software simplifies user life and ensures cars in good repair. In the event of a car breakdown, GPS integration enables customers to quickly identify service locations in their area. By studying high-demand regions, methods such as data mining allow for improved service suggestions. This improves efficiency and customization for users and increases cost-effectiveness by promoting prompt maintenance and lowering the need for unplanned repairs.

Cons

The app's scope has been limited still, as it mostly serves to normal vehicle demands and lacks features specifically designed for maintaining industrial machines. Requirements for manual data entry, including mileage, increase the possibility of mistakes, and the system's dependence on GPS may make it less useful in distant locations. The reliability and particular maintenance requirements of various machinery types may also be impacted by its restricted approach to preventative maintenance, which might result in less effective service scheduling.

Research Gap

The limited functionality of the current vehicle maintenance application for industrial equipment, which requires specific maintenance characteristics, presents research requires. In contrast to regular vehicles, equipment such as generators and HDD machines need a thorough materials management system, organized preventative maintenance plans, and daily meter-based tracking. Furthermore, automated paperwork, methodical reminders, and efficient staff allocation for machinery maintenance are absent from the current approach. In order to guarantee total preventative care and lower the possibility of neglected maintenance, these gaps underscore the need for a more reliable application that is suitable to the intricate needs of equipment maintenance.

Application-based support for machine maintenance.

The research paper's current approach for enhancing a company's machinery maintenance procedures is around Total Productive Maintenance (TPM) and its component, Autonomous Maintenance (AM). TPM encourages departmental cooperation for efficient equipment maintenance while optimizing the lifespan and performance of manufacturing equipment. Autonomous maintenance (AM) entails giving machine operators basic maintenance tasks such as periodic checks, oiling, minor repairs, and anomaly detection. By actively including operators in the maintenance process, this strategy aims to reduce maintenance costs, increase productivity, and decrease breakdowns. The research also looks at how an application might help with these maintenance tasks by facilitating effective task management with the use of technological devices, interactive resources, educational films, and simple access to maintenance data.

Pros

Improved efficiency, increased equipment dependability, fewer machine breakdowns, and lower operating costs are just a few benefits of using TPM and AM techniques. By using technology, technicians may more effectively carry out and document maintenance tasks, which promote greater adherence to quality standards and maintenance schedules. This lowers the possibility of human mistake, improves operator skill development, and encourages more interaction with the equipment (Ayele et al., 2017; Kosicka et al., 2018).

Cons

Frequent personnel turnover and the requirement for methodical training present difficulties, but it might take some time for new operators to become acquainted with repairs. Also, even if operators do basic maintenance, major repairs can still call for highly qualified workers, which, if improperly handled, might cause workflow disruptions. If technical help is insufficient, a possible reliance on digital tools for maintenance tasks could result in problems, especially for distant or limited-resource settings (Holik, 2018; Patalas-Maliszewska et al., 2018).

Research Gap

There is limited research on how a custom mobile application may enhance realtime monitoring, automate notifications for impending maintenance tasks, and track past service history in a preventive maintenance system, even if the study article offers a solid basis in TPM and AM. By creating a smartphone application that converts the whole maintenance process from registering machinery information to sending automated notifications for servicing requirements, employment planning, material purchase, and reporting generation, the suggested project seeks to close this gap. In addition to providing organized maintenance for large machinery, this solution offers a methodical approach to operational requirements, monitoring and management, lowering risks and enhancing output in locations where manual procedures are still commonly utilized.

2.3 Existing Systems

IBM Maximo Manage

IBM Maximo Manage is an Enterprise Asset Management software solution developed by Project Software & Development Inc. in 1985. Acquired by IBM in 2006, it is an AI-powered system used across industries like manufacturing, energy, transportation, utilities, and healthcare. It helps organizations monitor, maintain, and optimize their physical assets, reducing operational costs and enhancing asset reliability.

The platform integrates real-time asset monitoring, IoT capabilities, AI-driven analytics, and automation to support predictive maintenance strategies, enabling organizations to transition from reactive to proactive maintenance, ensuring equipment longevity and efficiency. (Ibm.com, 2025)

Features:

The system optimizes asset management by tracking all assets, including machinery, equipment, and facilities, while storing lifecycle details for better oversight. It automates maintenance task creation, assignment, and tracking, enabling field technicians to manage tasks remotely based on urgency and asset condition. AI-powered predictive maintenance, integrated with IoT sensors, monitors asset performance and schedules inspections to extend asset life. Inventory and supply chain management track spare parts, automate reordering, and integrate with procurement systems to prevent shortages. IoT sensors collect real-time asset data, detect anomalies, and trigger maintenance alerts, while AI predicts failures for proactive management. The system provides detailed reports, real-time dashboards, and compliance tracking. Technicians can access asset details and schedules via mobile devices, while cloud-based deployment ensures remote management and scalability. Seamless integration with ERP systems like SAP and Oracle, financial tools, and API-based connectivity enhances interoperability and operational efficiency.

SAP Plant Maintenance (SAP PM)

The Enterprise Resource Planning (ERP) system from SAP has an advanced maintenance management module called SAP Plant Maintenance (SAP PM). It is especially made for companies that require work order administration, preventative maintenance, and thorough monitoring of assets to increase equipment reliability and productivity.

By monitoring equipment, reducing delays, and maximizing maintenance expenses, SAP PM is extensively utilized in the manufacturing, utilities, oil and gas, transportation, and energy sectors to ensure uninterrupted service. (Top, 2025)

Features:

The system streamlines asset management by tracking machinery, equipment, and facilities while storing lifecycle details for efficient oversight. It automates maintenance tasks, enabling field technicians to manage and prioritize them remotely. AI-driven predictive maintenance leverages historical data and IoT sensors to monitor asset performance, schedule inspections, and enhance longevity. Inventory and supply chain management ensure spare parts availability by automating reorders and integrating with procurement systems. IoT sensors collect real-time asset data, detecting anomalies and triggering maintenance alerts, while AI predicts failures for proactive management. The system provides detailed reports, real-time dashboards, and compliance tracking. Technicians access asset details via mobile devices, with cloud-based deployment enabling remote management and scalability. Seamless integration with ERP systems like SAP and Oracle, financial tools, and API-based connectivity enhances interoperability and operational efficiency. (Top, 2025)

Fiix by Rockwell Automation

Rockwell Automation created Fiix, a cloud-based Computerized Maintenance Management System (CMMS), to assist industrial companies with asset monitoring, work order tracking, predictive maintenance, and maintenance operations optimization.

Designed for industries including utilities, manufacturing, energy, transportation, and food and beverage, Fiix helps companies move from reactive to proactive maintenance, which lowers downtime, increases asset dependability, and reduces maintenance costs.

Fiix is a cloud-native solution that provides flexibility by enabling remote data access, mobile work order management, and integration with IoT and AI-driven analytics for maintenance teams. (Fiix, n.d.)

Features:

Fiix provides complete maintenance management by automating assigning tasks, enabling field workers to remotely manage work orders through mobile access, and providing real-time assets and tracking work order. By scheduling maintenance based on usage patterns and data from IoT sensors, its AI-powered predictive and preventive maintenance capabilities set off alarms to avert unplanned malfunctions. By automating reorders, maintaining updated stock levels, and connecting with procurement systems, the system ensures effective inventory and spare parts tracking. Without the need for on-premises installations, a mobile and cloud-based strategy allows for real-time notifications, offline data entry, and remote access.
With AI-driven dashboards for well-informed decision-making, advanced analytics and reporting provide real-time insights into equipment performance, maintenance history, and compliance. Fiix ensures seamless process automation, cost tracking, and improved operational efficiency by integrating with ERP, IoT, and automation systems like SAP and Oracle. (Fiix, n.d.)

eMaint CMMS (by Fluke)

A cloud-based computerized maintenance management system (CMMS) with extensive customization capabilities, eMaint CMMS was created by Fluke Corporation. To decrease downtime, increase asset dependability, and streamline maintenance procedures, it is intended to assist companies in a variety of sectors, including manufacturing, oil and gas, energy, utilities, and facilities management. eMaint provides immediate data into asset health as part of Fluke Reliability by integrating with enterprise asset management (EAM) systems, condition monitoring sensors, and predictive maintenance solutions.

With its IoT-based predictive maintenance, automation features, and mobile accessibility, eMaint is a scalable solution that can be used by both small and big companies.

Features:

Preventive maintenance may be scheduled according to time, usage, or conditionbased triggers with eMaint CMMS, which also automates work order development, assignment, and tracking. Asset tracking is centralized, and maintenance records, part replacements, and service notes are stored. QR and barcode scanning are used for fast identification. Through the automation of reordering, integration with procurement systems, and stock level monitoring, the system improves inventory and components management. IoT sensors used for condition monitoring identify problems in asset performance, which in turn initiate automatic work orders and facilitate predictive maintenance. Real-time data and dashboards that may be customized offer information on compliance tracking, maintenance expenses, and asset outages. Its deployment via mobile and cloud platforms ensures maintenance teams real-time notifications, offline capability, and global access. Through REST APIs, eMaint CMMS easily connects with third-party apps, IoT platforms, and ERP systems like SAP and Oracle. This allows for remote maintenance operations, decreases downtime, and optimizes inventory.

Limble CMMS

Limble CMMS, or Computerized Maintenance Management System, is a cloudbased platform for maintenance management that helps small and mid-sized
Industrial organizations increase operational efficiency, reduce downtime, and streamline asset maintenance.

Preventive maintenance scheduling, asset lifecycle tracking, and work order management are all made simpler for maintenance teams by its user-friendly and straightforward interface. In sectors including manufacturing, healthcare, logistics, and facilities management, Limble CMMS is frequently used due to its AI-powered predictive maintenance, mobile accessibility, and real-time reporting capabilities.

Features:

Limble CMMS analyzes historical data and IoT sensor inputs using AI-powered predictive maintenance to identify possible equipment faults before they occur and save downtime. It allows for configurable priority levels and regular maintenance plans, and it automates the development, assignment, and monitoring of work orders. To support financial planning, the system keeps track of asset lifetime costs, performance, maintenance history, and depreciation. Technicians may see repair orders, quickly identify assets by scanning QR codes, and get real-time updates from any location thanks to complete offline and mobile support. Managers may make data-driven choices with the use of advanced reporting and KPI tracking, which offer real-time insights into asset health, work productivity, and maintenance performance. For companies of all sizes, Limble CMMS provides an easy-to-use, scalable system that lowers maintenance costs, increases equipment longevity, and improves technician productivity.

MPulse Maintenance Software

A computerized maintenance management system (CMMS) called MPulse Maintenance Software was created to assist businesses in effectively managing work orders, asset monitoring, and preventative maintenance.

With capabilities to enhance maintenance procedures, minimize downtime, and maximize inventory management, it is extensively utilized in the manufacturing, fleet management, healthcare, utilities, and government sectors. Real-time insights into equipment performance are made possible by MPulse's integration with IoT sensors, mobile applications, and customized dashboards. (MPulse Software, 2024)

Features:

By automating predictive and preventive scheduling and optimizing servicing intervals with sensor inputs and historical data, MPulse Maintenance Software simplifies fleet and equipment maintenance. To avoid shortages and overstocking, its inventory management system interfaces with procurement systems, automate reordering, and monitors the availability of replacement parts. Real-time sensor data is gathered via IoT-enabled asset status monitoring, which then uses anomaly detection to send out predictive maintenance notifications. With barcode/QR scanning for fast asset identification and offline use for remote sites, technicians may effectively handle work orders on mobile devices. Custom dashboards assist budget and compliance choices by offering real-time information into technician productivity, asset up time, and maintenance costs. MPulse is scalable for companies of all sizes since it lowers downtime, increases maintenance effectiveness, delays asset life, reduces inventory costs, and permits data-driven decision-making. (MPulse Software, 2024)

2.4 Use case Diagram

2.5 Drawbacks of the existing system

- High Implementation Costs

Many companies CMMS/EAM systems, such as SAP PM, IBM Maximo, and MPulse, are costly for small and medium-sized companies because to their high license, facilities and customization costs.

- Complexity with a High Learning Curve

Companies who have limited IT skills may find it challenging to deploy advanced systems with AI, IoT, and ERP connections (such as IBM Maximo, SAP PM, and Fiix) since they frequently require specialized training.

- Over-Designed for small companies

Solutions such as Limble CMMS and eMaint CMMS provide a wealth of functionality that small businesses might not need, resulting in underused features and higher maintenance expenses.

- Challenges with Flexibility and Customization

Because of their inflexible designs, most current systems need to be costly customized to meet specific company needs. As compared to this, MechniX is specifically designed for the workflow of its target company.

- Depending on cloud and internet services

Fiix, Limble CMMS, and eMaint are examples of cloud-based systems that rely significantly on internet access, which might cause operational issues if the company has connectivity problems.

- Complex Requirements for Integration

For companies without an established digital platform, integrating SAP PM and IBM Maximo with ERP, procurement, and finance systems can be difficult and resource intensive.

Disparities Between MechniX and Current Systems

The current systems, which integrate AI, IoT, and ERP systems to provide predictive maintenance, asset tracking, and inventory management, are enterprise-level CMMS and EAM solutions intended for large-scale industrial applications. These systems include IBM Maximo, SAP PM, Fiix, eMaint, Limble CMMS, and MPulse. For sectors including manufacturing, energy, and healthcare, these systems focus on automation, analytics, and scalability. On the other hand, MechniX is designed especially for private firm machinery maintenance, providing a more efficient, SME-friendly method. MechniX places more emphasis on role-based access for supervisors and operators, real-time email and in-app message notifications, and easier preventative maintenance monitoring than huge CMMS solutions. While it cannot be integrated with AIdriven analytics, IoT sensors, or ERP systems, it does concentrate on useful, affordable automation for material management, maintenance scheduling, machinery tracking, and service reporting. Because MechniX is a web application, it is easy for the target firm to use, while corporate solutions are frequently more feature-rich and difficult.

Chapter 03 - Requirements Specification

3.1 Functional requirements

Functional Requirements by Roles of Users

Supervisor

Supervisors are in the role of managing equipment, assigning work, and making sure maintenance plans are followed too.

- **Machine Registration and Database Creation -**

Entering the brand, model, and unique ID allows you to add new machinery. able to retain and handle meter readings, maintenance histories, and service information.
Able to change or remove information about machines as needed.

- **Meter readings and work-hour monitoring -**

Can check and monitor machine meter values daily.
Can manually update meter readings as necessary.
can track machine operating hours in real time for improved scheduling.

- **Service Notifications and Scheduling**

Depending on schedules or meter readings, automatically receives service notifications.
Ability to create regular maintenance plans for every equipment. able to alter maintenance plans in response to usage of equipment.

- **Task Allocation and Manpower Monitoring**

Can provide technicians with maintenance or repair assignments.

- **Planning the Purchase of Materials and Handling Stock**

Can see the maintenance material inventory that is currently available.
When supplies run short, they might request additional supplies.
Can accept or deny requests from technicians or inventory staff to acquire materials.

- **Service Documentation & Updates**

Allowed to check and accept technician-submitted service logs. May review and obtain historical maintenance records.

- **Reporting and Analyzing Historical Data**

Reports on machine health, maintenance expenses, and service frequency can be generated.
Used to optimize maintenance planning by analyzing patterns in machine failures.

Technician

Technicians oversee reporting machine problems and carrying out maintenance duties.

- **Getting Tasks Assigned**

Receive notifications when maintenance or repairs are assigned.

- **Readings from Meters and Tracking of Working Hours** Update machine meter readings and working hours after servicing.

- **Alerts and Notifications**

Receives reminders for tasks that have been assigned.

Inventory Employee

Employees in inventory control maintenance material stock levels and respond to purchase requests.

- **Checking Stock Levels**

Can monitor the supply of oils, replacement parts, and other maintenance supplies.

- **Responding to Requests for Materials**

Able to accept and examine requests for materials from supervisors and technicians.

- **Processing Purchase Order Processing**

Able to draft purchase orders for products that aren't in stock.

All Users Share Common Features (Supervisor, Technician, Inventory Employee)

- **Authentication and User Registration**

Any user with the proper position can register in the system.
Users must use secure authentication while logging in.
Passwords are encrypted and saved safely.

3.2 Non-Functional Requirements

- **Performance**

The system requires to react to user inputs quickly and be responsive. It should be no delays in the display of real-time meter reading updates, service alerts, and job progress.

- **Scalability**

The system must be scalable, allowing the addition of more machines, technicians, and data without compromising performance. As the company grows, the system should efficiently handle increased data storage and traffic demands, ensuring seamless operation even as the workload expands.

- **Usability**

The user interface should be intuitive and easy to navigate, catering to supervisors, technicians, and store employees. The app must be accessible on both desktop and mobile devices, with mobile optimization specifically designed to support technicians working on-site, ensuring a seamless experience across all platforms.

- **Security**

Data Encryption: Protect sensitive information by encrypting it both during transfer and storage, including machine information and maintenance records.

- **Reliability**

Access always should be ensured by the system's high availability and low downtime. To ensure optimal system performance and dependability, frequent software upgrades and maintenance checks should be planned, and backup procedures must be put in place to prevent data loss.

- **Compatibility**

The system should be compatible with multiple operating systems, including Windows, macOS, and mobile platforms (iOS and Android). It must also integrate seamlessly with other tools, such as email services like Nodemailer, to send notifications and alerts, ensuring smooth communication and workflow.

3.3 Hardware / Software Requirements

Hardware and devices requirements

Mobile devices - Android or IOS

Computers - For developer work.

Internet Access - Required for android studio, firebase and cloud services

Chapter 04 - Feasibility Study

4.1 Operational feasibility

1. **Benefits & Business Value**

The MachniX system delivers significant operational benefits by automating managing stock and machinery maintenance, which enhances productivity and reduces downtime. The main advantages consist of:

Eliminates manual record-keeping - Reduces human errors and ensures accurate maintenance management.

Improves the scheduling of maintenance - Reduces unexpected breakdowns and expensive repairs by ensuring prompt service.

Enhances the management of inventories - maintains records of replacement parts and sends out purchase alerts to avoid material shortages.

Enhances efficiency of tasks - allows managers to keep updated on manpower allocation, service records, and machine usage in real time.

Optimizes the use of resources - ensures that technicians and materials are assigned efficiently, minimizing inefficient expenditures.

Prevents expensive failures - Preventing equipment failures through timely alerts improves asset performance over time.

2. **User-Friendly Interface for Quick Adoption**

The system features an intuitive user interface with simple navigation, role-based views, and minimal data entry to enhance usability. Clear menus and dashboards ensure that supervisors, technicians, and inventory staff can easily access relevant features without unnecessary complexity. Automated calculations, pre-filled forms, and dropdown selections streamline data entry, while responsive design ensures seamless access across both desktop and mobile devices. With these user-friendly design principles, most users can quickly adopt the system with minimal training.

4.2 Technical Feasibility

Frontend – Next.js

Static site generation (SSG) and server-side rendering (SSR) are features of Next.js that ensure quick performance.

Field technicians require mobile optimization - Tailwind CSS responsive UI design.

Backend – Firebase (Cloud function)

Infrastructure administration reduces with serverless architecture.

manages event triggers in real time, such as maintenance alerts.

ensures effective performance by auto-scaling according to demand.

Database – MongoDB

NoSQL is perfect for dynamic maintenance records because of its flexibility.

Ensures effective management of expanding data by scaling horizontally.

Authentication – Firebase Authentication

Supports multi-factor authentication, email/password, and OAuth.

Administrators, technicians, and supervisors may easily manage access depending on requirements.

Notification – Firebase cloud Messaging + Nodemailer

FCM push notifications provide real-time maintenance job alerts.

Email notifications from Nodemailer verify that users receive important alerts.

Version control – GitHub

Enables pull requests and branches for collaborative development.

Supports automated testing and deployment using GitHub Actions.

4.3 Budget Outline

Frontend

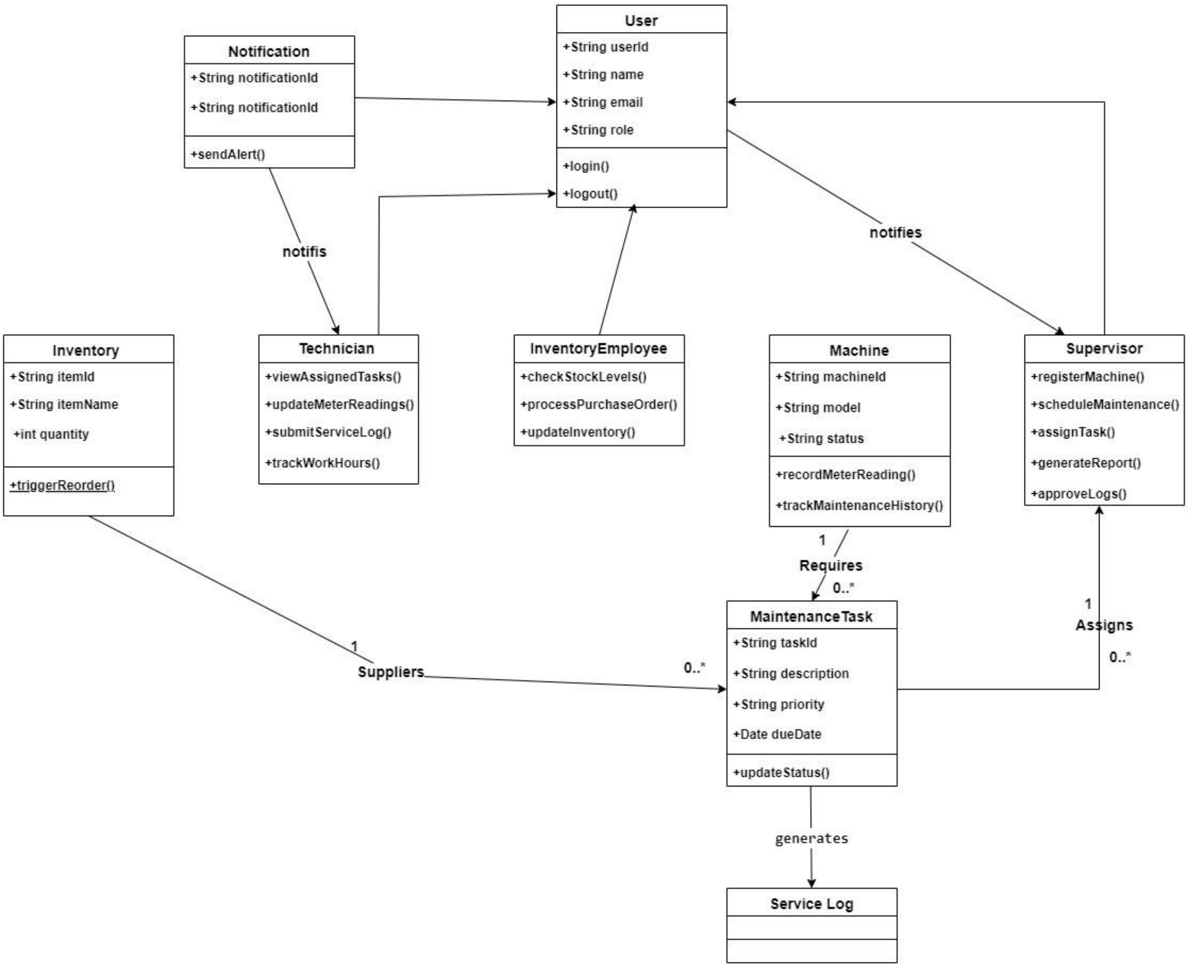
Next.js (React-based) - Free (Open Source)
Tailwind CSS - Free (Open Source)
React Context API -Free (Open Source)
React Hook Form - Free (Open Source)
Firebase Authentication - Free (with limits)

Backend

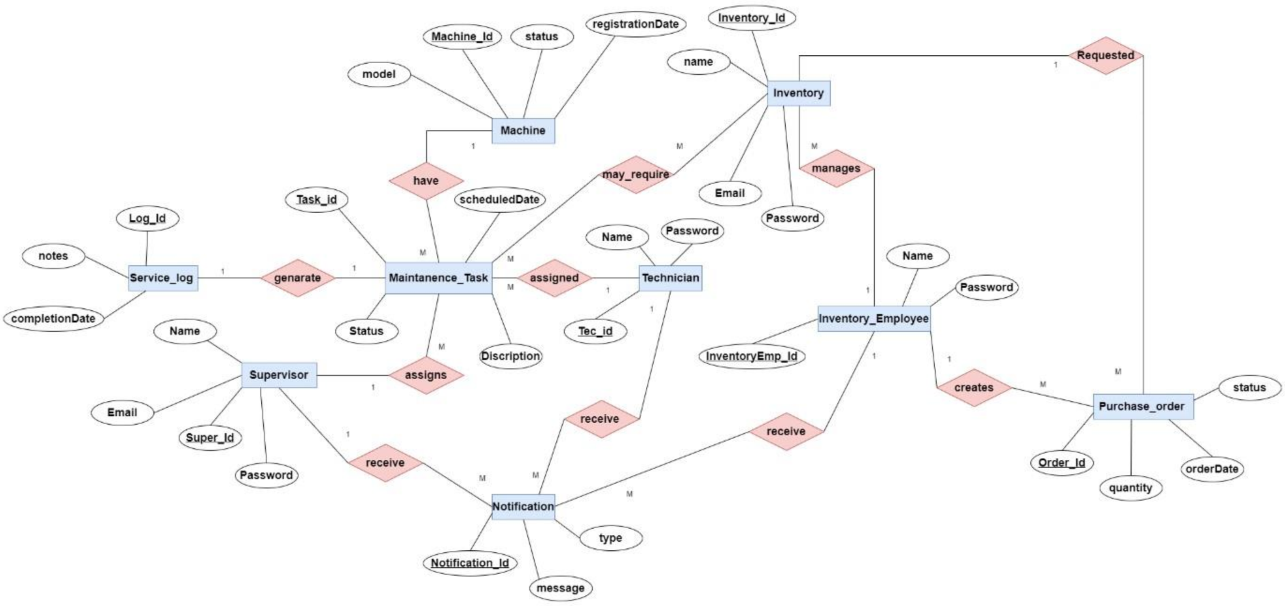
Node.js (Express.js) - Free (Open Source)
MongoDB Atlas (M0 Free Tier) - Free (5GB storage, shared cluster)
Firebase Cloud Functions -Free ($0.40 per month)
Express.js - Free (Open Source)
Node.js Cron Jobs - Free (Open Source)

Chapter 05 - System Architecture

5.1 Class Diagram of Proposed System



5.2 ER Diagram



Assumptions

Supervisors, technicians, and inventory employees are the three categories of users.

In the system, each function has distinct rights and duties.

A machine's model, status, and registration date are among the details that are entered into the system.

Every maintenance task has a machine associated with it and a technician assigned to it.

Technicians are given maintenance assignments by a supervisor.

There are statuses for maintenance jobs.

After the maintenance job is finished, a service log is created.

Every inventory item has a unique name, quantity, and ID.

Reorder levels for inventory items indicate when new inventory is required.

Multiple inventory items may be needed for a maintenance task, and a maintenance task may use an inventory item (many-to-many relationship).

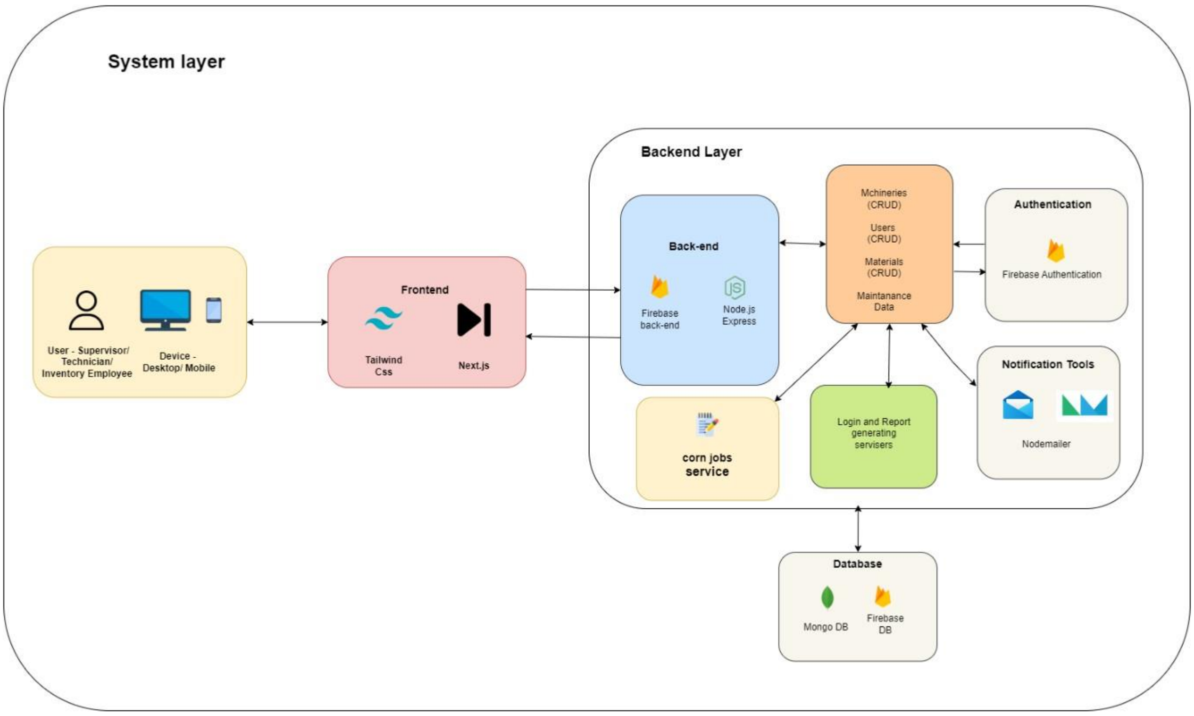
Inventory employees maintain a record of stock levels and issue purchase orders as necessary.

Every purchase order keeps track of the order quantity, date, and status and is connected to an inventory item.
You can request a purchase order for more than one item.

Inventory employees, technicians, and supervisors are informed about relevant tasks (e.g., job assignments, low stock alerts).

A unique source object (such as a maintenance job or purchase order) is associated with each type of notification.

5.3 High-level Architectural Diagram



Chapter 06 - Development Tools and Technologies

6.1 Development Methodology

Agile Development Methodology for Web Application for Machinery Maintenance

This flexible and iterative approach, known as the Agile development Methodology, allows for quick feature development, ongoing feedback, and flexibility. This approach is especially well-suited for the Machinery Maintenance Web Application due to its ongoing system enhancements, changing user requirements, and scalability requirements. The Agile methodology will enable me to:

- Create and develop the system gradually to ensure ongoing progress.
- To improve usability and efficacy, consider input from operators, supervisors, and other stakeholders.
- Improve system performance through iteration in response to user interactions and test findings.
- Make that the system works with real-world expectations, maintenance procedures, and business requirements.

The following stages form the iterative development approach:

- Requirements Gathering and Planning

Identify the main features and user requirements. Describe the restrictions, technological viability, and system goals. To develop key features, get feedback from operators and supervisors.

- Developing and Testing

Use Figma to create wireframes and user interface prototypes.
Give the backend architecture and database schema definitions.
Define access levels, user roles, and system navigation.

- Developing and Testing

Implement features in Firebase (backend services) and Next.js (frontend).
Carry out user, integration, and unit testing.
As going on to the following iteration, identify and fix any problems.

- Implementation and Management

Install the system with security settings on AWS/Vercel.
Keep an eye on error handling, logging, and performance.
Update often in response to comments and new business requirements.

6.2 Programming Languages and Tools

The technology stack is made up of relevant web development technologies that ensure maintainability, scalability, and performance.

- **Frontend**

Framework: Next.js (React-based, supports SSR/SSG)
Programming Language: TypeScript (ensures type safety)
Styling: Tailwind CSS (for a mobile-friendly responsive UI)
State Management: React Context API (or Zustand for lightweight state management)
From Handling: React Hook Form (for managing and validating user inputs)

- **Backend**

Backend Framework: Node.js with Firebase Cloud Functions
Programming Language: TypeScript
Database: MongoDB (NoSQL, flexible schema)
API Development: RESTful APIs with Express.js
Authentication: Firebase Authentication (MFA, OAuth, Email/Password)
Notifications: Firebase Cloud Messaging (FCM) + Nodemailer (for emails) Job Scheduling: Node.js Cron Jobs (for automated maintenance reminders) **Deployment & Hosting**

Frontend Hosting: Vercel (optimized for Next.js)
Backend & Database: Firebase + MongoDB Atlas (cloud-based NoSQL database)
Version Control: GitHub (for collaborative development)

6.3 Third-Party Components and Libraries

Frontend Libraries

next-auth → Authentication handling axios → HTTP client for API requests framer-motion → Smooth UI animations lucide-react → Icons for UI components

shadcn/ui → UI components (modals, forms, tables)

Backend Libraries

express → API routing and middleware firebase-admin → Firebase Cloud Functions and Authentication mongoose → MongoDB ORM for schema management

Nodemailer → Email notifications for maintenance reminders cron → Scheduling maintenance alerts

jsonwebtoken (JWT) → Token-based authentication

- **Deployment & Security**

bcryptjs → Hashing passwords for secure authentication helmet → Security middleware for HTTP headers cors→ Cross-Origin Resource Sharing (CORS) management

6.4 Algorithms

Key algorithms and Logic Implementation.

1. **Algorithm for Preventive Maintenance Scheduling**

Input - Last maintenance date, meter readings, predefined service interval.

Logic –

Compare the most recent maintenance reading that was recorded with the current meter reading.
A maintenance notice should be sent out whenever the threshold—for example, 5000 hours—is surpassed.
Set up alerts for impending maintenance duties.

Output - Alerts and reminders for maintenance.

2. **Logic for Machinery Assignment**

Input - Supervisor assignment, operator workload, and available machines.

Logic –

Machines can be assigned to different operators by supervisors.
Only allocated machines' readings can be updated by operators.

Output - Equipment assignments that are well managed.

3. **User Role-Based Access Control (RBAC)**

Input - Details about user authentication (password, email, OAuth, or multifactor authentication).
Role assigned: Inventory Employee, Technician, or Supervisor.

Logic -

Supervisor (Admin)

Full control and access to the system.
All entities (manpower, equipment, supplies, and maintenance records) may be created, updated, deleted, and managed.
Technicians are assigned to equipment.
schedules and authorizes maintenance work. checks maintenance compliance and checks reports.

Technicians can view and update the machinery that has been allocated to them. refreshes the machine's status and records maintenance activities.
requests the maintenance-related materials.

Inventory Employee manages the inventory of supplies and replacement components. updates availability and keeps track of stock levels.
Accepts requests for materials from technicians.

Output - User roles provide secure access control, ensure that each user may only carry out tasks relevant to their tasks.

Chapter 07 – Discussion

7.1 Overview of the Interim Report

The interim report focuses on developing MachniX, a web-based tool for equipment maintenance that will replace the company's give manual tracking system. The study discusses the inefficiencies of the current manual method, the significance of maintaining industrial machinery, and the many forms of maintenance.

To improve productivity, reduce human error, and better allocate resources, the project develops an automated maintenance management system. The feasibility study, system architecture, requirements definition, system analysis, and development tools are important parts of the report.

7.2 Summary of the Report

Introduction

explains how industrial machinery is used in many industries. explains the role that preventative maintenance (PM) plays in lowering equipment failure rates.

Problem Definition

Currently, the company uses a running sheet for manual record-keeping, which is error prone.
The lack of real-time tracking causes inefficiencies and delays in maintenance scheduling.

Description of the Project

The goals of MachniX are to automate real-time monitoring, inventory tracking, and maintenance scheduling.
Predictive maintenance, historical data tracking, and service alerts are among the features.

Analysis of Systems

Interviews with stakeholders reveal inefficiencies in inventory control and maintenance tracking.
Limitations in the present CMMS (Computerized Maintenance Management Systems) software are found by existing system assessment.

Specification of Requirements

Outlines both functional and non-functional needs, such as system scalability and user roles (supervisor, technician, and inventory staff).

Study of Feasibility

Demonstrates the project's viability from a technical, operational, and financial standpoint.
The cloud-based, economical method guarantees simple implementation and upkeep.

System Development and Architecture

MongoDB is used for data storage, Next.js is used for the front end, and Firebase is used for the back end.
guarantees iterative development by applying the Agile approach.

Challenges and Future Plans

Stakeholder availability and switching from Angular to Next.js for improved performance were the first obstacles.
Finalizing key features, improving UI/UX, and doing thorough testing are the next phases.

7.3 Challenges Faced

Organizing conferences with stakeholders in the requirements-gathering period was one of the main challenges because of their busy schedules. As a result, it takes more time to gather essential feedback and improve the project requirements.

The first frontend framework selection was a further major challenge. Angular was initially utilized for building the project, but I decided to use Next.js because of the intricacies of state management and general development efficiency. Refactoring the current code and adjusting to a new framework took more effort throughout this shift. But in the end, the transition enhanced maintainability and performance.

7.4 Future Plans / Upcoming Work

Completing Up Key Features -
Essential features like inventory control, work monitoring, and maintenance scheduling are available to complete.

Improving User Experience (UX) -
Using Tailwind CSS to create a more user-friendly design and streamlining form processing.

Bug fixing and testing -
Performing full testing to find and fix any security flaws or performance problems.

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