 ISSN 3063-864X (E)

DESIGN AND DEVELOPMENT OF AN N8N-BASED AI CHATBOT SYSTEM INTEGRATED WITH WHATSAPP AS AN INFORMATION SERVICE AT MAXY ACADEMY

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Abstract

Maxy Academy experiences operational inefficiency due to the high volume of customer inquiries on WhatsApp being handled manually. This study aims to design and develop an automated information service solution using an n8n-based AI Chatbot integrated with WhatsApp. Utilizing a Research and Development (R&D) approach with a Rapid Application Development (RAD) model, the system architecture incorporates the n8n orchestrator, WhatsApp HTTP API (WAHA), Large Language Model (LLM) agents, and a PERN Stack-based operational dashboard. The developed system successfully operates 24/7, proactively extracts customer data, and facilitates a silent handover mechanism for human agent intervention. Functional evaluation using Black Box Testing demonstrated a 100% validity rate across all test scenarios, confirming the software's functional reliability without any defects. The R&D process successfully produced a stable and responsive automated information service that effectively classifies message queues.

Kata kunci: *AI Chatbot*, *n8n*, *WhatsApp*, *Rapid Application Development*, *PERN Stack*

Abstrak

Maxy Academy mengalami inefisiensi operasional akibat tingginya volume pertanyaan pelanggan melalui WhatsApp yang masih ditangani secara manual. Penelitian ini bertujuan untuk merancang dan membangun sistem AI *Chatbot* berbasis n8n yang terintegrasi dengan WhatsApp sebagai solusi otomasi layanan informasi. Penerapan metodologi *Research and Development* (R&D) dengan model *Rapid Application Development* (RAD), arsitektur sistem ini dibangun melibatkan orkestrator n8n, WhatsApp HTTP API (WAHA), agen *Large Language Model* (LLM), serta *dashboard* operasional berbasis PERN *Stack* . Sistem cerdas ini terbukti mampu beroperasi secara otomatis 24 jam penuh, mengekstraksi data pelanggan secara proaktif, dan memfasilitasi admin untuk mengambil alih dialog melalui mekanisme *silent handover* . Evaluasi fungsionalitas menggunakan *Black Box Testing* menunjukkan tingkat validitas 100% pada seluruh skenario pengujian, memastikan sistem berjalan tanpa cacat fungsional. Proses R&D ini berhasil menghasilkan perangkat lunak otomasi layanan informasi yang stabil dalam mengelola klasifikasi antrean pesan.

Kata Kunci: *AI Chatbot, n8n, WhatsApp, Rapid Application Development, PERN Stack*

INTRODUCTION

The series of Industrial Revolutions, specifically the Fourth Industrial Revolution, has fundamentally altered how humans work, communicate, and conduct business (Berutu et al., 2024). Widely recognized as digital transformation, it focuses on implementing digital technology across various aspects of human life and industrial sectors (Oktareza et al., 2024). Consequently, organizations must continuously update their workflows, strategies, and business models to maintain relevance and competitiveness in this dynamic era (Anggoro et al., 2024). This urgency is highlighted by the Boston Consulting Group (BCG) in its 2020 Global Digital Transformation survey, which revealed that over 80% of business executives consider digital transformation a pressing necessity (Anggoro et al., 2024). Maxy Academy, an educational technology startup focused on developing digital talents in Indonesia, faces this exact imperative to digitize its operations.

Despite providing comprehensive information on its official website, Maxy Academy's customers predominantly prefer communicating via WhatsApp to seek quick and personalized responses. Based on preliminary observations and interviews conducted with the company's stakeholders, this preference has created a significant operational bottleneck. The academy receives an estimated volume of 500 to 600 inquiries daily, which are handled entirely manually by merely three to four staff members from the sales and marketing division. Relying only on basic WhatsApp Business features, this manual approach leads to two major operational issues: a lack of service availability outside working hours and severe workflow inefficiency, as staff spend excessive time answering repetitive questions rather than focusing on strategic tasks.

The implementation of an Artificial Intelligence (AI) Chatbot integrated directly with WhatsApp offers a strategic solution to provide 24/7 automated information services. However, a review of existing literature reveals that many previous chatbot developments still utilize the linear Waterfall development method, which lacks flexibility to adapt to rapidly changing requirements (Puspitasari et al., 2025). Additionally, existing systems often rely on rigid, rule-based matching that struggles to understand complex conversational contexts (Aji, 2022). To address these issues, alternative approaches utilizing low-code workflow automation platforms like n8n have been introduced to accelerate deployment and generate highly contextual AI responses (Bramanditya & Handoko, 2025; Ruhallah et al., 2025). Nevertheless, a critical research gap remains: previous studies lack a hybrid architecture that combines AI-driven automation with a structured 'silent handover' mechanism via a dedicated admin dashboard for complex escalations.

Therefore, this study aims to design and develop an n8n-based AI Chatbot system integrated with WhatsApp to automate information services at Maxy Academy. This study adopts a Research and Development (R&D) methodology with a Rapid Application Development (RAD) approach, which has been empirically proven to be highly effective and efficient in accelerating the software development cycle (Riadi et al., 2024; Bahari & Pramudwiatmoko, 2025). The proposed system is designed to seamlessly process natural language, extract customer data proactively, and facilitate manual interventions. Finally, the software's functional reliability is evaluated strictly using Black Box Testing to verify that all features operate precisely according to the defined technical specifications without defects.

RESEARCH METHOD

3.1 Research Flow

This study employs a Research and Development (R&D) methodology combined with the Rapid Application Development (RAD) model to accelerate the software development cycle. The RAD approach is highly iterative and consists of four main phases: Requirement Planning, User Design, Construction, and Cutover. This flexible methodology allows continuous refinement based on direct feedback from Maxy Academy's stakeholders, ensuring the final product aligns perfectly with operational needs.

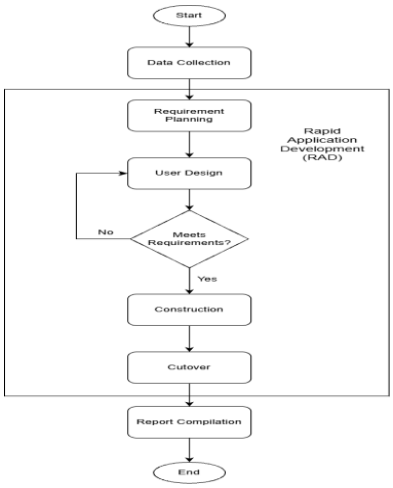

Figure 1. Research Phases

3.2 Requirement Analysis

During the Requirement Planning Phase, data was gathered through direct operational observations and stakeholder interviews. The functional requirements dictate that the system must operate 24/7 to automatically respond to customer inquiries, dynamically simulate human typing behaviors, and proactively extract customer profile data for Know Your Customer (KYC) purposes. Furthermore, a critical functional requirement is the implementation of a "silent handover" mechanism, which seamlessly transitions complex escalations from the AI Chatbot to human agents (Customer Service) without notifying the customer.

3.3 System Modeling and Design

In the User Design Phase, the system's architecture and interactions were modeled using Unified Modeling Language (UML). The Use Case Diagram was developed to define the operational boundaries and responsibilities of the three primary actors: the Customer, the Admin, and the Superadmin.

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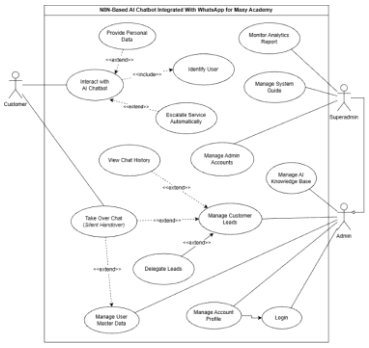

Figure 2. Use Case Diagram

To manage the automated conversational logic, the core architecture was designed using the n8n Workflow automation platform. The main workflow integrates webhook triggers, automated handling status validations, and AI context processing. To ensure system stability during manual interventions and lead delegations, the design incorporates a "zigzag" process flow within the backend API. This sequential request-response mechanism strictly validates data availability, effectively preventing data collision when multiple admins attempt to take over a customer lead simultaneously.

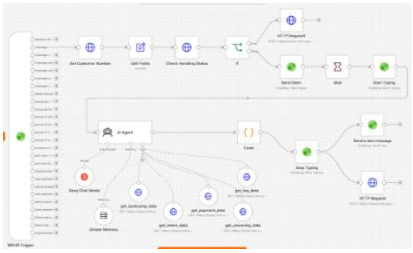

Figure 3. Design of the Main Workflow in N8N

3.4 System Development and Implementation

The Construction Phase translated the system models into a functional hybrid architecture. The automation layer utilizes n8n as the primary orchestrator, combined with the WhatsApp HTTP API (WAHA) as the communication gateway and Groq Chat Model as the Large Language Model (LLM) engine for natural language processing. Meanwhile, the operational dashboard is built on the robust PERN Stack, utilizing PostgreSQL for relational database management, Express.js and Node.js for the backend API, and React configured with Vite for the frontend. The user interface is styled using Tailwind CSS to provide a highly responsive, modern, and utility-first design experience.

Figure 4. System Technology Architecture

3.5 System Testing

The final Cutover Phase focuses on evaluating the software's functional reliability. This study strictly utilizes the Black Box Testing methodology to verify that all integrated features—including AI responsiveness, silent handover execution, and dashboard management—operate precisely according to the defined specifications. The testing evaluates the accuracy of inputs and outputs without examining the internal codebase. In alignment with the research scope, this evaluation is purely focused on technical functionality, explicitly excluding post-implementation commercial success analysis or user acceptance surveys.

RESULTS AND DISCUSSION

This section presents the practical implementation of the automated information service system and the subsequent functional evaluation. The implementation is divided into the AI Chatbot workflow and the web-based operational dashboard.

4.1 Infrastructure and AI Chatbot Implementation

The system's communication gateway utilizes the WhatsApp HTTP API (WAHA), which acts as a bridge between the WhatsApp application and the n8n orchestrator.

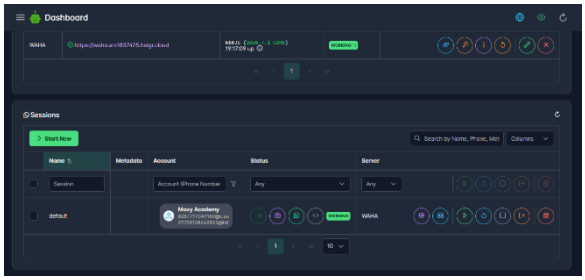

Figure 5. WAHA Dashboard

The core automation is orchestrated within the n8n platform, configured to handle the message lifecycle efficiently. The workflow begins with message initiation and handling status validation to ensure the customer is currently in 'bot mode'. To simulate natural human interaction, the workflow incorporates dynamic delays that trigger 'Send Seen' and 'Start Typing' indicators on the customer's device. The Groq-powered AI Agent then processes the natural language context, extracts JSON data, and formulates a response. Finally, the response is dispatched, and a background synchronization process securely logs the conversation data into the PostgreSQL database.

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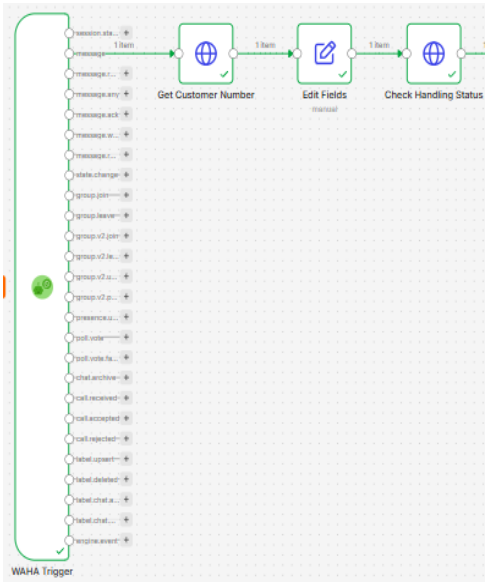

Figure 6. Message Initiation and Handling Status Validation on n8n

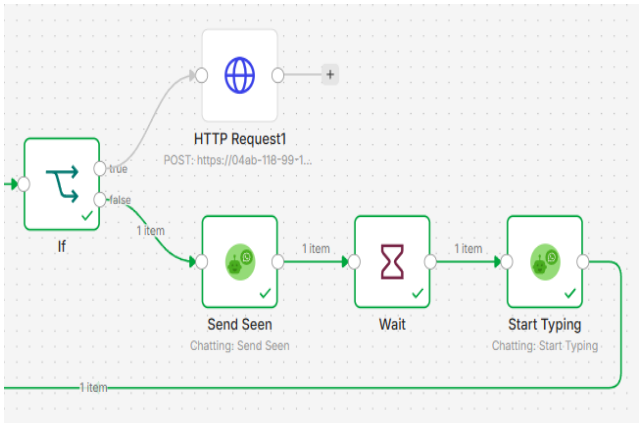

Figure 7. Branching Logic and Simulation of Human Interaction

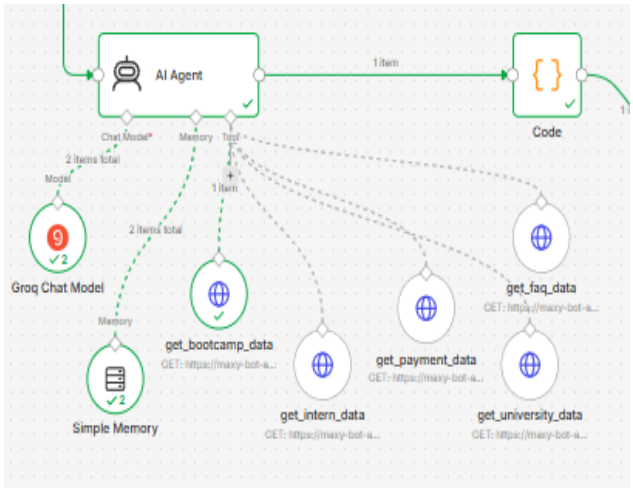

Figure 8. Reply Message Processing, Data Integration, and JSON Extraction in an AI Agent

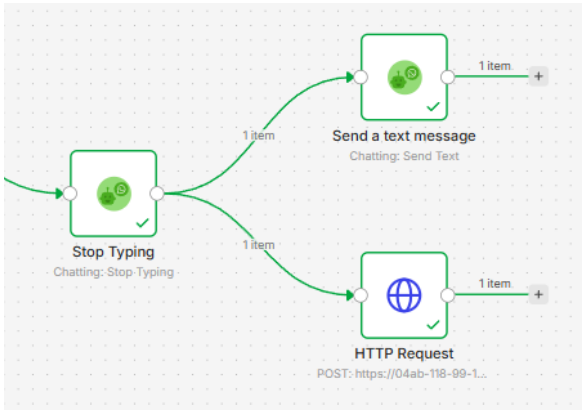

Figure 9. Response Transmission and Background Data Synchronization

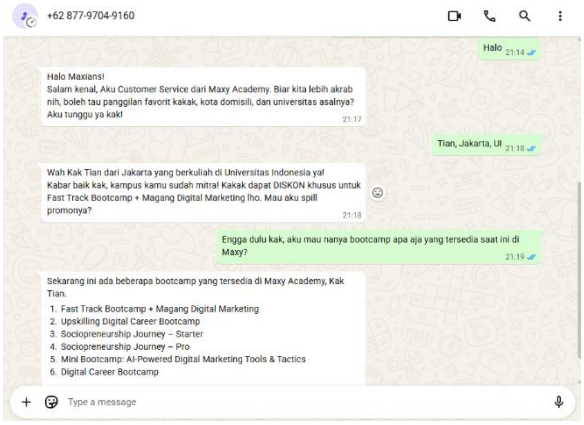

Figure 10. Screenshot of the AI Chatbot Conversation Interface on WhatsApp Customer

4.2 Operational Dashboard Implementation

The administrative dashboard was built using a React Vite configuration for optimized frontend performance and successfully deployed to Vercel for high availability. The user interface comprises several specialized pages designed to manage both the AI knowledge base and customer interactions:

1. Login Page

This page serves as the primary security layer, authenticating staff credentials against the database before granting session access.

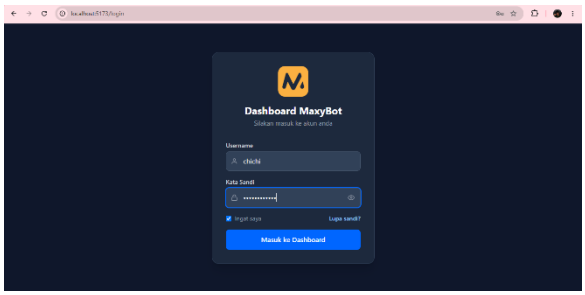

Figure 11. Login Page

2. Main Dashboard Page (Overview)

The Overview page presents an executive summary of daily metrics, including total incoming

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chats and categorized leads. It features data visualizations and a quick-access table for high-priority queues.

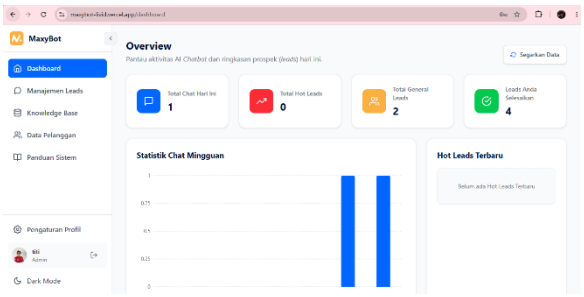

Figure 12. Admin Main Dashboard Page

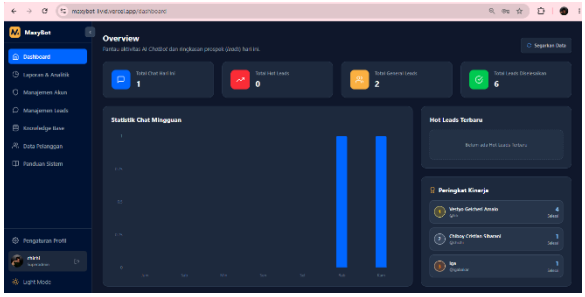

Figure 13. Superadmin Main Dashboard Page

3. Leads Management Page

This page allows Admins to monitor background queues categorized by urgency (Hot Leads and General Leads). It includes search and filter functionalities to streamline workflow prioritization.

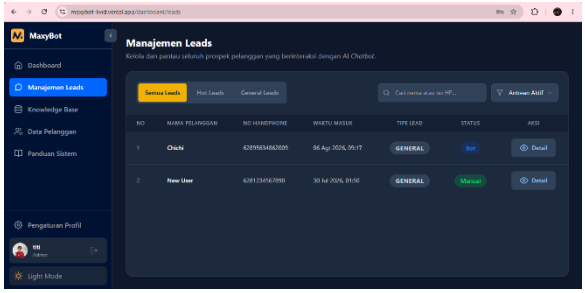

Figure 14. Lead Management Page

4. Lead Detail Page

This interface is the core of the 'silent handover' mechanism. It displays extracted customer data alongside the read-only chat history. When an Admin initiates a manual takeover or delegates a lead, the backend executes a sequential "zigzag" process flow to strictly validate data availability, effectively preventing concurrent data collisions among staff.

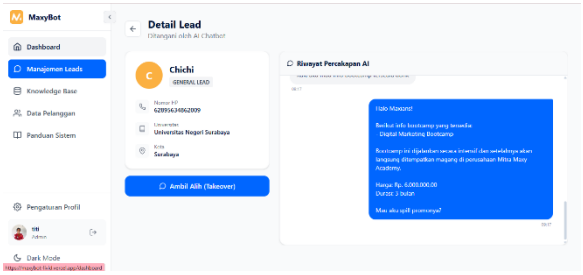

Figure 15. Detail Lead Page

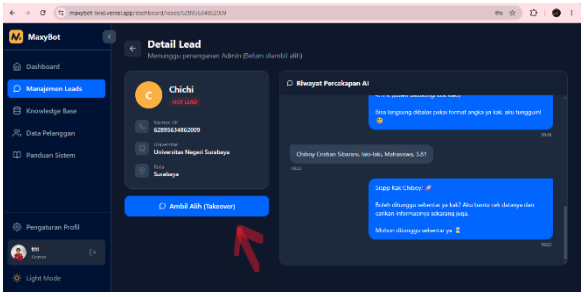

Figure 16. Initiation of a Takeover

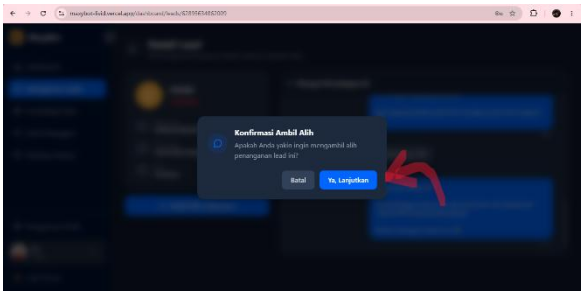

Figure 17. Lead Takeover Confirmation

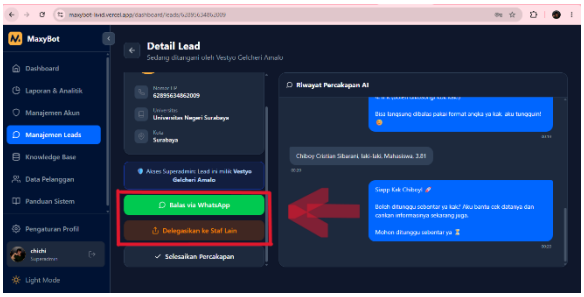

Figure 18. Post-Takeover Lead Details Interface

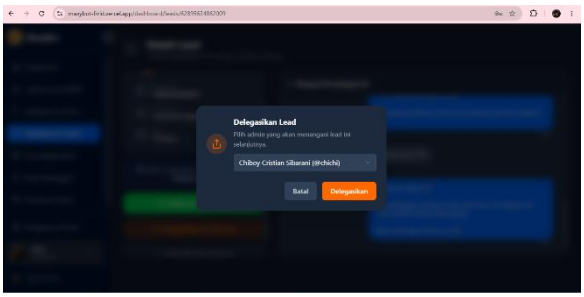

Figure 19. Staff Delegate Selection Dialog Box

5. Customer Master Data Page

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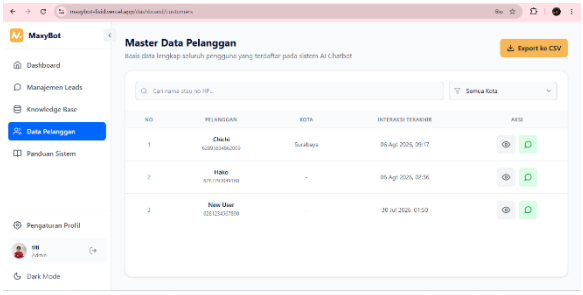

Figure 20. Customer Master Data Page

Functioning as a comprehensive database viewer, this page lists all customer profiles. Admins can export data to a CSV format for reporting or initiate proactive WhatsApp communications directly from the interface.

6. Profile Settings Page

This page provides independent control for staff to update their personal attributes and manage credential security (password changes) securely.

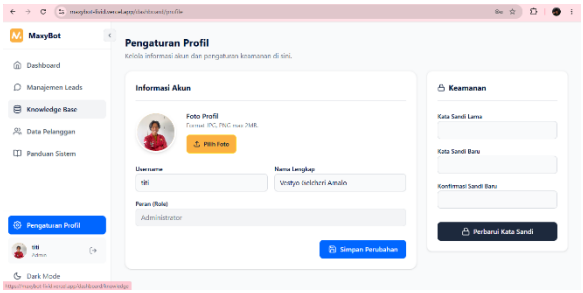

Figure 21. Profile Settings Page

7. AI Knowledge Base Page

This interface enables Admins to perform CRUD (Create, Read, Update, Delete) operations on the reference data consumed by the AI Chatbot. It is divided into specific categories such as Bootcamps, University Partners, and FAQs.

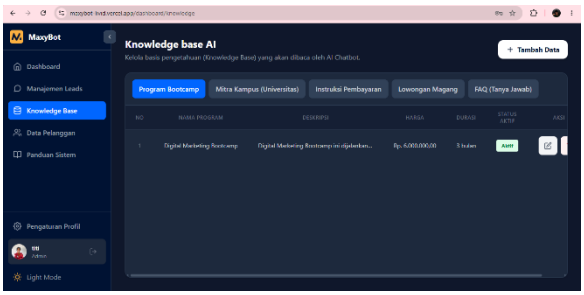

Figure 22. AI Knowledge Base Page

8. System Guide Page

Serving as an internal Standard Operating Procedure (SOP) repository, this page displays operational guides. Utilizing Role-Based Access Control (RBAC), only Superadmins can modify the content, while regular Admins retain read-only access.

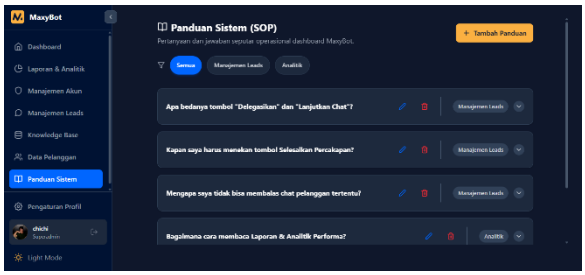

Figure 23. System Guide Page

9. Reports and Analytics Page

Exclusive to Superadmins, this analytical dashboard aggregates database metrics to visualize resolution ratios and evaluate individual staff performance through a dedicated leaderboard.

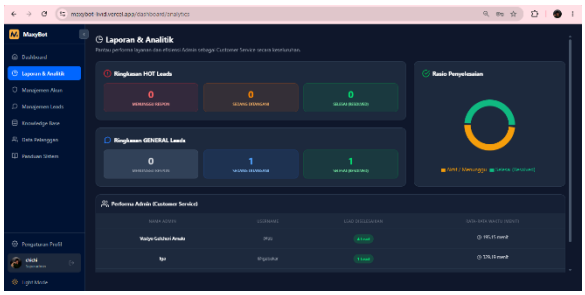

Figure 24. Reports and Analytics Page

10. Account Management Page

Also exclusive to Superadmins, this page facilitates the lifecycle management of staff accounts, including creating new credentials, resetting passwords, and executing logical deactivations (soft deletes).

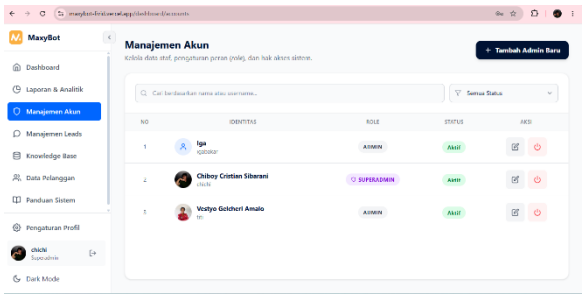

Figure 25. Account Management Page

4.3 Integration Architecture Limitations

Despite its functional stability during the prototyping phase, the current system architecture possesses specific integration limitations regarding the communication gateway. The prototype utilizes the WhatsApp HTTP API (WAHA), which operates as an unofficial interface. Operational testing revealed that utilizing an unofficial API carries a high risk of being unilaterally blocked (banned) by the platform provider (Meta). Meta's strict anti-spam algorithms aggressively detect automated activities, particularly on new numbers lacking an organic interaction history or a high trust core. Consequently, while WAHA is highly efficient for prototyping within a Research and

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Development (R&D) environment, it poses a significant operational stability risk for long-term production deployment due to external platform regulations.

4.4 System Performance and Endurance (Stress Testing)

To evaluate the prototype's stability under concurrent access conditions, a stress test was conducted using Postman. This test aimed to identify architectural bottlenecks by bombarding the system's webhook with simulated WhatsApp JSON payloads. The simulation utilized 3 Virtual Users (VU) acting as automated agents, sending parallel API requests continuously to replicate a scenario where multiple users send messages at the exact same second.

Figure 26. Postman Test

Analysis of the failure logs indicated that the system eventually halted, returning an "HTTP 429: Too Many Requests" error. Crucially, this denial of service was not caused by internal architectural flaws or logic failures. The bottleneck occurred purely because the cumulative complexity and memory allocation of the concurrent messages exceeded the Tokens Per Minute (TPM) limit of the free-tier Large Language Model (LLM) provider.

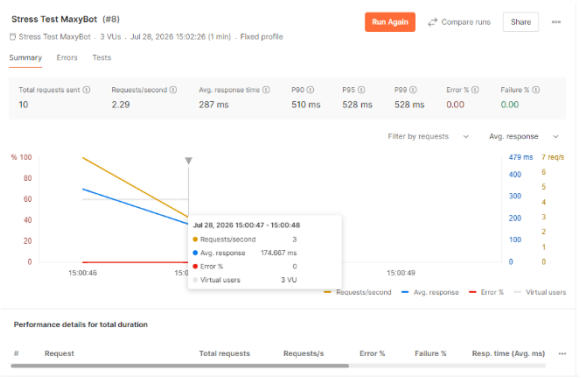

Figure 27. Postman Diagram

This test confirms that the structural design of the prototype is stable in handling data integration flows. Optimal scalability for future production implementation can be achieved simply by scaling up the third-party AI infrastructure tier.

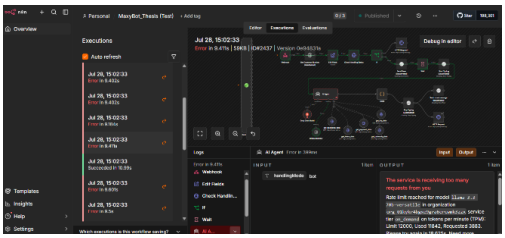

Figure 28. Failure Log

4.5 System Testing (Black Box Testing)

The final functional evaluation was executed strictly utilizing the Black Box Testing methodology, focusing entirely on input-output validation againts the predefined requirements. As summarized in Table 1, the comprehensive evaluation covered a total of 29 specific functional scenarios distributed across 10 main system modules.

Table 1. Summary of Black Box Testing Results

No	Testing Scope	Expected Output	Result
1	AI Chatbot Features (3 Scenarios)	AI responds contextually, classifies Hot Leads to trigger silent handover, and halts automated replies during manual mode.	Valid
2	Authentication (3 Scenarios)	System validates credentials, denies invalid/empty inputs, and successfully redirects users based on role authorization.	Valid
3	Main Dashboard (2 Scenarios)	System accurately loads real-time statistical data and dynamically updates metric cards and charts.	Valid
4	Lead Management & Silent Handover (6 Scenarios)	System filters queues dynamically, locks manual takeover, executes lead delegation, redirects to WhatsApp, and resets session.	Valid
5	Customer Master Data (2 Scenarios)	System successfully exports data to a valid CSV file and redirects to WhatsApp for	Valid

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		proactive escalations.	
6	Profile Settings (3 Scenarios)	System properly updates profile data, validates password mismatches, and securely destroys sessions upon logout.	Valid
7	Account Management (4 Scenarios)	System strictly limits access to Superadmin, handles new account creation, prevents duplicates, and performs logical soft deletes.	Valid
8	Reports and Analytics (2 Scenarios)	System accurately renders donut charts and performance tables, blocking any unauthorized access attempts by regular Admins.	Valid
9	Knowledge Base AI (2 Scenarios)	System executes stable CRUD operations (Add, Edit, Delete) and reflects database updates on the interface in real-time.	Valid
10	System Guide / SOP (2 Scenarios)	System strictly enforces RBAC: rendering a read-only interface for regular Admins and providing full CRUD controls for Superadmins.	Valid

Based on the Black Box Testing results, all 29 scenarios achieved a 100% validity rate, confirming that the system functions exactly as designed. This success indicates that all software architecture components—from the AI Chatbot automation via the n8n platform to the managerial information system on the PERN Stack Dashboard—operate synchronously. Crucial data flows, including incoming message capture via WAHA, Know Your Customer (KYC) entity extraction, urgency classification logic, and the silent handover mechanism, were validated to execute operational instructions precisely. Consequently, this confirms the completion of the testing phase within the Rapid Application Development (RAD) cycle, proving that the software prototype meets the technical feasibility standards for server deployment without any fatal bugs.

CONCLUSION

This study successfully designed and developed an automated information service utilizing an n8n-based AI Chatbot integrated with WhatsApp to address the operational inefficiencies at Maxy Academy. By adopting a Research and Development (R&D) methodology alongside a Rapid Application Development (RAD) approach, the system seamlessly bridged an AI orchestration layer with a robust PERN Stack operational dashboard. The implementation of the 'silent handover' mechanism, supported by a sequential 'zigzag' API request flow, effectively prevented data collisions and enabled smooth, unnoticeable transitions from automated bot handling to manual agent intervention.

The functional integrity of the software prototyp was rigorously evaluated using Black Box Testing. The results demonstrated a 100% validity rate across 29 test scenarios, confirming the system's capability to operate 24/7, proactively extract customer data, and accurately classify message queue urgency without any fatal defects. Consequently, the software fulfills the technical specifications required to automate and streamline the customer service workflow in a stable and responsive manner.

For future developments, it is recommended to enhance the system's architectural capabilities by incorporating native omnichannel live chat features within the dashboard, thereby eliminating the need for staff to be redirected to the WhatsApp application. Furthermore, integrating a Vector Database for Retrieval-Augmented Generation (RAG) to improve AI context retrieval, implementing advanced audit trail security management, and upgrading the customer satisfaction analytics modules will significantly broaden the system's operational impact and scalability.

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