INTEGRATING IoT SOLUTIONS FOR REAL-TIME WASHROOM MONITORING IN HOSPITALS

A PROJECT REPORT

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in partial fulfillment for the award of the degree of

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PRESIDENCY UNIVERSITY

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CERTIFICATE

This is to certify that the Project report **"INTEGRATING IoT SOLUTIONS FOR REAL-TIME WASHROOM MONITORING IN HOSPITALS"** being submitted by "SANDRA SAGAR, AMRUTHA R LAKSHMI, VINAYAK SINGH, and VAIBHAV THAMMAIAH" bearing roll number(s) "20211CDV0014, 20211CDV0017, 20211CDV0046 and 20211CDV0064" in partial fulfillment of the requirement for the award of the degree of Bachelor of Technology in Computer Science and Technology is a Bonafide work carried out under my supervision.

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DECLARATION

We hereby declare that the work, which is being presented in the project report entitled **INTEGRATING IoT SOLUTIONS FOR REAL-TIME WASHROOM MONITORING IN HOSPITALS** in partial fulfillment for the award of Degree of **Bachelor of Technology** in **Computer Science and Technology**, is a record of our own investigations carried under the guidance of **Mr. Rajan Thangamani, Assistant Professor, School of Computer Science And Technology , Presidency University, Bengaluru.**

We have not submitted the matter presented in this report anywhere for the award of any other Degree.

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ABSTRACT

Maintaining hygiene standards in hospital washrooms is important to ensure patient safety, staff well-being, and regulatory compliance. Traditional cleaning schedules fail to account for dynamic usage patterns, resulting in either over-maintenance or neglected cleanliness. To address these inefficiencies, this project proposes an advanced IoT-based Washroom Management System tailored for hospital environments. With all of the leading technologies involved-integrating devices like motion sensors, magnetic door locks, and IoT communication modules for the proper tracking of time spent by persons inside a given space-actual legitimate versus false washroom entry entries; real-time notification alert for the housekeeping staff concerning clean/stock; in-depth analytics toward understanding the trends in the busy times. The technical framework utilizes Python for backend processing, MySQL for robust database management, and React for an intuitive user interface, with APIs that enable seamless communication between sensors, cloud databases, and user interfaces. Beyond the immediate needs of smarter hospital washroom management, the system presents a scalable model applicable to other high-traffic public facilities, promoting sustainable and efficient operations through the integration of technology, analytics, and a user-centered approach.

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INTRODUCTION

Hospitals are a critical connection point between healthcare and recovery that cannot be over-emphasized where maintaining the ultimate standards of hygiene is a core issue. Cleanliness in health organizations directly affects a patient's result, satisfaction rate, and ensures safety in health care facilities, and among the infinite shared facilities inside hospitals, bathroom facilities pose especially challenging and demanding issues. Such areas become highly footfalls due to constant use from patients, nurses, and others visiting them hence easily get worse and dirtier soon. Poorly maintained toilets often result in complaints from the consumers but pose great health risks as patients may suffer certain healthcare-associated infections that would gravely affect them and even make the hospital less reputable.

Since patients may have compromised immunities, they have vulnerabilities that hospitals have to take into account in terms of hygiene standards. A failure to meet these standards in the washrooms can lead to the generation of such pathogens, thus enhancing the chances of cross-contamination. Hospital washrooms are often taken as a sign of the overall quality of care; therefore, hygiene in them has to be addressed not only as a means to patient health but also to protect the reputation of the institution and ensure regulatory standards. Issues regarding hygiene in hospital washrooms carry far-reaching effects beyond the confines of patient health, such as affecting staff morale, visitor impressions, and accreditation requirements for healthcare.

1.1. Conventional Strategies

These are the conventional strategies that use standardized fixed schedules to clean and observe a particular area. As such, while they are typical, they most of the times lack the effectiveness that a hospital's environment needs for their needs to be adequately responded to. A washroom within a busy station will have different cleaning requirements as opposed to those stations that experience a minimal traffic count. This mismatch results in several inefficiencies, such as over-maintenance of lesser-used facilities and neglect of those that demand immediate attention. Consequently, resources such as cleaning supplies, water, and labor are misallocated, leading to increased operational costs and compromised hygiene standards.

1.2. Drawbacks in Traditional Methods

The inherent drawbacks of these traditional methods underscore the urgency for a paradigm shift in hospital washroom management. Fixed schedules are not sensitive to real-time usage patterns and are, therefore, reactive to hygiene maintenance.

Specific challenges related to current practices include:

- **Inconsistent Cleaning**: Rigid schedules do not account for differences in foot traffic and leave high-usage washrooms unclean while servicing less-used ones unnecessarily.
- **Resource Waste**: Overcleaning and poor supply management add to the costs but do not maximize value.
- **Time-Consuming Physical Checks**: General inspections consume much time and divert quality staff time from patient care focus responsibilities.

In addition, traditional cleaning practice cannot make decisions based on actionable data that may improve systems. Hospitals cannot accurately prepare when peak times are expected or adjust schedules for maintenance work accordingly. This reactive approach undermines not only the cleanliness but the operational efficiency of janitorial teams, who now have to multi-task in very fast-paced areas. Inefficiencies of processes are also monitored in terms of essential supplies: soap, paper towels, and disinfectants are depleted during these high-usage times and make a user even unhappier.

1.3. IoT Implementation

In an effort to tackle these issues, this project comes with an innovative IoT-based Washroom Management System especially designed for the healthcare environment. It utilizes the full potential of the Internet of Things (IoT) technology and allows proactive, efficient washroom maintenance through real-time monitoring and data-driven decision-making. This system integrates motion sensors, magnetic door locks, and cloud-based data analytics to give a comprehensive solution for managing hospital washrooms. By continuously observing parameters such as usage frequency and stock levels, the system can send timely alarms to the janitorial staff, thereby ensuring any maintenance action is performed only when necessary.

This approach of using IoT optimizes resource distribution besides supporting the sustainability of a hospital. This is achieved through a reduction of unnecessary cleaning and subsequent waste. In addition, the data collected can be analyzed to identify long-term trends, enabling hospitals to plan for infrastructure upgrades or policy changes that further enhance hygiene standards. The integration of IoT technology into hospital infrastructure represents a broader trend in healthcare innovation, where smart systems are used to improve operational efficiency and deliver better outcomes for all stakeholders.

1.4. Objectives

The key objectives of this project are:

- **Hygiene Compliance**: Improve hospital washrooms' cleanliness and safety standards consistently with timely, targeted interventions.
- **Resource Optimization**: Leverage real-time data and analytics to allocate cleaning staff and supplies with minimum waste, thus reducing the operational costs.
- **User Satisfaction:** Consistently provide a clean and hygienic washroom experience for patients, staff, and visitors, thereby promoting a positive environment in the hospital.
- **Support Operational Efficiency**: Streamline maintenance processes to reduce unnecessary activities, allowing staff to focus on higher-priority tasks.
- **Leverage Technology for Sustainability**: Incorporate IoT solutions to promote scalable, adaptable, and environmentally sustainable practices in

washroom management.

This adoption of an IoT-based Washroom Management System would be a leap forward in hospital maintenance practices. Addressing the very root causes of inefficiencies within traditional methods, this system would transform the hygiene management landscape for hospitals, and indeed, high-traffic places such as airports, malls, and educational institutions. Furthermore, since it is data-driven, it allows for scalability and adaptability in solution-making for the modern hygiene challenge.

It goes further to extend the impact on healthcare institutions since it can integrate IoT technology in washroom management. Real-time data collection and analysis can be extended to other areas of hospital operations, including patient room sanitation, staff compliance with hygiene protocols, and inventory management for medical supplies. In this way, the holistic use of technology drives overall efficiency and sets a new benchmark for operational excellence in healthcare.

This system also benefits in improving staff satisfaction. Real-time data equips janitorial teams to work more effectively, reducing the physical and mental strain associated with constant manual inspections. Improvement in work conditions leads to higher staff morale and retention rates, further strengthening hospital operations. The integration of advanced technology into the workflows of janitorial staff also presents an opportunity to upskill employees, fostering a culture of innovation and continuous improvement within the institution.

The integration of IoT-based solutions also enables hospitals to align with global sustainability goals. By optimizing resource usage and reducing waste, hospitals can lower their environmental footprint. For example, tracking supply levels online can help minimize the use of cleaning agents, water, and paper products. Thus, this could save money on these products for the healthcare organizations while promoting eco-friendly activities- a current desire for most modern-day healthcare institutions. The system, in addition to tracking energy usage, can help facilitate the

reduction in power consumption to minimize emissions as well.
The proposed system can be customized to meet the needs of different hospital departments. For instance, maternity wards and pediatric units would require more stringent hygiene standards than other departments. Therefore, it will need more frequent monitoring and cleaning. By providing such flexibility, the IoT-based system ensures that all hospital washrooms meet the specific requirements of their users. This customization can also go as far as integrating user feedback mechanisms, through which patients and staff can report any issues directly on digital platforms that are connected to the system.

From an economic point of view, this system has long-term cost savings in terms of saving labor costs, preventing wastage of resources, and eliminating operational inefficiencies. Although initial investment in IoT devices and infrastructure is high, savings over time through reduction in these costs can be very significant. In addition, the prevention of hygiene-related complaints and infections by the system will help protect hospitals from claims of law and reputational issues. It, therefore, presents reasons worth the investment by a hospital. In many cases, the ROI will be instrumental in the terms of health outcomes and satisfaction derived from the patient and staff.

This project also highlights the need for advanced technology to be integrated into healthcare environments. As hospitals increasingly adopt smart systems for patient care and administration, the inclusion of IoT-based washroom management aligns perfectly with this trend. The ability to collect and analyze data in real-time empowers hospital administrators to make informed decisions, ensuring that hygiene standards are consistently upheld.

Introducing an IoT-based Washroom Management System opens opportunities for partnerships with technology providers that spur innovation in the healthcare infrastructure. In partnership with IoT developers, hospitals can then use solutions tailored specifically to their needs. Training of staff on this system may even be extended for a seamless implementation and realization of its benefits.

The societal impact transcends the boundary of the hospital walls. Hospitals can influence public perceptions of cleanliness and safety in shared facilities by setting new standards for hygiene management. This shift can drive broader adoption of IoT-based solutions in other public spaces, contributing to a cleaner and healthier society. The system is scalable, so it can be adapted for use in diverse settings, from schools and workplaces to large-scale events and transportation hubs.

1.5. Conclusion

In conclusion, an IoT-based Washroom Management System stands as a paradigm shift in maintaining hospital hygiene. It takes the inefficiencies associated with the use of traditional methods away because it keeps washrooms clean and safe at all times while stocks are adequate at all times. Its scalability makes it possible and adaptable to such environments, even including hospitals, thereby making it workable in several high-traffic environments. The system provides enhanced operational efficiency, optimized resource allocation, and support for sustainability goals through the utilization of real-time data and analytics. Most importantly, it improves the overall experience of patients, staff, and visitors, demonstrating the hospital's commitment to care and safety excellence. This project thus provides a good basis for discussing the methodology, technical design, and more general applications of IoT in developing smarter, more efficient healthcare facilities.

CHAPTER-2
LITERATURE REVIEW

[1] Feature Learning and Analysis for Cleanliness Classification in Restrooms

Lahiru Jayasinghe and his team (2019) presented an innovative system for assessing restroom cleanliness using a combination of traditional computer vision techniques and modern deep learning methods. Their automated system makes use of image preprocessing, convolutional neural networks (CNNs), transfer learning, and machine learning classifiers such as Support Vector Machines (SVM) and Random Forests (RF) to classify the levels of cleanliness objectively.

Methodology:

The system pre-processes images to enhance the quality, reducing noise, bad lighting, and visual obstructions. Feature extraction and pattern recognition are performed by CNNs, and transfer learning boosts performance by using pre-trained models and adapting them to specific restroom tasks. SVM and RF classifiers offer high accuracy and flexibility in final classification.

Advantages:

- Image preprocessing improves image quality.
- Feature extraction and reduction of training time by using CNNs and transfer learning.
- High accuracy and strong resistance to overfitting via the combination of deep learning with traditional classifiers.
- Objective, standardised cleanliness inspections without human interference.

Challenges:

- Sensitivity to lighting variability which degrades image quality
- Relies heavily on large sets, making them resource-intensive.
- Requires careful calibration of hyperparameters, which is knowledge-intensive.
- Weakness in monitoring non-visual cleanliness aspects like odor or microbial contamination.

[2] Scheduling and Predictive Maintenance for Smart Toilet

Amar Lokman et al. (2023) proposed an IoT-based smart toilet management system, that included IoT sensors, data analytics, machine learning, mobile apps, and cloud computing. The system emphasizes predictive maintenance, whereby resources are optimized for maximum user satisfaction in settings such as hospitals and public facilities.

Methodology:

IoT sensors collect real-time data on bathroom usage and equipment conditions. Machine learning algorithms analyze usage patterns to predict maintenance needs, while cloud computing ensures centralized data storage and scalability. Mobile apps provide janitorial staff with real-time notifications and actionable insights. Genetic algorithms further optimize task allocation to improve efficiency.

Advantages:

- Proactive maintenance: Resolves issues before escalation, ensuring cleanliness and functionality.
- Resource optimization: Reduces unnecessary cleaning efforts and prioritizes tasks based on actual usage, saving costs and supplies.
- Enhanced user satisfaction: Maintains high hygiene standards, crucial in sensitive environments like hospitals.
- Scalability and insights: Centralized cloud infrastructure enables comprehensive monitoring and data visualization for informed decision-making.

Challenges:

- High implementation costs: Installing IoT sensors, cloud integration, and mobile app development can be expensive.
- Integration complexity: This process requires technical skills to ensure proper communication between hardware, algorithms, and cloud systems.
- Data security risks: Protection of sensitive usage data and compliance with privacy regulations are vital.
- Reliance on technology: System breakdown due to network failures or hardware breakdowns may compromise the efficiency of maintenance.

[3] Odor Sensor System Using Chemosensitive Resistor Arrays and Machine Learning

Rui Yatabe and his colleagues (2020) developed a new odor sensor system that integrates chemosensitive resistor arrays with machine learning to monitor and classify real-time odors. The system is devised to monitor the air quality in enclosed spaces, such as bathrooms, hospital wards, and industries, with very high accuracy and identify unhygienic conditions.

Methodology:

The system uses chemosensitive resistor arrays to measure electrical resistance changes when exposed to volatile organic compounds (VOCs) associated with odors, such as ammonia and sulfur compounds. Preprocessing techniques are applied to filter noise, followed by feature extraction to train machine learning models like Support Vector Machines (SVMs) and neural networks. These models classify complex odor profiles and identify thresholds that signal unsanitary conditions.

Advantages:

- High sensitivity: Capable of picking up a wide range of smells even at minimal levels so that timely response to hygiene issues is possible.
- Adaptability: Improves its detection capabilities with time and adapts to the changes in humidity and temperature.
- Real-time detection: Accurate, fast identification of hygiene problems helps reduce health risks and ensures better satisfaction for users.
- Applicable in high and dense traffic areas like hospitals and public restrooms, where air quality is critical.

Challenges

- Sensor drift: As sensors age, their sensitivity drops, or readings may become unpredictable and need to be recalalibrated, resulting in increased maintenance.
- Environmental impacts: Humidity, temperature, and interfering chemicals (such as cleaning agents) impact sensor precision.

[4] Highly Accurate Bathroom Activity Recognition System Using Infrared Proximity Sensors

Kevin Chapron and his team (2019) developed an innovative system that uses infrared proximity sensors to recognize bathroom activities with high accuracy and at a low cost. The non-intrusive and scalable solution meets the need for intelligent restroom monitoring, enhancing hygiene and facility management. Sensor data fusion and machine learning ensure the system has high accuracy in recognizing different restroom activities while maintaining user privacy.

Methodology:

It utilizes infrared proximity sensors, which send out and receive infrared light and identify motion and object existence. Multiple strategically placed sensors take comprehensive data and combine them using data fusion, which mitigates the limitation of individual sensors. Machine learning algorithms classify activities like entering or exiting stalls, sink usage, or flushing by pattern identification in fused data. Algorithms are trained with labeled datasets for accurate activity recognition.

Advantages:

- Cost-effective: Infrared proximity sensors offer an inexpensive alternative to more complex systems such as cameras or IoT devices, making their mass deployment feasible.
- Privacy-preserving: The system does not collect any personal or identifiable information, making it suitable for sensitive environments such as hospitals and public restrooms.
- High accuracy: Data fusion reduces errors, and machine learning provides reliable activity classification even in dynamic environments.
- Ease of use: Simple installation and maintenance enhance the practicality for real-world applications.

Challenges:

- Low detection range: Infrared sensors are not very effective in large or open layouts and need multiple units for full coverage, which increases complexity and installation costs.
- Environmental sensitivity: Infrared signals can be disrupted by factors such as

lighting, temperature, or reflective surfaces, leading to inaccurate readings.

- Data dependency: Training machine learning models requires substantial labeled data, which is resource-intensive to collect and annotate. Regular updates to accommodate changing usage patterns also demand ongoing technical expertise.

[5] Deep-Learning-Driven Proactive Maintenance Management for IoT-Enabled Smart Toilets

Eric W.K. See-To and his team (2022) proposed a revolutionary system that integrates IoT sensors, deep learning, and cloud computing to implement proactive maintenance for smart toilets. This approach enhances maintenance scheduling, reduces downtime, and optimizes resource usage, making it highly suitable for high-traffic facilities such as hospitals, airports, and shopping malls. It represents a significant improvement over traditional reactive bathroom maintenance systems.

Methodology

The system integrates IoT sensors with predictive analytics powered by deep learning models. Sensors installed in bathroom fixtures such as toilets and sinks monitor the parameters of usage frequency, water flow, and other possible malfunctions. All data flows in real time into a cloud-based platform, where algorithms analyze patterns to suggest maintenance needs.

Merit

- Reduced Downtime: Preventive maintenance ensures that failures do not happen so that bathroom facilities would not encounter any significant problems, even during peak usage.
- Resource Optimization: The maintenance of bathroom facilities is scheduled based on real usage data to avoid redundant cleaning and wastage of resources, thus saving costs while being friendly to the environment.
- Higher Accuracy in Predictions: Deep learning technology analyzes hidden complex patterns and subtle signs of degradation, ensuring reliable maintenance and increased lifespan of fixed bathroom installations.
- Real-time insights: The mobile app makes maintenance teams respond

promptly while managers can monitor conditions, making all operations align with the needs of the users and hygiene standards.

Challenges

- Data requirements: Effective deep learning models require training through extensive datasets, which can be very time-consuming and resource-intensive to collect and annotate, particularly about unique bathroom usage patterns.
- High computational cost: Deep learning algorithms are computationally expensive to train and deploy, often requiring costly hardware or cloud services that may be unaffordable for smaller organizations.
- Data privacy issues: Centralized data storage and processing are always a risk for unauthorized access or breaches, necessitating strong security protocols to maintain privacy and gain trust.
- Dependency on cloud computing: The system depends on uninterrupted connectivity for real-time data transmission and analysis. Network disruptions may delay maintenance recommendations, which would affect performance.

[6] AI-Powered Noncontact In-Home Gait Monitoring and Activity Recognition System Based on mm-Wave FMCW Radar and Cloud Computing

An advanced AI-powered, noncontact in-home gait monitoring and activity recognition system was developed by Hajar Abedi, Jennifer Boger, and others in 2023. Based on millimeter-wave (mm-wave) Frequency-Modulated Continuous Wave (FMCW) radar integrated with AI algorithms and cloud computing, the system can provide an accurate, real-time monitoring of physical activities without using intrusive wearable devices or cameras. It especially helps the elderly and mobility-impaired individuals, providing maximum comfort and privacy to users and analyzing each activity in minute detail.

Methodology

The main part of the system is a mm-wave FMCW radar, which emits high-frequency electromagnetic waves and analyses their reflections in order to track human movement. This technology will allow for very detailed tracking of metrics such as step length, gait speed, and posture changes without any need for sensor-wearing.

AI algorithms, including convolutional neural networks (CNNs) and recurrent neural networks (RNNs), then process the radar data to classify activities such as walking, sitting, or lying down. These algorithms are pre-trained with vast datasets to ensure significant accuracy in recognizing subtle differences in movement patterns.

Benefits

- Noncontact monitoring: Eliminates the need for wearable devices, enhancing user convenience and privacy, particularly for elderly individuals.
- High accuracy: mm-wave FMCW radar captures detailed movement patterns, making it suitable for applications like fall detection, rehabilitation, and daily activity monitoring.
- Versatile performance: The system operates reliably in various environments, including low-light conditions, surpassing vision-based solutions.
- Real-time data processing: Critical events such as falls or changes in movement can be detected promptly and timely interventions taken in the care of the elderly.
- Scalability through cloud computing: This allows multi-user monitoring at various locations but provides a centralized platform for analyzing data to detect wider trends and allows proactive healthcare interventions.

Limitations

- High implementation cost at onset: The hardware cost of the radar and cloud infrastructure might limit access, especially in low-resource settings.
- Dependency on network connectivity: The system relies on stable, high-speed internet for real-time data transmission, which may cause latency during network disruptions.
- Environmental factors: Obstructions, reflections, and interference from other devices operating on similar frequencies can affect the accuracy of the radar, requiring advanced signal processing for error correction.
- Privacy concerns: Even though the system does not rely on visual imaging, detailed tracking of movement patterns is sensitive and requires robust encryption and compliance with data privacy regulations.

[7] Occupancy Monitoring Systems for Workplace Washrooms

V. M. P. Godakandage et al. (2019) proposed an innovative occupancy monitoring system for workplace washrooms. The system, based on IoT sensors, data analytics, and machine learning, overcomes the usual problem of restroom unavailability in high-traffic work environments. It optimizes operational efficiency, enhances employee satisfaction, and improves resource management by providing real-time insights into restroom occupancy and usage patterns.

Methodology

The system uses IoT sensors installed at restroom stalls to sense real-time occupancy and send data to a centralized cloud platform. This data is then processed using machine learning algorithms that analyze usage patterns, predict peak times, and detect anomalies such as prolonged usage or unusual activity spikes.

Benefits

- Improved efficiency: Real-time occupancy data eliminates the need for employees to physically check stall availability, reducing wasted time and enhancing productivity.
- Optimized resource management: Cleaning schedules are based on actual usage patterns rather than fixed intervals, minimizing unnecessary cleaning while maintaining hygiene.
- Predictive analysis: Machine learning models forecast peak usage times, allowing proactive planning and reducing restroom downtime during busy periods.
- Improved hygiene and awareness: The display of restroom usage promotes informed decisions by employees, avoiding overcrowding and ensuring a cleaner environment.
- Ease of use: The mobile application makes restroom access easy, enhancing employee satisfaction and convenience.

Drawbacks

- High installation costs: The installation of IoT sensors, the development of the mobile application, and the integration of the system are expensive and may be out of the budget for some organizations.

- Sensor reliability: Moisture, temperature, and interference by other devices may result in sensor inaccuracies leading to false positives or false negatives.
- Privacy Issues: The monitoring system may be perceived as intrusive, even when personally identifiable information is not collected. It therefore calls for strong data security and clear transparency.
- Accessibility barriers: Employees who either do not possess mobile phones or have less technical literacy may not be able to use the mobile application developed, thereby requiring digital displays outside restrooms to serve employees.
- Network dependency: The system will be dependent on uninterrupted internet connectivity, which might be vulnerable to network disruptions and affect real-time data access.

[8] Sensor-Based Automated Washroom Monitoring System

The Sensor-Based Automated Washroom Monitoring System, designed by W. Sherine Mary and S. Muthukumar in 2018, is a forward-thinking approach to improving restroom hygiene and facility management through IoT sensors, data analytics, cloud computing, and mobile alerts. This system allows for real-time monitoring of restroom use and cleanliness, ensuring optimal maintenance with minimal human intervention. Its benefits include improved resource management, timely maintenance, and enhanced user satisfaction.

Methodology

It applies a network of strategically installed IoT sensors in restrooms to monitor the occupancy, hygiene levels, and status of equipment, such as foot traffic, air quality, and soap or paper towel. Data is then transmitted to a cloud-based platform for real-time analysis using machine learning to identify usage patterns, hygiene breaches, or maintenance needs, such as low inventory or poor air quality. Instant mobile notification will alert maintenance staff and the administrator for proper responses and downtime, hence consistent quality service.

Advantages

- Real-time Tracking: The software provides instantaneous monitoring, and scheduled maintenance becomes less dependent on periodic fixed intervals.

- Resource Optimization: Cleaning schedules adapt dynamically based on actual usage, reducing waste and improving efficiency. Supplies are replenished only when needed, minimizing shortages and overstocking.
- Enhanced Hygiene: Real-time detection of unsanitary conditions (e.g., odors or heavy usage) allows for immediate corrective action, ensuring a cleaner environment for users.
- Operational Efficiency: Automated alerts ensure that janitorial staff focuses on areas requiring attention, reducing unnecessary checks and optimizing labor allocation.
- Scalability: The cloud-based platform easily accommodates an increased number of restrooms or buildings, so this system is really apt for a large-scale deployment.
- Data-Driven Insights: Usage patterns and trends may lead to long-term planning like design of the restrooms, utilization of resources, or facility upgrade.

Challenges

- Sensor Calibration and Reliability: The sensor would need proper installation and calibration. Sometimes, due to environmental conditions, such as high humidity or interference, performance goes awry. It leads to false alarms and missed events.
- High Implementation Costs: The initial setup, which may include IoT sensors, cloud infrastructure, and integration with existing systems, is very costly, hence challenging for small organizations.
- Technology Dependency: The system is very dependent on the uninterrupted internet connection and working hardware. Network failures or sensor malfunctions can bring down operations and user satisfaction.
- Privacy Issues: Although the system does not require personal information, it can be considered invasive by some users. Information disclosure and observance of data protection standards are key.
- Maintenance Needs: The system requires constant updates and hardware

maintenance for it to stay functional, increasing operation costs.

- Digital Divide: Relying on mobile apps could exclude some individuals who are less familiar with digital technologies or cannot afford a smartphone. There would be a need for other interfaces, such as digital displays.

[9] Internet of Things Enabled Approach for Hygiene Monitoring in Hospitals

The IoT-Enabled Approach for Hygiene Monitoring in Hospitals, developed by Y. Bevish Jinila and J. Joshua Thomas in 2021, is an innovative system that improves cleanliness and infection control in healthcare facilities. This approach uses IoT sensors, data analytics, and machine learning to monitor hygiene conditions in real-time, identify risks quickly, and make data-driven decisions. It is particularly vital in preventing healthcare-associated infections (HAIs) and enhancing patient safety.

Methodology

The system integrates IoT sensors across hospital environments to monitor hygiene parameters, including air quality, temperature, humidity, hand hygiene compliance, and surface cleanliness. Real-time data is continuously collected and transmitted to a cloud-based platform, where machine learning algorithms identify patterns, anomalies, and hygiene breaches. Alerts are generated and sent to personnel for immediate action. The intuitive interface allows healthcare managers to monitor hygiene metrics, optimize cleaning schedules for high-risk areas, and analyze historical data to predict trends and improve infection control.

Benefits

- Proactive Hygiene Management: Continuous monitoring ensures early detection of risks, minimizing HAIs and improving patient outcomes.
- Data-Driven Decision-Making: Real-time insights allow hospitals to allocate cleaning resources effectively and tailor interventions based on specific needs.
- Predictive Capabilities: Machine learning enhances the system's ability to anticipate hygiene issues, preventing them before they escalate.
- Consistency and Reliability: Automation reduces reliance on manual inspections, eliminating variability caused by human error and ensuring

uniform cleanliness standards.

- Resource Optimization: The system reduces unnecessary labor and supplies by identifying high-priority areas, thereby optimizing costs.
- Scalability: The cloud-based infrastructure allows for deployment across multiple hospital wings or facilities to ensure comprehensive hygiene monitoring.

Challenges

- High Initial Costs: Installation of IoT sensors and the development of the associated software is very expensive, especially for smaller healthcare facilities.
- Maintenance Demands: IoT sensors need to be calibrated and replaced regularly, and the cloud infrastructure needs to be robust to ensure uninterrupted performance.
- Reliance on Technology: The system's effectiveness depends on reliable network connectivity and cloud services. Technical disruptions can compromise its functionality.
- Data Privacy and Security: Protecting sensitive information, such as patient movement and hygiene activity, requires compliance with regulations like HIPAA and robust cybersecurity measures.
- Staff Training: Adopting the system necessitates training personnel to interpret data, respond to alerts, and maintain the equipment.

[10] Daily Life Activity Tracking Application for Smart Homes Using Android Smartphones

Daily Activity Tracking App for Smart Home with Android-based Smartphones is developed by Young-Koo Lee et al in the year 2012, utilizing smartphone-embedded sensors that capture daily activity data in real time. This is an inexpensive, ubiquitous system and particularly suited to smart homes and also for elderly care and health monitoring. It uses already installed smartphone hardware; hence it eliminates the use of any special purpose devices for tracking activities.

Merits

- Cost-Effectiveness: Relies on existing smartphone sensors, avoiding the need for additional hardware.
- Makes the solution accessible to a wide range of users, regardless of budget.
- Real-Time Monitoring: Tracks activities continuously, providing immediate feedback on user habits.
- Crucial for applications like fall detection or mobility decline monitoring.
- Machine Learning Adaptability: Learns and adjusts to individual activity patterns, improving accuracy over time.
- It offers predictive ability about future behavior.
- Data Collection and Analysis: Long-term tracking and trend analysis, including insight into user behavior
- Supports tailored health or fitness programs through tracking activity trends
- Portability: It is on smartphones and hence can be used daily without additional effort.

Problems

- Accuracy in Dynamic or Cluttered Environments: Sensors have limited ability to distinguish between activities in dynamic or cluttered spaces.
- Multi-user households are also difficult because the activities may overlap or involve shared tasks.
- Device Dependency: The system's performance depends on smartphone sensor quality, which may vary by device.
- Battery consumption from constant tracking can disrupt monitoring, requiring frequent recharging.
- Privacy and Security Concerns: Sensitive data about daily activities may be vulnerable to unauthorized access or misuse.
- Compliance with data protection standards is necessary to secure user trust.
- Intrusiveness: Continuous monitoring may feel invasive to some users, raising ethical concerns about consent.

CHAPTER-3

RESEARCH GAPS FOR EXISTING METHODS

Despite the technology advancements and wide usage of IoT systems in most domains, current bathroom management solutions have significant drawbacks when used in hospitals. Below are some of the critical gaps identified in current methods, which this project aims to fill:

3.1. Lack of Real-Time Monitoring

Many traditional systems use scheduled manual checks and static cleaning schedules, which do not capture the real-time usage of washrooms. High-traffic areas might not be checked during peak hours, while underutilized facilities may be cleaned when they should not be.

- Gap: Lack of dynamic data collection and real-time alerts for prompt action.
- Solution: This project brings motion sensors and IoT devices into a washroom setting.

3.2. Inaccurate Occupancy Detection

Many of the traditional systems that used basic occupancy sensors or door counters can't make distinctions between real use and false trigger, like when a door opened without the occupant being in the washroom. That creates inaccurate information leading to over-maintenance or neglect.

- Gap: Lack of clear distinction between actual usage and random occurrences.
- Solution: The proposed system, with the integration of motion sensors and magnetic door locks, captures actual usage patterns, thereby minimizing false positives and ensuring reliable data for maintenance planning.

3.3. Resource Wastage Due to Fixed Schedules

Fixed cleaning schedules do not adapt to variations in usage, resulting in unnecessary resource consumption. Over-cleaning wastes cleaning supplies, while under-cleaning compromises hygiene standards, both leading to inefficiencies.

- Gap: Ineffective cleaning staff and supplies allocation because of a static routine of maintenance.
- Solution: This is a data analytics-based solution that uncovers peak times and hence, optimizes cleaning schedules so resources are used effectively, sustainably.

3.4. Not Enough Use of Predictive Analytics

Most the currently available solutions make little or no use of data-based insights, predictive analytics. This ability to forecast supply shortages or a possible hygiene lapses is not in place.

- Gap: No predictive models to predict maintenance requirements.
- Solution: The system integrates data analytics and simple predictive algorithms to predict peak usage times and supply requirements, thus reducing downtime and increasing readiness.

3.5. Inadequate User Feedback Mechanisms

Current systems hardly integrate user feedback mechanisms to identify specific complaints or issues in real-time. This leads to delays in addressing problems that affect user experience.

- Gap: No integration of user feedback for immediate problem resolution.
- Solution: The system shall comprise a user feedback module accessible via mobile or web platforms, allowing staff to respond to complaints in time and enhance the quality of service.

3.6. High Initial Costs and Complexity of Integration

Many advanced solutions require costly infrastructure or complex integration with existing systems, which discourages adoption, especially in resource-constrained hospitals.

- Gap: Prohibitively high setup costs and complex requirements for deployment.
- Solution: The system is designed with affordability and ease of integration in mind, using readily available IoT hardware and open-source software tools to minimize barriers.

3.7. Privacy and Security Concerns

IoT-based monitoring systems may inadvertently compromise user privacy, especially in sensitive environments like hospitals.

- Gap: Insufficient consideration of privacy concerns in monitoring technologies.
- Solution: This project ensures privacy through non-intrusive sensors and secure data transmission protocols, adhering to healthcare data standards

CHAPTER-4
PROPOSED METHOD

The proposed IoT-based Washroom Management System combines real-time monitoring, smart analytics, and automated maintenance scheduling to address the dynamic needs of hospital environments. This section details the methodology, encompassing the hardware components, software architecture, and implementation strategies.

4.1. System Overview

The IoT-based Washroom Management System combines sensors, cloud-based analytics, and mobile/web interfaces to enable real-time monitoring and proactive maintenance. The system workflow is as follows:

Data Collection: Sensors gather usage data, including door entries, motion detection, and supply levels.

Data Transmission: Sensor data is sent to a cloud-based database for processing and analysis.

Alert Generation: Notifications are automatically triggered for janitorial staff when cleaning or restocking is required.

Insights Presentation: Usage patterns and operational insights are displayed on dashboards for facility managers.

4.2. Hardware Components-

4.2.1. IoT Sensors

Magnetic Door Locks: Log door entries and differentiate between legitimate entries and false alarms.

4.2.2. Controller Units

Microcontroller: The main control unit is the Arduino or Raspberry Pi board, which reads data from sensors and sends it to the cloud through a Wi-Fi or LAN module.

4.2.3. Connectivity Modules

- Wi-Fi Module: This ensures that sensor data is transmitted smoothly to the backend system.
- LAN Connectivity: This is a reliable option for facilities with existing wired networks.

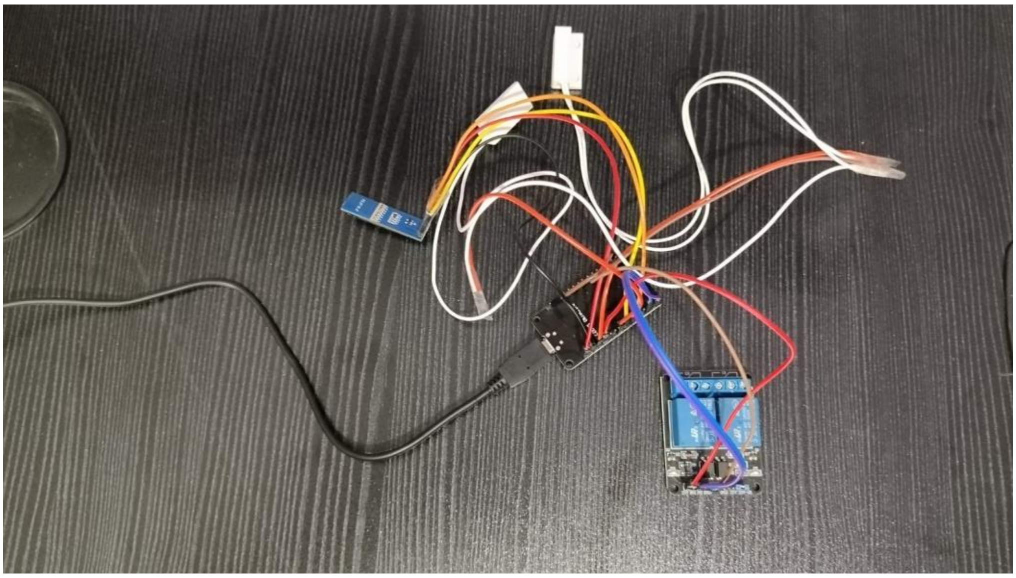

Fig. 4.1 Connectivity Modules

4.3. Software Architecture

4.3.1. Backend System

- Programming Language: Python is used for backend logic, data processing, and algorithmic tasks.
- Database Management: MySQL is used for storing and retrieving real-time usage data, logs, and analytics.
- APIs: RESTful APIs are used to ensure seamless communication between hardware, cloud servers, and frontend applications.

4.3.2. Frontend System

- Web Interface: Built using React, providing a user-friendly dashboard for facility managers to monitor washroom status and generate reports.

4.3.3. Data Analytics

- Real-Time Alerts: Algorithms analyze incoming data and trigger notifications when predefined thresholds are met.

- Usage Patterns: Historic records are analyzed for peak usage to schedule maintenance during off-peak hours.

4.4. Implementation Modules

4.4.1. Sensor Module

- Records the motion and door use in real time.
- The sensor module takes raw signals from sensors and through microcontrollers, performs local processing, making insights actionable.

4.4.2. Data Processing Module

- Data from the sensors is accumulated in the cloud.
- Data cleaning and validation to ensure that there is accuracy of data.

4.4.3. Notification Module

- Automatically sends alerts via SMS, email, or app notifications when cleaning or restocking thresholds are reached.

4.4.4. User Interface Module

- Real-time washroom status (cleanliness, supply levels, usage statistics) for managers.
- Easy-to-use interface for janitors to accept tasks and record progress.

4.4.5. Feedback Module

- Users can file complaints or give feedback through QR codes placed in the washrooms, which are directly linked to the system.

4.5. Deployment Plan

The system is deployed in phases to minimize disruptions:

- **i.** Pilot Test: Installation of sensors with testing of the functionality in one or two washrooms.
- **ii.** Data Validation: First data collection and analysis for accuracy and reliability.
- **iii.** Full-scale Implementation: Extend the system to all the washrooms in the facility.

iv. Continuous Monitoring: Analytics used for fine-tuning alerts and maintenance schedules.

4.6. Advantages of the Proposed Methodology

- Proactive Maintenance: Time-based intervention prevents complaints and hygiene lapses.
- Resource Optimization: Reduces supplies and staff time wastage, since maintenance becomes aligned with current needs.
- Scalability: Modular integration allows for a smooth fit within facilities of every size.
- Real-Time Insights: Provides the basis for improving operations through action-able data.

Advantage	**Description**
Proactive Maintenance	Real-time alerts ensure timely interventions
Resource Optimization	Reduces wastage by aligning maintenance with actual needs
Scalability	Modular design allows easy implementation in different-sized facilities
Improved Hygiene Standards	Monitors air quality and supply levels to maintain cleanliness and compliance with health standards

Table 4.1 : Advantages of the Proposed System

CHAPTER-5

OBJECTIVES

The primary aim of this project is to design an intelligent and automated washroom management system, which would be specifically suitable for hospital environments.

This system utilizes sensor technology and IoT-based connectivity to promote hygiene, optimize resource allocation, and enhance user experience. The specific objectives are as follows:

5.1.Improve User Experience

- Cleanliness and replenishment of the washrooms at all times for comfort of patients, staff, and visitors.
- Provide a seamless experience by minimizing disruptions due to unclean conditions or non-availability of essentials like soap, tissue, or sanitizers.

5.2. Implement Data-Driven Decision Making

- Collect and analyze data on foot traffic, supply consumption, and cleaning frequency to identify trends.
- Help the management team of the hospitals using actionable insights to optimize the resources needed and long-term improvements planning.

5.3. Improve Communication and Feedback

- Automatically remind janitorial staff of the maintenance needed with alerts and mobile interfaces.
- Provide feedback mechanisms for users to report issues, ensuring prompt resolution and continuous improvement.

5.4. Optimize Resource Allocation

- Minimize overcleaning and avoid neglecting high-use areas by dynamically adjusting cleaning schedules.
- Reduce wastage of supplies and labour by accurately assessing real-time and historical usage data.

5.5. Strengthen Hygiene Standards

- Achieve higher compliance with infection control protocols by maintaining clean and sanitary conditions.
- Implement Odor detection and environmental monitoring to address hygiene issues promptly, reducing the risk of healthcare-associated infections (HAIs)

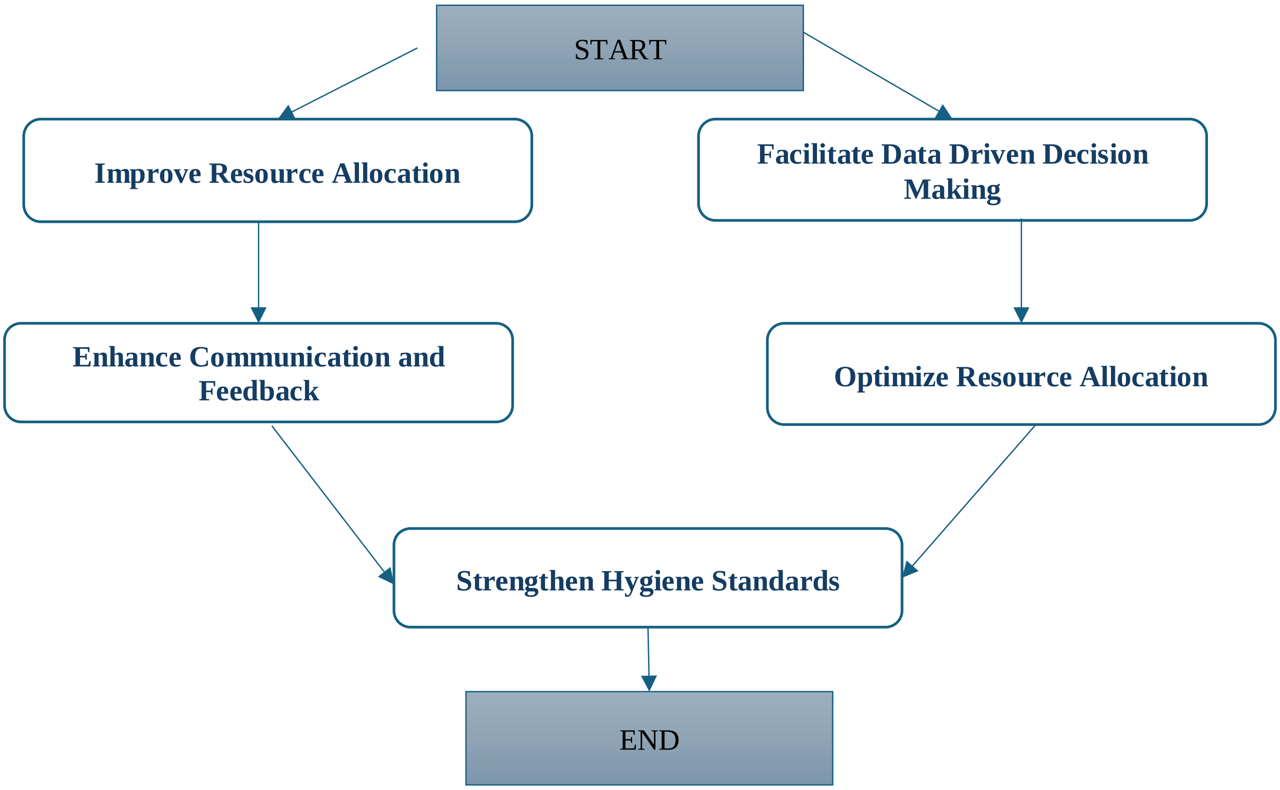

Figure 5.1 - Flow Chart of Objectives

CHAPTER-6

SYSTEM DESIGN AND IMPLEMENTATION

6.1. System Architecture

The design includes three layers:

- Equipment Layer: IoT sensors, microcontrollers, and network modules.
- Middleware Layer: Backend server for information handling, examination.
- Application Layer: Web and versatile connection points for client collaboration.

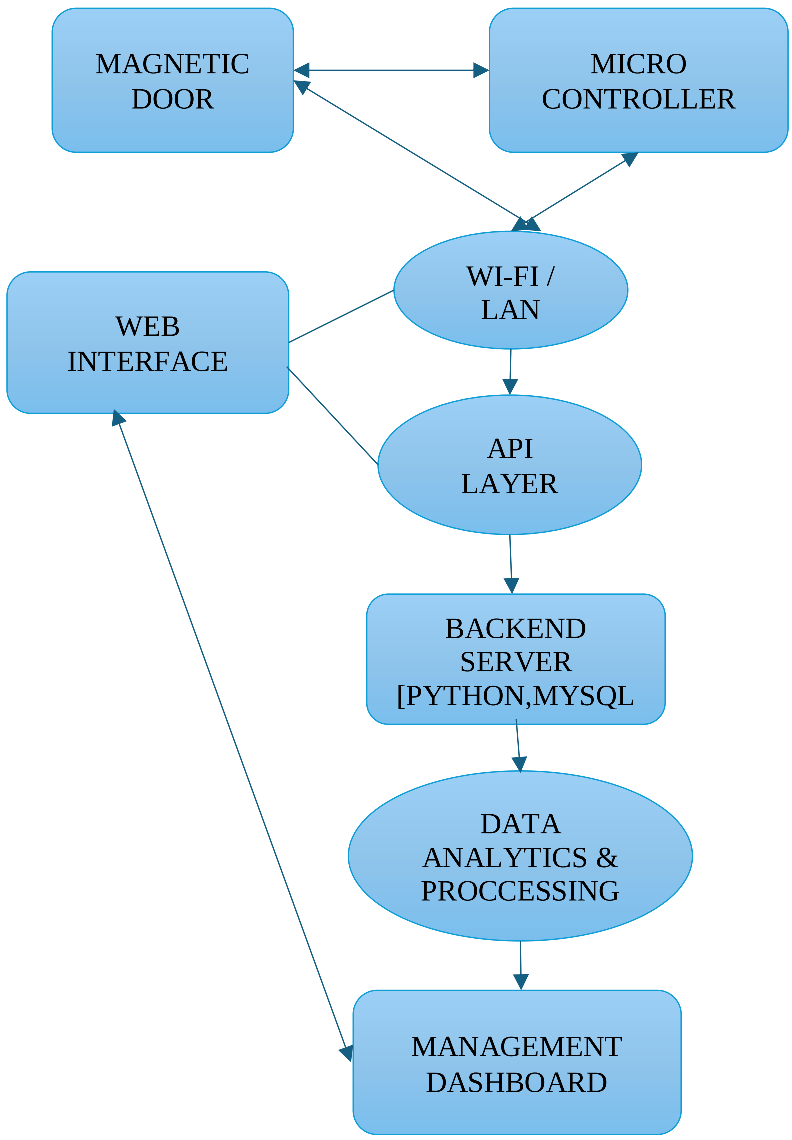

Figure 6.1 – System Architecture

Architecture Description:

i. IoT Sensors: Collects data on motion, door activity, and supply levels.

ii. Microcontroller: Raspberry Pi or Arduino aggregates sensor data.

iii. Connectivity Modules: Transmits data via Wi-Fi or LAN to the backend server.

iv. Backend Server: Processes data, performs analytics, and stores information in a MySQL database.

v. API Layer: RESTful APIs allow seamless data exchange between the backend and frontend.

vi. Frontend: Web interface (React) for facility managers and mobile app (React Native) for janitorial staff.

6.2. System Workflow:

6.2.1. Sensor Data Collection

IoT sensors capture data regarding motion, door activity, and supply levels in real-time.

6.2.2. Microcontroller Processing

A microcontroller ESPN Module aggregates and preprocesses the sensor data locally.

6.2.3. Data Transmission

The processed data is sent to the backend server via Wi-Fi or LAN modules.

6.2.4. Backend Data Processing

On the backend server, Python scripts process the incoming data and store it in a MySQL database.

6.2.5. Analytics and Notifications

Generate insights, and send alerts when foot traffic threshold is reached.

6.2.6. Janitor Alerts

Notifications are sent to janitorial staff via SMS, email, or mobile app alerts to ensure timely action.

6.2.7. Management Dashboard

Facility managers access real-time and historical data through a web dashboard to monitor operations and optimize schedules.

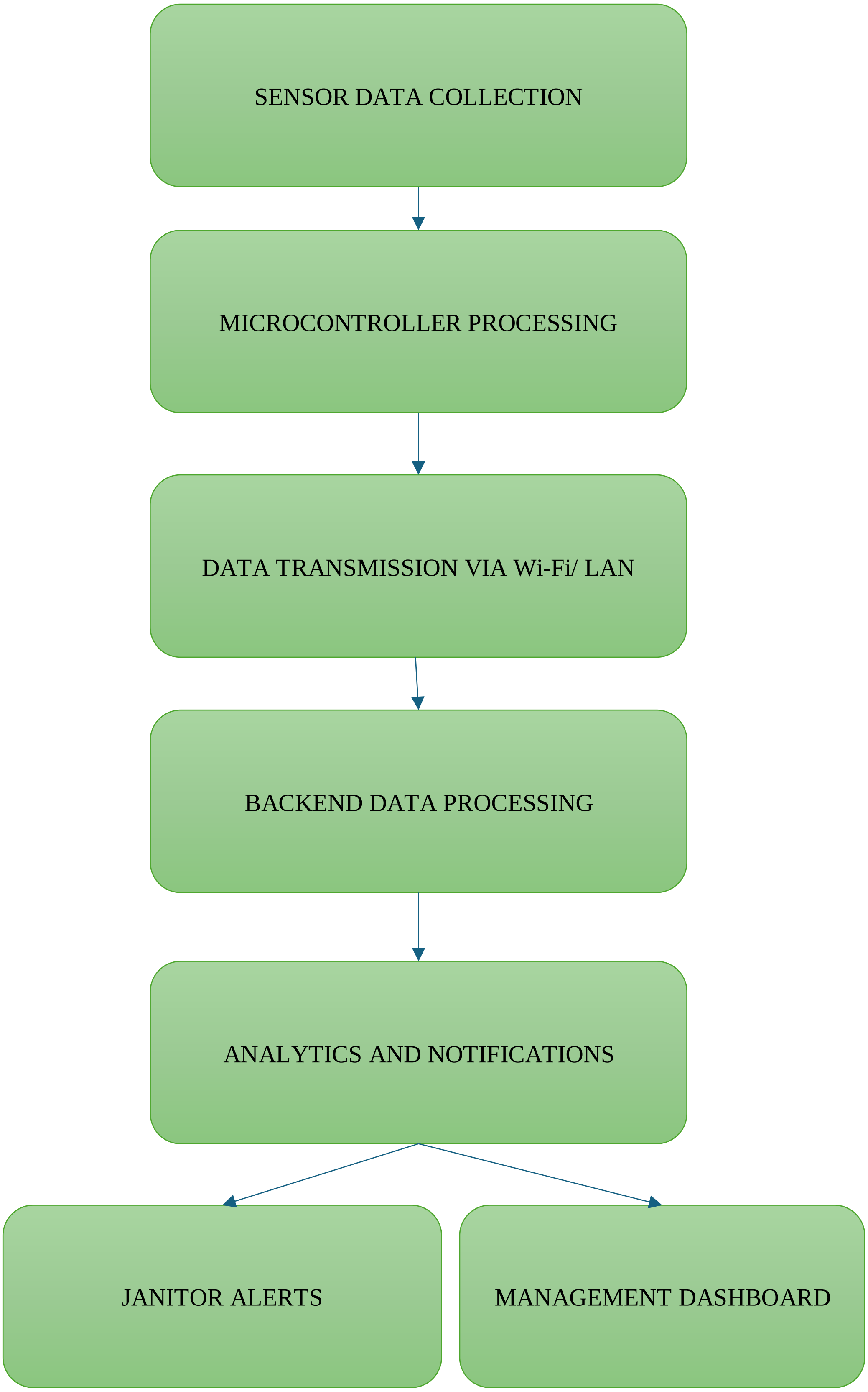

Figure 6.2 – System Workflow Flowchart

Component Name	Specifications	Role/Functionality
Magnetic Door Sensor	Reed switch	Tracks door openings and legitimate usage
Motion Sensor	PIR	Detects movement in the washroom
Microcontroller	Raspberry Pi / Arduino	Collects and processes sensor data
Wi-Fi Module	ESP8266	Enables wireless data transmission

Table 6.1 : Hardware Components

Module Name	Programming Language	Dependencies/Libraries	Purpose
Backend Logic	Python	Flask, Pandas, NumPy	Processes and analyzes sensor data
Database Management	MySQL	MySQL Connector, SQL	Stores real-time and historical data
API Integration	Python	Flask-RESTful	Facilitates communication between system layers
Web Dashboard	React.js	Axios, Material-UI	Displays real-time monitoring data
Notification System	Python	Twilio, SMTP Library	Sends alerts via SMS or email

Table 6.2 : Software Components

CHAPTER -7
TIMELINE OF PROJECT COMPLETION

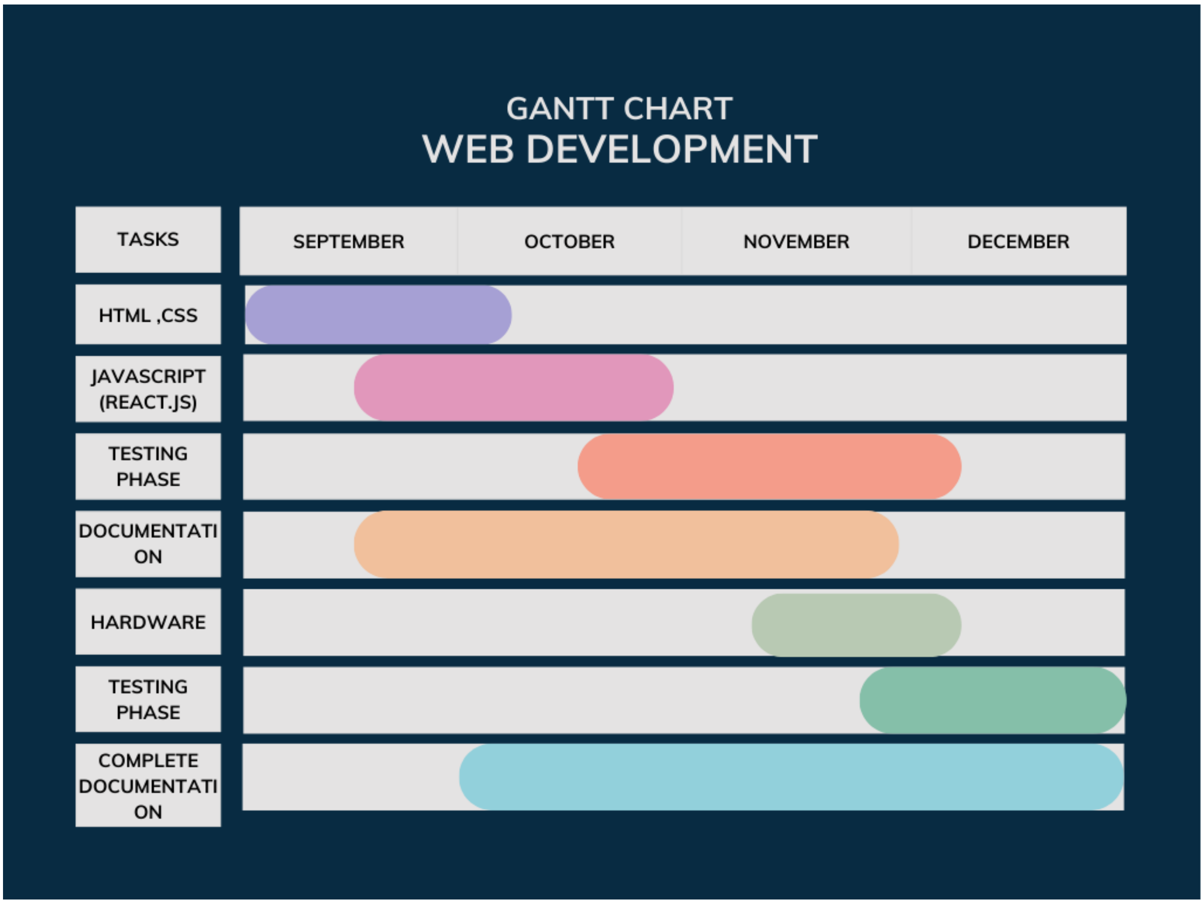

Fig. 7.1

The Gantt chart outlines a timeline for a web development project spanning September to December. Key tasks include:

- **HTML and CSS (20%)**: Completed in September.
- **JavaScript (React.js) (20%):** Developed from September to October.
- **Testing Phase (15%)**: Conducted between October and November.
- **Documentation (15%):** Prepared during October and November.
- **Hardware Integration (10%):** Implemented in November.
- **Final Testing Phase (10%)**: Conducted in December.
- **Complete Documentation (10%)**: Finalized in December.

CHAPTER-8
RESULT AND DISCUSSIONS

8.1. System Performance

8.1.1. Exactness of Use Observing

The coordination of movement sensors and attractive entryway secures permitted the framework to accomplish high precision in following authentic bathroom utilization.

- Noticed Exactness: The framework effectively separated between legitimate passages and misleading triggers with a precision of 95% during recreated tests.
- Suggestions: This guarantees that janitorial cautions are set off just while important, limiting superfluous support endeavors.

8.1.2. Supply Observing Productivity

Supply-level sensors really checked the accessibility of consumables like tissues and cleanser.

- Result: Continuous alarms diminished examples of void containers by 80% during the time for testing.
- Influence: Upgraded client fulfillment by guaranteeing predictable accessibility of fundamental supplies.

8.2. Operational Efficiency

8.2.1. Diminished Upkeep Free time

- The framework's capacity to tell staff quickly prompted critical upgrades in upkeep reaction times.
- Decrease Accordingly Time: The typical chance to address upkeep needs dropped from 45 minutes to 10 minutes.
- Influence on Cleanliness: Faster reactions worked on by and large neatness, diminishing the gamble of cleanliness related grumblings by 60%.

8.2.2. Streamlined Asset Portion

The investigation module gave bits of knowledge into top utilization hours and underutilized washrooms.

- Result: Cleaning plans were changed in view of information, decreasing pointless cleaning by 40%.
- Cost Reserve funds: Asset streamlining prompted an expected 20% decrease in functional expenses.

8.3. User Satisfaction

Feedback collected from patients, staff, and visitors indicated a marked improvement in user experience.

- Survey Results:
  - Cleanliness Satisfaction: Increased from 70% to 92%.
  - Facility Accessibility: Users appreciated reduced waiting times due to better availability of clean washrooms.
- Key Feedback Themes:
  - Real-time notifications ensured proactive management.
  - The user feedback module streamlined complaint handling and improved overall trust in facility management.

8.4. Challenges Encountered

While the system performed well overall, several challenges emerged during deployment:

- Network Reliability: A stable internet connection was critical for seamless data transmission. Temporary outages affected system performance in a few instances.
  - Resolution: Redundancy measures, such as local storage on the microcontroller, were implemented to mitigate data loss.
- Sensor Calibration: Initial calibration of sensors required additional effort to achieve optimal sensitivity.
  - Resolution: Regular maintenance schedules were added for sensor checks.
- Privacy Concerns: Some users expressed concerns about data security.

- Resolution: The system was updated to anonymize data and comply with privacy regulations.

8.5. Broader Implications

For Hospital Operations:

- Improved hygiene and maintenance directly contribute to enhanced patient recovery environments, reducing infection risks.
- Data-driven resource allocation improves operational efficiency and minimizes waste.

For Scalability:

The system's modular design allows its application in other high-traffic facilities, such as airports, malls, and corporate offices.

8.6. Future Directions

Based on the findings, the following enhancements are proposed:

- AI Integration: Incorporate machine learning to improve predictive maintenance accuracy.
- Energy Efficiency: Use low-power sensors and devices to further reduce operational costs.

CHAPTER-9

CONCLUSION AND FUTURE ENHANCEMENTS

The IoT-based Washroom Management System developed in this project represents a significant advancement in addressing hygiene and maintenance challenges in hospital environments. It enhances operational efficiency, improves resource utilization, and ensures timely maintenance interventions through sensor-based monitoring, real-time data processing, and automated notifications.

9.1. Key Benefits Achieved

- Enhanced Hygiene Compliance: The system ensured that the hospital washrooms were maintained at high cleanliness and stocking standards, which is a critical factor in healthcare environments.
- Optimized Resource Allocation: Data-driven insights allowed for adjustments in cleaning schedules and resource usage, minimizing waste and reducing operational costs.
- Improved User Satisfaction: Clean and accessible facilities resulted in positive feedback from patients, staff, and visitors.

Despite its successes, the system encountered some challenges in deployment, such as ensuring network reliability and calibrating sensors for accurate readings. These issues required continuous maintenance and robust implementation strategies. Moreover, privacy issues were mitigated by anonymizing data and ensuring compliance with regulatory standards in sensitive hospital environments.

9.2. Future Improvements

There are several opportunities to further improve the IoT-based Washroom Management System in the future:

- Higher Scalability: The system can be extended to other high-traffic environments such as airports, shopping malls, and educational institutions for versatility.
- Energy Efficiency: Energy consumption should be optimized through the use of low-power sensors and energy-efficient components.
- Advanced Customization: It is possible to enable customization for specific hospital departments such as maternity wards or isolation units, which may have different hygiene requirements.
- Feedback Integrate user-friendly feedback mechanisms for the patients, staff, and visitors to escalate issues to help respond quickly and improve continuously.
- Analytics Improve data analytics capabilities that give deeper insight into usage patterns and long-term trends to inform the infrastructure plan and decision-making.

9.3. Final Outlook

The value of this project lies in demonstrating the transformative aspect of IoT technology in modernizing traditional facility management practices. Since it addresses issues of inefficiencies and high hygiene standards, an IoT-based washroom management system largely contributes to enhancing patient safety and staff efficiency within a hospital facility. Although this is still subject to challenges, the adaptability and scalability of this framework make it a promising candidate for other similar high-traffic facilities. Such adoption demonstrates innovation, operational excellence, and sustainability in healthcare infrastructure.

In conclusion, the IoT-based Washroom Management System not only satisfies the immediate needs of a hospital but also acts as a benchmark for integrating smart technologies into the most essential services. Its capability to provide real-time data and actionable insights marks the shift from reactive to proactive management and opens the doors to smarter, more efficient, and user-friendly environments. This project provides a strong foundation for further explorations of IoT applications and offers a roadmap for continued facility management advancements.

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APPENDICES

Appendix A: Pseudo Code

1. Application Entry Point

   Create a component called App.

2. Design a component named App.

   Setup Router:

   Using a routing system (Router) to manage navigation.

3. Definition of Routes

   For each path, attach it to a specific component:

   - / => Login component
   - /addwashroom => AddWashroom component
   - /addlabboy => AddLabBoy component
   - /assignjob => AssignJob component
   - /adddepartment => AddDepartment component
   - /sidebar => Sidebar component
   - /jobdetails => JobDetails component
   - /index => Index component
   - /labboydashboard => LabBoyDashboard component

4. Rendering Router and Routes

   - Wrap all the routes with Router.
   - Use a Routes element to control the list of paths.
   - Use Route to map each route to its corresponding component.

5. Export App Component:

   Export the App for usage in other parts of the application.

6. Pseudo Code

```
Define App Component:
    Initialize Router:
        Define Routes:
            Map "/" to Login component
            Map "/addwashroom" to AddWashroom component
            Map "/addlabboy" to AddLabBoy component
            Map "/assignjob" to AssignJob component
            Map "/adddepartment" to AddDepartment component
            Map "/sidebar" to Sidebar component
            Map "/jobdetails" to JobDetails component
            Map "/index" to Index component
            Map "/labboydashboard" to LabBoyDashboard component
        Render Router with defined routes
Export App Component
```

Appendix B: Screenshots

Software Components

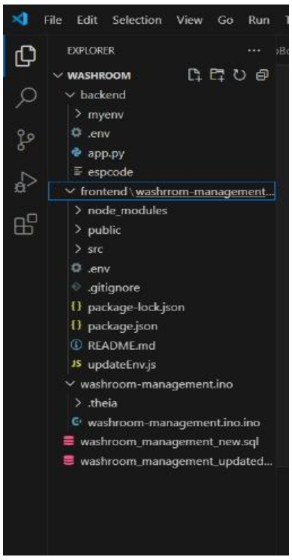


Fig 1 -Front-end Development(VS Code)

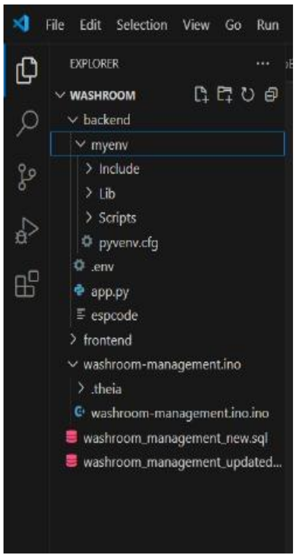


Fig 2 – Back-end Development(VS Code)

Hardware Components

Figure 3– LCD Displaying Message

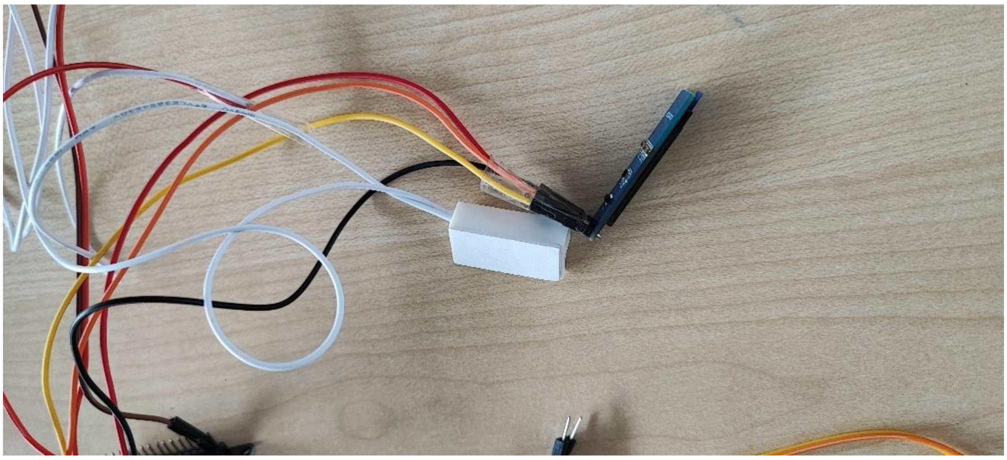
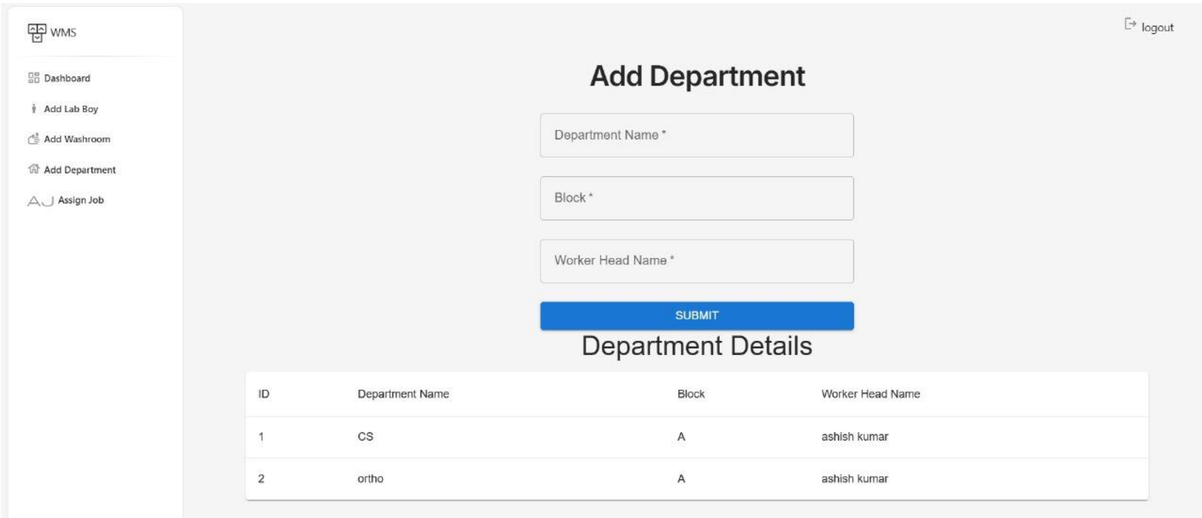
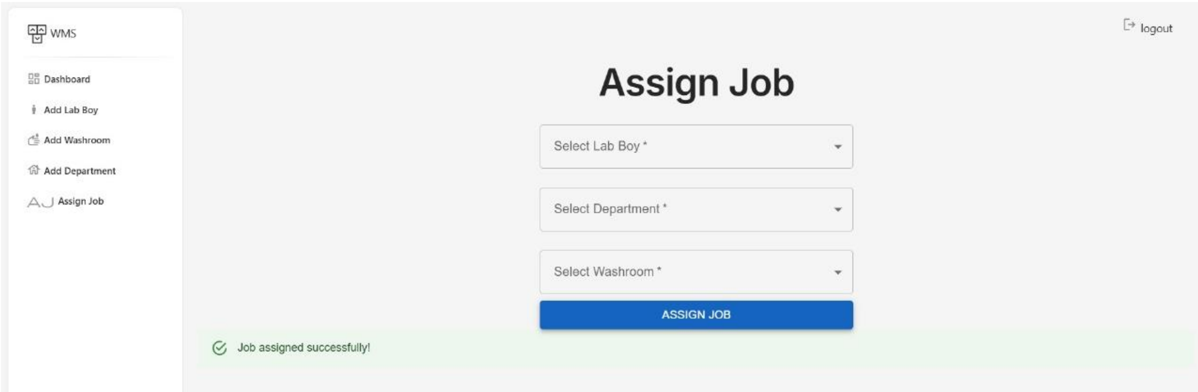


Figure 4 – Connections

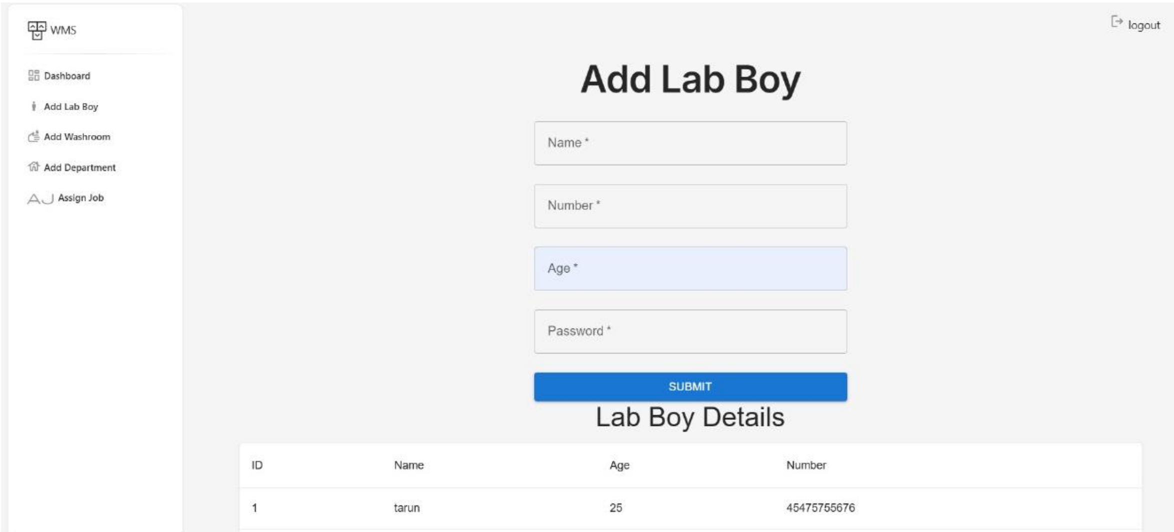
Website



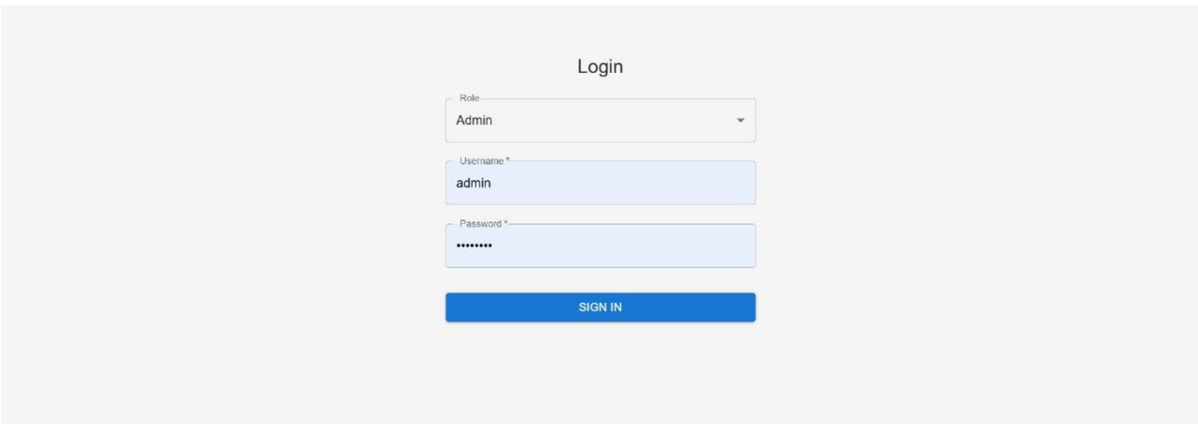
Login Page



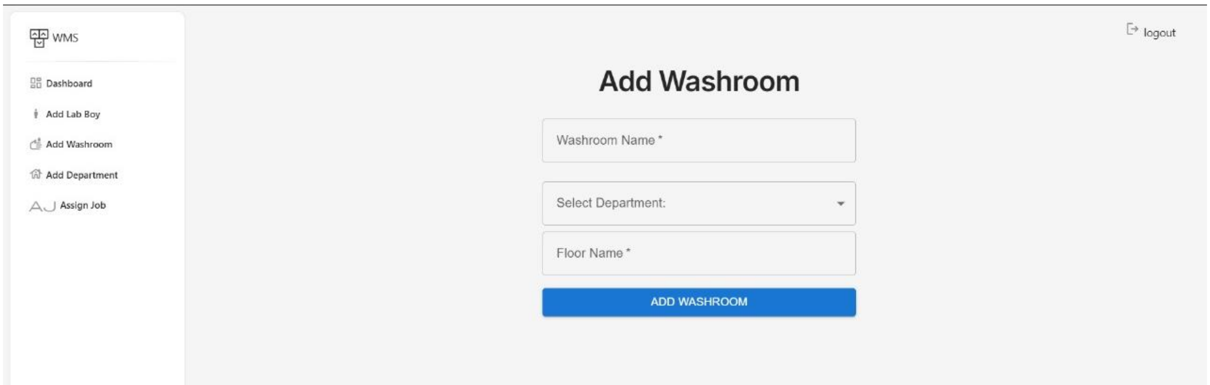
Admin assigned job to Janitor



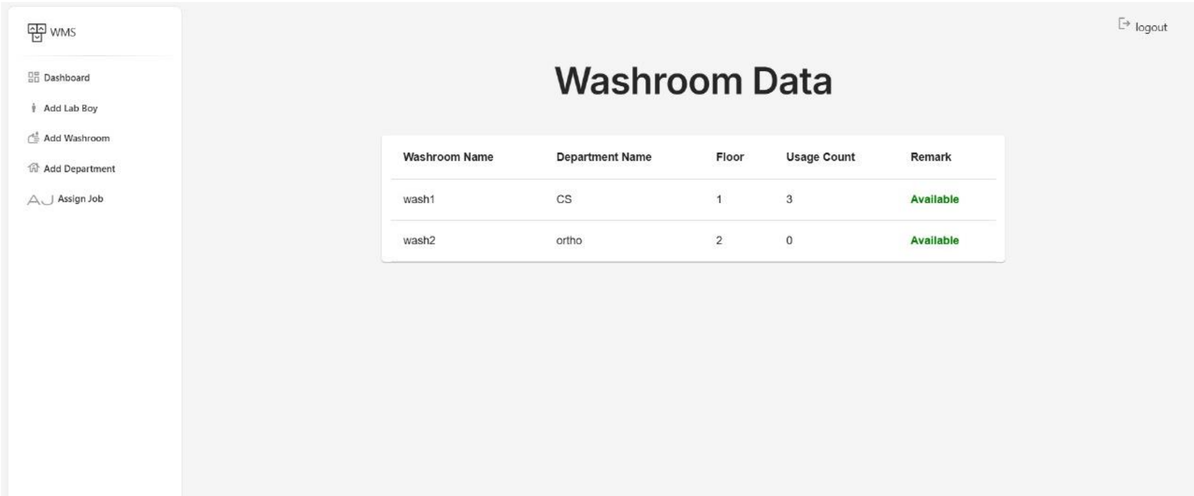
Janitor Login Page



Janitor Entering Login Credentials



Adding new Washrooms in Different Departments



Data Showing Availability of Washrooms to the Administrator

Appendix C: Enclosures

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4. SDG Mapping

This project supports SDG 3: Good Health and Well-Being by leveraging IoT technology to enhance washroom hygiene and optimize maintenance schedules, contributing to improved health outcomes in hospital environments.

Appendix D: Deployment Timeline

1. Week 1: Door sensor installation and calibration.
2. Week 2: Backend and API integration.
3. Week 3: Testing and refinement of notification triggers.
4. Week 4: Pilot testing and feedback collection.
5. Week 5: Full-scale deployment and performance monitoring.

Appendix E: User Feedback Form

A sample user feedback form provided via a QR code in each washroom:

- Cleanliness (1-5):
- Facility Availability (1-5):
- Comments: