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

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Abstract

Manual service flow and data management is still one of the challenges faced by many businesses and institutions, even in today's digital age. One such institution is the UPV RRC, which currently relies on manual processes, using Google Apps for their entire service delivery process. Although functional, this system is inefficient and limits the center's potential, posing challenges not only to the staff but to the clients as well. This proposal aims to develop TUKIB, a centralized system to automate the service flow process and data management of the UPV RRC. Additionally, this paper also explores the development and integration of a chatbot to enhance user support and interaction, as well as streamline communication with stakeholders. The proposed system aims to reduce manual tasks, improve data management, and provide ease for both staff and clients of UPV RRC, enhancing the overall operational efficiency of the institution.

Keywords: Workflow Automation, Chatbot, Rasa, Data Management, Service Flow

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Chapter 1

Introduction

1.1 Overview

In the era of digital transformation, efficient data management and optimized service workflows are crucial for the success of any business or institution. Perhaps one of the most remarkable and known products of technology is the conversion of paper-based or manually-operated systems to automated systems. It is unquestionable 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. Currently, the institution relies heavily on manual processes, using tools such as Google Apps throughout their entire service delivery process from handling service requests, tracking, to data management. Although this method offers a foundational level of functionality, it falls short in addressing the specific needs of the UPV RRC, in their service delivery workflow. This poses challenges not only for the staff but for the clients of the institution as well.

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. It also helps in reducing costs and provides greater value to customers (Zayas-Cabán, Haque, & Kemper, 2021).

Over the years, various technologies have emerged to address the pressing need for automation. The proliferation of advanced software solutions offers organizations and institutions an opportunity to enhance their operational efficiency. However, existing systems fall short in addressing the specific needs of some institutions. Adapting these existing systems often give birth to other problems as integrating and customizing ready made softwares can be difficult and costly. In cases like this, developing a new software tailored to the specific needs of an institution can be a much better option.

Recognizing this gap, this paper explores the design and implementation of a software solution that is tailored to the unique needs of the UPV RRC, aiming to replace the institution's current system by automating its service delivery flow and data management. Additionally, this study includes the development and integration of a chatbot, using the Rasa framework, to enhance and streamline the institution's client support, interaction, and communication. With the use of modern technologies and best practices in software development, this paper seeks to add knowledge on building a practical and scalable system, specifically one that can be used by the UPV RRC for their service delivery processes.

1.2 Problem Statement

In today's fast-paced world, success is often associated with efficiency, especially in the business environment. A report by McKinsey & Company (Manyika et al., 2017) reveals that about 60% of occupations involve at least 30% of tasks that are automatable. Despite the growing recognition for the need of automation and even with the rise of different technologies, many businesses and institutions are still dependent on manual or semi-automated workflows. While various workflow automation technologies exist, adapting off-the-shelf softwares is costly and challenging as this softwares often requires extensive customization to fit the institution's unique needs and is difficult to integrate.

The University of the Philippines Visayas Regional Research Center (UPV RRC) is one such institution that is still reliant on manual processes, especially on their service flow delivery and data management. Various tasks including handling of client requests, managing laboratory services, and tracking service-related activities are carried out with the use of semi-automated tools like Google Apps, which is technically still dependent on human intervention. This leads to inefficiencies such as delays, difficulty in tracking, and errors, ultimately compromising the institution's overall productivity.

To address these issues, an integrated workflow automation system that is tailored to the needs of the UPV RRC can be developed to ease the difficulties faced by the institution in their service delivery. This system will automate service requests, improve data management, enhance communication between RRC staff and clients, and enhance overall operations. With automation, the center can improve the efficiency, accuracy, and accessibility of its services, supporting both the internal management and external client 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. Develop a centralized data management system for the RRC to ensure secure, efficient storage, retrieval, and management of information related to service requests, laboratory usage, and client transactions.

2. Design and implement an automated chatbot to handle consultations, enabling clients to interact with the system for service inquiries and support in real-time.

3. Implement an intuitive and user-friendly design that ensures ease of use and accessibility for both staff and clients of UPV RRC.

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

1.4 Scope and Limitations of the Research

This special problem focuses on developing the TUKIB- short for Tracking Utility for Knowledge Integration and Benchmarking, a workflow automation system designed for the UPV Regional Research Center (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, facility and equipment availability tracking, and a centralized platform for storing and managing service-related 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 included in the development. With this, data accuracy throughout the service flow process will be ensured by minimizing manual input and automating repetitive processes, reducing errors and improving operational efficiency of the UPV RRC. This special problem will also involve the development and integration of a chatbot to enhance user support and communication between clients and staff, providing instant responses to inquiries. Additionally, the system will be scalable, allowing it to be flexible for further modification as the needs of UPV RRC evolves.

The system's functionalities will be limited to the service-related processes by the UPV RRC and may not cover other internal and external functions. The development will be tailored to the specific workflows of UPV RRC, so modifications would be needed for implementation in different institutions or industries. Additionally, this special problem will focus on workflow automation but will not delve into advanced analytics or AI beyond using chatbots for customer communication and basic statistics for service feedback reports. The system will require a stable internet connection for real-time features like notifications and status tracking; thus, its performance may be compromised in areas with poor connectivity. Moreover, 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

This study offers great significance in many domains, benefiting the UPV RRC and its clients, the researchers, other institutions, and the computer science community.

- **The Researchers.** This study provides a great opportunity for the researchers to apply their theoretical knowledge and practical skills to solve real-world problems. This allows them to demonstrate their competency in system design and software development.

- **The UPV RRC and its clients.** The development of TUKIB will significantly improve the operational efficiency of the UPV Regional Research Center by automating its service request workflows and data management processes. This will not only benefit the staff but the clients as well.

- **Other Institutions.** Other institutions facing similar challenges in managing their service flow processes and data can also benefit from this special problem. They can adapt TUKIB to their own workflows or this study can serve as a guide for them in creating their own specialized software solution.

- **The Computer Science Community.** The Computer Science Community also benefits from this study. This contributes to the existing knowledge in developing a tailored workflow automation system by providing perspective into the practical application of various software development tools and methods. Additionally, this special problem also serves as a case study in designing a user-centered software. Other developers can gain valuable insights and inspiration from this for their own projects.

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 (Barchard & Pace, 2011). 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). It is also defined as "the application of technology, programs, robotics or processes to achieve outcomes with minimal human input" (IBM, 2024). 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, Bernardi, Maus, Sintek, & Wenzel, 2000; Aversano, Canfora, Lucia, & Gallucci, 2002). It can also enhance efficiency, ensure quality data collection, and improve overall output quality (Pakdil et al., 2009). Suitable processes for automation typically exhibit characteristics such as repeatability and predictability (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.

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 et al., 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 (Gupta & Arora, 2020). 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 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 (Blahušiaková, 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.

2.4 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, Bogerd, Yücesan, & van Wassenhove, 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; Sarker & Lee, 2003; Scott & Vessey, 2000).

2.5 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. Inarguably, chatbots are used daily by some people. Some instances of this are Siri from Apple, Alexa from Amazon, Microsoft Cortana and Bixby from Samsung that have the ability to open apps, play music, set calendar events and, overall, be a virtual assistant.

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).

Table 2.1 shows the key differences between an AI chatbot and a non-AI chatbot. As seen, AI chabots are more adaptive in nature and have advanced capabilities than non-AI chatbots.

	Non-AI Chatbots	**AI Chatbots**
Conversation Capabilities	• Linear, rigid chat flow primarily driven by radio button selections • Ignores user free-text input • Context insensitive	• Dynamic, flexible chat flow based on user input • Understands and responds to free-text input • Context-aware interactions
People Insights from Chat	• Only from user explicit choices	• Read between the lines to infer people's insights
Suitable Tasks	• Task-oriented app • Structured, simple tasks that require little user input	• Task-oriented + social chitchat (semi-structured) • Semi-structured tasks with many varied paths • Diverse user actions or questions

Table 2.1: Comparison of Non-AI vs AI Chatbots
From https://juji.io/docs/why-ai-chatbots/

2.5.1 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 (Nawaz & Gomes, 2019; Bakouan, Kamagate, Kone, Oumtanaga, & Babri, 2018). Externally, chatbots are increasingly replacing traditional branded websites, offering a more interactive platform for customer relationship management, sales, and marketing (Van den Broeck, Carpini, & Diefendorff[3], 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.

2.5.2 Chatbot Frameworks

Building a chatbot from scratch is not an easy task, that's why chatbot development frameworks have emerged over the years. Chatbot development frameworks are software frameworks that provide built-in functions to simplify the complexities of creating a chatbot (GeeksforGeeks, 2024).

A study by (Hourrane, Ouchra, Eddaoui, Benlahmar, & Zahour, 2020), provides a comprehensive analysis of various frameworks that can be used in developing chatbots. Table 2.2 shows the analysis between different chatbot frameworks. The analysis is only limited to the existing frameworks during the study was conducted. Although most of the frameworks are free, they offer limited capabilities, and further access to services requires a subscription. Only Rasa offers an open-source version.

Framework	Company	Paid/Free	Ease of Use	Out of box integration	Open Source	Popularity	Web-based	Language
QnA Maker	Microsoft	Free	High	Yes	No	Medium	Yes	C#
DialogFlow	Google	Free	High	Yes	No	High	Yes	JavaScript
Rasa	RASA	Free	Low	No	Yes	High	No	Python
Wit.ai	Facebook	Free	High	Yes (Facebook)	No	High	Yes	JavaScript
Luis.ai	Microsoft	Free	High	Yes	No	Medium	Yes	JavaScript
Botkit.ai	Botkit	Free	Low	Yes	No	Medium	No	JavaScript

Table 2.2: Comparative analysis of different chatbot development frameworks.

2.6 Synthesis

As mentioned in Chapter 1, 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 delivery flow and data management. Currently, the institution is using manual processes employing tools such as Google apps.

Manual processes, especially when involving large amounts of data and interrelated activities, pose a lot of challenges and limitations. This includes being prone to error, reliance on human intervention, and delays in processing. Several studies mentioned above indicate that workflow automation can significantly streamline repetitive tasks, improve data accuracy, and enhance decision-making, ultimately reducing human intervention.

While existing systems for workflow automation are available, there are still gaps that these systems cannot fill, such as customization limitations, 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 can enhance the UPV RRC's client support and interaction.

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.

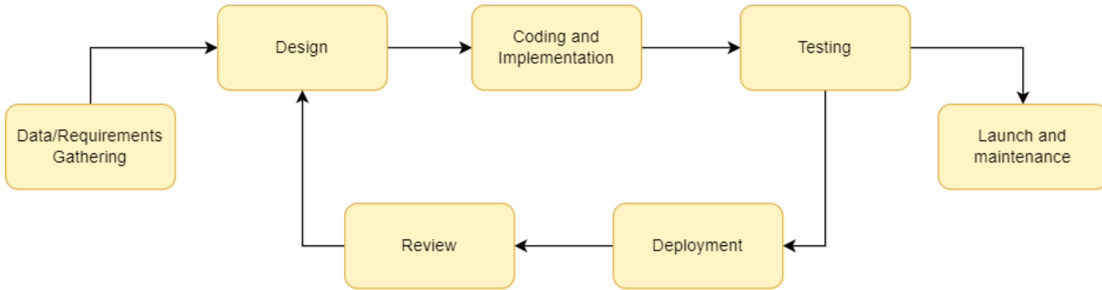

Figure 3.1: Agile Methodology

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 Chatbot architecture and development

3.2.1 Rasa Chatbot Architecture

The chatbot for the system will be created using the Rasa framework. Rasa is an open source conversational AI framework that allows developers to build, deploy, and improve AI-powered chatbots and virtual assistants. Figure 3.2 shows the details about the architecture of RASA chatbot design. Specifically, this study will utilize the Open Source framework of Rasa.

There are two main components in Rasa Open Source architecture namely: Rasa NLU and Rasa Dialogue Policies. The Rasa NLU, shown as NLU pipeline in the figure, is like the primary senses of the chatbot which receive the input from the users. It identifies, classifies, and extracts the intents and entities from the given input. It is also responsible for choosing and retrieving the appropriate response to the user.

The dialogue management also called the Rasa Core, shown as Dialogue Policies in the figure, decides the next action in a conversation based on the context of the conversation. Rasa SDK is an action server which is responsible for running custom actions. The Tracker store is where the conversations are stored. The chatbot saves the context which helps give personalized interactions with the user. Rasa also uses a ticket lock mechanism in order to ensure that incoming messages for a given conversation ID are processed in the right order, and locks conversations while messages are actively processed. This allows for multiple Rasa servers to be run in parallel. File system consists of Models and Training data needed for the functionality of the chatbot.

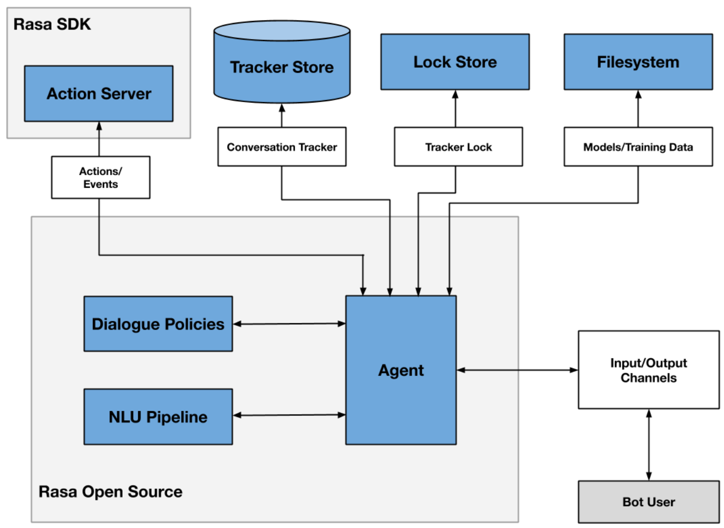

Figure 3.2: Rasa Open Source Chatbot Architecture
photo from https://rasa.com/docs/rasa/arch-overview/

3.2.2 Conversation Processing

Rasa mainly includes three stages in its conversation processing. They are:

- **NLP pipeline (Natural Language Processing)**

  The input or message is given by the user in this stage. The chatbot mainly tries to understand the context of the user's message and meaningful information is extracted. This stage involves tokenization, intent and entity recognition, and featurization. The extracted information is then mapped or matched with the training data.

- **Dialogue management (Response selection stage)**

  Once the input is processed by the NLP pipeline, it proceeds to the dialogue management stage. This stage involves decision-making about how the bot should respond based on the user's given input and the context of the conversation.

- **Response generation / Output**

  Once the appropriate response or action has been determined, the final stage is to generate the bot's response to the user. There are two main approaches for generating these responses. First is the template-based responses which are the pre-defined response templates based on the extracted intent and entities from the user's message. These responses are static and are typically used for simple and predictable replies. Another is the custom action. This is for complex responses, such as calling an API or performing specific logic. For example, the chatbot will call from the backend to fetch service details or event schedules, and then dynamically generate a response based on the result.

3.2.3 Model Training

Training data will be in the form of conversations between the RRC staff and clients. The data collection will be done with the help of RRC staff to ensure its accuracy and validity. The gathered data will be used to train Rasa's NLU model, allowing it to recognize user intents and extract relevant information accurately. As per Rasa's capability, continuous use of the chatbot will further train the model, allowing it to learn from interactions and improve its understanding over time. This ongoing training process will enhance the chatbot's performance, ensuring it becomes more adept at addressing user needs and providing relevant and more accurate responses as it accumulates more data from real-world users.

3.3 Development Tools

3.3.1 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.

3.3.2 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 design.

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 Rental.** 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.

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 website 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 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.

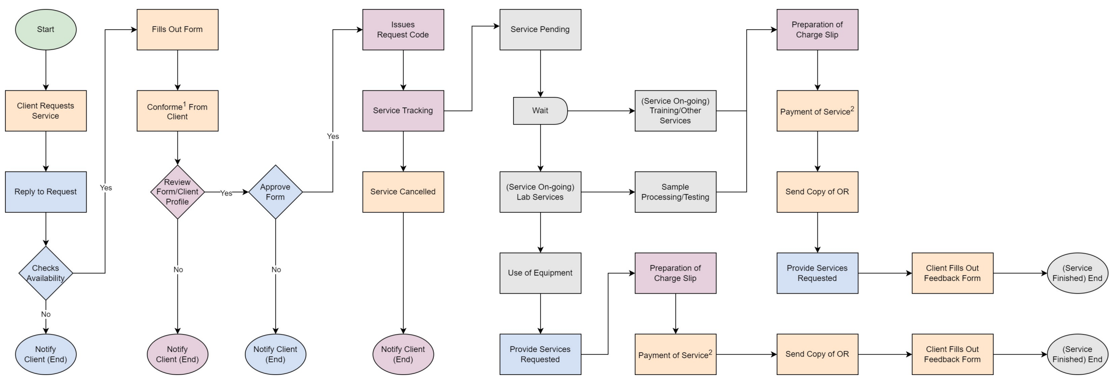

Figure 4.1: Process Flow Diagram

4.2.2 Context Model

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

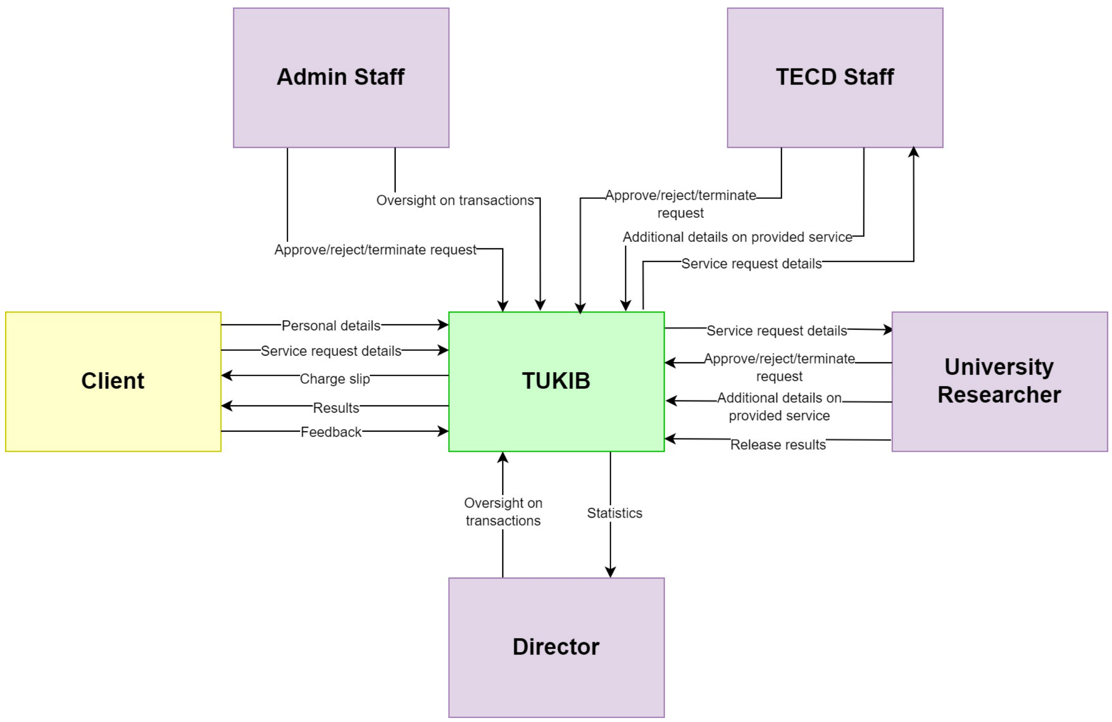

Figure 4.2: Context Model

4.2.3 Data Flow Diagram

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.

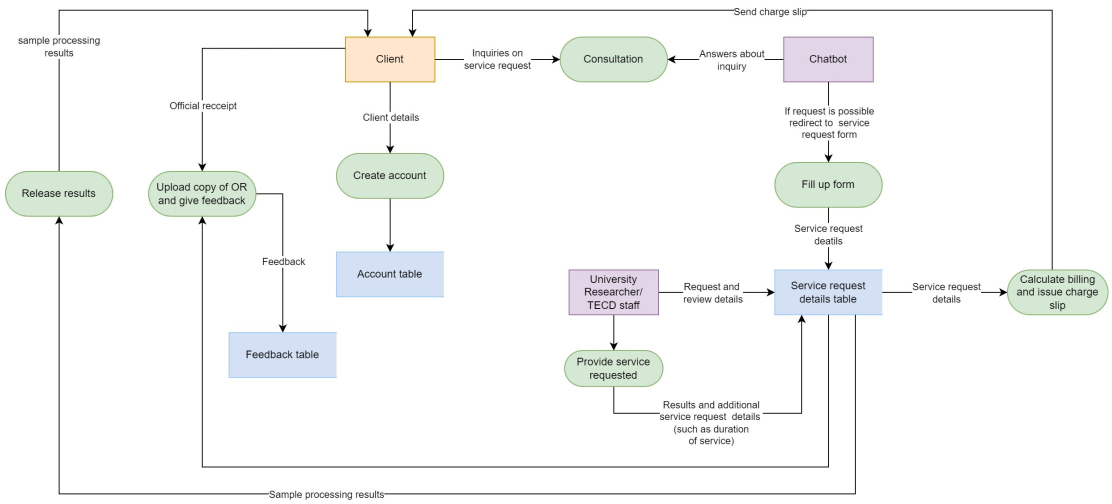

Figure 4.3: Data Flow Diagram

4.2.4 Database Diagram

The database design for TUKIB revolves around tracking and managing various service related data through several interrelated entities to ensure easy storing and retrieval. As seen in Figure 4.4, there are 11 tables in the database design for the system.

The **client** table stores essential information about the clients, such as their name, contact details, and addresses. When a client wishes to avail a service, a corresponding **service request** is created, linking the request to both the client and the staff members handling the service. This table also records the type of service (e.g., use of equipment, use of facility, sample processing, or training) and its status. To track the usage of specific resources, there are separate tables for the **use of equipment** and **use of facility**, which log the details of which equipment of facility was used for a particular service request, including the time of use and duration. For other services, the **sample processing** table tracks the handling and status of samples, while the **training service** table records information about any training sessions provided to clients, including the assigned staff and training details. The **equipment** table stores the information about availability of equipments and history usage. Once services are rendered, the **payment** table ensures that all transactions are logged, tracking the payment amounts and methods linked to specific services. Additionally, **feedback** from clients on their experience on availing a service is stored in the feedback table, providing valuable insights into the service quality and client satisfaction.

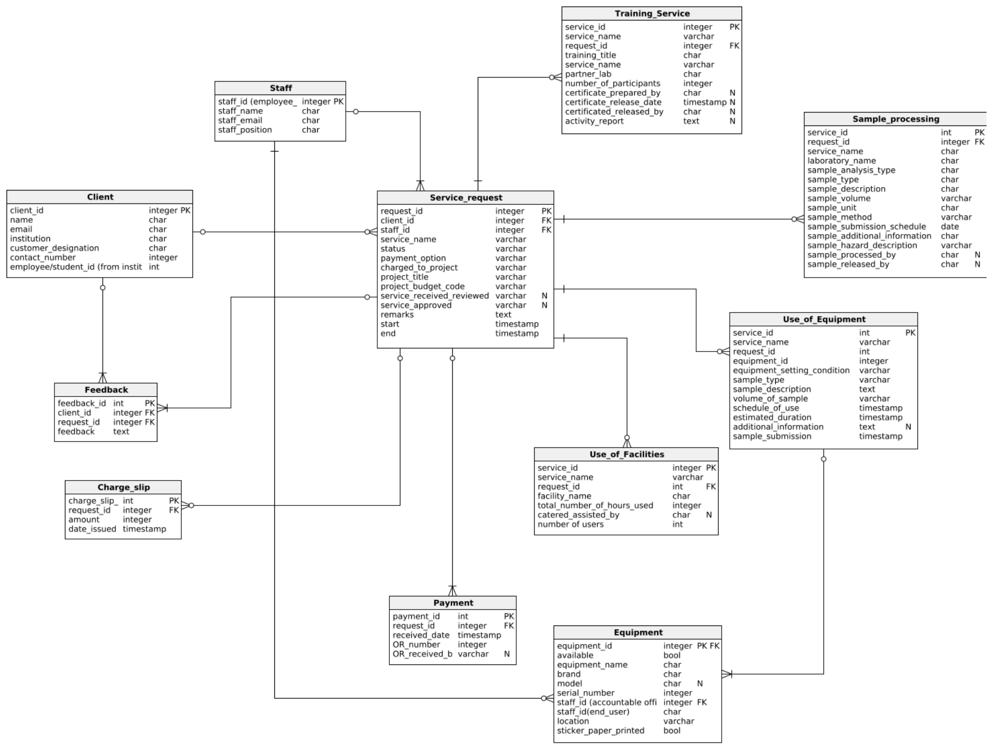

Figure 4.4: Database Design Diagram

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 name of the equipment and desired time for renting in order to indicate the equipment's availability.

Conversation Flow

Figure 4.5 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.

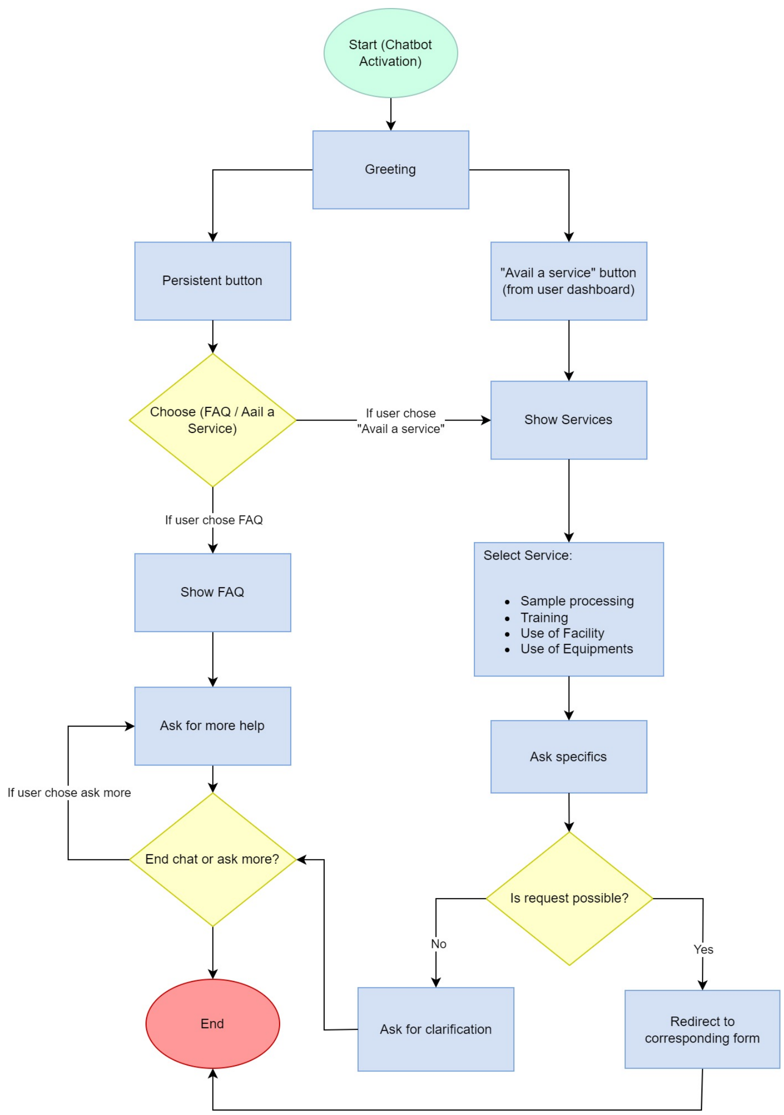

Figure 4.5: LIRA conversation flow

The structure 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-ups

4.4.1 User authentication and dashboard

Users will have a premade account. For staff, accounts are automatically created, while clients will have accounts created only after their first consultation is approved. On the login page, users will need to enter their email address and password. Passwords will be hidden by default, but the eye icon in the password field can be clicked to toggle visibility, shown in Figure 4.6. After successfully logging in, users will be redirected to their dashboard.

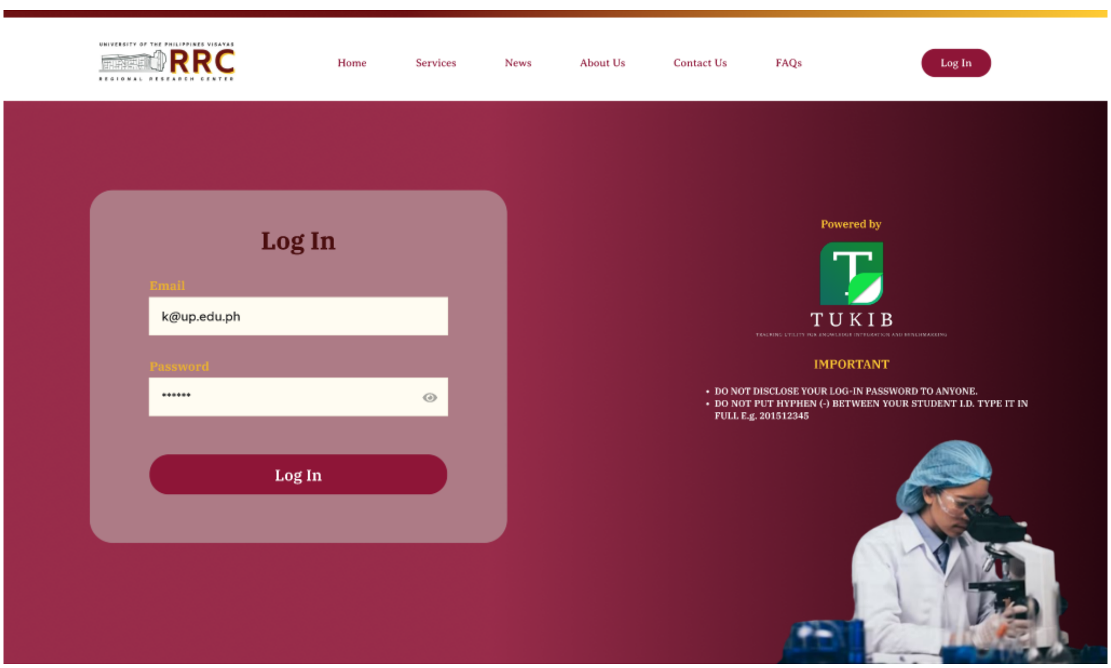

Figure 4.6: Log in page

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 as seen from Figure 4.7 and Figure 4.8.

For the client's 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.

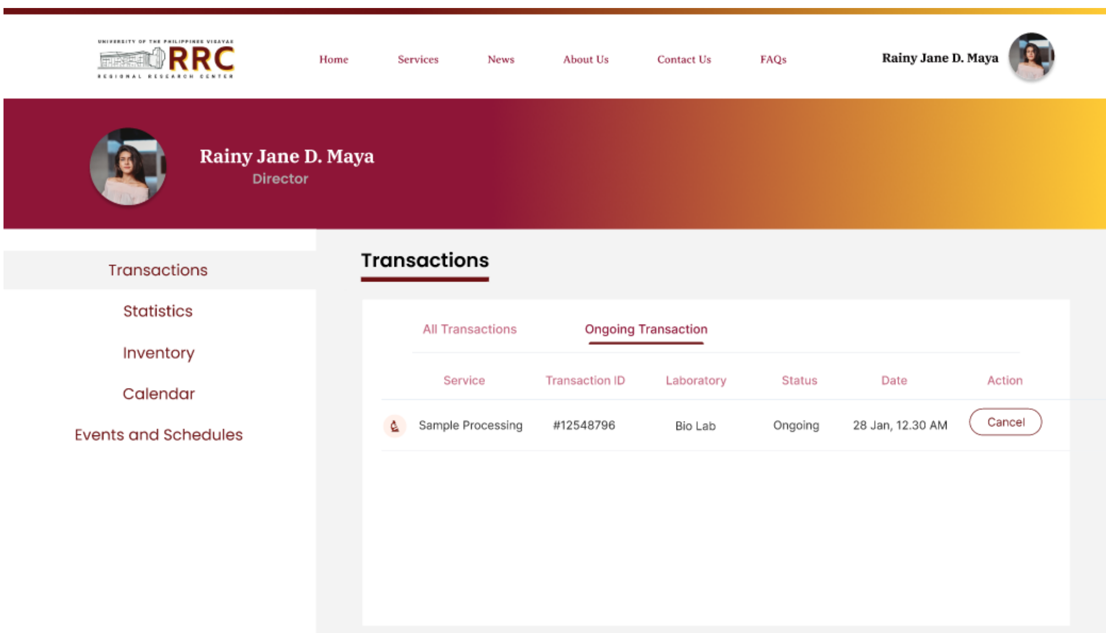

Figure 4.7: Staff dashboard

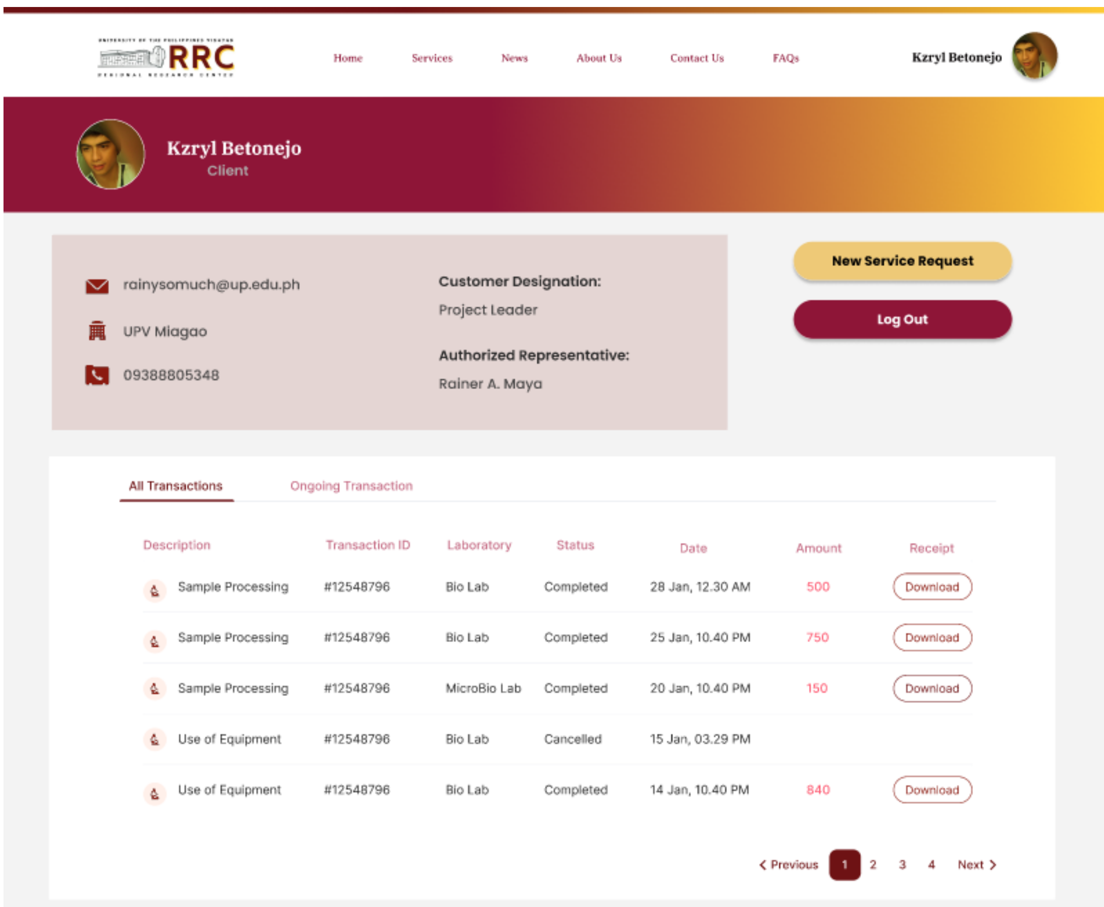

Figure 4.8: Client dashboard

References

Abecker, A., Bernardi, A., Maus, H., Sintek, M., & Wenzel, C. (2000, 10). Information supply for business processes: Coupling workflow with document analysis and information retrieval. *Knowledge-Based Systems*, *13*, 271-284. doi: 10.1016/S0950-7051(00)00087-3

Adams, M., Edmond, D., & Ter, A. (2011, 10). The application of activity theory to dynamic workflow adaptation issues.

Aguirre, S., & Rodriguez, A. (2017, 08). Automation of a business process using robotic process automation (rpa): A case study. In (p. 65-71). doi: 10.1007/978-3-319-66963-2_7

Akkermans, H. A., Bogerd, P., Yücesan, E., & van Wassenhove, L. N. (2003). The impact of erp on supply chain management: Exploratory findings from a european delphi study. *European Journal of Operational Research*, *146*(2), 284-301. Retrieved from `https://www.sciencedirect.com/science/article/pii/S0377221702005507` doi: https://doi.org/10.1016/S0377-2217(02)00550-7

Aleixo, F., Freire, M., Santos, W., & Kulesza, U. (2010, 06). Automating the variability management, customization and deployment of software processes: A model-driven approach. In (Vol. 73, p. 372-387). doi: 10.1007/978-3-642-19802-1_26

Altamimi, I., Altamimi, A., Alhumimidi, A., Altamimi, A., & Temsah, M.-H. (2023, 06). Artificial intelligence (ai) chatbots in medicine: A supplement, not a substitute. *Cureus*, *15*. doi: 10.7759/cureus.40922

Austin Beattie, A. P. E., & Edwards, C. (2020). A bot and a smile: Interpersonal impressions of chatbots and humans using emoji in computer-mediated communication. *Communication Studies*, *71*(3), 409–427. Retrieved from `https://doi.org/10.1080/10510974.2020.1725082` doi: 10.1080/10510974.2020.1725082

Aversano, L., Canfora, G., Lucia, A., & Gallucci, P. (2002, 07). Business process reengineering and workflow automation: A technology transfer experience. *Journal of Systems and Software*, *63*, 29-44. doi: 10.1016/S0164-1212(01)00128-5

Bakouan, M., Kamagate, B. H., Kone, T., Oumtanaga, S., & Babri, M. (2018). A chatbot for automatic processing of learner concerns in an online learning platform. *International Journal of Advanced Computer Science and Applications*, *9*(5). Retrieved from http://dx.doi.org/10.14569/IJACSA.2018.090521 doi: 10.14569/IJACSA.2018.090521

Barchard, K. A., & Pace, L. A. (2011). Preventing human error: The impact of data entry methods on data accuracy and statistical results. *Computers in Human Behavior*, *27*(5), 1834-1839. Retrieved from https://www.sciencedirect.com/science/article/pii/S0747563211000707 (2009 Fifth International Conference on Intelligent Computing) doi: https://doi.org/10.1016/j.chb.2011.04.004

Basu, A., & Kumar, A. (2002, 03). Research commentary: Workflow management issues in e-business. *Information Systems Research*, *13*, 1-14. doi: 10.1287/isre.13.1.1.94

Blahušiaková, M. (2023, 01). Business process automation: New challenges to increasing the efficiency and competitiveness of companies. *Strategic Management*, *28*, 37-37. doi: 10.5937/StraMan2300038B

Choudhary, R., Tariq, H., Chaudhry, N. R., Maneha, & Awan, R. (2024, Mar.). Streamlining workflow processes in public sector universities: A modeling and simulation-based automation solution. *Pakistan Journal of Science*, *76*(01), 169–177. Retrieved from https://pjosr.com/index.php/pjs/article/view/1131 doi: 10.57041/pjs.v76i01.1131

Fan, X., Chao, D., Zhang, Z., Wang, D., Li, X., & Tian, F. (2021, Jan 6). Utilization of self-diagnosis health chatbots in real-world settings: Case study. *J Med Internet Research*, *23*(1). Retrieved from https://www.jmir.org/2021/1/e19928 doi: 10.2196/19928

GeeksforGeeks. (2024, 09). *Top 7 frameworks for building chatbots.* Retrieved from https://www.geeksforgeeks.org/top-frameworks-for-building-chatbots/

Gupta, V., & Arora, A. (2020, 01). Automation in healthcare services. In (p. 1-19). doi: 10.4018/978-1-7998-2101-4.ch001

Hagberg, J., Sundström, M., & Egels-Zandén, N. (2016, 07). The digitalization of retailing: an exploratory framework. *International Journal of Retail Distribution Management*, *44*, 694-712. doi: 10.1108/IJRDM-09-2015-0140

Hourrane, O., Ouchra, H., Eddaoui, A., Benlahmar, E. H., & Zahour, O. (2020, 04). Towards a chatbot for educational and vocational guidance in morocco: Chatbot e-orientation. *International Journal of Advanced Trends in Computer Science and Engineering*, *9*, 2479-2487. doi: 10.30534/ijatcse/2020/237922020

IBM. (2024). *What is automation?* Retrieved from https://www.ibm.com/topics/automation ([Accessed 28-10-2024])

Kar, R., & Haldar, R. (2016). Applying chatbots to the internet of things:

Opportunities and architectural elements. *International Journal of Advanced Computer Science and Applications*, *7*(11). Retrieved from http://dx.doi.org/10.14569/IJACSA.2016.071119 doi: 10.14569/IJACSA.2016.071119

Kimberling, E. (2024). *The benefits of erp for human resources management.* Retrieved from https://www.thirdstage-consulting.com/erp-for-human-resources-management/ (Accessed: 2024-11-06)

Madhu Goel, S. G. (2012, July). Open source vs proprietary application and technologies. *International Journal of Computer Applications*, *49*(22), 33-37. Retrieved from https://ijcaonline.org/archives/volume49/number22/7905-1279/ doi: 10.5120/7905-1279

Manyika, J., Chui, M., Miremadi, M., Bughin, J., George, K., Willmott, P., & Dewhurst, M. (2017, 01). A future that works: Automation, employment, and productivity. In *Mckinsey global institute report.* McKinsey & Company.

McQuilken, T. (2014). Automation is the future of print workflows. *Editor & Publisher*.

Nawaz, N., & Gomes, A. M. (2019). Artificial intelligence chatbots are new recruiters. *International Journal of Advanced Computer Science and Applications*, *10*(9). Retrieved from http://dx.doi.org/10.14569/IJACSA.2019.0100901 doi: 10.14569/IJACSA.2019.0100901

Nuruzzaman, M., & Hussain, O. K. (2018). A survey on chatbot implementation in customer service industry through deep neural networks. In *2018 ieee 15th international conference on e-business engineering (icebe)* (p. 54-61). doi: 10.1109/ICEBE.2018.00019

Pakdil, F., Özkök, O., Dengiz, B., Kara, I., Selvi, N., & Kargı, A. (2009, 01). A systematic approach to reduce human and system-related errors causing customer dissatisfaction in a production environment. *Total Quality Management Business Excellence - TOTAL QUAL MANAG BUS EXCELL*, *20*, 129-137. doi: 10.1080/14783360802351728

PennState. (2020). *Penn State launches AI-powered chatbot to assist students around the clock.* Retrieved from https://www.psu.edu/news/academics/story/penn-state-launches-ai-powered-chatbot-assist-students-around-clock ([Accessed 24-10-2024])

Prasad, D., & Reddy, D. (2013, aug). Understanding the differences between proprietary free and open source software. *International Journal of Engineering Research and Applications (IJERA)*, *3*.

Rese, A., Ganster, L., & Baier, D. (2020). Chatbots in retailers' customer communication: How to measure their acceptance? *Journal of Retailing and Consumer Services*, *56*, 102176. Retrieved from https://www.sciencedirect.com/science/article/pii/S0969698920308286 doi: https://doi.org/10.1016/j.jretconser.2020.102176

Sarker, S., & Lee, A. S. (2003). Using a case study to test the role of three key social enablers in erp implementation. *Information Management*, *40*(8), 813-829. Retrieved from https://www.sciencedirect.com/science/article/pii/S0378720602001039 doi: https://doi.org/10.1016/S0378-7206(02)00103-9

Scott, J., & Vessey, I. (2000, 08). Implementing enterprise resource planning systems: The role of learning from failure. *Information Systems Frontiers*, *2*, 213-232. doi: 10.1023/A:1026504325010

ServiceNow. (n.d.). *What is workflow automation?* Retrieved from https://www.servicenow.com/now-platform/what-is-workflow-automation.html#what-is-process-automation

Van den Broeck, A., Carpini, J., & Diefendorff[3], J. (2019, 08). Work motivation: Where do the different perspectives lead us? In (p. 354-372). doi: 10.1093/oxfordhb/9780190666453.013.27

Winarko, H. (2021, 11). The digital payment service automation attributes model: Empirical evidence of railway public transport. In (p. 138-152). doi: 10.4018/978-1-7998-8524-5.ch008

Zarouali, B., Van den Broeck, E., Walrave, M., & Poels, K. (2018, 07). Predicting consumer responses to a chatbot on facebook. *Cyberpsychology, Behavior, and Social Networking*, *21*. doi: 10.1089/cyber.2017.0518

Zayas-Cabán, T., Haque, S., & Kemper, N. (2021, 05). Identifying opportunities for workflow automation in health care: Lessons learned from other industries. *Applied Clinical Informatics*, *12*, 686-697. doi: 10.1055/s-0041-1731744

Appendix A

Appendix Title

Appendix B

Resource Persons

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