Tracking Utility for Knowledge Integration and Benchmarking (TUKIB): An Integrated Automation System for the University of the Philippines Visayas - Regional Research Center

A Special Problem Proposal
Presented to
the Faculty of the Division of Physical Sciences and Mathematics
College of Arts and Sciences
University of the Philippines Visayas
Miag-ao, Iloilo

In Partial Fulfillment
of the Requirements for the Degree of
Bachelor of Science in Computer Science by

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November 5, 2024

Abstract

From 150 to 200 words of short, direct and complete sentences, the abstract should be informative enough to serve as a substitute for reading the entire SP document itself. It states the rationale and the objectives of the research. In the final Special Problem document (i.e., the document you'll submit for your final defense), the abstract should also contain a description of your research results, findings, and contribution(s).

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Chapter 1

Introduction

1.1 Overview

In the era of digital transformation, efficient data management and streamlined service workflows are critical for the success of any business or institution. Perhaps one of the remarkable and known products of technology is converting paper-based or manually-operated systems to automated systems. It is irrefutable that automation greatly impacts people's lives, providing increased efficiency and productivity.

The University of the Philippines Visayas - Regional Research Center (UPV RRC) is a centralized facility that strengthens UP Visayas' research and innovation capabilities by providing researchers access to and training on advanced analytical equipment and method development. It provides several services catering to different fields of natural and physical sciences. Current practices on the service flow of the institution rely heavily on manual processes, using tools such as Google Forms and Google Sheets for service request handling, tracking, and data management. While these methods provide a foundational level of functionality, they fall short in addressing the specific needs of service flow requirements of the RRC, posing challenges not only for the staff but also for the clients.

Automation, defined as "the application of technology, programs, robotics or processes to achieve outcomes with minimal human input" (IBM, 2024), has been effectively adopted across various industries to enhance quality, productivity, efficiency, timeliness, effectiveness, and operational safety. Additionally, it helps lower costs and provides greater value to customers (Caban, 2024). Over the years, various technologies have emerged to address the pressing need for automation.

The increase in advanced software solutions presents an opportunity to enhance operational efficiency by automating service flow tasks. However, existing systems fail to provide the specific necessities of some institutions hence, a more sophisticated software is often needed. By developing a specialized software solution tailored to the unique needs of RRC, it is possible to significantly improve productivity, data accuracy, and overall effectiveness. This project explores the design and implementation of such a software solution, aiming to replace the existing reliance on Google Apps with a more robust, integrated system.

The proposed software seeks to address several key challenges faced by the institution, including the automation of repetitive tasks and the facilitation of seamless communication among team members. By making use of modern technologies and best practices in software development, this research aims to provide a practical, scalable solution that can be adapted to various research environments.

1.2 Problem Statement

The UPV Regional Research Center (RRC) currently relies on a manual service workflow for handling client requests, managing laboratory services, and tracking service-related activities. These processes, which are dependent on Google Forms and Sheets, lacks automation, leading to inefficiencies such as delays in service requests, difficulty in tracking progress, and limited scalability as the demand for RRC services grows. Furthermore, the absence of a centralized system makes it challenging for staff to manage and monitor multiple services and for clients to access real-time information about their requests.

To address these issues, a comprehensive and integrated workflow automation system, named TUKIB, is necessary. The system aims to automate service requests, improve data management, enhance communication between RRC staff and clients, and streamline overall operations. With automation, the center can improve the efficiency, accuracy, and accessibility of its services, supporting both the internal management and external customer experience.

1.3 Research Objectives

1.3.1 General Objective

The general objective of this paper is to develop a system to automate and optimize the service flow and data management at UPV Regional Research Center and evaluate its effectiveness. The system will be called TUKIB, an acronym for Tracking Utility for Knowledge Integration and Benchmarking.

1.3.2 Specific Objectives

Specifically this study aims to:

1. Automate the management of service requests and tracking, enabling real-time monitoring of ongoing tasks and requests for both RRC staff and clients by developing an integrated workflow automation system that streamlines the UPV Regional Research Center's (RRC) service processes, reducing manual intervention and enhancing operational efficiency.

2. Create a centralized data management system for RRC that ensures secure, efficient storage and retrieval of information related to service requests, laboratory usage, and client transactions.

3. Improve communication and feedback mechanisms between RRC staff and clients, enabling the RRC to gather the necessary information and statistics for customer satisfaction, and identify their service strengths and weaknesses.

4. Design and implement a chatbot, allowing the automation of the initial consultation process and for clients to interact with the system for service inquiries and assistance, providing immediate and accurate responses.

5. Evaluate the system's impact on operational efficiency, compare the automated workflow with the previous manual processes in terms of speed, accuracy, and user satisfaction.

6. Ensure the system is scalable and adaptable to future requirements, allowing the RRC to accommodate increased demand and potentially integrate additional features in the long term.

1.4 Scope and Limitations of the Research

This special problem focuses on developing the Tracking Utility for Knowledge Integration and Benchmarking (TUKIB), an integrated workflow automation system designed for the UPV Regional Research Center (RRC). The system aims to automate key service flow and data management aspects within the RRC.

TUKIB will cover the full-service management cycle of the UPV RRC, from initial client service requests to the completion and feedback stage. It will include features such as real-time tracking of service requests, a full inventory list and management of the RRC equipment, automated notifications to clients and staff, and an integrated platform for storing and managing service data. Key components such as user interfaces for staff and clients, real-time service status updates, events and schedule management, transaction records, and a feedback collection mechanism will be developed. Data accuracy will be ensured by minimizing manual input and automating repetitive processes, reducing errors and improving operational efficiency. The project will also involve the deployment of chatbots to enhance the communication flow between clients and staff, providing instant responses to inquiries and updates on service requests. The system will be scalable, allowing it to be adapted to other similar research institutions in the future.

The system's functionalities will be limited to the services provided by the UPV RRC and may not cover other internal or external functions and services. Customization will be tailored to the specific workflows of UPV RRC, so further modification would be needed for implementation of different institutions or industries. The project will focus on workflow automation but will not delve into advanced analytics or AI beyond using chatbots for customer communication and statistics for service feedback reports. The system also requires a stable internet connection for real-time features like notifications and status tracking; thus, its performance may be compromised in areas with poor connectivity. The effectiveness of the system depends on staff and client adaptability to the new system, which may require a period of training and adjustment.

1.5 Significance of the Research

The development of TUKIB offers significant contributions on multiple fronts, benefiting the researchers, the UPV RRC, and other research institutions facing similar challenges in service and data management, the computer science community, and the general society.

- **The Researchers**

  The TUKIB project provides an invaluable opportunity for researchers to apply their theoretical knowledge and practical skills to solve real-world problems. It allows them to demonstrate their competency in system design, workflow automation, and software development, contributing to the completion of their degree requirements.

  Beyond academic fulfillment, the project also equips the researchers with hands-on experience in managing complex systems, collaborating with stakeholders, and implementing scalable technological solutions, which will be beneficial in their future careers in computer science and related fields.

- **The UPV RRC and Other Research Institutions**

  The TUKIB system will significantly improve the operational efficiency of the UPV Regional Research Center by automating its service request workflows and data management processes. The integration of this system will reduce the time and effort spent on manual tasks such as request processing, service tracking, and data entry. This not only streamlines the internal processes but also enhances the overall user experience for both researchers and external clients, who will benefit from a more transparent and efficient service flow.

  Furthermore, other research institutions facing similar challenges in managing their services and data will be able to adapt TUKIB to their own workflows, allowing them to optimize resource allocation and improve communication between staff and clients. TUKIB's customizable and scalable nature makes it a valuable model for research institutions looking to enhance their operations without investing in entirely new systems.

- **The Computer Science Community**

  For the computer science community, TUKIB represents a meaningful contribution in terms of integrating workflow automation, real-time tracking, and chatbot technology into a research-driven service environment. The project showcases an innovative approach to solving a niche problem, providing a practical application for the latest software development methods and techniques in workflow optimization. Additionally, it demonstrates the importance of developing scalable, customizable solutions that can be adapted to a variety of organizational contexts.

  This research also serves as a case study in designing user-centered automation systems, contributing to the knowledge of software solutions that bridge the gap between operational requirements and technological advancements. The learnings from TUKIB could inspire future research in workflow management, data accuracy, and intelligent user interfaces.

- **The General Society**

  On a broader scale, the TUKIB project has the potential to benefit society by promoting more efficient research processes. By optimizing how research institutions manage their services, TUKIB indirectly supports the advancement of scientific research. With more streamlined workflows and reduced administrative burdens, research institutions can focus their resources on the core activities of scientific discovery and innovation. This, in turn, may lead to faster advancements in areas like environmental science, technology development, and public health, which could have far-reaching societal impacts.

In summary, TUKIB stands as an important system not only for those immediately involved in its implementation but also for the larger community of researchers, developers, and society as a whole. Its contributions reach across the fields of computer science, research, and institutional management, offering lasting benefits in terms of technological innovation and service improvement.

Chapter 2

Review of Related Literature

The purpose of this literature review is to provide a comprehensive background on automated systems for workflow automation, especially on service processes, which will inform the development of the system for the University of the Philippines Visayas - Regional Research Center (UPV RRC). This review aims to identify existing solutions, highlight gaps and challenges, and explore technologies that can be used to develop the system to improve the UPV RRC's operational efficiency.

2.1 Challenges in Manual Service Handling

Manual handling of service processes and data management can often lead to challenges, including inefficiencies, errors, and delays. One of the most common issues is the risk of data entry errors. Even small data entry errors can devastate outcomes, corrupting important data. A study involving three different data entry methods (double entry, visual checking, and single entry) revealed that manual entry, particularly visual checking, has a significantly higher number of errors-2958% more than double entry methods (Beaty, 1999). These errors can be subtle and difficult to detect, compounding their negative impact on operational efficiency.

Another limitation of manual service handling is its reliance on human intervention, which frequently results in mistakes that are hard to correct. These errors can escalate operational costs, affect service quality, and lead to customer dissatisfaction. For organizations with manual systems, human error compromises not just data integrity but also the scalability and effectiveness of service operations. Additionally, manual systems lack real-time monitoring capabilities, which are critical for improving service processes. Without automated tracking tools, organizations often miss out on insights that could highlight areas needing improvement.

Current practices in manual service handling also highlight limitations in widely used tools like Google Sheets and Google Docs, which are often insufficient for managing large-scale workflows. These tools lack advanced data retrieval capabilities, and users have reported issues with data not being pulled correctly. According to Okta's documentation on Google Sheets limitations, there are significant challenges when retrieving and integrating data, leading to inefficiencies in data management processes. Moreover, manual entry in Google Forms is prone to errors, which can undermine the accuracy of collected data.

The impact of these manual methods on stakeholders is substantial. Organizations relying on manual workflows often experience extended processing times, directly affecting service delivery. For instance, tasks that could be automated are unnecessarily prolonged when handled manually, delaying customer satisfaction. Furthermore, manual systems offer limited visibility and tracking capabilities. Without real-time performance metrics, organizations cannot effectively monitor their workflows or identify improvement areas. According to research, companies that automate their workflows experience reduced errors and faster processing times, which lead to improved operational efficiency and better customer outcomes. Thus, the inefficiencies inherent in manual service handling are a barrier to organizational growth, and stakeholders across all levels—from employees to customers—are adversely affected (Davis, n.d.).

2.2 Workflow Automation

Workflow automation refers to the utilization of technology systems, usually involving several software and hardware integrations, to efficiently carry out repetitive tasks, thereby reducing the roles of humans in it (Winarko, 2021). Workflow automation simplifies the sequencing and completion of tasks within a process by minimizing manual input. Also known as business process automation (BPA), this approach replaces human intervention with digital technologies to automate workflows. At the core of workflow automation is the ability to streamline processes in various job functions—such as HR, accounting, and procurement—into a series of repeated steps without human involvement. Users can define these steps and use tools like drag-and-drop interfaces to create automated workflows.

Research indicates that automating business processes through workflow automation can re-engineer operations, increase productivity, and improve decision-making timeliness (Abecker et al., 2000; Aversano et al., 2002; Kumar & Zhao, 1999). It can also enhance efficiency, ensure quality data collection, and improve overall output quality (London et al., 2009; Pakdil et al., 2009). Suitable processes for automation typically exhibit characteristics such as repeatability and predictability (Baresi et al., 1999; Basu & Kumar, 2002).

A workflow automation software uses rule-based logic to automate tasks that would otherwise require manual effort, such as data entry. While traditionally seen as a tool for IT departments, this software simplifies complex business operations, enhancing efficiency, productivity, and overall customer satisfaction. It is a valuable resource across the entire organization. Connecting various business processes automates critical tasks, sequences, and approvals, allowing workflows to progress automatically without human intervention. This leads to several key advantages for businesses (ServiceNow, n.d.).

Automating workflows offers significant benefits by addressing the limitations and inefficiencies associated with manual processes. While employees are crucial assets, their capacity to handle repetitive tasks is limited, and relying solely on them can lead to bottlenecks, errors, and revenue loss. By automating key steps and handoffs, workflows proceed more swiftly, reducing the time spent on manual tasks and enabling employees to focus on strategic initiatives. Furthermore, automated workflows provide transparency and detailed records, which improve accountability by clearly documenting task progress and responsibilities. Automation also minimizes errors by adhering to predefined rules and methodologies set by programmers, maintaining consistent results. Ultimately, these improvements improve customer experience by speeding up processes, reducing errors, and enhancing service delivery.

2.2.1 Workflow automation in different industries

Automation was used for several workflows across a range of industries. Certain industries, like manufacturing and banking, have a long history of using automation, while others, such as legal consultation, hospitality, and transportation, are newer to automation (Zayas-Cabán, Haque, & Kemper, 2021). Across industries, various workflows have been automated, such as accounting tasks, document routing, resource allocation, quality monitoring and control, report generation, and supply chain and logistics management (Aguirre & Rodriguez, 2017; McQuilken, 2014).

In the education sector, many universities worldwide use automation tools of some form, driven by the need for efficiency and compliance with educational standards. These tools facilitate various processes, including enrollment, grading, and course management, allowing educators to focus more on teaching and student engagement (Choudhary, Tariq, Chaudhry, Maneha, & Awan, 2024). Similarly, automation in healthcare has improved the accuracy and accessibility of patient information, resulting in more informed decision-making. Even in government offices, the evident use of automation tools for service processes can also be observed to enhance service efficiency and transparency.

2.3 Client and stakeholder feedback mechanisms

Automated systems enhance client and stakeholder feedback mechanisms, offering faster, more accurate, and easily accessible ways to gather feedback. In contrast to manual systems, where feedback collection is often slow and inefficient, automation streamlines the process and allows organizations to capture valuable insights in real-time. Automated feedback systems provide multiple channels for clients to share their experiences, such as surveys, feedback forms, chatbots, and email prompts, making it more convenient for them to respond.

One of the key advantages of automation in feedback mechanisms is its ability to increase client satisfaction. Automated systems ensure timely follow-up, enabling organizations to respond to client issues promptly. This immediacy improves client trust, as they feel heard and valued. Furthermore, automation allows consistent feedback collection without burdening staff with repetitive tasks. For instance, after a service interaction or product delivery, an automated system can trigger a feedback request immediately, reducing the chances of missed feedback opportunities. Automation also enhances the quality and volume of feedback collected. By integrating analytics tools, organizations can sort and analyze client responses faster, identifying trends and areas for improvement more effectively than manual methods. This enables companies to act swiftly on the feedback received, leading to quicker improvements in service quality and customer satisfaction. Additionally, automated feedback systems can be configured to send reminders to clients who have not yet provided feedback, thus increasing the response rate.

Moreover, automated systems contribute to data centralization and organization, making tracking feedback over time and measuring progress on key performance indicators (KPIs) easier. For example, client satisfaction scores, Net Promoter Scores (NPS), and other metrics can be automatically compiled and visualized in dashboards, providing stakeholders with actionable insights. This real-time access to data helps address individual client concerns and allows businesses to refine their services based on aggregate feedback.

In stakeholder management, automated systems enhance transparency and engagement. Regular automated reports on client satisfaction metrics keep stakeholders informed about service performance and areas that require attention. This fosters a culture of continuous improvement, as stakeholders can actively shape the business strategy based on real-time feedback. As summary, automated feedback mechanisms lead to greater client satisfaction by streamlining the feedback process, improving response times, and providing actionable insights that support long-term business growth.

2.4 Existing Systems

The development of various digital automation systems and platforms has proliferated over the years. These systems encompass a wide range of functionalities - from automating tasks to facilitating collaboration among staff.

For instance, Enterprise Resource Planning (ERP) Systems are integrated software solutions that manage the core business processes of an organization (Blahusiakova, 2023). ERP systems integrate various business processes, such as Finance, Human Resources, Supply Chain Management, and Customer Relationship Management (CRM), into one complete system to streamline processes and information across the organization (Kimberling, 2024). Examples of existing ERP systems that are used by businesses and organizations are Microsoft Dynamics 365 Business Central, Syspro, QT9, and Acumatica. In addition to these comprehensive systems, some businesses and institutions are also utilizing Google apps like Google Drive, Docs, and Sheets to facilitate easier information sharing, enabling teams to work collaboratively.

Moreover, online automation platforms like Zapier and Integromat (Make) help automate interactions between different apps, enabling businesses to integrate multiple systems and optimize workflows without the need for coding (Wolf, 2020). These systems are examples of how institutions tackle complex tasks, reduce manual data entry, and improve decision-making.

2.5 Gaps in the existing systems and solutions

Despite the availability of various existing automation systems, significant gaps persist that hinder their effectiveness. One major gap is customization limitations which prevent organizations from tailoring solutions to their specific workflows (Aleixo, Freire, Santos, & Kulesza, 2010). These one-size-fits-all solutions can lead to inefficiencies, as standardized systems may not align with different organizations' unique processes or requirements. Employees might adapt their workflows to fit the software rather than the software, enhancing their operational efficiency.

Additionally, the lack of adaptability to changing processes can render these existing systems ineffective over time. While these existing solutions might be beneficial to some companies, they can be detrimental to organizations that rely on their capacity to meet customer demands(Akkermans et al., 2003). Also, as organizations evolve, they often need to adjust their workflows in response to new challenges, regulations, or market demands. Rigid Systems that cannot easily accommodate such changes can become obsolete.

Furthermore, many existing software solutions are proprietary, increasing costs for organizations. Proprietary systems often have high licensing fees, maintenance costs, and limited scalability (Madhu Goel, 2012; Prasad & Reddy, 2013). Organizations may find themselves locked into contracts that are not cost-effective, particularly if the software does not deliver the expected return on investment. On top of that, the difficulty of adapting and getting these automation systems to work effectively is also well documented (Adams, Edmond, & Ter, 2011).

2.6 Chatbot

With the increasing use of the Internet, many businesses and institutions are utilizing online platforms to manage customer inquiries. Consequently, a growing number of them are adopting chatbots to enhance customer service, streamline operations, and boost productivity (Suta et al., 2020). In recent years, chatbots have become an important tool across various industries, particularly in service delivery and automation.

The word "chatbot" is a portmanteau word that is a combination of the words "chatting" and "robot" (Rese, Ganster, & Baier, 2020). A chatbot is an example of technology that is used in computer-mediated communication, where an intelligent system occupies roles once served by humans (Austin Beattie & Edwards, 2020). It is also defined as conversational software that is capable of simulating human conversation with an end user through text or voice interaction (Nuruzzaman & Hussain, 2018).

Chatbots can be broadly categorized into two types; rule-based and AI-based chatbots. Rule-based chatbots function with a set of guidelines through pattern-matching and are limited in their conversation. This means that it can only respond to a limited range of queries and vocabulary. AI-based chatbots leverage artificial intelligence(AI), natural language processing(NLP), and machine learning(ML) technologies and algorithms to understand different keywords that users type in when chatting with them. This integration significantly enhances user experience and operational efficiency as these chatbots learn and adapt over time (Kar & Haldar, 2016).

2.6.1 Chatbots in Service Automation

Chatbots are deployed across different platforms, including websites, social media, and instant messaging applications, making them good tools for both internal and external organizational tasks (Hagberg, Sundström, & Egels-Zandén, 2016; Zarouali, Van den Broeck, Walrave, & Poels, 2018). Internally, chatbots support services, including IT Service Management (ITSM), Human Resource Management (HRM), and learning management systems (Wolf, 2020; Nawaz& Gomes, 2019; Bakouan, 2018). Externally, chatbots are increasingly replacing traditional branded websites, offering a more interactive platform for customer relationship management, sales, and marketing (Broeck, 2019).

Institutions are utilizing chatbots for various applications. For instance, Pennsylvania State University employs a chatbot called "LionChat" to address frequently asked questions regarding admissions, student aid, and tuition costs (PennState, 2020). In healthcare, AI chatbots can be utilized to enhance patient care and streamline processes such as checking symptoms, reminders, and appointment scheduling (Altamimi, Altamimi, Alhumimidi, Altamimi, & Temsah, 2023). Moreover, a case study by (Fan et al., 2021) on the utilization of a self-diagnosis chatbot in China highlighted the potential for chatbots to improve user engagement by offering real-time feedback and personalized responses.

2.7 Synthesis

As previously mentioned, the researchers aim to create a workflow automation system specifically for the University of the Philippines Visayas Regional Research

Center (UPV RRC) to streamline and optimize their service flow and data management. Currently, the institution is using manual processes employing tools such as Google apps.

The difficulty of manual service handling is discussed in this chapter, as well as the benefits of having an automated system. Several studies mentioned indicate that workflow automation can significantly streamline repetitive tasks, improve data accuracy, and enhance decision-making processes reducing human intervention.

While existing systems for workflow automation are available, there are still gaps that these systems cannot fill, such as limitations with customization, cost-effectiveness, adaptability, and integration issues. The proposed system for UPV RRC aims to address these specific gaps by offering a tailored solution that meets the specific needs of the institution. One technology that can be particularly beneficial for this is a chatbot, which will enhance the consultation process when availing a service from the institution by providing instant responses to inquiries.

Chapter 3

Research Methodology

This chapter presents the tools, techniques, and methodologies used in the development of the TUKIB system, an integrated workflow automation solution designed for the UPV Regional Research Center (RRC). It specifies the software and hardware requirements, as well as the comprehensive process involved in creating the system.

3.1 Research Activities

3.1.1 Development Framework

Agile Methodology

The software development approach that the developers will follow in developing TUKIB is the agile methodology. Agile methodology, or simply agile, is a framework that emphasizes iterative development and features communication and collaboration, adaptive planning, and continuous development (Agile Framework, 2022). The developers chose this framework because of its flexibility and adaptability to change, which is beneficial, especially with evolving user requirements.

As seen from Figure 3.1, agile involves continuously cycling through phases of development, testing, and review or feedback before finally launching the system. This enables developers to make adjustments and improvements based on user input.

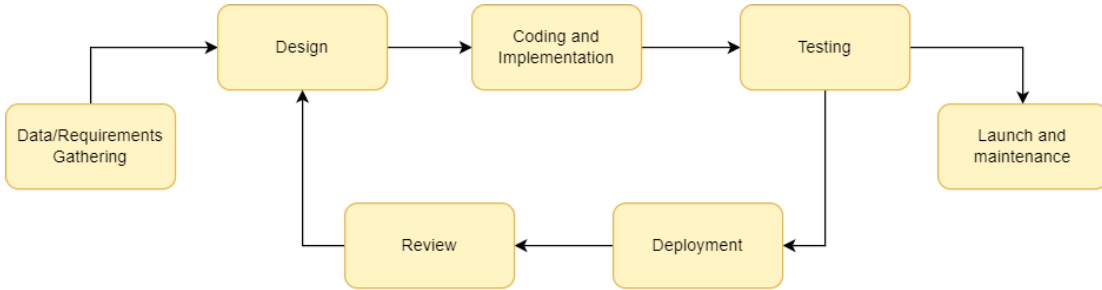

Figure 3.1: Agile Methodology

Data Gathering and Documentation

The developers will begin the project by visiting the UPV RRC, where they will conduct interviews with stakeholders. This phase is essential for gaining a comprehensive understanding of the institution's specific needs and for planning the system features accordingly. The data gathered during these interviews will guide the subsequent phases of the project, ensuring that the system is tailored to meet the requirements and expectations of its users.

This phase will include the following activities:

- **Defining Objectives.** Establishing the primary goals of TUKIB based on preliminary research and stakeholder input, ensuring that the project aligns with user needs.
- **Stakeholder Identification.** Identifying key stakeholders, including RRC personnel and potential users, to ensure that a diverse range of needs is considered and addressed throughout the development process.
- **Defining User Requirements.** Collecting and analyzing user requirements through interviews and interactions with stakeholders. This will involve creating user stories to capture the specific needs and expectations of different user groups, ensuring that the system design is informed based on real-world usage scenarios.

System Design

After data gathering, the system's architectural design will be developed. This process will involve creating a context model to outline the system's interactions with external entities, as well as a data flow diagram to illustrate how data moves through the components of the system. A process flow diagram will also be constructed to detail the specific processes and workflows, while database models will be designed to ensure efficient data storage and retrieval.

The researchers will also focus on effective user interfaces (UI) for service request handling and management, investigating best practices and design principles that enhance user experience based on feedback from users of existing similar software or systems. Once all necessary information is gathered, a mock-up design of TUKIB will be created, serving as the basis for the system's prototype. Together, these diagrams and designs will provide a comprehensive framework that will guide the development and implementation of the system effectively.

Implementation

From the design phase, the development of the system will start. The frontend will be built to ensure a user-friendly interface, while the backend will support functionality through efficient data processing and secure user authentication. A chatbot will also be integrated to facilitate real-time support and user interaction with the system.

Since the developers are following the Agile methodology, the implementation phase will occur alongside testing. This iterative process will involve cycles of development and testing during each sprint, with each sprint lasting two weeks. This approach allows for continuous feedback and improvements, ensuring the system meets user needs effectively.

Testing

The testing of the system will be consisted of 3 main components to ensure its reliability, usability, and overall performance.

- **Alpha Testing.** During and after the development of each feature, extensive user testing will be conducted to ensure that each feature works as intended. Any bugs or problems will be immediately fixed. For features dependent on other features (i.e. user account creation must function correctly before user can log in), thorough testing will ensure and verify that the integration between these features operates smoothly.

- **Automated testing.** Automated testing will be implemented to ensure reliability and efficiency in testing the features of the system. This approach will allow for the execution of predefined test cases that can be run repeatedly with minimal manual intervention.

- **Beta Testing.** Beta testing will be done with a limited group of users composed of available RRC staff and selected potential customers of RRC (e.g. students and faculty). This phase will allow real-world usage feedback and will help in identifying any remaining bugs and usability issues. Users will test the system in various environments and will be encouraged to provide insights on functionality, performance, and overall experience.

Deployment and Maintenance

The final product of the study, TUKIB, will made available to the intended users. In this phase, ongoing maintenance and regular performance monitoring, especially of the backend, are essential to ensure stability and reliability. Feedback form will be issued to users in to gather their thoughts and insights about the system or if they have encountered any bugs. Constant feedback from users during this phase will guide further improvements and updates.

3.2 Development Tools

3.2.1 Hardware

The hardware requirements for the development of the system include a computer or laptop with the following specifications:

- Processor: Intel Core i5, its equivalent on other brands or higher
- RAM: 6GB or higher
- Storage: 200GB SSD or more for faster data access and retrieval Operating System: Windows 10 or higher, macOS, or Linux

These specifications are necessary to ensure smooth development and testing of the system, especially when handling large datasets and concurrent processes.

3.2.2 Software

The TUKIB system will be developed using a range of modern software tools tailored to meet the specific needs of the research center's workflow automation and data management processes.

- **HTML5, CSS, and ReactJS**

  These technologies will be used for front-end development of the system. HTML5 will structure the webpages, CSS will be responsible for the visual styling, and ReactJS enables dynamic and interactive user interfaces.

- **PostgreSQL**

  For backend development, PostgreSQL is will be used as the database management system, offering robust data storage, querying, and management capabilities.

- **Rasa Framework**

  Rasa will be used for the chatbot development. It allows the creation of a conversational AI system which will handle the service requests, queries, and management capabilities of the system.

- **Figma**

  Figma will be utilized for designing the UI/UX of the system. Figma allows design collaboration, which will ebavle the team to create the system prototype, wireframe, and mock-up interfaces before implementation, ensuring a user-friendly experience for both clients and researchers.

- **VS Code**

  Visual Studio Code (VS Code) is the primary code editor that will be used to develop the system. Its features, such as syntax highlighting, extensions, integrated Git, and debugging tools, make it the most suitable environment for writing and testing front-end and back-end code.

- **Github**

  GitHub will be used to facilitate for version control and collaboration thoughout the development of the system. The project code is stored in repositories, allowing the team to manage changes, track progress, and collaborate effectively. It also serves as a backup and source for future development or modification.

Chapter 4

Preliminary Results/System Prototype

This chapter presents the preliminary results of the study, including findings from data gathering, the system's diagrams and designs, initial user interface (mockup UI) for the front end, and the chatbot's architecture.

4.1 Data Gathering Results

The research process for developing TUKIB started with a comprehensive visit to the UPV RRC during the researchers' internship. This phase involved engaging with key personnel and understanding the intricacies of the center's operations. The following sections detail the key activities and information undertaken and gathered during this visit.

4.1.1 Facility Tour

During the researcher's visit, they met with the center's director, administrative staff, and laboratory heads. This introduction provided valuable insights into the roles and responsibilities of various individuals and departments within the RRC. Understanding these dynamics was crucial for tailoring the system to fit the center's workflows.

The researchers were also given a guided tour, which provided an overview of various laboratories and services offered. These services includes:

- **Sample Processing.**The RRC provides critical sample processing services, essential for research and analysis.
- **Laboratory Equipment Rental** Various pieces of laboratory equipment are available for rent, which supports a wide range of scientific projects.
- **Training and Workshops.** The RRC offers training sessions on laboratory equipment, promoting user proficiency.
- **Facility Rentals.** Access to spaces like the Audio-Visual Room (AVR) and conference rooms was noted as a valuable resource for users.

Each laboratory, including the Biology, Microbiology, Nanotechnology, and Applied Chemistry labs, was introduced in detail, with specific equipment and services discussed in terms of their availability and purpose. The UPV RRC houses five (5) laboratories, namely: Biology, Microbiology, Nanotechnology, Applied Chemistry Laboratory, and Food, Feeds, and Functional Nutrition Laboratory.

4.1.2 Stakeholder Identification and Engagement

The success of workflow automation hinges on understanding the needs and expectations of its key stakeholders. These stakeholders include the RRC laboratory and administrative staff, the clients (university and student researchers and external users of the RRC facilities), the developers, and the member/s of the Computer Science Faculty guiding the project.

The researcher's interaction with the stakeholders allowed them to gather valuable feedback on the existing system and the challenges they faced. This feedback played a crucial role in shaping the direction of our system design, as it highlighted the need for automation, service tracking, and streamlined communication between stakeholders. Additionally, stakeholders were interviewed on their specific needs and pain points. These discussions led to the creation of user stories, which helped to contextualize the requirements from various perspectives.

This in-depth exposure to the center's operations was essential for the initial design and development phase of TUKIB, providing a strong foundation for creating a system tailored to the specific needs of the RRC and other research institutions with similar setups.

4.1.3 Scope and Limitations of the Services

Through direct discussions with the center's director and administrative staff, the researchers obtained a clear picture of the scope of services provided by each facility, as well as the current limitations they face. Some of these limitations include:

- The UPV RRC currently has no centralized system available to the public which describes its mission, vision, services offered, as well as, steps on how to request a service, and other relevant information. This limits clients from acquiring necessary information about the center and its services.
- The staff also has difficulty in tracking equipment and facility availability in real-time, as it is essential to ensure that no one else is using an equipment or facility before it can be rented out on a specific time and date.
- Manual service request and data management are also a problem as the RRC's current system relies mainly on Google Forms and Sheets, which poses challenges in efficiency and scalability.

4.1.4 User Requirements

Based on the gathered data with stakeholders and observations during the facility tour, several key user requirements were identified for the development of TUKIB.

- **Service Information Accessibility**
- **Automated Service Requests**
- **Equipment and Facility Availability Tracking**
- **Data Management and Reporting**
- **User Account Management**
- **Feedback Mechanism.**

4.2 System Design

4.2.1 Process Flow Diagram

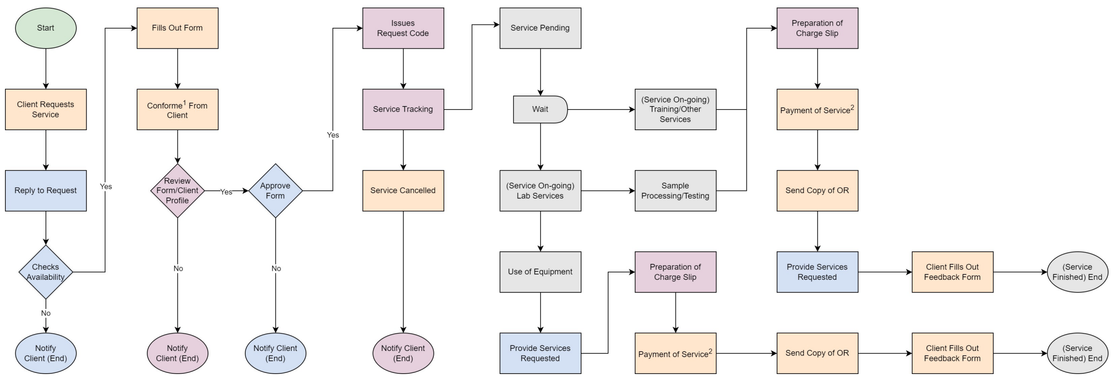

Figure 4.1: Process flow diagram from service request to feedbacking

Figure 4.1 illustrates the entire service delivery process of RRC. The process starts with a service request from the client and ends with a feed back from them.

4.2.2 Context Model

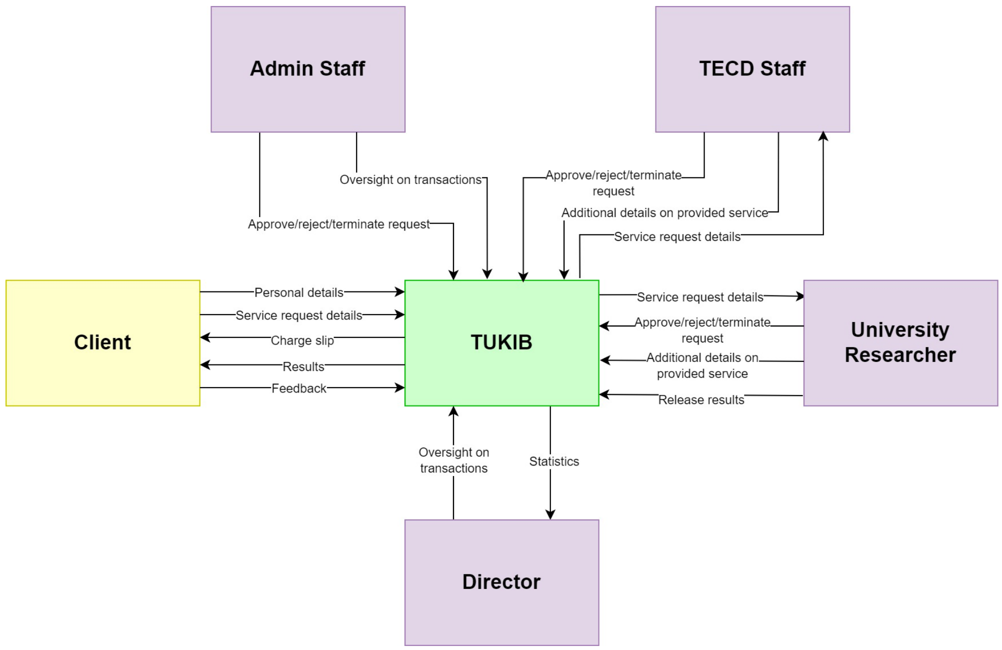

Figure 4.2: Context model for interactions between the TUKIB and its users

Figure 4.2 illustrates the interactions between the system and both internal and external entities. It highlights how the system communicates with different stakeholders, including client, staff, director, and university researcher. The model also outlines how information flows entities to the system and vice versa, showing how the system works and its role within the institution.

4.2.3 Data Flow Diagram

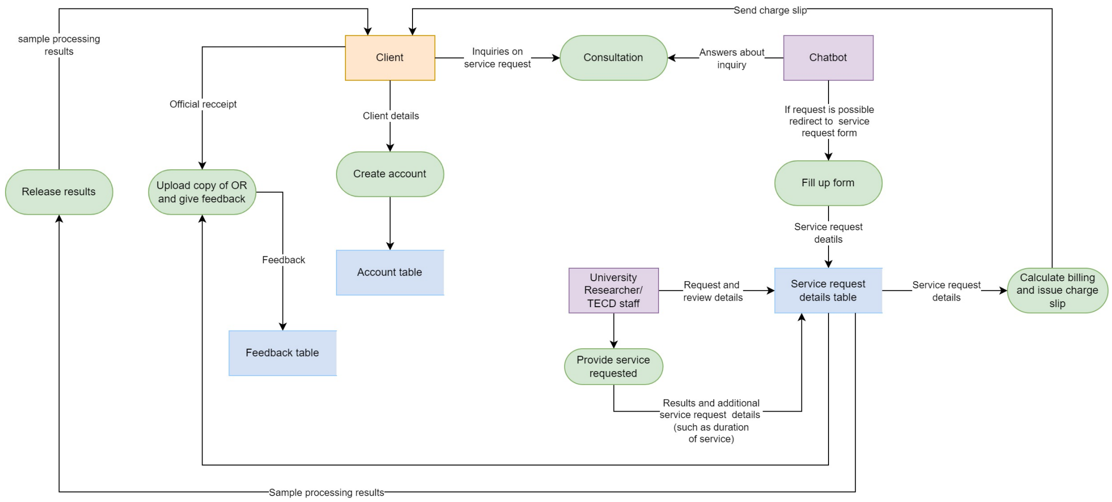

Figure 4.3: Data flow diagram from service request to feedbacking

Figure 4.3 shows the flow of data within the system, illustrating how information is exchanged between different components and users. The diagram also illustrates the pathways through which data moves, providing overview into how information are stored and retrieved within the system.

4.2.4 Database Diagram

Figure something illustrates the database diagram of the system.

4.3 Chatbot

Entities and Intents

From the data gathering phase, the developers were able to identify common user queries and specific service requirements needed for the development of the chatbot. The collected data was used to construct the intents and entities which are essential for the chatbot's functionality.

Intents represent the goal the users want to achieve when interacting with the chatbot (e.g., "start consultation," "ask about lab rental procedures," "inquire about service status"). The intents are divided into greeting, general, service requests, frequently asked questions, feedback, and end or closing message.

On the other hand, entities are specific pieces of information that the chatbot needs to get from the user in order to fulfill a task. For example, the chatbot needs to know the laboratory name and desired time for renting the equipment in order to indicate its availability.

Conversation Flow

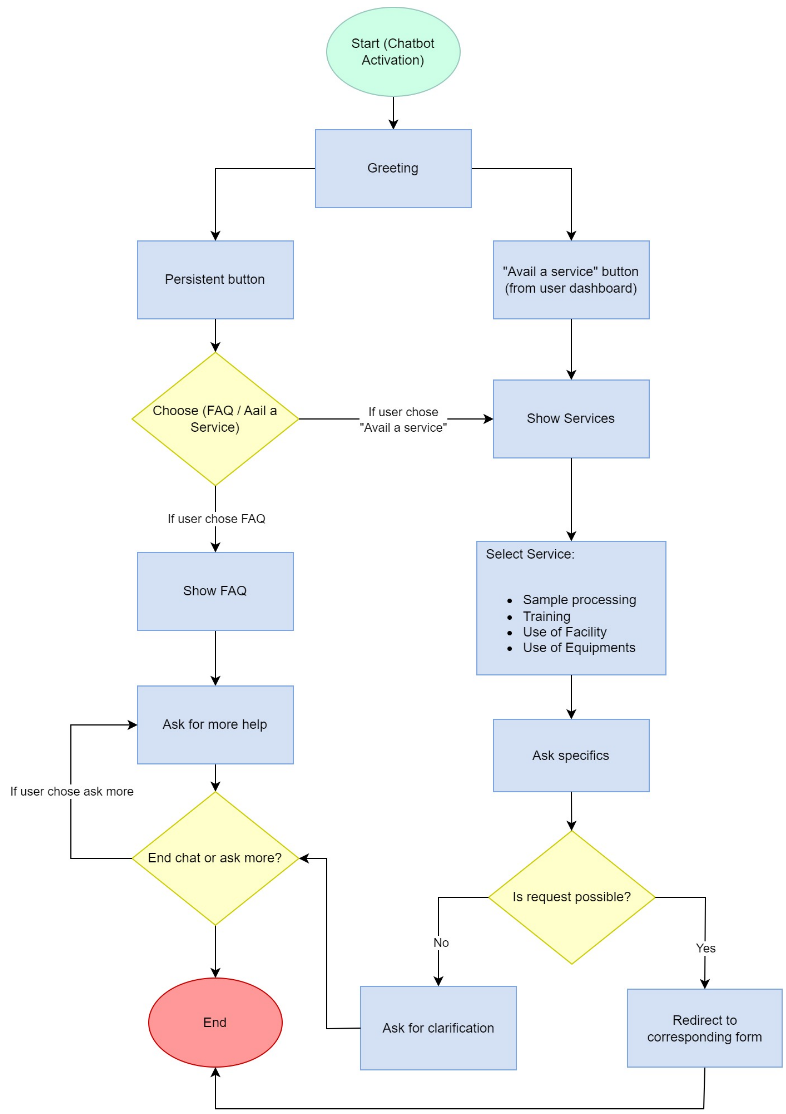

Figure 4.4: LIRA conversation flow

Figure 4.4 illustrates the conversation flow for TUKIB's chatbot, named LIRA—short for Learning, Innovation, and Research Assistant. LIRA will be accessible throughout the entire website, ensuring that all users, whether logged in or not, can obtain support whenever needed. Users can initiate a chat with LIRA via a persistent button that remains visible across the site or by selecting the dedicated "Avail a Service" button found on the user dashboard.

The architecture of the chatbot is centered around a conversational flow that guides users through various tasks, from inquiries to service requests. The chatbot's design consists of the following core components:

- **Welcome Greeting**

  Present a welcome message where the chatbot greets users with a friendly introduction and offers assistance, presenting options such as "Service Inquiry" and "Frequently Asked Questions/FAQs"

- **Flow for Service Inquiry**

  If the user chooses the option "Service Inquiry," the chatbot will ask a follow-up question to identify which service the user wishes to inquire about. Sample service choices include sample processing, lab equipment rental, etc. Then, the chatbot uses the user's answer details to present accurate information about each service.

- **Flow for Consultation**

  The flow for consultation is designed to facilitate user inquiries about the services they wish to avail. As the primary purpose of the chatbot, this interaction allows users to ask questions about the services offered by RRC. When a user expresses interest, the chatbot engages by asking for specific details related to their request. For instance, if a user inquires about sample processing (e.g., the type of sample and processing methods needed), the chatbot will guide them through the details. This interactive process ensures that users receive tailored information while the chatbot gathers necessary details to asses service feasibility.

- **Flow for General Questions / FAQ**

  The chatbot should be able to answer and handle frequently asked questions by clients. These would include questions about general services, rental pricing methods, facility rental processes, etc.

- **Chatbot User Feedback**

  After chatbot services are completed, the chatbot will prompt the user to rate or provide feedback on their experience, which will help the developers and the RRC enhance their service quality.

- **Error Handling**

  Chatbot failures will lead to conversational dead ends if not dealt with properly. Thus negating the main purpose of chatbot in this system which is to provide efficient customer service. The chatbot will have a fallback mechanism whenever user input is unexpected or a system error occurs. For example, if the chatbot cannot understand the user input, there will be rules on how the chatbot would handle this situation. Sample fallback methods would be redirecting the conversation to a live agent.

Another option would be presenting friendly-toned error messages to the users, letting them know that the chatbot is having trouble understanding their input. Sample error messages would be "Sorry, I didn't catch that. Could you rephrase your question?" or "I'm sorry, I have a hard time understanding. Could you please rephrase your query?" and "I'm sorry, but what you're asking is not clear to me. Could you paraphrase it?"

4.4 User Interface Mock-up

4.4.1 Landing Page

4.4.2 User authentication and dashboard

User dashboard is designed for the needs of two primary user groups of TUKIB who are the staff and clients. Each user group has a different user interface to cater to their specific needs.

For the customers' user interface, the developers designed a dashboard that shows the user's profile, transaction history, and a button to avail a new service. For the staffs' user interface, a layout was designed specifically for their tasks, featuring information and capabilities necessary for efficient management and oversight. This includes tools for monitoring workflows, accessing reports, and managing user requests.

The layout for both staff and customers' user interface ensures easy navigation and quick access to essential information, enhancing the overall user experience.

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Appendix A

Appendix Title

Appendix B

Resource Persons

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