American International University-Bangladesh (AIUB)

Department of Computer Science

Faculty of Science & Technology (FST)

Garments Waste Classification and Recycle System

A Software Engineering Project Submitted
By

Semester: Summer_21_22		**Section:**	**Group Number:**	
SN	Student Name	Student ID	Contribution (CO1+CO2)	Individual Marks
01	Mohammad Yeasin Ali	22-46206-1	21%	
02	Tasnuva Tasnim Mim	22-46854-1	20%	
03	Md. Nazmul Hassan Bhuiyan	21-45293-2	20%	
04	Mahir Shariar Ratul	22-47178-1	20%	
05	Md. Nakib Munsif	21-45314-2	19%	

The project will be Evaluated for the following Course Outcomes

CO1: *Analyze* the impact of software engineering models over various context of software development to assess societal, health, safety, legal and cultural issues.	Total Marks	
Project Background Analysis and feasibility (needs, goal, benefits, etc.)	[5 Marks]	
Analysis the impact of societal, health, safety, legal and cultural issues	[5Marks]	
Review of existing Studies and Relevant Example	[5Marks]	
CO2: *Explain* appropriate software engineering model, project management roles and their skills in the context of professional engineering practice and solutions to complex engineering problems in a software development environment.	Total Marks	
Appropriate Process Model Selection and Argumentation with Evidence	[5Marks]	
Evidence of Argumentation regarding process model selection	[5Marks]	
Submission, Defense, Completeness, Spelling, grammar and Organization of the Project report	[5Marks]	

Description of Student's Contribution in the Project work

Student Name: Tasnuva Tasnim Mim
Student ID: 22-46854-1
Contribution in Percentage (%): 20
Contribution in the Project:

- Solution to the problem (30%)
- Functional requirements (20%)
- Use case diagram.
- Comparison of chosen models to other models.
- Roles and responsibilities of the chosen model.
- Wireframes
- Test Cases (2)
- Project Estimation
- Timeline Chart 02
- EVA Analysis
- Risks Estimation

_____Tasnuva Tasnim Mim_____
Signature of the Student

Student Name: Mohammad Yeasin Ali
Student ID: 22-46206-1
Contribution in Percentage (%): 21
Contribution in the Project:

- Solution to the problem (30%)
- Functional requirements (20%)
- Non-functional requirements (40%)
- Sequence diagram.
- Choosing suitable process model.
- Arguments for the chosen model.
- Wireframes
- Test Cases (4)
- WBS
- Project Estimation
- Timeline Chart 01
- Timeline Chart 02
- EVA Analysis
- Risks Estimation

____Mohammad Yeasin Ali_____
Signature of the Student

Student Name: Md. Nazmul Hassan Bhuiyan
Student ID: 21-45293-2
Contribution in Percentage (%): 20%
Contribution in the Project:

- Solution to the problem (20%)
- Functional requirements (20%)
- Non-functional requirements (30%)
- Class diagram.
- Choosing suitable process model.
- Arguments for the chosen model.
- Wireframes
- Test Cases (2)
- Project Estimation
- Timeline Chart 02
- EVA Analysis
- Risks Estimation

_____Nazmul Hassan Bhuiyan_____
Signature of the Student

Student Name: Mahir Shariar Ratul
Student ID: 22-47178-1
Contribution in Percentage (%): 20%
Contribution in the Project:

- Background to the problem
- Functional requirements (20%)
- Non-functional requirements (20%)
- Activity diagram.
- Comparison of chosen model to other models.
- Wireframes
- Test Cases (4)
- Project Estimation
- Timeline Chart 01
- Timeline Chart 02
- EVA Analysis
- Risks Estimation

Mahir Shariar Ratul
Signature of the Student

Student Name: Md. Nakib Munsif
Student ID: 21-45314-2
Contribution in Percentage (%): 19%
Contribution in the Project:

- Solution to the problem (20%)
- Functional requirements (20%)
- Class diagram
- Comparison of chosen model to other models
- Wireframes
- Test Cases (2)
- Project Estimation
- Timeline Chart 02
- EVA Analysis
- Risks Estimation

Nakib Munsif
Signature of the Student

1. PROJECT PROPOSAL

1.1 Background to the Problem

- Write the background description that helps putting your project into the right context of a problem domain and gives everyone involved a common view of the project.
- What is the root cause of this problem? Why this problem is so important to consider?

1.2 Solution to the Problem

- Describe what is your project/thesis objective? What solutions are you going to provide to solve the above-mentioned problems?
- What are the solutions you are going to propose to deal with the problem? why is this solution is particularly appropriate to solve the problem? Is the solution feasible to the meet the business objective?
- Describe the basic functionalities of your proposed solution that makes the best use of state-of-art technology and produced a significant result that is likely to have a major impact on societal, health, safety, legal and cultural issues. Provide a deep insight that demonstrate and preset a creative solution to the real-life problem.
- Describe the target group of users of your solution? And how they will be benefited by your proposed solution to the problem?
- Describe the contribution of your project to the development of scientific results that is identified and well documented.
- Provide a literature review on what are the other studies that have discussed the same topic of yours in the literature and explain how your study has utilized and extended the problems of existing studies.
- Provide a description of all the existing studies presented in the problem area. What are the existing software solutions (for project) are available to solve the aforementioned problems?
- What are the existing software solutions are available to solve the aforementioned problem? And how your proposed solution is going to extend them in providing more benefits to the users?

2. SOFTWARE DEVELOPMENT LIFE CYCLE

2.1 Process Model

- Provide an analysis regarding the nature and environment of the software that you are going to develop and select the best suitable method(s) to develop the software.
- Present your arguments based on your analysis about why your selected method(s) is the best choice among all other methods to develop your proposed software.
- Presents sufficient amount of evidence to support argument for your model selection in developing your proposed solution.

2.2 Project Role Identification and Responsibilities

- Identify all the roles/stakeholder in the software/project management activities in software development.
- Describes the responsibilities of the role in the software development.

Text Format:

- Style: Times New Roman
- Size: 12
- Space: 1.0
- Alignment: Justify
- Length: Maximum 6 pages (including cover page)

Rubric for Project Assessment (CO1)

Marking Criteria	Marks Distribution (Maximum 3X5=15)				Acquired Marks
	Inadequate (1-2)	Satisfactory (3)	Good (4)	Excellent (5)	
Background Analysis	No background information regarding the project is given; project goals and benefits are missing.	Insufficient background information is given; project goals and benefits are poorly stated	Sufficient background information is given; the purpose and goals of the project are explained.	Thorough and relevant background information is given; project goals are clear and easy to identify.	
Analysis the impact of societal, health, safety, legal and cultural issues	Student vaguely discuss the impact of societal, health, safety, legal and cultural issues in their project	Student provided with partial relevance to the impact of societal, health, safety, legal and cultural issues in their project	Student fairly provided the analysis to the impact of societal, health, safety, legal and cultural issues in their project	Student comprehensively provided the analysis to the impact of societal, health, safety, legal and cultural issues in their project	
Existing Studies and Relevant Example	Ambiguous representative example.	Partially identify / indicate towards real-life example.	Real-life example is fairly connected towards the definition.	Comprehensively defend with real life example.	
				Acquired Marks:	
				CO Pass / Fail:	

Rubric for Project Assessment (CO2)

Criteria	Marks distribution (Max 3X5= 15)				Acquired Marks
	Inadequate (1-2)	Satisfactory (3)	Good (4)	Excellent (5)	
Argumentation of Model selection with Evidence of Argumentation	Does not articulate a position or argument of choosing appropriate model. Does not present any evidence to support the arguments for the choice of the model	Articulates a position or argument for choosing models that is unfocused or ambiguous. Presents incomplete/vague evidence to support argument for model choice	Articulates a position or argument of choosing models that is limited in scope. Does not present enough evidence to support the argument for the choice of the model	Clearly articulates a position or argument for the choosing software engineering models. Presents sufficient amount of evidence to support argument for the model selection	
Role identification and Responsibility Allocation	The project has poor project management plans for identifying roles and assigning the responsibilities	Identify few roles in the project management where some of the roles are left alone with any project responsibilities	Identify most of the roles in the project management and assign their responsibilities	Well planned project with proper role identification and responsibility allocation in the project management activities	
Submission, Completeness, Spelling, grammar and Organization of the Project report	Project report is not complete and Several errors in spelling and grammar. Present a Confusing organization of concepts, supporting arguments, and real-life example. Sentences rambling, and details are repeated.	Some errors in spelling and grammar. Some problems of organizing the answer in a logical order of defining, elaborating, and providing real-life examples.	Few errors in spelling and grammar. Presents most of the details in a logical flow of organization in definition, details, and example.	Project report is complete and No errors in spelling and grammar. Consistently presents a logical and effective organization of definition, details, and real-life example of the topic.	
				Acquired marks:	
				CO Pass / Fail:	

1.1 Background to the Problem

In recent years, the fashion industry has witnessed an exponential growth in the production and consumption of garments worldwide. This surge in demand has led to a concerning rise in textile waste, presenting significant environmental and social challenges. The production process itself, along with consumer habits and disposal practices, contribute to this mounting issue. Textile waste, including discarded garments, scraps, and unused fabric, poses a multifaceted problem. Firstly, it burdens landfills and incinerators, contributing to environmental degradation and greenhouse gas emissions. Secondly, it reflects inefficiencies within the fashion supply chain, where overproduction, unsold inventory, and excess material contribute to waste. Additionally, the social implications are profound, as textile production often involves exploitative labor practices and harms communities where garments are manufactured. In response to this pressing concern, innovative solutions are being sought to mitigate garment waste throughout the production, distribution, consumption, and disposal stages. One such solution is the development of a Garments Waste Detector. This technological tool aims to address the problem at its source by identifying and reducing waste during the manufacturing process. The Garments Waste Detector utilizes advanced sensing technologies, machine learning algorithms, and data analytics to detect and categorize waste in real-time. By integrating this system into the production line, manufacturers can identify defects, optimize material usage, and minimize waste generation. Additionally, the Garments Waste Detector offers valuable insights into production inefficiencies, enabling proactive decision-making and process improvements. Moreover, this technology empowers consumers by promoting transparency and accountability within the fashion industry. By providing information on garment sustainability and waste reduction efforts, consumers can make more informed purchasing decisions and advocate for responsible practices. Furthermore, the Garments Waste Detector goes beyond mere detection by facilitating the recycling of waste materials. By identifying reusable materials within the production process, manufacturers can implement recycling initiatives to minimize environmental impact and promote circularity. This closed-loop approach not only reduces waste but also conserves resources and lowers the carbon footprint of garment production. Ultimately, the development and implementation of a Garments Waste Detector, coupled with recycling initiatives, represent a pivotal step towards a more sustainable. and ethical fashion ecosystem. By addressing the root causes of textile waste and promoting circularity, this innovative solution aligns with global efforts to reduce environmental impact and foster social responsibility within the fashion industry.

The root causes of garment waste are multifaceted and stem from various aspects of the fashion industry:

1. Overproduction: Fashion brands often produce more garments than the market demands, driven by fast fashion trends and the desire to constantly refresh collections. This overproduction leads to excess inventory and unsold items, which eventually end up as waste.

2. Fast Fashion Culture: The rise of fast fashion has accelerated the pace of clothing production and consumption. With new styles hitting the shelves weekly or even daily, consumers are

encouraged to buy more frequently and discard items quickly, contributing to a disposable mindset and increased waste.

3. Poor Quality Control: Inadequate quality control measures during garment production can result in defects and imperfections in clothing. Garments that do not meet quality standards may be discarded or discounted, adding to waste levels.

4. Short Lifecycle of Trends: Fashion trends change rapidly, often rendering garments obsolete within a short period. This encourages consumers to discard perfectly wearable clothing in favor of the latest styles, contributing to waste accumulation.

5. Material Waste: Textile manufacturing processes generate significant waste, including offcuts, scraps, and unused fabric. Inefficient material usage and lack of recycling initiatives further exacerbate this issue.

6. Lack of Sustainable Practices: Historically, sustainability has not been a priority in the fashion industry. Practices such as excessive water usage, chemical pollution, and reliance on non-renewable resources contribute to environmental degradation and waste generation.

This problem is crucial to address for several reasons:

1. Environmental Impact: The fashion industry is one of the largest contributors to environmental pollution and resource depletion. Garment waste adds to this burden by filling up landfills, emitting greenhouse gases, and polluting waterways.

2. Social Responsibility: The fashion industry's supply chain often involves exploitative labor practices, particularly in developing countries where garments are manufactured. Addressing waste can lead to more efficient production processes, potentially improving working conditions and livelihoods for garment workers.

3. Resource Conservation: Textile production requires significant amounts of water, energy, and raw materials. By reducing waste and implementing recycling initiatives, the industry can conserve resources and minimize its ecological footprint.

4. Economic Efficiency: Reducing waste can result in cost savings for fashion brands through improved inventory management, reduced material wastage, and increased operational efficiency.

5. Consumer Awareness: As consumers become more conscious of the environmental and social impacts of their purchasing decisions, addressing garment waste is essential for maintaining brand reputation and meeting consumer expectations for sustainability.

Overall, tackling garment waste is crucial for building a more sustainable and ethical fashion industry that respects both people and the planet.

1.2 Solution to the Problem

With an emphasis on supporting recycling initiatives, the goal of this project is to create a comprehensive software solution for waste tracking and detection in textile manufacturers. The objective is to develop a system that can effectively recognize and classify waste in the production process, keep an accurate account of all waste produced, and offer useful information for recycling programs.

The suggested solutions are seen to be workable given the state of technology and industry standards at the moment. The development of IoT, computer vision, machine learning, and data processing technologies offers a strong platform for the integration of garbage monitoring and recycling systems. The availability of open-source software, reasonably priced hardware, and the textile industry's rising emphasis on ecological methods all lend further credence to the practicality. Before the system is widely used, pilot testing and iterative development can also be used to improve its viability and efficacy.

The suggested approach combines cutting-edge technology, such as IoT and computer vision, to classify flaws, automate waste identification in textile manufacturing, and guarantee accuracy in detecting minute problems. IoT devices used for real-time monitoring enable continuous data collection, facilitating prompt responses to abnormalities and reducing faults while improving safety. Strong data analytics provide insightful conclusions that support data-driven decision-making and environmental regulation compliance. In order to generate intelligent recycling recommendations that promote a circular economy and lessen environmental impact, machine learning algorithms evaluate historical waste data. Stakeholder empowerment with an intuitive interface improves transparency, safety, and health. Incorporating recycling facilities seamlessly solves legal and societal issues while promoting environmental preservation. Flexibility and scalability guarantee wide use, promoting a transition in society toward environmentally friendly textile processes. In summary, this comprehensive solution leverages cutting-edge technologies to drive a sustainable and responsible approach to waste management in the textile industry, with impactful implications for societal, health, safety, legal, and cultural dimensions.

The initiative significantly advances our understanding of waste management and detection in textile manufacturing. Through the utilization of cutting-edge technologies such as IoT, machine learning, and computer vision, the project presents novel approaches to automate data analytics, real-time monitoring, waste identification, and intelligent recycling recommendations. The science of human-computer interaction and successful cooperation between industrial systems and outside partners are further enhanced by the intuitive interface design and smooth integration with recycling facilities. With a focus on system design that is both flexible and scalable, the project tackles important requirements in the investigation of flexible solutions for various industrial settings. In general, the results offer significant perspectives to the scientific community, influencing environmentally friendly and technologically advanced methods of managing industrial waste.

An existing study addressing the same topic:

- **A Review on Textile Wastewater Characterization in Bangladesh:** Offers a comprehensive analysis of textile wastewater properties in Bangladesh, focusing on parameters like pH, COD, BOD, TSS, color, and pollutants. In contrast, our study concentrates on developing software to manage liquid waste in real-time within textile factories, leveraging IoT for waste detection and reporting. Our research extends existing studies by proposing a practical solution for waste management, emphasizing connectivity to IoT devices, and introducing features like device selection and search functionalities, thus bridging the gap between wastewater characterization and practical waste management solutions in textile industries.

There seems to exist a number of existing software for garments in the problem area. Enterprise Resource Planning (ERP) systems may be addressed as one of them which for textiles often include modules for production planning, quality control, and inventory management but these systems lack the feature of processing the waste generated from the textile factories after dyeing products. Our proposed solution could provide an end-to-end waste management system, from detection and categorization to tracking and recycling recommendations. This comprehensive approach distinguishes it from solutions that might focus on specific aspects.

Implementing the Scrum model for developing an IoT-based waste management software can yield significant environmental and business benefits. By employing iterative development cycles and continuous feedback loops, the Scrum framework enables rapid prototyping and deployment, facilitating quicker identification and resolution of environmental issues associated with waste management. Additionally, Scrum's emphasis on collaboration and adaptability allows for efficient allocation of resources and prioritization of features, resulting in a streamlined development process and potentially reducing time-to-market. Ultimately, this approach can contribute to more sustainable waste management practices while also enhancing the software's market competitiveness and long-term viability. Moreover, by adopting the Scrum model for out waste management software, positive environmental and business impacts can be expected. Scrum's iterative cycles allow for quick adaptation and integration of feedback, enabling the team to refine features like waste categorization and recycling efficiency along the way. This focus on continuous improvement can lead to a more effective solution, potentially reducing waste volume and associated environmental burdens. Additionally, Scrum's emphasis on collaboration and transparency can foster innovation and cost-effectiveness within the development process, leading to a more sustainable business model overall.

Requirement Analysis

Functional Requirements

1. **Signup Functional Requirements**

1.1 Users should provide their Full name, Date of Birth, Gender contract information (Phone no.) and Employee ID to create a new user account in the software. The software shall offer accessible input methods.
1.2 The system shall check the uniqueness of the employee id, ensuring it has not been previously used by any user.
1.3 The system will need admin authorization to confirm and create a new account.
1.4 To create a strong password, the user shall set a passphrase with a minimum length of 8 characters.
1.5 After a successful account creation, all the user information will be stored in the database.

Priority Level- High

Precondition - Users have software access and a unique employee ID from his Workplace.

2. **Login Functional Requirements**

2.1 The software shall provide a login mechanism for users.
2.2 Users shall be able to login using their unique user id and password.
2.3 The identification method shall be verified from the secured database.
2.4 If the maximum login attempts exceed, the user account login will be disabled and it can be enabled by the admin authorization.

Priority Level- High

Preconditions- Users must have a unique user id provided by the signup process.

3. Settings Panel Functional Requirements

3.1 The software shall provide users options to update their Name and Contract information.
3.2 Users shall have an offline toggle option so that they don't get any notifications after enabling this option.
3.3 For security purposes, users can change their passwords by verifying their old password.
3.4 The software shall have the option to change the language and Toggle Dark mode.

Priority Level- Medium

Preconditions- Users must be logged into their account.

4. Live Monitoring Functional Requirements

4.1 The software should show all the activated devices and their conditions in the live monitoring page.
4.2 The user can see the live update of the wastage that was stored when the page refreshes.
4.3 The software shall show alerts in the same page when the wastage limitation exceeds.

Priority Level - High

Preconditions - User must have to logged into the account and the IOT devices should be connected and activated.

5. Controlling Functional Requirements

5.1 The software shall enable remote access to the system for monitoring and control purposes in the control page.
5.2 The software shall implement power management controls to remotely activate/deactivate IoT devices or adjust power-saving settings. This feature helps optimize energy consumption and prolong device battery life.

5.3 The software shall display waste levels through a user interface accessible via web or mobile application
5.4 Provide alerts when waste levels exceed set thresholds.
5.5 Allow users to remotely adjust settings or receive notifications.

Priority Level: High

Precondition: All devices should be connected to the network and accessible for control actions.

6. Page-view Functional Requirements

6.1 Allow users to view any pages according to his requirements.
6.2 The software shall provide a search bar or tool for users to quickly find specific content or information within the application.
6.3 Allow users to customize their page viewing preferences, such as font size, color themes, or language settings.

Priority Level: High

Precondition: Users must authenticate themselves before accessing pages.

7. Connectivity to IoT and Monitoring Devices Functional Requirements

7.1 The software shall establish secure connections with IoT devices deployed within the textile factory premises for seamless integration and communication when the user chooses to connect to certain sensors.
7.2 The software must support various communication protocols compatible with IoT devices to ensure interoperability and efficient data exchange.
7.3 The software shall ask for user permission to establish connections with corresponding monitoring devices when the user tries to establish connection.
7.4 The software shall afford users the capability to select and connect to specific IoT or monitoring devices according to their requirements and operational needs.

Priority level: High

Precondition: The software must possess robust connectivity functionalities compatible with IoT and monitoring devices.

8. Search Functionality Functional Requirements

8.1 The software shall provide users with a separate search page interface enabling them to locate specific IoT devices within the textile factory.
8.2 Users should be able to search for devices based on criteria such as device type, location, or unique identifier.

Priority level: Medium

Precondition: The software must have access to the factory's layout and device inventory data to facilitate accurate device search functionalities.

9. IoT Device's Functionality Functional Requirements

9.1 The software shall have a separate page for connections with the IoT sensors.
9.2 Different sensors include optical sensor to detect substances in the waste, chemical sensor for detecting organic compound, pH sensor for detecting contaminants or pollutants in the waste.
9.3 Based on all the sensors' report, an automated final verdict shall be generated analyzing the particular results of the sensors on whether the waste is recyclable or not.
9.4 The software shall provide a view-report option to show a report about the recyclable and non-recyclable liquid waste.
9.5 The software will let users know when the quantity of waste reaches the limit for a single day. It will be shown in the same page.
9.6 The software shall provide a user-friendly interface for navigating the sensor devices along with a voice command system.

Priority level: High

Precondition: The software must have connection functionalities with the IoT and monitoring devices.

10. Report Panel Functional Requirements

10.1 The software shall provide users with an option to report the quantity of detected waste on a regular basis.
10.2 The users shall be able to request for a recycling operation of the waste material through the report panel to the corresponding authority.
10.3 The software shall provide an option to the users about feedback of the service provided by the authority.

Priority level: Medium

Precondition: The software must be successfully installed and authenticated on the user's device, with the user having appropriate permissions to access the reporting functionalities and communicate with the corresponding waste management authority.

Non-Functional Requirements

1. **Availability**
   - The software shall maintain a minimum availability of 99% during standard operating hours, which are defined as Monday to Friday from 8:00 a.m. to 6:00 p.m. local time. Additionally, during critical operational periods, such as peak production hours, the software shall ensure a higher availability rate of at least 99.95%.

2. **Performance**
   - Every page should download in less then 10 seconds or less over a 50KBps modem connection.
   - Authorization of a recycle waste request should not take more than 7 days to be responded.

3. **Efficiency**
   - The software shall process and analyze incoming data from IoT devices with an average response time of less than 500 milliseconds per transaction during normal operating conditions. Additionally, the software should be capable of handling a minimum of 1000 transactions per minute without experiencing degradation in performance, ensuring efficient real-time monitoring and management of liquid waste in textile factories.

4. **Flexibility**
   - A maintenance programmer with a minimum of six months of experience supporting this software shall be able to implement a new feature or functionality, including coding, testing, and integration, within a maximum of two hours of work. This includes tasks such as adding support for new IoT devices, enhancing existing algorithms, or integrating third-party APIs. Additionally, the software's modular architecture should facilitate the addition of new modules or components with minimal disruption to the existing codebase, allowing for rapid development and deployment of updates and enhancements.

5. **Integrity**
   - The software shall ensure data integrity by implementing encryption mechanisms to protect sensitive information, such as user credentials, waste monitoring data, and reporting records, during transmission and storage. Access to critical system functionalities and data shall be restricted to authorized users with appropriate

permissions, such as administrators and authorized personnel, through robust authentication and authorization mechanisms. Additionally, the software shall maintain an audit trail of user actions and system activities to facilitate traceability and accountability, ensuring the integrity and reliability of the data stored and processed by the system.

6. **Interoperability**
   - The Liquid Waste Management Software shall be capable of seamlessly integrating with the factory's existing inventory management system to import data regarding chemical usage, quantities, and compositions. This integration shall facilitate the automatic identification and tracking of liquid waste generated from specific chemical processes within the textile factory. Additionally, the software shall support interoperability with regulatory compliance databases, allowing for the exchange of data related to waste disposal regulations and reporting requirements.

7. **Probability**
   - The Liquid Waste Management Software shall achieve a reliability rate of at least 99.9%, indicating that no more than 0.1% of operations result in software failures over a continuous operating period of 30 days. This requirement ensures that the software maintains a high level of reliability to prevent disruptions in waste monitoring and management processes within textile factories. Additionally, the software shall be designed with high testability to facilitate the detection and resolution of defects that may compromise reliability, thereby further enhancing the overall robustness of the system.

8. **Robustness**
   - In the event of a communication failure between the Liquid Waste Management Software and IoT devices, the software shall store locally any unsynchronized waste monitoring data for up to 24 hours. Upon re-establishment of communication, the software shall automatically synchronize and upload the stored data to ensure no loss of critical information. This robustness requirement ensures that the system can gracefully handle temporary disruptions in connectivity without compromising the integrity of waste monitoring processes within textile factories. Additionally, the software shall provide informative error messages and prompts to guide users in resolving connectivity issues and recovering from unexpected operating conditions, thereby enhancing user experience and minimizing the impact of system failures.

9. **Usability**

- A new user, with minimal training, shall be able to navigate the Liquid Waste Management Software interface and successfully initiate a waste monitoring process within a maximum of 15 minutes from the initial login. This usability requirement ensures that the software is intuitive and user-friendly, allowing users to quickly grasp its functionalities and perform essential tasks without extensive training or guidance. Additionally, the software shall provide clear instructions and prompts to assist users in completing tasks effectively, enhancing ease of use and facilitating rapid adoption by users with varying levels of expertise.

10. Maintainability

- A maintenance programmer should be able to identify, implement, and test software modifications or bug fixes within four hours. This ensures efficient correction of defects and timely adaptation to evolving regulatory standards or user requirements.

11. Reusability

- The waste monitoring algorithm modules within the Liquid Waste Management Software shall be designed to be modular, well-documented, and independent of specific factory configurations. These modules should be reusable in other waste management systems deployed in different industrial settings, provided they utilize similar waste monitoring methodologies and standards. This requirement ensures that the software components can be repurposed efficiently, reducing development costs and accelerating the implementation of waste management solutions across diverse industrial environments.

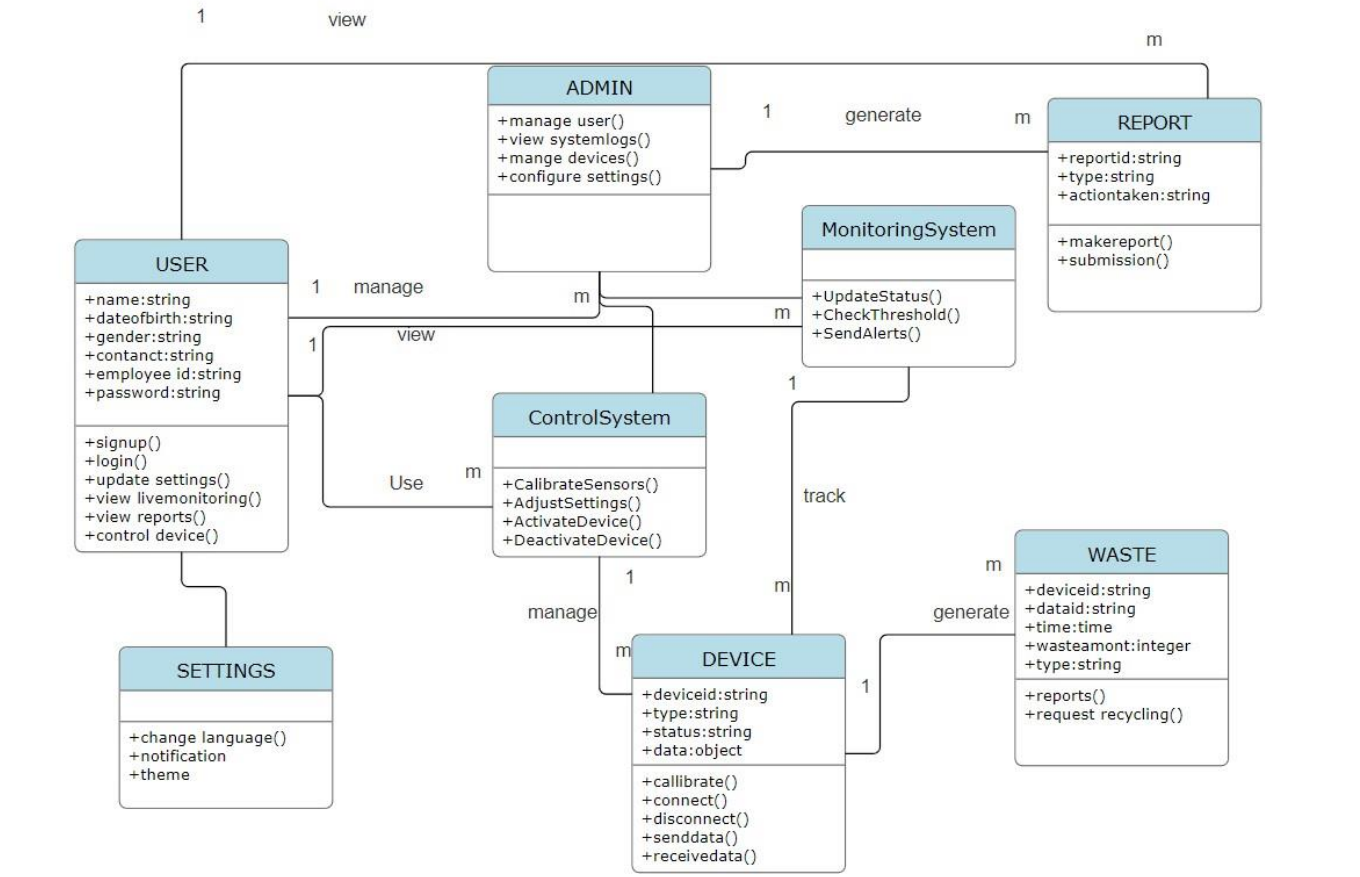
12. Testability

- The Liquid Waste Management Software shall feature modular design and clear interfaces to ensure ease of testing at unit and integration levels. Additionally, the *cyclomatic complexity** of each software module shall not exceed 15, facilitating comprehensive testing and efficient identification of defects.

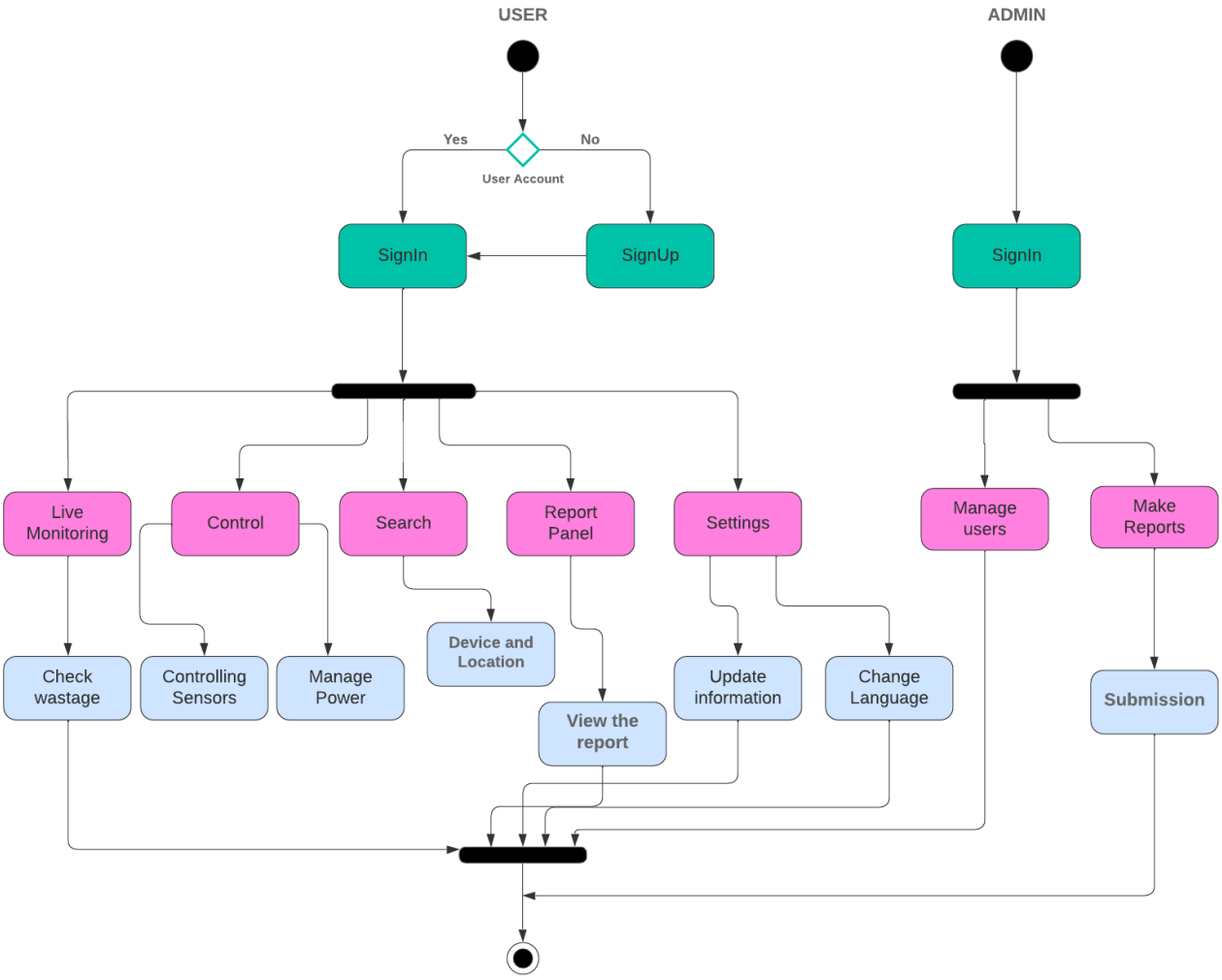
**Cyclomatic complexity* is a measure of the number of logic branches in a source code module.

1. Use Case Diagram:

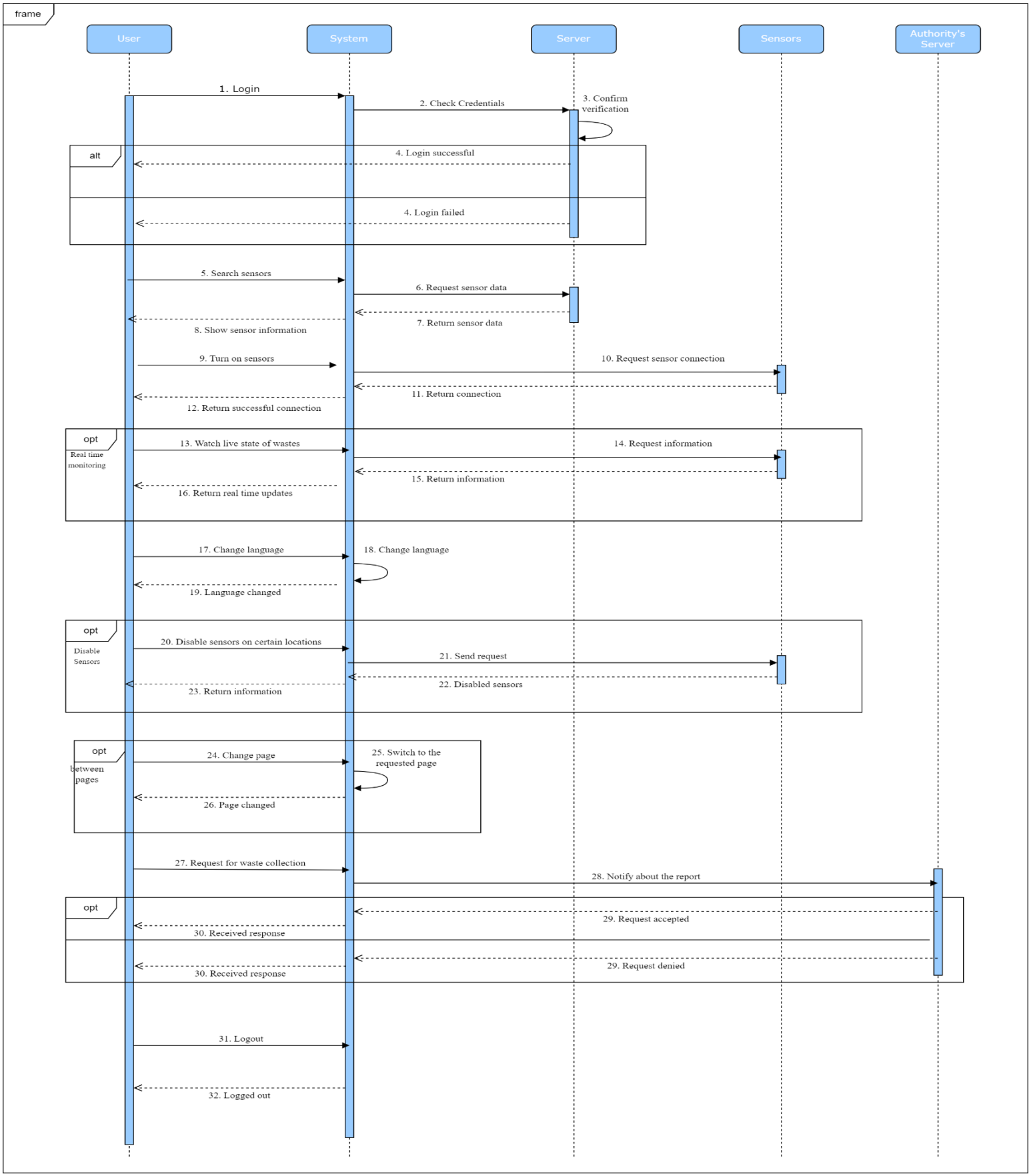
2. Class Diagram:



3. Activity Diagram:



4. Sequence Diagram:



2.1 Process Model

After thorough analysis, it is decided that Scrum process model aligns with the system requirements. Developing such software system may require what Scrum process model offers.

Choosing Scrum for the "Garments Waste Detector and Recycle System" project is a strategic decision that aligns with the specific needs and challenges of developing a technologically advanced solution in a dynamic and uncertain environment. We used Scrum particularly for this project because of its Iterative and Incremental Development, Enhanced Collaboration and Communication, Rapid Feedback and Adaptation, Focus on Value and Prioritization, Transparency and Visibility, and Risk Management. Also, Scrum is chosen for its ability to handle the complexities and uncertainties inherent in integrating software with IoT technologies for environmental sustainability. Its principles of iterative development, constant feedback, collaboration, and focus on delivering value align well with the project's goals, making it the preferred methodology for guiding the development of the "Garments Waste Detector and Recycle System" towards success.

In the context of developing a software solution for IoT-based waste detection, tracking, and recycling in garment factories, the choice of the Agile Scrum process model over traditional models like Waterfall or V-Model is particularly advantageous. Scrum's iterative approach aligns seamlessly with the dynamic nature of IoT projects, allowing for the accommodation of evolving requirements, especially in a domain where regulatory shifts, such as changing accessibility standards, are frequent. The regular user feedback loop in Scrum ensures constant validation of accessibility features, addressing the need for ongoing improvements in a domain as nuanced as waste detection and tracking for garment factories. The flexibility in prioritization within Scrum enables early and consistent focus on accessibility, a critical aspect for ensuring the success and inclusivity of the software. Continuous testing throughout the development process in Scrum aids in the validation and adjustment of accessibility features, providing a more responsive and adaptive approach compared to traditional methods like Waterfall, where testing is often relegated to later stages. Additionally, Scrum's emphasis on cross-functional collaboration is crucial for addressing the complexities inherent in IoT projects, fostering better communication and understanding among team members. The incremental nature of Scrum also contributes to superior risk management, with frequent deliveries allowing for early issue identification and mitigation. In contrast, traditional models like Waterfall may pose higher risks due to their rigid, sequential phases and delayed feedback loops, making Scrum an optimal choice for efficiently delivering a responsive and adaptable solution in the realm of waste detection and recycling for garment factories. Additionally, Scrum's adaptability is particularly essential in addressing the ever-changing landscape of accessibility regulations, ensuring that the software remains compliant with evolving standards. The iterative cycles in Scrum not only accommodate dynamic requirements but also provide the opportunity for the integration of emerging technologies or methodologies in waste management and recycling. This adaptability is a significant advantage over traditional models like Waterfall or V-Model, where changes are often challenging to implement once the project has progressed past certain stages.

2.2 Roles and Responsibilities:

Scrum Master:

The Scrum Master plays a crucial role in ensuring that the project adheres to Scrum practices, values, and rules, progressing as planned. This role involves interactions with the project team, customers, and management throughout the project lifecycle.

Product Owner:

The Product Owner holds official responsibility for the project, overseeing the management, control, and visibility of the Product Backlog list. Appointed by the Scrum Master, customer, and management, the Product Owner makes final decisions on tasks related to the product Backlog.

Scrum Team:

The Scrum Team, vested with the authority to make decisions and self-organize, is the project team tasked with achieving Sprint goals. Responsibilities include effort estimation, crafting the Sprint Backlog, reviewing the product Backlog, and identifying impediments for resolution.

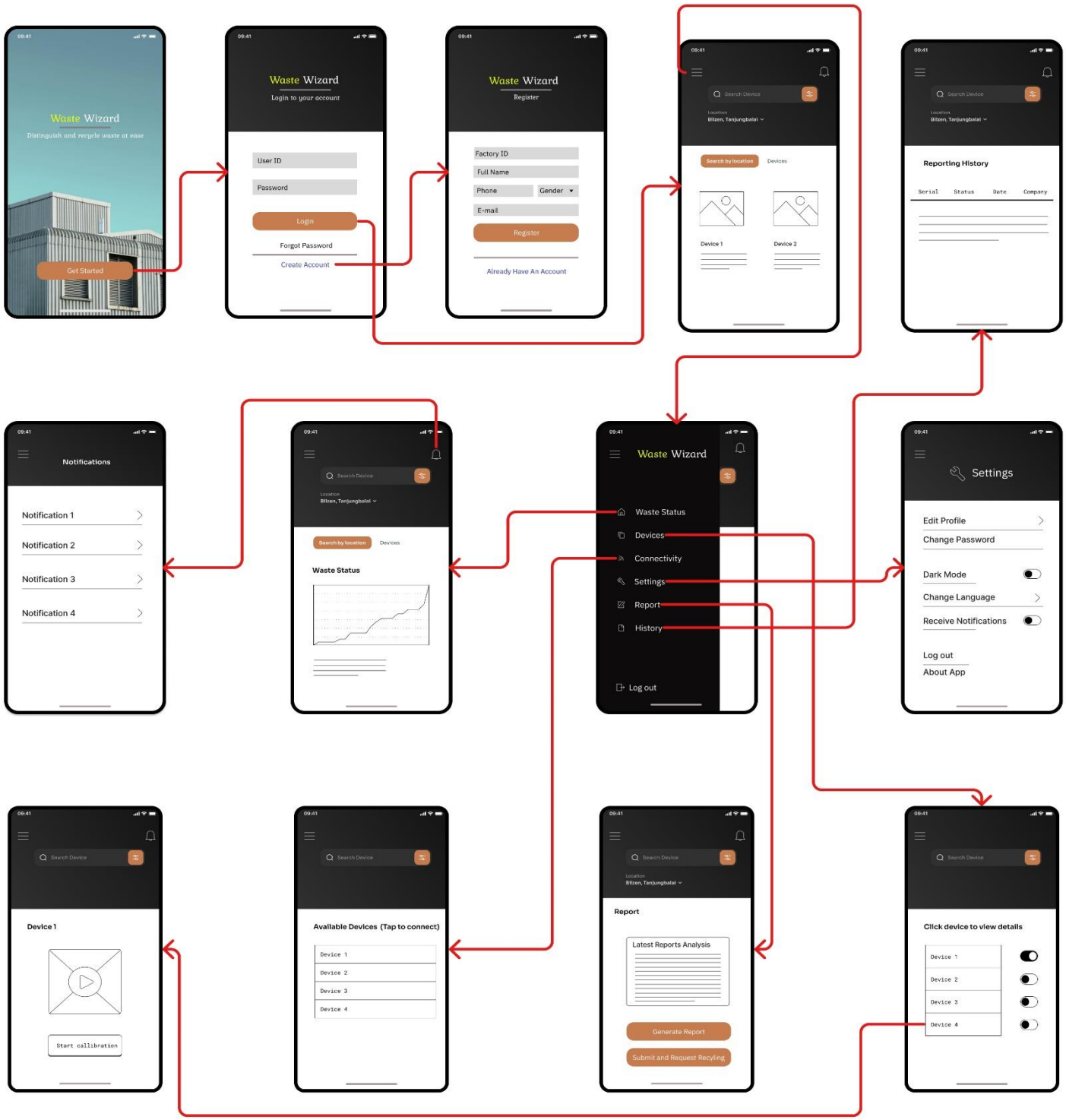
Customer:

Active participation from the customer is integral to tasks related to product Backlog items, contributing to the development or enhancement of the system.

Management:

Management holds the ultimate decision-making authority and is responsible for establishing agreements, standards, and project conventions. Additionally, they play a role in goal-setting, requirements definition, and project governance.

Wireframes:


Waste Wizard
Distinguish and recycle waste at ease
Get Started
Waste Wizard
Login to your account
User ID
Password
Login
Forgot Password
Create Account
Waste Wizard
Register
Factory ID
Full Name
Phone
Gender
E-mail
Register
Already Have An Account
Search Device
Location
Bilzen, Tanjungbalai
Search by location
Devices
Device 1
Device 2
Reporting History
Serial
Status
Date
Company
Notifications
Notification 1
Notification 2
Notification 3
Notification 4
Waste Status
Waste Wizard
Waste Status
Devices
Connectivity
Settings
Report
History
Log out
Settings
Edit Profile
Change Password
Dark Mode
Change Language
Receive Notifications
Log out
About App
Device 1
Start callibration
Available Devices (Tap to connect)
Device 1
Device 2
Device 3
Device 4
Report
Latest Reports Analysis
Generate Report
Submit and Request Recyling
Click device to view details
Device 1
Device 2
Device 3
Device 4

Test Cases

Project Name: Garments waste detection and recycle management			Test Designed by: Nazmul Hassan	
Test Case ID: Signup_1			Test Designed date: 30/03/2024	
Test Priority (Low, Medium, High): High			Test Executed by:	
Module Name: Signup Session			Test Execution date:	
Test Title: verify signup with valid information				
Description: Test website Signup page				
Precondition (If any): User must have a valid organization ID				
Test Steps	Test Data	Expected Results	Actual Results	Status (Pass/Fail)
1. Go to the app 2. Go to the signup page 3. Fill-up information 4. Click submit	Org ID: 12121 Username: 99 Email: abc@aa Password: 321 Re-enter Pass: 321	User should get notified about the successful account creation		
Post Condition: User Org ID is validated with the database and successfully created an account. The ID details are logged in the database.				

Project Name: Garments waste detection and recycle management	Test Designed by: Nazmul Hassan
Test Case ID: Live_monitoring_4	Test Designed date: 30/03/2024
Test Priority (Low, Medium, High): High	Test Executed by:
Module Name: Monitoring Session	Test Execution date:
Test Title: Verify Live monitor	
Description: Test Live monitoring page for accurate data	
Precondition (If any): User must be Logged In	

Test Steps	Test Data	Expected Results	Actual Results	Status (Pass/Fail)
1. Go to the app 2. Login to the account 3. Go to the Waste Status page	Sensor 1: Good Sensor 2: Good Waste level: 50%	The monitoring system shows the real-time sensor conditions and waste level		
Post Condition: The system displays accurate, up-to-date information on sensors and waste capacity.				

Project Name: Garments waste detection and recycle management			Test Designed by: Mahir	
Test Case ID: Control_5-1			Test Designed date: 30/03/24	
Test Priority (Low, Medium, High): High			Test Executed by:	
Module Name: Sensor Calibration and Settings			Test Execution date:	
Test Title: Verify sensor calibration and settings adjustment functionality				
Description: Ensure sensors can be calibrated for accurate waste detection and settings can be adjusted as needed.				
Precondition (If any): Sensors are online and accessible for calibration.				
Test Steps	Test Data	Expected Results	Actual Results	Status (Pass/Fail)
1. Log into the system with administrative privileges. 2. Navigate to the sensor calibration section. 3. Select a sensor and perform the calibration process. 4. Adjust sensor settings as needed and save.	Specific sensor ID, calibration settings.	Sensor calibration is successful, settings are adjusted accordingly, and system updates are reflected immediately.	As expected,	Pass
Post Condition: Sensor accuracy is improved, and settings are customized as per requirements				

.

Project Name: Garments waste detection and recycle management			Test Designed by: Mahir	
Test Case ID: Control_5-2			Test Designed date: 30/03/24	
Test Priority (Low, Medium, High): Medium			Test Executed by:	
Module Name: Remote Access and Control			Test Execution date:	
Test Title: verify remote system access and control functionality				
Description: Confirm that authorized users can remotely access and control the system.				
Precondition (If any): User has valid credentials and internet connection.				
Test Steps	Test Data	Expected Results	Actual Results	Status (Pass/Fail)
1. Log in to the system remotely. 2. Access various control features (e.g., activating/deactivating devices, adjusting settings). 3. Make changes and verify they are applied.	User credentials, control actions to be performed.	User successfully logs in and performs control actions remotely, with changes reflecting in real-time	As expected,	Pass
Post Condition: System settings are updated according to remote commands.				

Project Name: Garments waste detection and recycle management			Test Designed by: Mahir	
Test Case ID: Control_5-3			Test Designed date: 30/03/24	
Test Priority (Low, Medium, High): High			Test Executed by:	
Module Name: Power Management and Notifications			Test Execution date:	
Test Title: Test power management features and alert notifications				
Description: Ensure power management controls are functional and notifications are sent for specified events.				
Precondition (If any): IoT devices are connected and operational.				
Test Steps	Test Data	Expected Results	Actual Results	Status (Pass/Fail)
1. Navigate to power management controls. 2. Select a device and toggle power or adjust settings. 3. Configure alerts for specific thresholds or events. 4. Trigger an event that meets the alert criteria.	Device ID, power settings, alert configurations.	Device power state or settings are successfully updated, and alerts are sent to the user upon event occurrence.	As expected,	Pass
Post Condition: Energy consumption is optimized, and users are promptly notified of critical events.				

Project Name: Garments waste detection and recycle management			Test Designed by: Mahir	
Test Case ID: Page_View_6			Test Designed date: 30/03/24	
Test Priority (Low, Medium, High): Medium			Test Executed by:	
Module Name: Page Access and Customization			Test Execution date:	
Test Title: Verify user access to pages and customization options				
Description: Ensure users can access pages as per their requirements and customize viewing preferences.				
Precondition (If any): User is authenticated and logged in.				
Test Steps	Test Data	Expected Results	Actual Results	Status (Pass/Fail)
1. Access different pages within the application. 2. Use the search bar to find specific content. 3. Adjust viewing preferences (font size, color theme, language)..	Specific pages or content to access, customization settings..	User accesses pages and content as required, and customization changes are applied and saved..	As expected,	Pass
Post Condition: Application reflects the user's viewing preferences across sessions.				

Project Name: Garments waste detection and recycle management			Test Designed by: Nakib Munsif	
Test Case ID: Settings _3			Test Designed date: 30/03/2024	
Test Priority (Low, Medium, High): High			Test Executed by:	
Module Name: Settings Session			Test Execution date:	
Test Title: verify the application language change				
Description: Test website settings page for change language				
Precondition (If any): User must be logged in				
Test Steps	Test Data	Expected Results	Actual Results	Status (Pass/Fail)
1. Go to the website 2. Login to the account 3. Go to the Settings 4. Click Language 5. Select the desired language	Language: English Bangla	All text labels, buttons, and other UI elements are displayed in the newly selected language.	As expected,	Pass
Post Condition: All UI elements (text, buttons, menus) are displayed in the chosen language, including dynamically generated content.				

Project Name: Garments waste detection and recycle management	Test Designed by: Nakib Munsif
Test Case ID: Login_2	Test Designed date: 30/03/2024
Test Priority (Low, Medium, High): High	Test Executed by:
Module Name: Login Session	Test Execution date:

Test Title: verify login with valid information				
Description: Test website login page				
Precondition (If any): User must have a valid Username and Password				
Test Steps	Test Data	Expected Results	Actual Results	Status (Pass/Fail)
1. Go to the website 2. Enter username and password 3. Click submit	Factory ID: 10032499 Password: 32153	User should log into the application		
Post Condition: User is validated with database and successfully login account. The account session details are logged in the database.				

Project Name: Garments waste detection and recycle management			Test Designed by: Tasnuva Tasnim Mim	
Test Case ID: Connectivity_7			Test Designed date: 03/30/2024	
Test Priority (Low, Medium, High): High			Test Executed by:	
Module Name: Connectivity of monitoring devices			Test Execution date:	
Test Title: Connect to different devices available in the factory.				
Description: Test monitoring device connection.				
Precondition (If any): user must allow necessary permissions when asked to establish connection to the corresponding device				
Test Steps	Test Data	Expected Results	Actual Results	Status (Pass/Fail)
1. Login to system 2. Go to connectivity page from menu 3. Click search devices 4. Press 'connect' to available devices	Devices: I234222KW	A successful connection message dialogue should be shown to user.		
Post Condition: After connection, the devices are shown as connected and available controlling and calibration in the connected devices section.				

Project Name: Garments waste detection and recycle management			Test Designed by: Tasnuva Tasnim Mim	
Test Case ID: Search_8			Test Designed date: 03/30/2024	
Test Priority (Low, Medium, High): Medium			Test Executed by:	
Module Name: Search operation			Test Execution date:	
Test Title: Search different devices filtered by location or name				
Description: Test searching devices.				
Precondition (If any): user must connect devices before performing search operation.				
Test Steps	Test Data	Expected Results	Actual Results	Status (Pass/Fail)
1. Login to system 2. Click on search bar 3. Write down unique identifier (name) of the device 4. Press enters to search	Devices: I234222KW	The information catalogue of the searched device should be shown to the user.		
Post Condition: After searching, the device is shown in the result section along with the results along with the data of the searched device.				

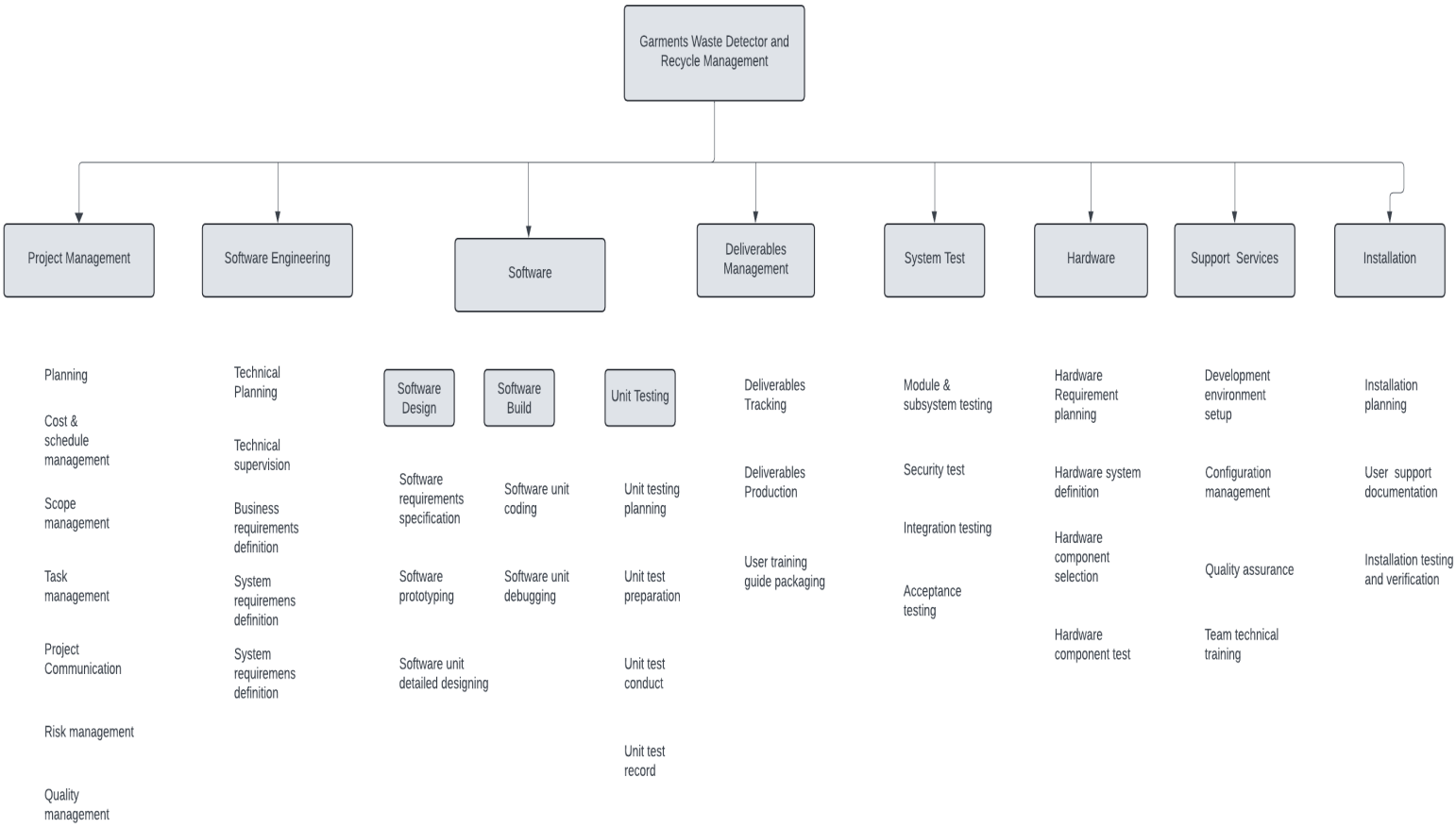
Project Name: Garments waste detection and recycle management			Test Designed by: Mohammad Yeasin Ali	
Test Case ID: Device_Analysis_9-1			Test Designed date: 03/30/2024	
Test Priority (Low, Medium, High): High			Test Executed by:	
Module Name: Monitoring devices' analysis			Test Execution date:	
Test Title: View waste data analysis generated by the corresponding IoT devices				
Description: Test result generated by IoT devices				
Precondition (If any): The IoT sensors must be enabled				
Test Steps	Test Data	Expected Results	Actual Results	Status (Pass/Fail)
1. Login to system 2. Go to sensor page 3. Filter by sensor or warehouse location 4. Select sensor 5. Click view report	Reported by: 101324321	User should be able to view correct results and all the necessary parameters about whether the waste is recyclable or not.		
Post Condition: Results are validated with database and shown to user.				

Project Name: Garments waste detection and recycle management			Test Designed by: Mohammad Yeasin Ali	
Test Case ID: Device_Analysis_9-2			Test Designed date: 03/30/2024	
Test Priority (Low, Medium, High): High			Test Executed by:	
Module Name: Monitoring devices' analysis			Test Execution date:	
Test Title: Test alert feature when waste level reaches to 90%				
Description: Test alert feature generated from the reports of IoT devices				
Precondition (If any): The IoT sensors must be enabled				
Test Steps	Test Data	Expected Results	Actual Results	Status (Pass/Fail)
1. Login to system 2. Go to waste status page 3. Notice the warning sign in the waste level viewing section	Waste Level in Database: 90%	User should be able to view correct results and all the necessary parameters		
Post Condition: Alerts are matched with server database and shown to user.				

Project Name: Garments waste detection and recycle management			Test Designed by: Mohammad Yeasin Ali	
Test Case ID: Reporting_Panel_10			Test Designed date: 03/30/2024	
Test Priority (Low, Medium, High): High			Test Executed by:	
Module Name: Reporting session			Test Execution date:	
Test Title: Report for the recycling operation to the authority				
Description: Test application report operation				
Precondition (If any): user must have appropriate permissions to access the reporting functionalities and communicate with the corresponding waste management authority				
Test Steps	Test Data	Expected Results	Actual Results	Status (Pass/Fail)
1. Login to system 2. Go to report panel option 3. Select service 4. Click generate report 5. Click submit	Reported by: 101324321 Authority: Basf Chemcycling	User should receive a confirmation email		
Post Condition: Reporting is validated with database and successfully saved to account.				

Project Name: Garments waste detection and recycle management			Test Designed by: Mohammad Yeasin Ali	
Test Case ID: Reporting_Panel_10			Test Designed date: 03/30/2024	
Test Priority (Low, Medium, High): Low			Test Executed by:	
Module Name: Reporting Session			Test Execution date:	
Test Title: Provide feedback of the previous service provided by authority about the recycling operation				
Description: Test application service feedback operation				
Precondition (If any): user must have appropriate permissions to access the reporting functionalities and communicate with the corresponding waste management authority				
Test Steps	Test Data	Expected Results	Actual Results	Status (Pass/Fail)
1. Login to system 2. Go to report panel option 3. Select service 4. Write feedback 5. Click submit	Reported by: 101324321 Authority: Basf Chemcycling	User shall see a successful message		
Post Condition: Feedback is validated with database and successfully saved to account.				

Work Bench Structure:



Project Estimation

Project Type: Organic

P = 1.05

T = 0.38

Coefficient=2.4

SLOC = 6000

Effort = PM = $Coefficient_{<Effort\ Estimation>}$ * (SLOC/1000) ^ P

= 2.4*(6000/1000) ^ 1.05

= 15.74

DM = 2.5 * (PM) ^T

= 2.5*(16) ^ 0.38

= 7.16

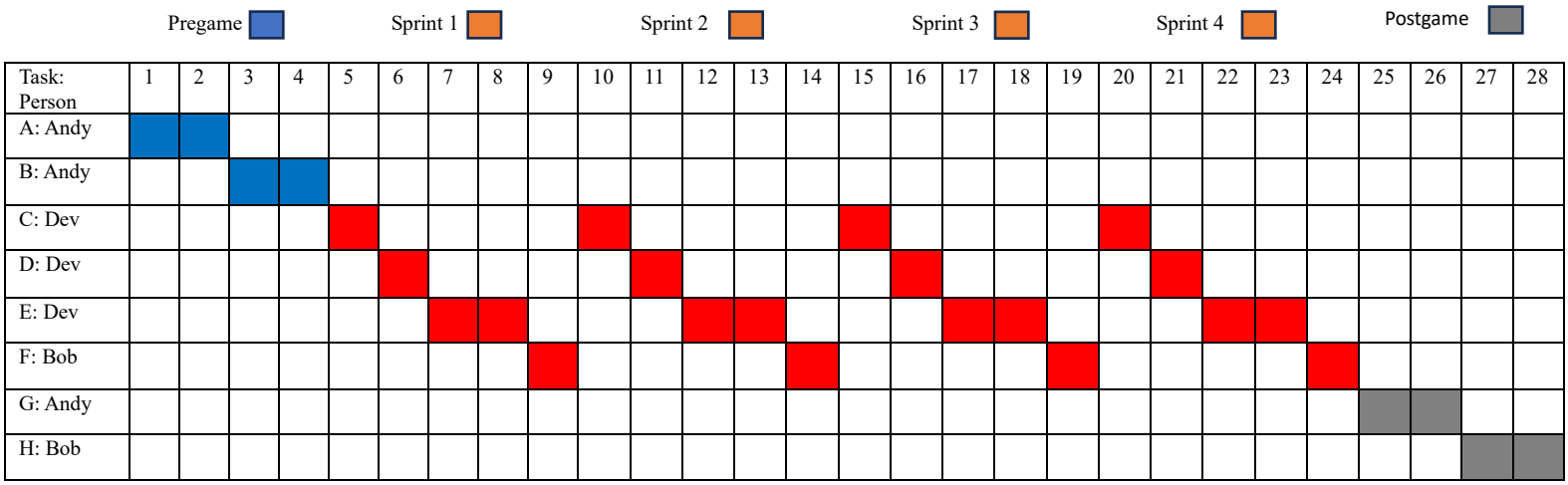
ST = PM/DM

= 15.74/7.16

= 2.19

≈ 3 (Required number of people)

Timeline Chart 01



A: Planning

B: High Level Architecture Design

C: Analysis

D: Design

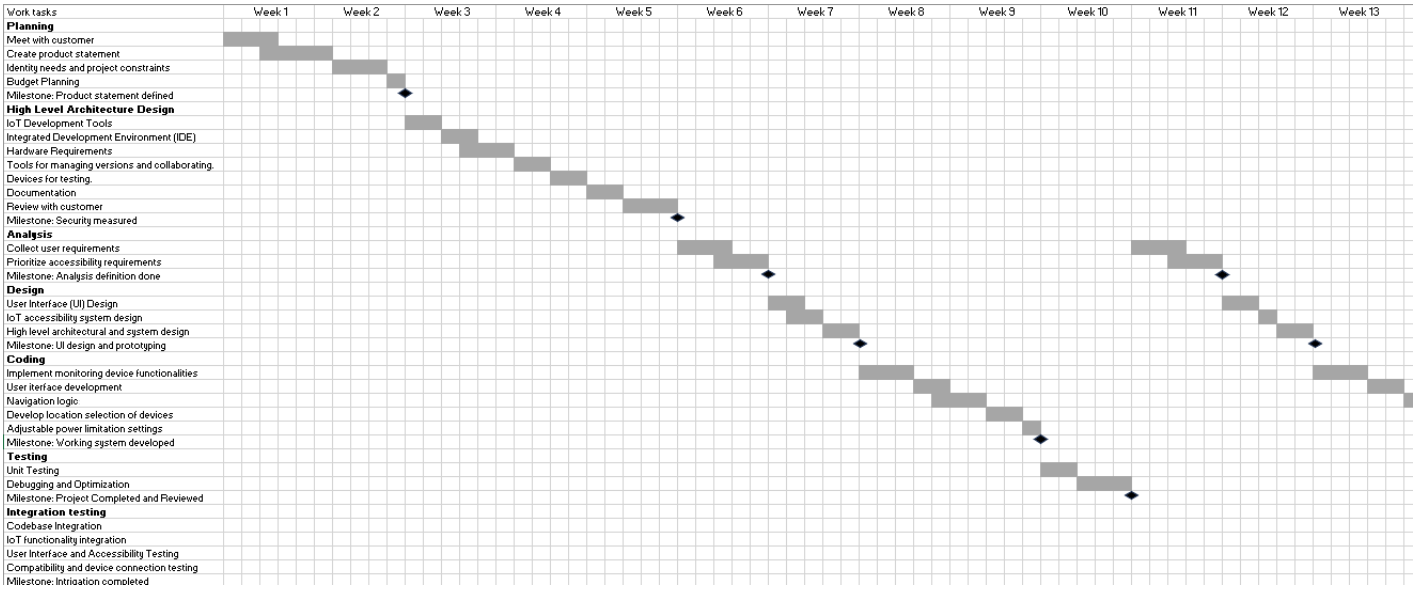
E: Coding

F: Evolution

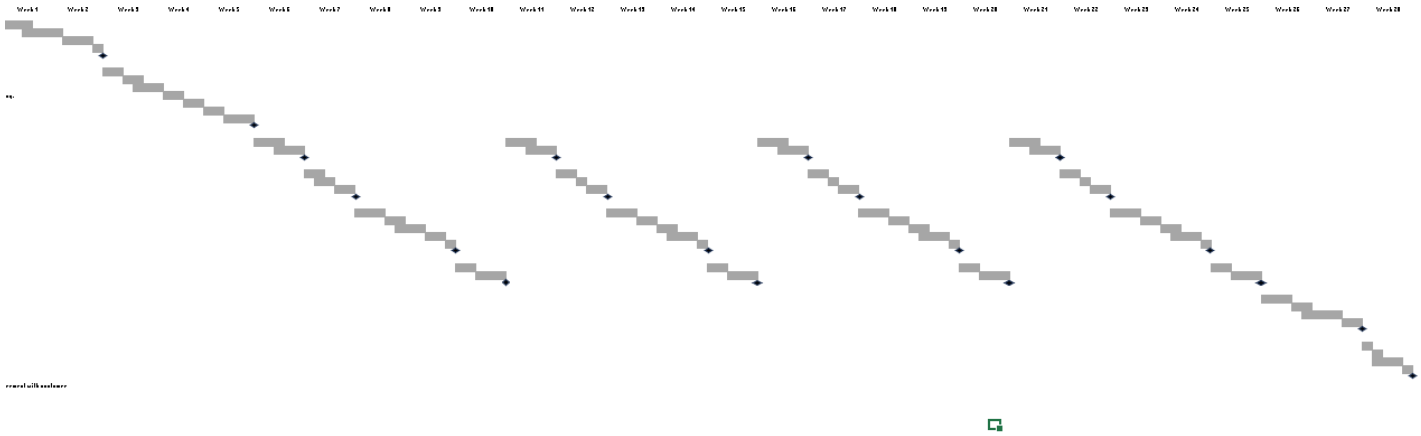
G: Integration Testing

H: System Testing and Documentation

Timeline Chart 02:



Navigation logic
Develop location selection of devices
Adjustable power limitation settings
Milestone: Working system developed
Testing
Unit Testing
Debugging and Optimization
Milestone: Project Completed and Reviewed
Integration testing
Codebase Integration
IoT functionality integration
User Interface and Accessibility Testing
Compatibility and device connection testing
Milestone: Intrigation completed
System testing
Usability Testing
Accessibility Testing
Performance Testing
Recovery testing
Security Testing
Milestone: Completed system testing and agreement with customer
Documentation
Write technical specifications
Write code comments
Explain module logics
Test plan, test cases and test results
Release notes
Milestone: Ensured clarity in documentation


Week 1
Week 2
Week 3
Week 4
Week 5
Week 6
Week 7
Week 8
Week 9
Week 10
Week 11
Week 12
Week 13
Week 14
Week 15
Week 16
Week 17
Week 18
Week 19
Week 20
Week 21
Week 22
Week 23
Week 24
Week 25
Week 26
Week 27
Week 28

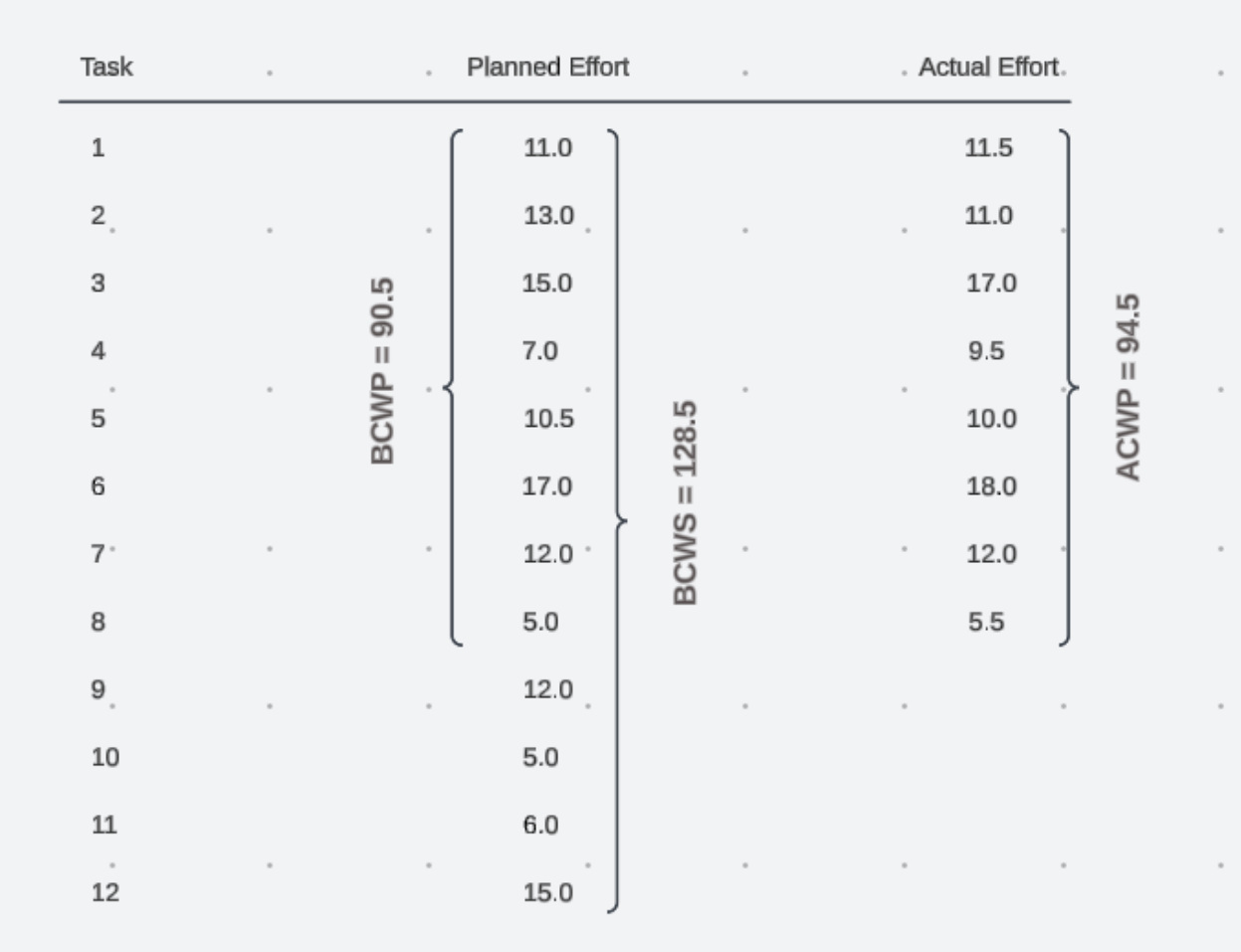
Eva Analysis

Effort Estimated = 15.74 * 22

= 346 person-day

Total Task = 51

8 tasks have been completed but according to the project schedule, 12 tasks should have been completed by the scheduled time.



- BAC = 346.00
- SPI = BCWP/ BCWS = 90.5/ 128.5 = 0.70428
- SV = BCWP - BCWS = 90.5 – 128.5 = -38 person-day

- CPI = BCWP/ ACWP = 0.9577
- CV = BCWP – ACWP = -4 person-day

- % schedule for completion = BCWS/ BAC = 128.5/ 346.00

  = 37.14%

[% of work scheduled to be done at this time]

- % complete = BCWP/ BAC = 90.5/ 346.00 = 26.16%

  [% of work completed at this time]

Risk Estimation:

Risks	Category	Probability	Impact
Size estimate maybe significantly low	PS	70%	2
Less reuse than planned	PS	80%	2
End- users resist system	BU	30%	3
Funding will be lost	CU	30%	1
Customer will change requirements	PS	70%	2
Technology will not meet expectations	TE	40%	1
Staff inexperienced	ST	50%	3
Change in team structure during software project	PR	40%	2
User interface will not seem user friendly after development	TE	40%	2
Development team will be unable to stay in constant contact with the customer	CU	40%	2
Functions do not work as planned after development	TE	30%	1
Software will face security vulnerabilities	TE	30%	1
Software will potentially fall behind in adapting to the dynamic evolution of the landscape.	CU	40%	3

Impact values:

1— catastrophic

2—critical

3—marginal

4—negligible

Risks	RMMM
Size estimate maybe significantly low	To reduce the risk of underestimating project size in software engineering, involve domain experts early, break down tasks into smaller units, use historical data for estimation, employ various estimation techniques, account for contingencies, adopt iterative planning, regularly review estimates with stakeholders, and learn from past experiences through post-mortem analyses. These strategies help refine estimates, mitigate risks, and improve overall estimation accuracy, ensuring successful project delivery.
Less reuse than planned	Focus on comprehensive planning to identify reusable components, promote modular design, establish repositories for storing reusable code, and emphasize documentation and communication. Foster a culture that values code reuse, conduct regular code reviews, provide training on best practices, and track reuse metrics to monitor progress and make adjustments as needed. These efforts encourage the efficient utilization of reusable assets, leading to improved productivity and software quality.
End users resist the system	Involve users early in the development process for feedback and buy-in, provide comprehensive training and support, ensure the system meets user needs and is intuitive to use, address concerns and objections proactively, and foster a culture of change management and communication to facilitate acceptance and adoption.
Funding will be lost	Prioritize transparent communication, closely monitor and report project progress, manage costs effectively, address budget constraints early, and consider alternative funding options or contingency plans.
Customer will change requirements	Prioritize clear communication, document requirements thoroughly, implement change management processes, educate customers on the impacts of changes, and adopt iterative development with frequent feedback loops.
Technology will not meet expectations	Conduct thorough research and feasibility studies, involve technical experts in technology selection, perform prototypes or proofs of concept, set realistic expectations, establish clear criteria for evaluating technology.

Risks	RMMM
Staff inexperienced	Training, mentorship, and hiring experienced personnel, foster a collaborative team environment, provide support, and leverage external expertise when necessary.
Change in team structure during software project	Clarify roles, communicate effectively, document processes, offer cross-training, plan for contingencies, and ensure smooth transitions for new team members.
User interface will not seem user friendly after development	Involve users in design and testing, prioritize usability testing, gather feedback iteratively, adhere to design principles, and incorporate user-centered design practices.
Development team will be unable to stay in constant contact with the customer	Establish regular communication channels, schedule frequent check-ins and updates, leverage collaboration tools for remote communication, assign dedicated points of contact, prioritize customer involvement in decision-making, and maintain transparency throughout the project.
Functions do not work as planned after development	Focus on rigorous testing, adhere to coding standards, involve stakeholders in acceptance testing, maintain clear documentation, and iterate based on feedback.
Software will face security vulnerabilities	Employ secure coding, conduct regular audits, stay updated on patches, use strong authentication, encrypt data, employ intrusion detection, and educate stakeholders.
Software will potentially fall behind in adapting to the dynamic evolution of the landscape.	To mitigate the risk of software falling behind in adapting to the dynamic landscape, prioritize flexibility and scalability in design, adopt agile development methodologies, continuously monitor industry trends and customer needs, implement regular updates and feature enhancements, foster a culture of innovation and adaptation within the team, and maintain open communication with stakeholders to gather feedback and adjust accordingly.