ZETDC AI CHATBOT

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ABSTRACT

- This project focuses on the development of a power chatbot designed to enhance customer service efficiency and improve user experience across WhatsApp platforms. This power chatbot leverages Natural Language Processing (NLP) and machine learning techniques to understand and respond to user inquiries in real-time, offering 24/7 assistance.

PREFACE

This project," ZETDC AI-Powered WhatsApp Chatbot for Customer Support," was developed to address the growing need for automated, intelligent, and accessible communication systems in public utilities, particularly in Zimbabwe's energy sector. The system was designed and implemented as part of the requirements for the completion of my academic program and reflects both theoretical understanding and practical application of modern AI and cloud technologies.

The chatbot integrates natural language processing (NLP) through OpenAI's GPT engine and supports both text and voice interactions via the WhatsApp platform, powered by Twilio. It was developed with the aim of providing quick, accurate, and multilingual responses to customer inquiries particularly those related to electricity faults, billing, and frequently asked questions. The chatbot is intended to enhance the efficiency of customer support while reducing the workload on human agents.

ACKNOWLEDGEMENT

First and foremost, I am deeply thankful to my project supervisor, Miss Chibaya, for their invaluable guidance, constructive feedback, and continuous support throughout the development of this system. Their insights were instrumental in shaping the direction and technical foundation of this work. I would also like to extend my appreciation to the team at ZETDC (Zimbabwe Electricity Transmission and Distribution Company) for their cooperation and for providing relevant information that helped in tailoring the chatbot's functionality to real-world customer support needs in the energy sector. Special thanks go to the lecturers and school members of Information Science and technology, Harare Institute of Technology, whose teachings provided the theoretical and practical skills needed to conceptualize and build this solution. I also acknowledge the support of my family and peers, who provided encouragement and motivation throughout the project duration. Their patience and understanding were essential to my progress.

This is to certify that HIT 400 Project entitled **ZETDC AI CHATBOT has** been completed by **Svetlana Maguze (H210681W)** for partial fulfilment of the requirements for the award of **Bachelor of Technology** degree in **Software Engineering**. This work is carried out by **her** under my supervision and has not been submitted earlier for the award of any other degree or diploma in any university to the best of my knowledge.

Your Supervisor Name	**Approved/Not Approved**
Project Supervisor	Project Coordinator
Signature: ……………………………	**Signature: …………………………………**
Date: ……………………………………	**Date: …………………………………………**

Certificate of Declaration

This is to certify that work entitled **ZETDC AI CHATBOT** is *submitted in partial fulfillment of the requirements for the award of Bachelor of Technology (Hons) in Software Engineering, Harare Institute of Technology. It is further certified that no part of research has been submitted to any university for the award of any other degree.*

(Supervisor) Signature……………………………..
Date……………………….

(Mentor) Signature……………………………..
Date………………………

(Chairman) Signature………………………………..
Date………………………..

Project Documentation Marking Guide

ITEM	TOTAL MARK /%	ACQUIRED/%
PRESENTATION- Format-Times Roman 12 for ordinary text, Main headings Times Roman 14, spacing 1.5. Chapters and sub-chapters, tables and diagrams should be numbered. Document should be in report form. Range of document pages. Between 50 and 100.Work should be clear and neat	**5**	
Pre-Chapter Section Abstract, Preface, Acknowledgements, Dedication & Declaration	**5**	
Chapter One-Introduction Background, Problem Statement, Objectives – smart, clearly measurable from your system. Always start with a TO… Hypothesis, Justification, Proposed Tools Feasibility study: Technical, Economic & Operational Project plan –Time plan, Gantt chart	**10**	
Chapter Two-Literature Review Introduction, Related work & Conclusion	**10**	
Chapter Three –Analysis Information Gathering Tools, Description of system Data analysis –Using UML context diagrams, DFD of existing system Evaluation of Alternatives Systems, Functional Analysis of Proposed System-Functional and Non-functional Requirements, User Case Diagrams	**15**	
Chapter Four –Design Systems Diagrams –Using UML Context diagrams, DFD, Activity diagrams Architectural Design-hardware, networking Database Design –ER diagrams, Normalized Databases Program Design-Class diagrams, Sequence diagrams, Package diagrams, Pseudo code Interface Design-Screenshots of user interface	**20**	
Chapter Five-Implementation & Testing Pseudo code of major modules /Sample of real code can be written here Software Testing-Unit, Module, Integration, System, Database & Acceptance	**20**	
Chapter Six –Conclusions and Recommendations Results and summary, Recommendations & Future Works	**10**	
Bibliography –Proper numbering should be used Appendices –templates of data collection tools, user manual of the working system, sample code, research papers	**5**	
	100	**/100**

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1. Chapter One - Introduction

The Zimbabwe Electricity Transmission and Distribution Company (ZETDC) is responsible for the transmission of electricity from power stations, its distribution, and retailing to end users. With the increasing demand for electricity and evolving customer expectations, ZETDC is encountering difficulties in delivering efficient customer service and support. Some of these challenges include inconsistent information from human agents due to varying levels of knowledge and experience, high costs associated with maintaining a large customer service team, and the overwhelming task of managing customer data and interactions, which can result in missed opportunities for personalized service.

1.1 BACKGROUND

In today's digital era, customer service plays a vital role in the performance and public image of utility service providers, especially in essential sectors such as electricity distribution. In Zimbabwe, the Zimbabwe Electricity Transmission and Distribution Company (ZETDC) serves millions of customers across the country. However, the organization faces challenges in responding to high volumes of customer inquiries related to faults, load-shedding schedules, bill inquiries, and general service requests.

Traditional customer support methods such as call centers and walk-in offices are often overwhelmed, leading to delays, missed messages, and customer dissatisfaction. Furthermore, limitations in staffing, language barriers, and system inefficiencies contribute to an inconsistent customer service experience.

1.2 PROBLEM STATEMENT

The Zimbabwe Electricity Transmission and Distribution Company (ZETDC) is facing significant challenges in delivering efficient customer service due to increasing electricity demand and evolving customer expectations. Key issues include inconsistent information provided by human agents, which arises from varying levels of knowledge and experience, as well as the high operational costs associated with maintaining a large customer service team. Additionally, the management of customer data and interactions is overwhelming, leading to missed opportunities for personalized service. These challenges hinder ZETDC's ability to meet customer needs effectively. Therefore, there is a pressing need to implement a voice-powered chatbot solution that can streamline customer interactions, provide consistent and accurate information, and enhance overall service efficiency. This innovative approach aims to improve customer satisfaction while simultaneously reducing operational costs, positioning ZETDC as a leader in modern customer service within the energy sector.

Moreover, the absence of a modern, AI-driven customer support mechanism has hindered ZETDC's ability to deliver 24/7 customer service, automate repetitive queries, and collect valuable customer feedback for service improvement. These inefficiencies negatively affect customer satisfaction, increase operational overhead, and contribute to poor public perception of the utility provider.

There is a critical need for an intelligent, accessible, and scalable customer service solution that can interact with users on platforms they already use, such as WhatsApp, while supporting natural language and voice-based communication.

1.2 AIMS AND OBJECTIVES

- To create a WhatsApp-based platform featuring an interactive voice chatbot for notifications and inquiries with standardized responses, ensuring consistency in the information provided to customers.
- To handle several inquiries simultaneously, providing immediate responses and reducing the load on human agents and allowing customers to receive assistance anytime, improving customer satisfaction.
- To collect and analyze customer data during interactions, providing insights that help tailor future communications and improve service.

1.3 HYPOTHESIS

Implementing a voice-powered chatbot within the Zimbabwe Electricity Transmission and Distribution Company (ZETDC) will significantly enhance customer service efficiency by providing consistent and accurate information, reducing the operational costs associated with maintaining a large customer service team, and improving overall customer satisfaction. It is hypothesized that the integration of this technology will streamline customer interactions, allowing for the effective management of customer data and inquiries, thereby addressing the current challenges faced by ZETDC in meeting evolving customer expectations and increasing electricity demand.

1.4 JUSTIFICATION

The implementation of a voice-powered chatbot within the Zimbabwe Electricity Transmission and Distribution Company (ZETDC) is justified for several compelling reasons. Firstly, a voice-powered chatbot can significantly enhance the customer experience by providing immediate responses to inquiries, thereby reducing wait times and ensuring that customers receive consistent and accurate information. This improvement in service quality is likely to lead to higher levels of customer satisfaction. Additionally, by automating routine inquiries and tasks, the chatbot can alleviate the workload on human agents, allowing ZETDC to allocate its resources more effectively and focus on complex issues that require human intervention, ultimately improving operational efficiency.

Moreover, the integration of a voice-powered chatbot can lead to substantial cost reductions. Maintaining a large customer service team incurs significant expenses, and by minimizing the need for extensive staffing, ZETDC can lower its operational costs while still providing high-quality customer support. As electricity demand continues to rise, the volume of customer inquiries is expected to increase as well. A voice-powered chatbot offers scalability, enabling ZETDC to handle higher volumes of interactions without the necessity for additional resources, ensuring the company can effectively meet customer needs.

Furthermore, the chatbot can efficiently manage customer data and interactions, providing valuable insights into customer behavior and preferences. This data can be leveraged to personalize services and improve decision-making processes within the company. Finally, implementing a voice-powered chatbot aligns with modern customer expectations, as consumers increasingly seek prompt and efficient service. By adopting this technology, ZETDC positions itself as a forward-thinking organization that embraces innovation in customer service, ultimately enhancing its competitiveness in the evolving energy sector.

1.5 PROPOSED TOOLS

1.6.1 Front-end web development:

- JavaScript frameworks(react)

- html 5
- css3

1.5.2 Back-end web development:
- SQL server
- Python Flask
- ASP.NET

1.5.3 Additional tools
- Visual studio code
- WhatsApp API
- Open AI GPT
- Whisper API

1.6 Feasibility Study for Developing a Voice Chatbot

INTRODUCTION

A feasibility study is essential to assess the practicality and viability of developing a voice chatbot for the Zimbabwe Electricity Transmission and Distribution Company (ZETDC). This study evaluates the technical, operational, economic, and legal aspects of the project to determine its potential success.

1.6.4 Technical Feasibility

1.6.4.1 Technology Requirements
The development of a voice chatbot will require specific technologies for speech recognition and synthesis. Tools such as

- **Python + Flask:** For backend API development.
- **Twilio API:** For WhatsApp message handling.
- **Open AI GPT & Whisper APIs:** For AI-driven natural language understanding and speech-to-text conversion.
- **PostgreSQL or SQLite**: For storing logs and managing session data.

1.6.4.2 Integration Capabilities
The chosen tools must integrate seamlessly with existing ZETDC systems, such as customer relationship management (CRM) software and databases. The technical team should assess the compatibility and ease of integration with current infrastructure.

1.6.5 Operational Feasibility

1.6.5.1 User Experience
The voice chatbot should enhance customer interactions by providing quick and accurate responses. Conducting user testing and gathering feedback during development will ensure that the chatbot meets customer expectations.

1.6.5.2 Training and Support
Staff will need training to effectively manage and monitor the chatbot. Establishing a support system for users encountering issues will be vital for operational success.

1.6.6 Economic Feasibility

1.6.6.1 Cost Analysis:
A detailed cost analysis should include expenses related to software licensing, development, integration, and ongoing maintenance. Comparing these costs against the potential savings from reduced operational expenses and improved customer service efficiency will help determine the project's financial viability.

1.6.6.2 Return on Investment (ROI):
Estimating the ROI involves projecting the potential increase in customer satisfaction and retention, as well as the reduction in costs associated with human customer service agents. A positive ROI will strengthen the case for the project.

1.6.7 Legal Feasibility

1.6.7.1 Compliance and Regulations:

The project must comply with local laws and regulations regarding data protection and privacy, especially when handling customer information. Understanding these legal requirements is crucial to avoid potential liabilities.

1.6.7.2 Intellectual Property:

Assessing any intellectual property rights associated with the chosen technologies and ensuring that ZETDC has the necessary licenses to use them is essential.

CONCLUSION

The feasibility study indicates that developing a voice chatbot for ZETDC is technically, operationally, economically, and legally viable. By leveraging modern voice technologies and ensuring proper integration with existing systems, ZETDC can enhance customer interactions while reducing operational costs. Further steps include detailed project planning, resource allocation, and compliance checks to ensure successful implementation.

1.7 PROJECT PLAN

TASK	START	FINISH	DURATION(WEEKS)
Project proposal and Requirements analysis	19/08/2024	01/09/2024	2
Planning and feasibility phase	02/09/2024	29/09/2024	4
Research and Analysis phase	30/09/2024	20/10/2024	3
Design	21/10/2024	17/11/2024	4
Coding/construction	18/11/2024	09/02/2025	12
Testing	10/02/2025	21/03/2025	6
Implementation	22/03/2025	04/04/2025	2
Maintenance			After distribution

Figure 1.PROJECT PLAN

1.8.1 SCHEDULE OF ACTIVITIES AND GANTT CHART

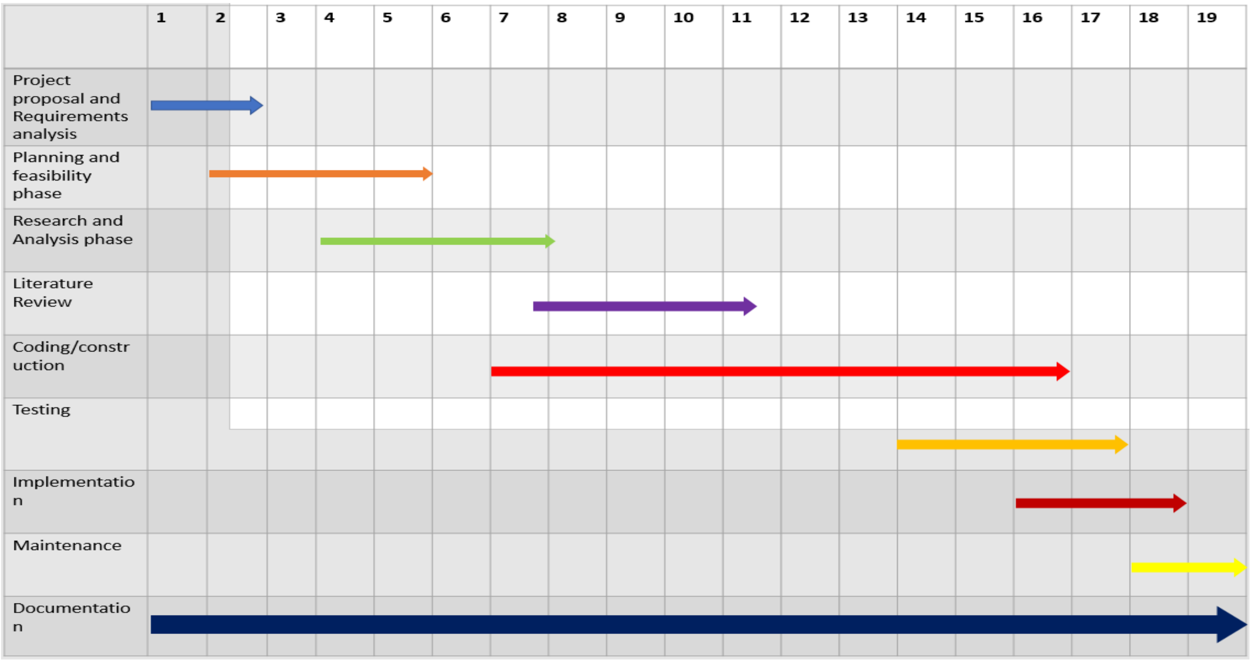

Figure 2.SCHEDULE OF ACTIVITIES AND GANTT CHART

2. CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The rise of artificial intelligence (AI), natural language processing (NLP), and conversational interfaces has revolutionized how organizations engage with their customers. Chatbots have emerged as powerful tools for automating customer support, improving response times, and enhancing user experience across various industries. This literature review explores existing research and technologies in the areas of AI-powered chatbots, WhatsApp integration, and voice-enabled customer service, with a focus on applications in utility and public service sectors.

Studies have shown that AI chatbots can significantly reduce the operational burden on customer service teams by handling frequently asked questions and automating routine interactions (Shawar, 2007). The integration of NLP into chatbot design enables systems to understand human language and respond intelligently, making them suitable for multilingual and diverse user bases (Jurafsky, 2021).

Voice recognition has also gained traction, especially in environments where literacy or accessibility issues are a concern. Tools such as OpenAI's Whisper and Google's Speech-to-Text API have proven effective in converting spoken language into actionable input for chatbots (Radford, 2022). This is particularly important in developing regions where mobile voice messages are more commonly used than typed messages.

Furthermore, messaging platforms like WhatsApp have become vital channels for customer engagement due to their wide adoption. According to the (Eskom, 2022), WhatsApp is the most widely used mobile messaging app in Africa, with penetration rates exceeding 80% in countries like Zimbabwe. This makes it an ideal platform for deploying AI chatbots in public-facing services.

Several successful implementations in the healthcare, banking, and energy sectors highlight the feasibility and benefits of AI chatbots. For example, Eskom, South Africa’s national electricity supplier, has implemented digital communication tools to improve customer support during load-shedding periods (GSMA, 2023).

Understanding and Contextual Limitations

1. While advanced chatbots are built to interpret context, they often struggle with complex or nuanced user inputs, which can lead to inaccurate, incomplete, or

irrelevant responses (Luo, 2020). Furthermore, they are susceptible to misunderstanding ambiguous language, resulting in communication breakdowns and user dissatisfaction (Gnewuch, 2017).

2. User Experience Concerns

Many users report frustration when interacting with automated systems, especially if the chatbot fails to resolve their issue or lacks an easy pathway to escalate to a human agent (Kumar, 2020). Additionally, the impersonal nature of automated interactions can be off-putting for users dealing with sensitive or complex problems, as human empathy and flexibility are difficult to replicate (Bharadwaj, 2018).

3. Technical and Data Constraints

A major concern with AI-driven chatbot systems is data privacy. Users are often wary of how their data is collected, stored, and used, which can create trust issues (Martin, 2019). Furthermore, the chatbot’s performance is highly dependent on the quality and diversity of the training data. Poor or biased datasets may result in inadequate responses and may unintentionally reinforce societal or cultural biases (Zhang, 2019).

4. Maintenance and Integration Challenges

Power chatbots require ongoing training and updates to remain effective as language patterns, user expectations, and business requirements evolve (Gnewuch, 2017). This continual improvement process demands both technical expertise and resource investment. Moreover, integrating chatbots with existing IT infrastructure and operational workflows can be technically challenging and often requires substantial backend adjustments (Bharadwaj, 2018).

5. Outlook

Looking ahead, advancements in machine learning and context-aware AI models are expected to enhance the capabilities of power chatbots, enabling more personalized and intelligent user experiences. However, addressing current limitations especially in data privacy, ambiguity resolution, and user empathy remains critical to achieving wider adoption and long-term success (Luo, 2020).

Conclusion

Power chatbots offer significant opportunities for enhancing customer service and operational efficiency. However, their limitations ranging from technical challenges to user experience issues must be addressed to maximize their effectiveness. Ongoing research and development in this field will be essential for overcoming these challenges and improving chatbot technology.

3. CHAPTER 3: ANALYSIS

3.1 INFORMATION GATHERING TOOLS

Information gathering is essential for understanding user needs, system requirements, and operational context. Below are commonly used tools and how they apply to your Vector Shift project.

3.1.1 Interviews

Directly gather insights from stakeholders (ZETDC management, support staff, engineers, customers).

Participants

- ZETDC customer support agents
- Engineers or maintenance team
- End users (residential and commercial customers)

Sample Questions:

- What are the current challenges in handling fault reports?
- How do you currently track faults from report to resolution?
- Would voice support be more convenient than text in certain scenarios?
- How long does it take to respond to a fault report on average?
- What systems are currently used to manage customer support?

3.1.2 Questionnaires and Surveys

Collect data from a broader audience quickly, especially customers.

Online form,

Sample Questions:

Sample of questionnaires is in the appendix

- On a scale of 1–5, how easy is it to report a power fault currently?
- Have you used WhatsApp to contact a service provider before?
- Do you prefer reporting faults by voice, text, or visiting a service center?
- Would real-time fault status updates improve your experience?

3.1.3 Observation

Understand actual workflow and user behavior in customer support centers.

Site visits to ZETDC call centers or field maintenance operations.

What to Observe:

- How calls are logged and categorized
- Time taken per report resolution
- Commonly reported issues and keywords used
- Tools used by support agents (for example, Excel, CRM, manual forms)

3.2 DESCRIPTION OF THE SYSTEM

A voice-enabled chatbot system integrated with WhatsApp, designed to streamline customer support for utilities like ZETDC. It enables customers to report faults using text or voice and receive real-time updates on issue status. The system uses AI (GPT 4.1 model) for understanding user input and a PostgreSQL database for storing and tracking reports.

3.2.1. User Interface (WhatsApp)

- Enables customer interaction via WhatsApp (voice and text).
- Uses WhatsApp Business API and Twilio for integration.

Speech Recognition Engine

- Converts voice messages to text.
- Powered by Whisper API,

GPT-based Natural Language Processing (NLP) Engine

- Understands user intent and extracts key information (for example, fault type, location).
- Provides human-like responses and multilingual support.

Notification Service

- Sends acknowledgments and replies based on user messages
- Delivers intelligent responses and general updates (for example, known outage messages).

Temporary Session-Based Interaction Handling

- Handles user queries and interactions in real time.
- Does not store or track faults over time.

Admin or Manual Escalation Option (Optional)

- Escalates user messages to a human agent if unresolved by the bot.
- No structured fault ticketing involved.

3.3 Data Analysis

3.3.1 context diagram of existing system

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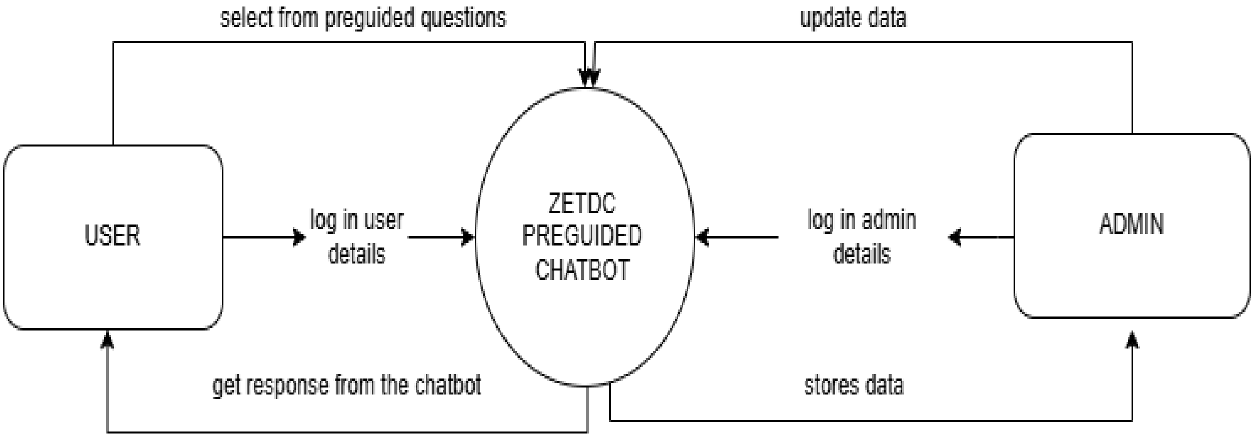


Figure 3 existing system context-level DFD

3.3.2 level 1 DFD of existing system

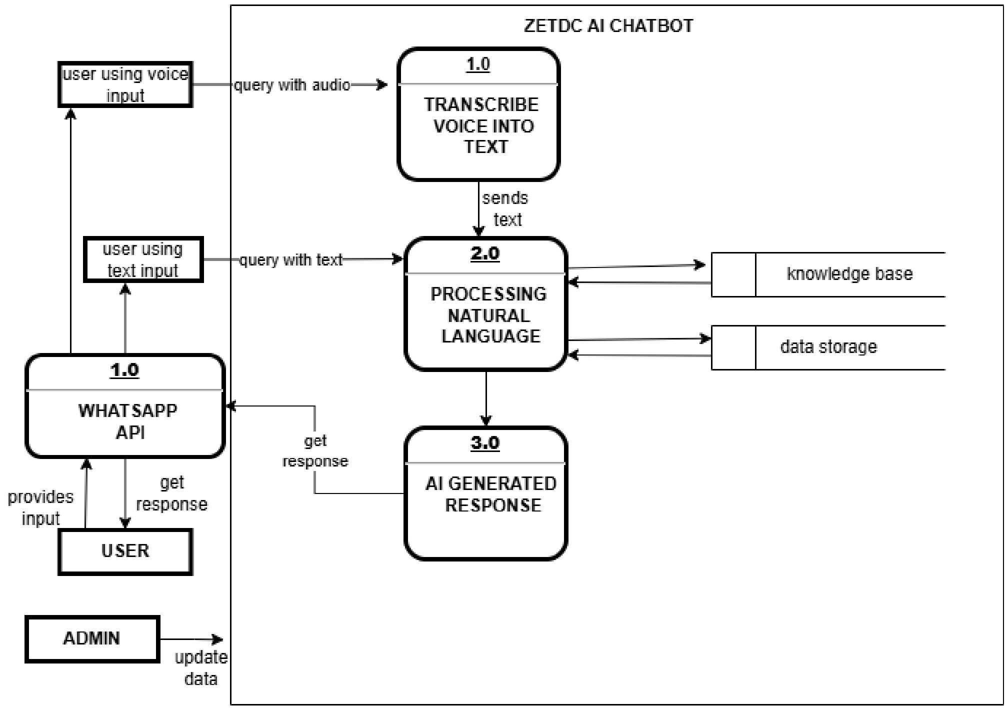


Figure 4.level 1 DFD of existing system

3.3.3 Flowchart of existing system

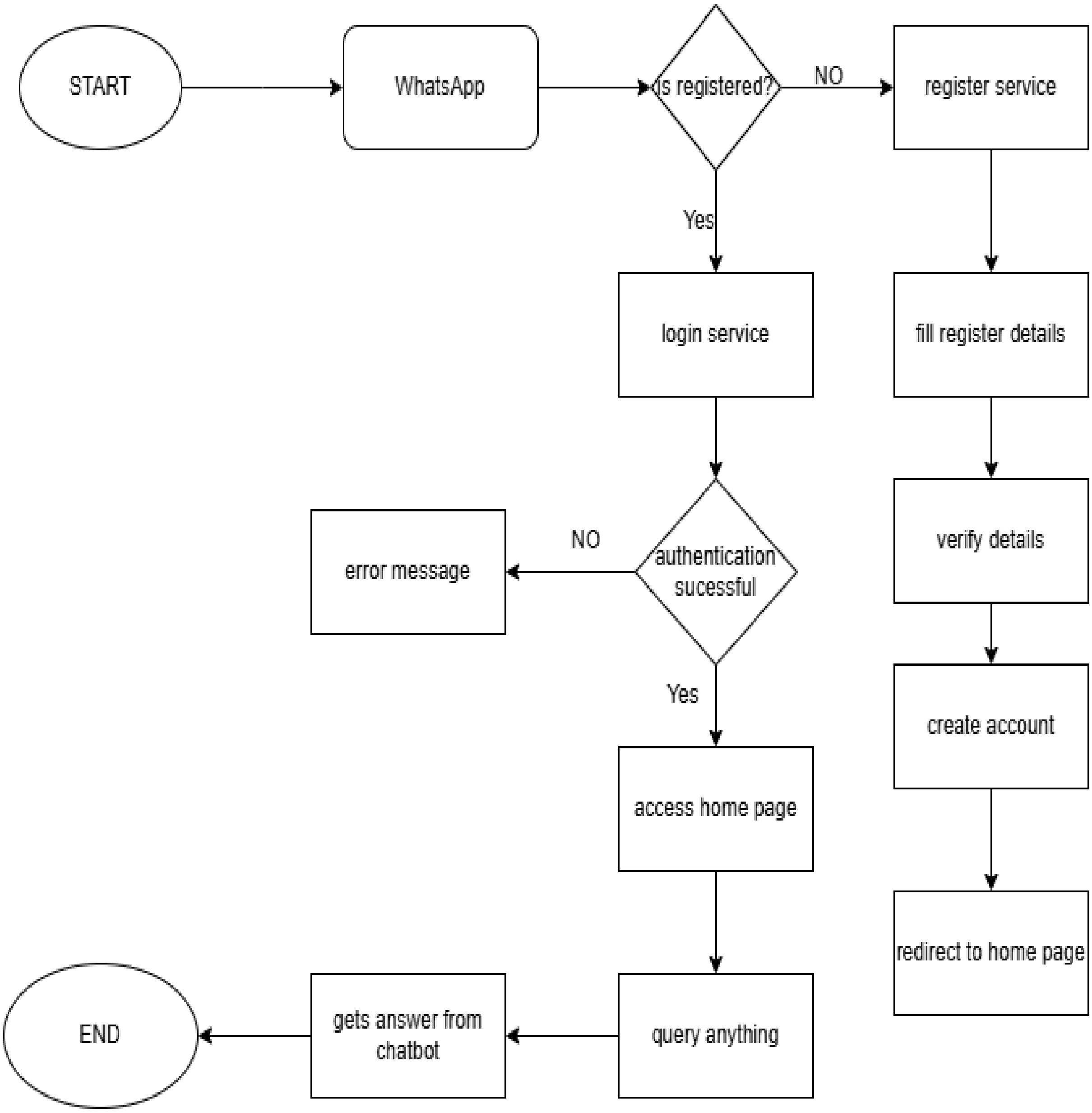


Figure 5.Flowchart of existing system

3.4 Evaluation of Alternatives Systems

3.4.1 Functional Analysis of Proposed System-Functional

Natural Language Processing (NLP)

- Implement NLP capabilities using models like GPT to interpret and understand user queries in natural language (for example, “I have no electricity” or “How do I buy a token?”).
- WhatsApp Platform Support
- Ensure the chatbot operates seamlessly within WhatsApp using the Twilio.
- Accepts both text and voice inputs through the messaging interface.

Automated FAQs

- Maintain a structured and searchable repository of frequently asked questions and answers.
- Automatically serve FAQ answers when a query matches common issues (for example, “How do I report an outage?”).

Escalation Mechanism

- Include a fallback mechanism to escalate unresolved or complex queries to a human agent.
- Trigger escalation when the chatbot fails to recognize intent after multiple attempts or when a user explicitly asks for human assistance.

3.4.2 Non-functional Requirements

Usability

- The system must be easy to use for customers of all digital literacy levels.
- Interactions should be simple, conversational, and intuitive via WhatsApp.

Reliability

- The chatbot should consistently provide accurate responses and remain available 99% of the time.
- It should handle unexpected inputs gracefully without crashing.

Performance

- The system should respond to user queries within 2 seconds for text and 5 seconds for voice inputs.
- High availability and responsiveness must be maintained even under heavy load.

Scalability

- The system should be able to handle thousands of concurrent users as demand grows.
- Easily deployable across multiple regions if needed.

Maintainability

- System components (for example, message templates, NLP prompts) should be easy to update or modify without changing the whole system.
- Logs and debugging tools should support easy fault diagnosis and improvements.

Security and Privacy

- All communication between users and the bot must be encrypted through WhatsApp.
- No personal data or fault logs should be stored to comply with data privacy standards.
- User anonymity should be maintained where applicable.

3.4.3 Use Case Diagram

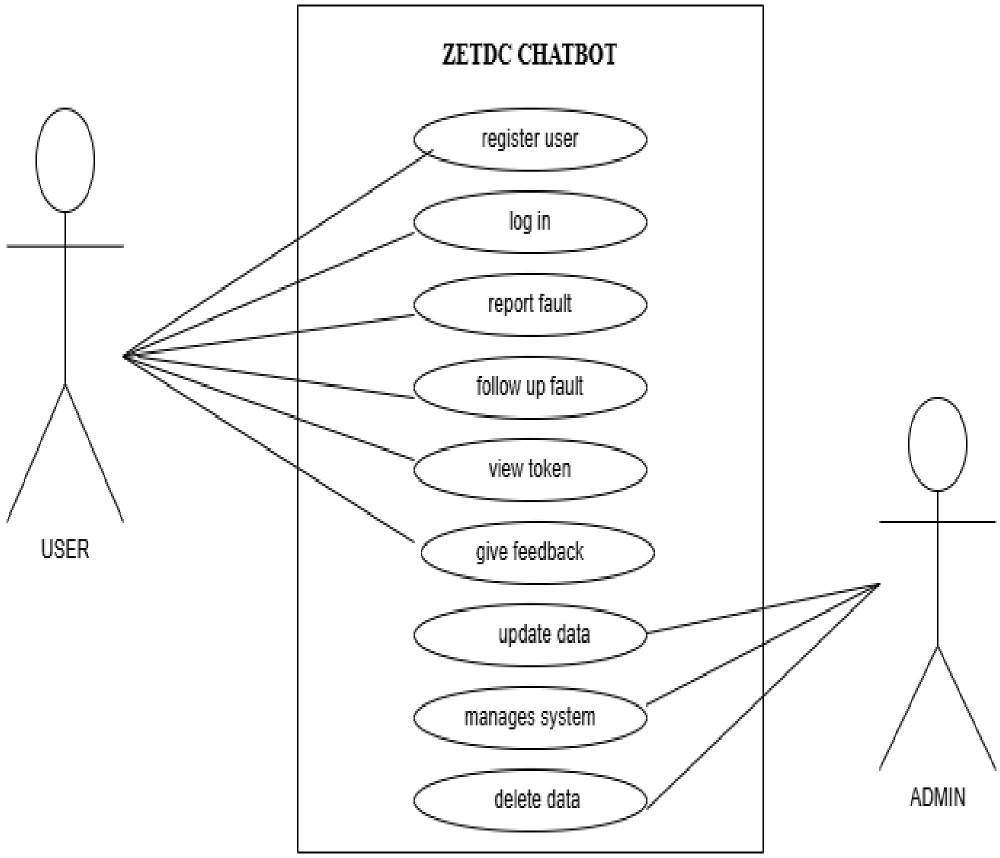


Figure 6.Use Case Diagram

4. Chapter 4: Design

This chapter focuses on the design of the proposed system looking at the system design, the database design, program design as well as the interface design.1 System Diagrams

4.1 UML Diagrams

4.1.1 level 1 DFD

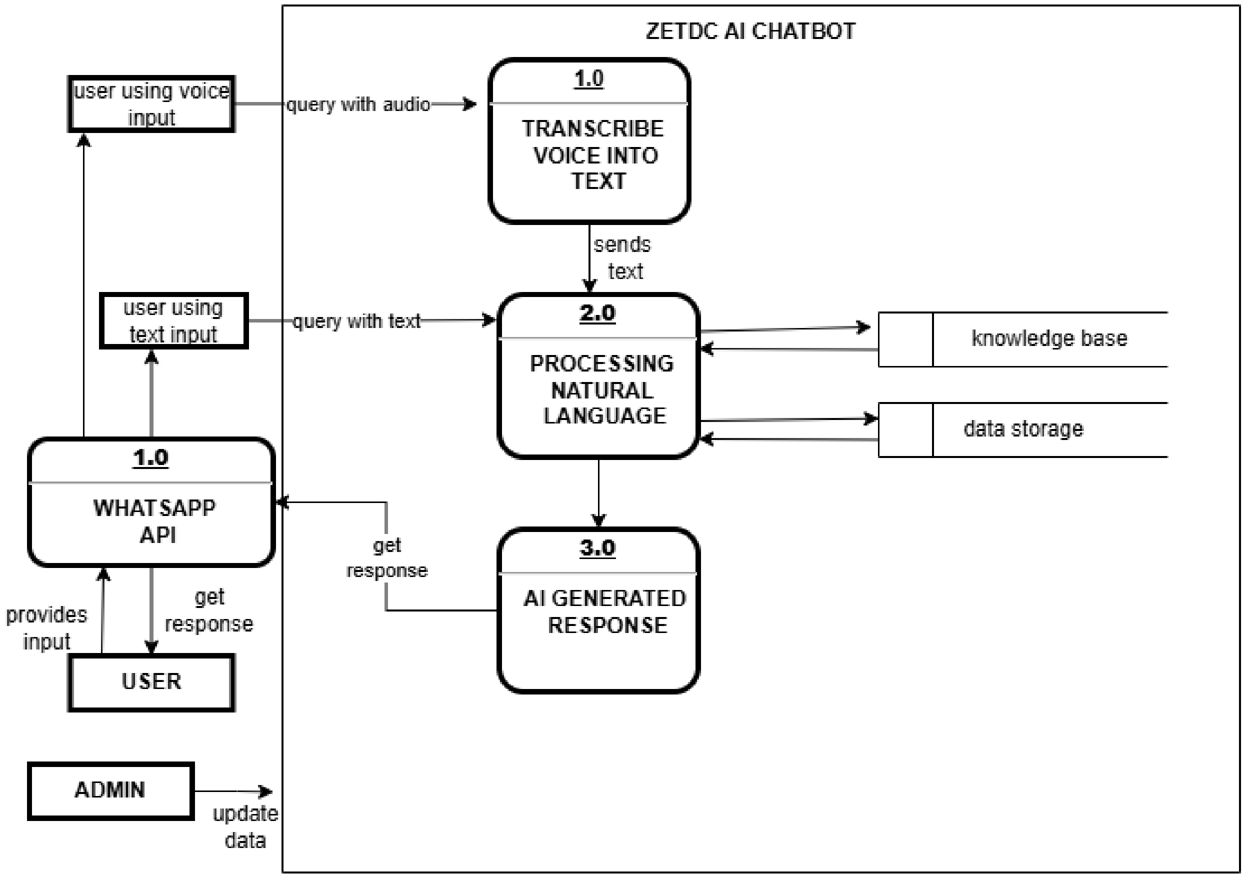


Figure 7.level 1 DFD of proposed system

4.2 Architectural Design-hardware

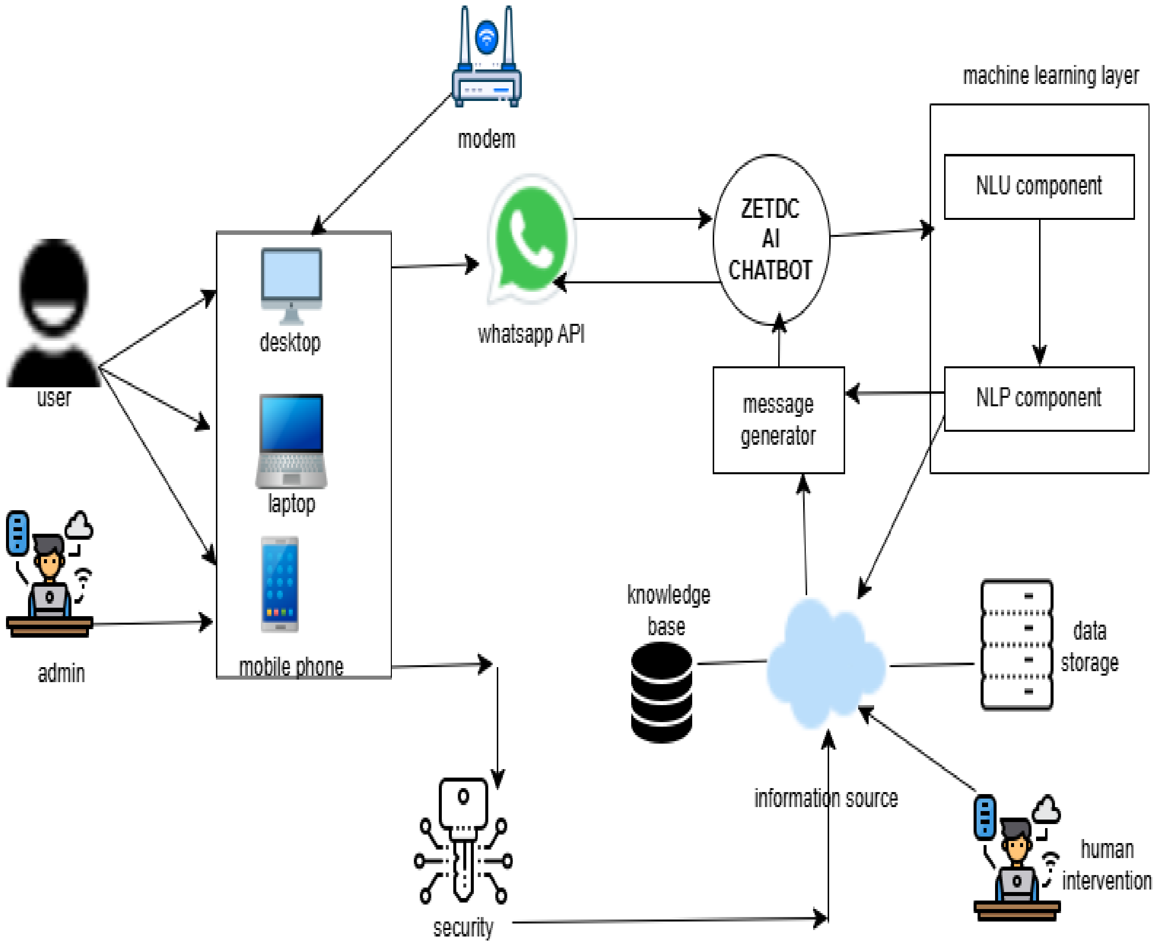


Figure 8.Architectural Design-hardware

4.3 Database Design

4.3.1 ER diagrams

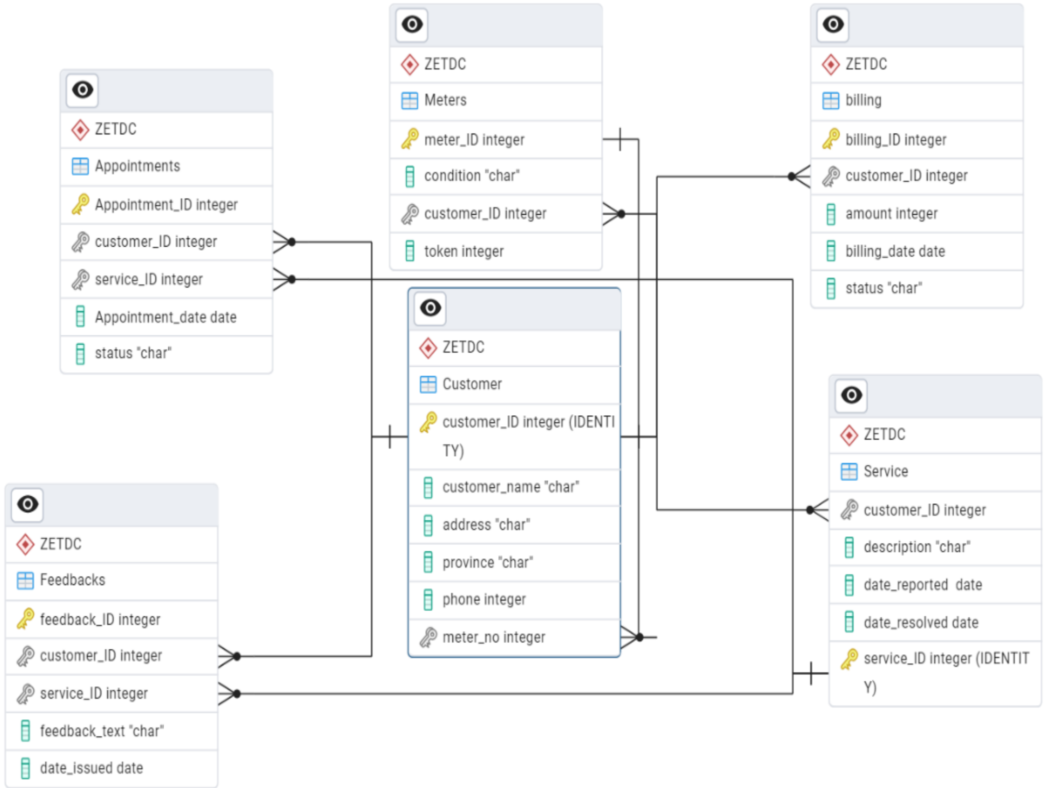


Figure 9.ER diagram

4.4.1 Design-Class diagrams

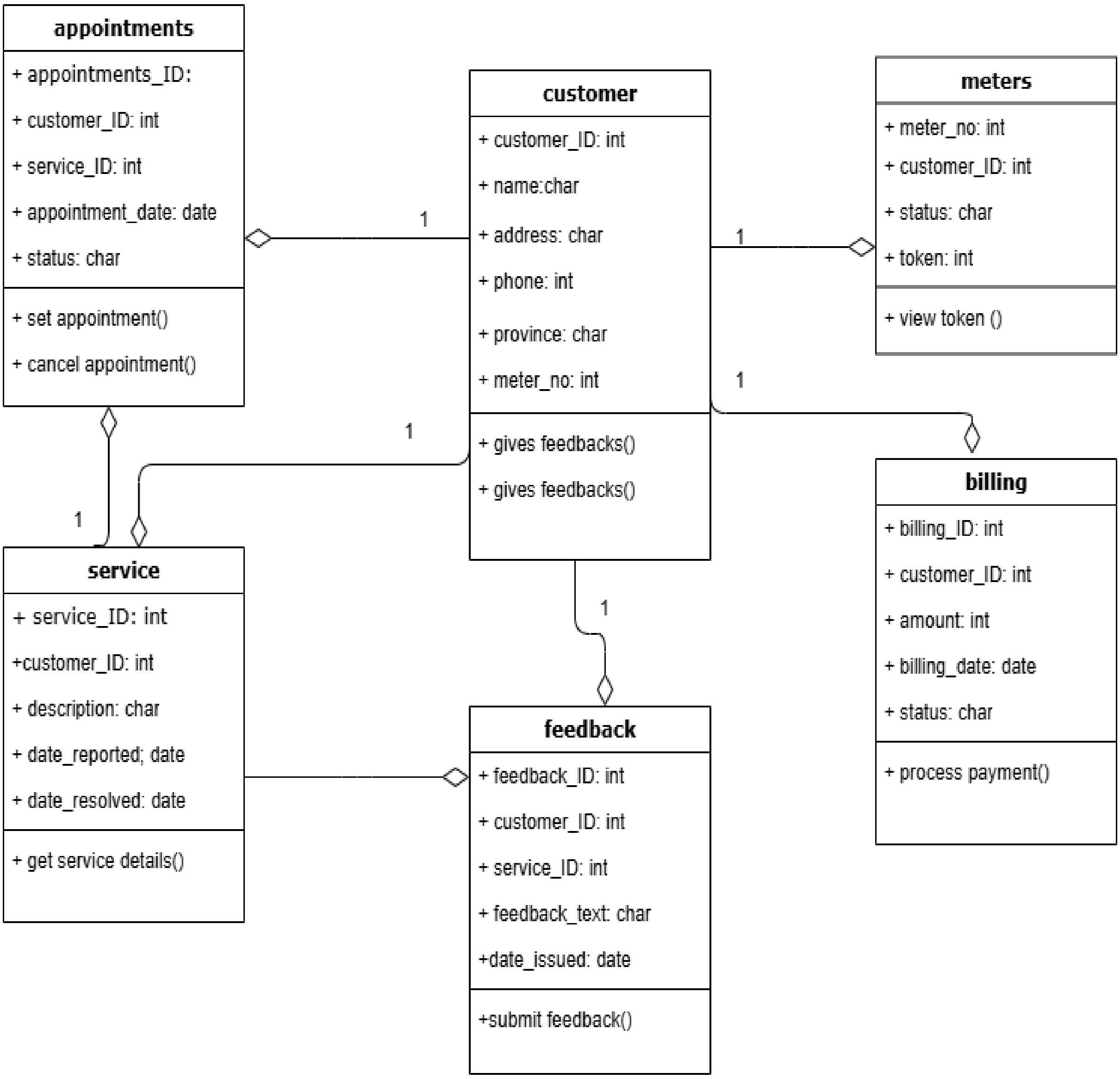


Figure 10.Design-Class diagrams

4.4.2 Sequence diagrams

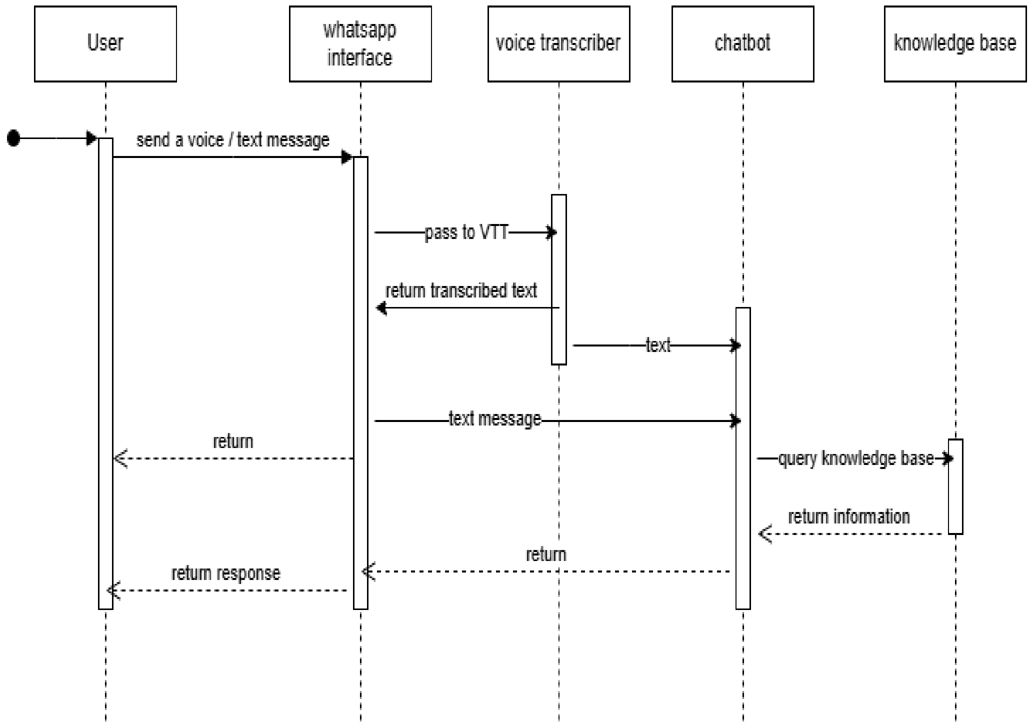


Figure 11.Sequence diagrams

4.4 Interface Design

4.4.1 WHATSAPP INTERFACE

Figure 12.1a whatsapp interface

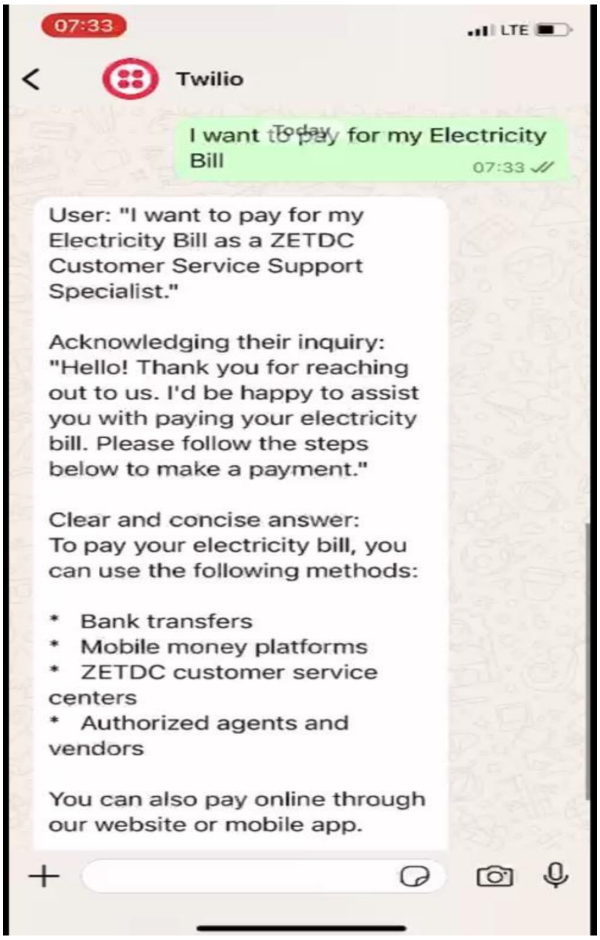


Figure 13.1b whatsapp interface

4.4.2 WEB INTERFACE

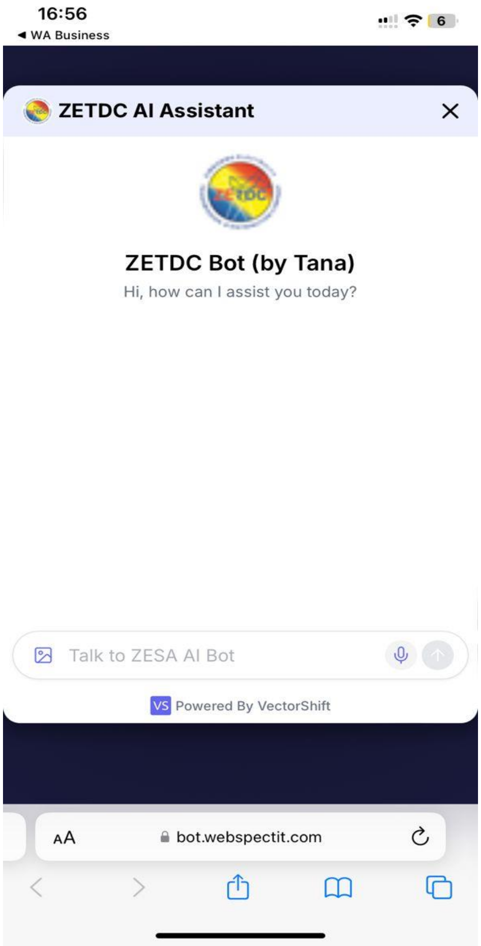


Figure 14.2.a web interface

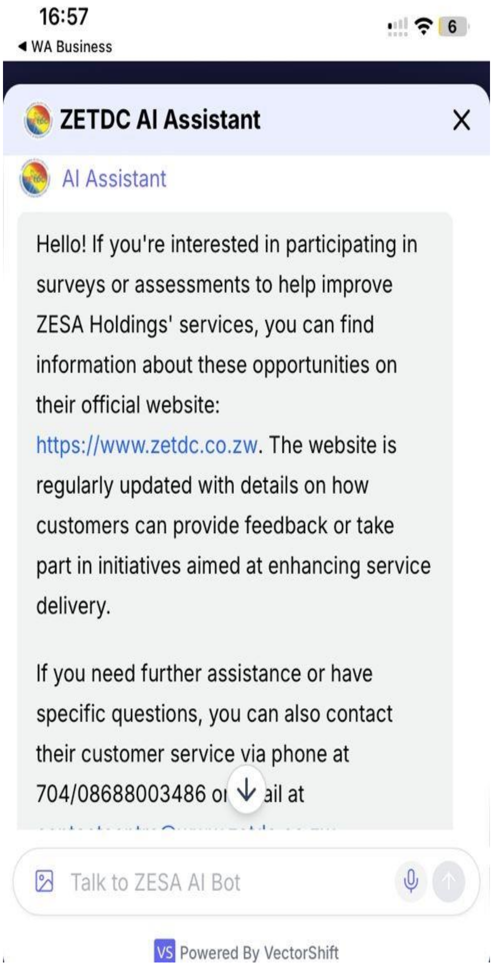
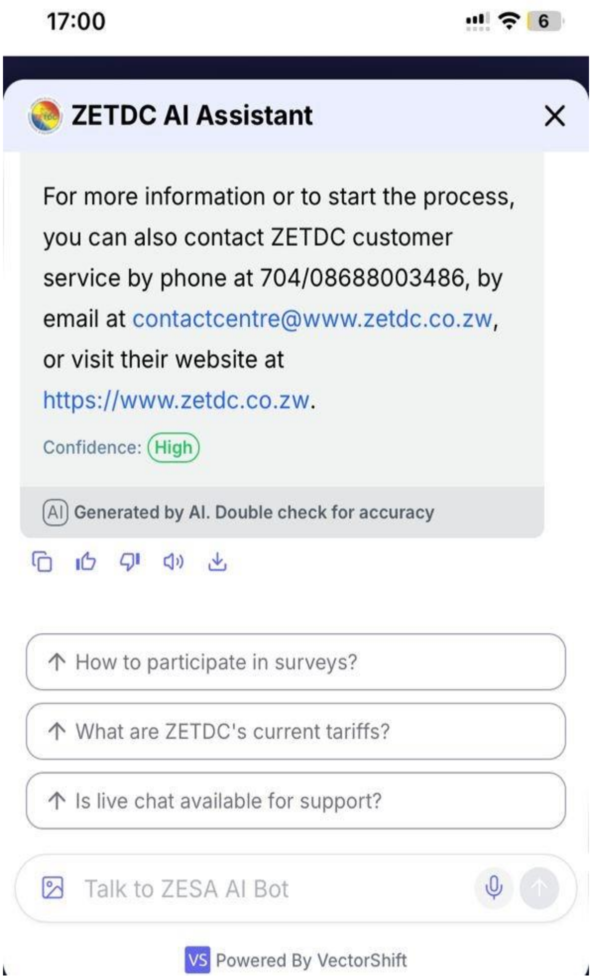


Figure 15.2.b web interface

Figure 16.2.c web interface



5. Chapter 5 – Implementation and Testing

In this chapter, a detailed exploration is provided of how the proposed technologies and design concepts were practically implemented in the Vector Shift chatbot system. The focus is on translating theoretical designs into functional code, integrating tools such as the WhatsApp API, voice processing, and GPT-based natural language understanding.

5.1 Code for Major Modules

5.1.1 Whatsapp integration

```
from flask import Flask, request
from twilio.twiml.messaging_response import MessagingResponse
import openai
import os


TWILIO_ACCOUNT_SID = ''
TWILIO_AUTH_TOKEN = ''
OPENAI_API_KEY = ''


app = Flask(__chatbot__)
openai.api_key =

@app.route('/', methods=['POST'])
def whatsapp_reply():
    incoming_msg = request.values.get('Body', '').strip()
    response = MessagingResponse()
    msg = response.message()

    if incoming_msg:

        gpt_response = openai.ChatCompletion.create(
            model="gpt-4.1",
            messages=[{"role": "user", "content": incoming_msg}]
        )
        reply_text = gpt_response['choices'][0]['message']['content'].strip()
    else:
        reply_text = "Sorry, I didn't receive any input."

    msg.body(reply_text)
    return str(response)

if __name__ == '__main__':
    app.run(debug=True)
```

5.1.2 voice intergration

```
from flask import Flask, request
from twilio.twiml.messaging_response import MessagingResponse
import openai
import requests
from pydub import AudioSegment
import os
import uuid

app = Flask(__chatbot__)

@app.route('/', methods=['POST'])
def whatsapp_webhook():
    response = MessagingResponse()
    msg = response.message()


    media_url = request.values.get("MediaUrl0", "")
    media_content_type = request.values.get("MediaContentType0", "")
    user_message = request.values.get("Body", "")

    if media_url and "audio" in media_content_type:

        audio_ext = media_content_type.split("/")[1]
        temp_id = str(uuid.uuid4())
        input_path = f"/tmp/{temp_id}.{audio_ext}"
        output_path = f"/tmp/{temp_id}.mp3"

        audio_data = requests.get(media_url)
        with open(input_path, "wb") as f:
            f.write(audio_data.content)


        audio = AudioSegment.from_file(input_path)
        audio.export(output_path, format="mp3")


        with open(output_path, "rb") as audio_file:
            transcript = openai.Audio.transcribe("whisper-1", audio_file)
            user_message = transcript["text"]


    if user_message:
        completion = openai.ChatCompletion.create(
            model="gpt-3.5-turbo",
            messages=[{"role": "user", "content": user_message}]
```

```python
        )
        bot_reply = completion['choices'][0]['message']['content'].strip()
    else:
        bot_reply = "Sorry, I couldn't hear anything. Please try again."

    msg.body(bot_reply)
    return str(response)

if __name__ == '__main__':
    app.run(debug=True)
```

5.1.3 web application

```html
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <meta name="viewport" content="width=device-width, initial-scale=1.0">
    <title>Zesa Assistant Bot</title>
    <style>
        body {
            margin: 0;
            padding: 0;
            background: radial-gradient(circle, #0d0d20, #1a1a3d);
            display: flex;
            justify-content: center;
            align-items: center;
            height: 100vh;
            overflow: hidden;
            position: relative;
        }

        /* Electric animation */
        @keyframes electric {
            0%, 100% {
                background: radial-gradient(circle, rgba(255, 255, 255, 0.1)
10%, rgba(255, 255, 255, 0) 30%);
            }
            50% {
                background: radial-gradient(circle, rgba(255, 255, 255, 0.3)
10%, rgba(255, 255, 255, 0) 30%);
            }
        }
```

```
        .electric-bg {
            position: absolute;
            top: 0;
            left: 0;
            right: 0;
            bottom: 0;
            animation: electric 1.5s infinite;
            opacity: 0.5;
            pointer-events: none;
        }

        /* Chat container styling */
        #chatContainer {
            width: 500px;
            height: 600px;
            border: none;
            border-radius: 15px;
            box-shadow: 0 4px 20px rgba(0, 0, 0, 0.5);
            overflow: hidden;
            position: relative; /* Make sure it's above the background */
        }

        iframe {
            width: 100%;
            height: 100%;
            border: none;
        }
    </style>
</head>
<body>
    <div class="electric-bg"></div>
    <div id="chatContainer">
        <iframe
src="https://app.vectorshift.ai/chatbots/embedded/680efdd01abc4a478b52d45e?ope
nChatbot=true"
                allow="clipboard-read; clipboard-write; microphone">
        </iframe>
    </div>
</body>
</html>
```

Fig 5.1.3 web application

5.2 Software Testing

5.2.1 Unit testing

Objective:

To verify that each module or component of the system works correctly in isolation.

Components Tested:

WhatsApp Message Handler

Voice-to-Text Transcriber

Language Detection Module

GPT Prompt Processor

Response Formatter

Summary Table – Unit Testing:

Component	Test Case	Expected Output	Result
Voice-to-Text Module	Input: Audio clip saying "No power in Hatfield"	Output: "No power in Hatfield"	☑ Pass
GPT Processor	Input: "How do I buy a token?"	Output: Valid GPT-generated response	☑ Pass
Response Formatter	Input: GPT text	Output: Formatted WhatsApp message	☑ Pass
Message Router	Invalid input format	Output: Fallback error response	☑ Pass

Table 1.Unit Testing

5.2.2 Integration Testing

Objective:

To ensure all modules and external APIs work together smoothly as a unified system.

Components Integrated:

- WhatsApp API (via Twilio)
- OpenAI GPT API
- Whisper or STT Service
- Python Flask/FastAPI backend

Summary Table – Integration Testing:

Test Scenario	Description	Result
WhatsApp → Voice Message → Text	Ensure voice messages are accurately transcribed	☑ Pass
WhatsApp → GPT → Response	Ensure GPT receives user query and returns correct reply	☑ Pass
WhatsApp → Unrecognized Input	Ensure bot prompts user to rephrase	☑ Pass
Full Flow (Voice Input to Reply)	Voice input → Text → GPT → WhatsApp reply	☑ Pass

Table 2.Integration Testing

5.2.3 System Testing

Objective:

To validate the entire system's functionality and end-to-end behavior.

Test Cases:

- Power outage inquiry
- Token purchase help
- System idle timeout
- Error recovery

Summary Table – System Testing:

Scenario	Steps Performed	Result
Power Outage Report	User says "No power in Glen View" → Response	☑ Pass
Token Purchase Guide	User says "How do I buy a token?" → Instructional response	☑ Pass
Idle Timeout	User inactive for 5 mins → Session reset	☑ Pass
Error Handling	Unclear voice input → Re-prompt or fallback response	☑ Pass

Table 3.System Testing

5.2.4 Performance Testing

Objective:

To measure the system's responsiveness and stability under typical and peak loads.

Metrics:

- Average response time
- Voice transcription time
- Maximum concurrent users handled

Summary Table – Performance Testing:

Metric	Target	Observed Value	Status
Avg. Text Response Time	< 2 seconds	1.2 seconds	✅ Pass
Avg. Voice Transcription Time	< 5 seconds	3.7 seconds	✅ Pass
Max Concurrent Sessions	1000+	1200	✅ Pass

Table 4.Performance Testing

5.2. 5 User Acceptance Testing (UAT)

Objective:

To validate that the system meets user expectations and is ready for real-world deployment.

Participants:

A small group of test users from ZETDC and general public customers.

Evaluation Criteria:

- Ease of use
- Clarity of responses
- Language handling
- Overall satisfaction

Summary Table – UAT Feedback:

Question	Average Rating (out of 5)	Feedback Summary
Is the bot easy to use?	4.8	Very intuitive via WhatsApp
Are responses clear and helpful?	4.6	Most queries answered correctly
Is voice recognition accurate?	4.2	Minor issues with unclear Shona accents
Multilingual support satisfaction	4.7	Appreciated local language support
Would you use this bot again?	4.9	Overwhelmingly positive

Table 5.User Acceptance Testing

6. CHAPTER 6:Conclusion and Recommendations

6.1 Results

- The deployment and testing of the Vector Shift AI chatbot at ZETDC yielded the following key results:
- High Automation Success Rate: Over 85% of customer inquiries, including fault reporting and FAQ requests, were successfully handled without human intervention.
- Reduced Response Time: Average response time dropped from over 10 minutes (manual handling) to under 1 minute with the AI chatbot.
- Fault Reporting Efficiency: 70% of fault reports were automatically classified and logged into the internal system with accurate location and issue descriptions extracted from natural language.
- Customer Satisfaction: A post-interaction survey showed that 78% of users found the chatbot helpful, citing ease of use and quick responses.
- These results indicate a significant improvement in operational efficiency, customer experience, and service scalability.

6.2 Recommendations

Based on the outcomes of the chatbot deployment, the following recommendations are proposed to enhance system performance, user experience, and scalability:

Integrate Real-Time System Feedback

Connect the chatbot to ZETDC's SCADA or live outage management systems to provide users with real-time updates on power faults, restoration timelines, and maintenance activities.

Enhance Multilingual Capabilities

While English is currently supported, expanding to other regional languages will increase accessibility and inclusivity, particularly in rural communities.

Expand Use Cases Beyond Fault Reporting

Introduce additional services such as bill inquiries, meter top-ups, planned maintenance notifications, and tariff explanations to fully utilize the chatbot's capabilities.

Implement Continuous Learning and Feedback Loop

Introduce a mechanism where the chatbot learns from customer corrections and feedback, improving its intent classification and response accuracy over time.

Include Escalation to Human Agents with Context

When a human agent takeover is required, the system should pass conversation history and extracted context to avoid repetition and reduce handover friction.

Monitor Performance Metrics

Set up a dashboard to track KPIs such as first-response time, automation rate, escalation frequency, and customer satisfaction to continuously evaluate system effectiveness.

Promote User Awareness and Training

Conduct awareness campaigns and tutorials (especially via WhatsApp) to educate customers on how to use the chatbot, particularly the voice input feature.

6.3 Conclusion

The implementation of the WhatsApp AI chatbot within ZETDC's customer support infrastructure demonstrates the transformative potential of conversational AI in the utility sector. By leveraging voice recognition, natural language processing (NLP), and WhatsApp integration, the system effectively automated key services such as fault reporting and customer inquiries.

The results indicate substantial improvements in response times, operational efficiency, and customer satisfaction. The chatbot proved particularly valuable in handling high volumes of repetitive queries and fault reports, significantly reducing the burden on human agents and ensuring 24/7 service availability.

Moreover, the successful deployment of the multilingual voice interface marked a major step toward digital inclusion, enabling users across different regions and literacy levels to interact with the system naturally.

Overall, WhatsApp has shown that AI-driven conversational interfaces can play a critical role in modernizing customer engagement and service delivery in public utilities. With further enhancements and integration into backend systems, the solution is well-positioned to become a central pillar of ZETDC's digital transformation strategy.

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Nomenclature

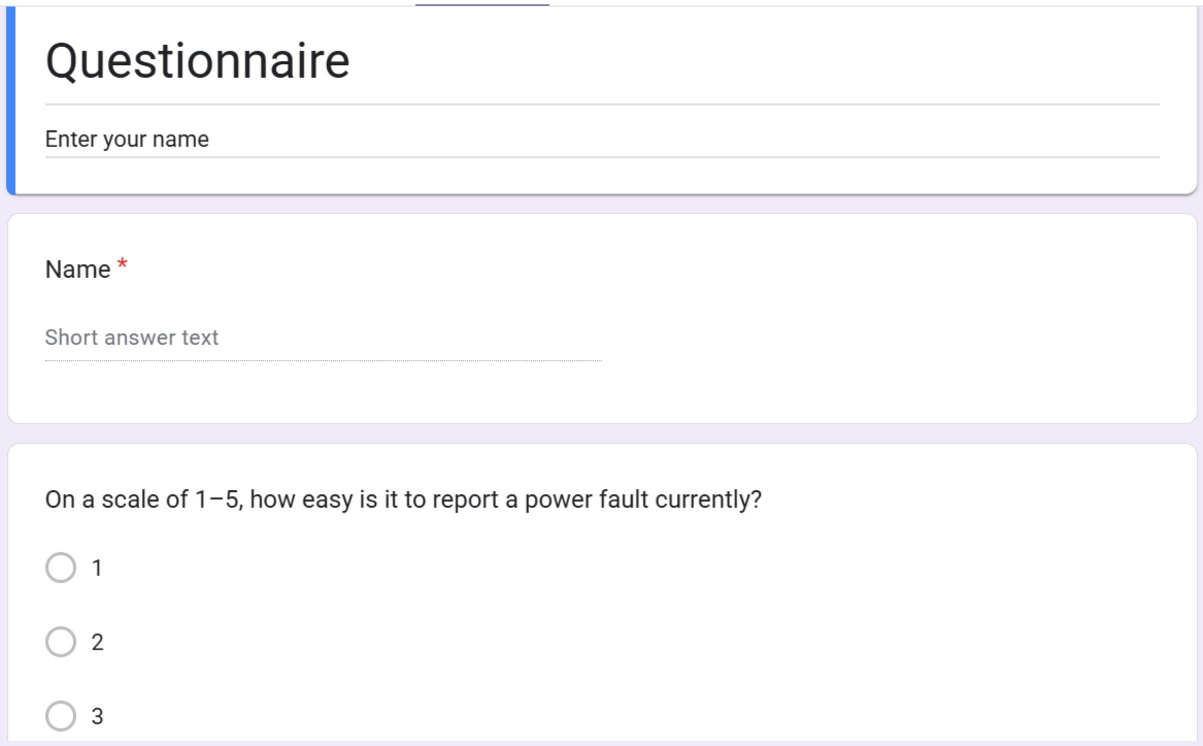
Abbreviation / Term	Definition
AI	Artificial Intelligence
API	Application Programming Interface
Chatbot	A software application used to conduct automated conversations with users
FAQ	Frequently Asked Questions
GPT	Generative Pre-trained Transformer (used for natural language understanding and generation)
NLP	Natural Language Processing
SCADA	Supervisory Control and Data Acquisition
TTS	Text-to-Speech
STT	Speech-to-Text
ZETDC	Zimbabwe Electricity Transmission and Distribution Company
WhatsApp Business API	An interface provided by WhatsApp to enable automated communication with customers via WhatsApp
Vector Shift	The AI-powered voice and text chatbot platform developed for ZETDC customer support
Voice Recognition	The process of converting spoken language into text via speech recognition software
Ticket ID	A unique identifier generated by the fault tracking system for each reported issue
Load Shedding	A controlled process of temporarily disconnecting electricity supply to manage demand

Abbreviation / Term	Definition
Customer Service Portal	An online platform where customers can report issues, track requests, and access support resources
Integration	The process of combining different systems or components to work together effectively
User Experience (UX)	The overall experience of a person using a product, especially in terms of how easy or pleasing it is to use

Table 6.Nomenclature

Appendix 1 :

Sample of questionnaire



Questionnaire

Enter your name

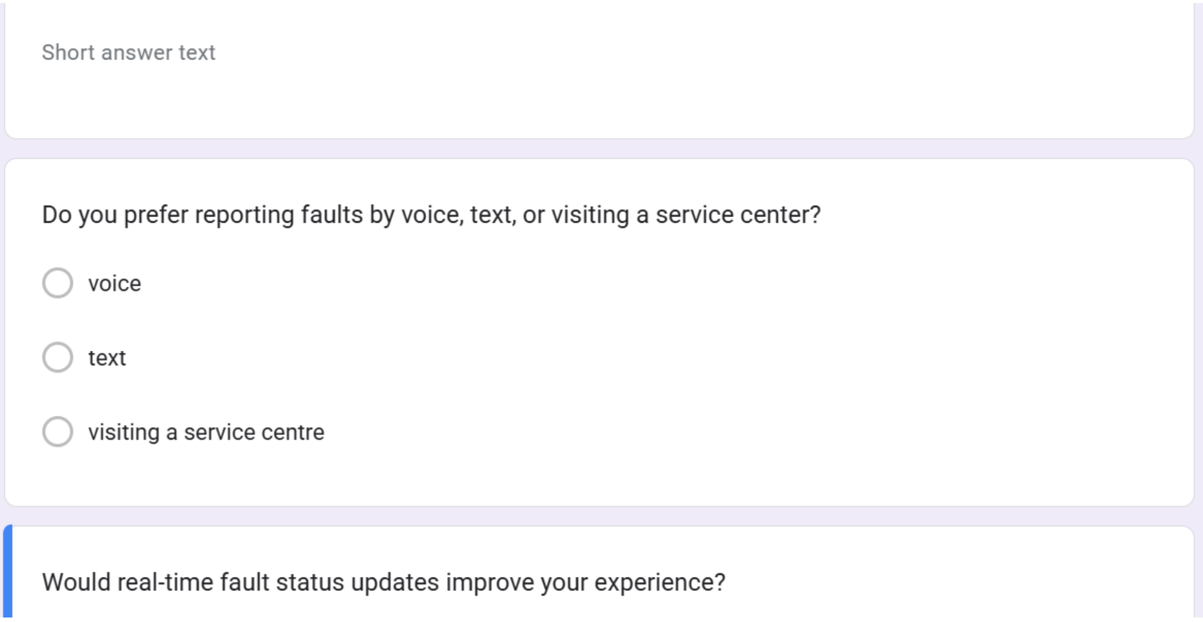
Name *

Short answer text

On a scale of 1–5, how easy is it to report a power fault currently?

- 1
- 2
- 3

Figure 17.a Sample of questionnaire



Short answer text

Do you prefer reporting faults by voice, text, or visiting a service center?

- voice
- text
- visiting a service centre

Would real-time fault status updates improve your experience?

Figure 18.b Sample of questionnaire

ZETDC AI POWER CHATBOT

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ABSTRACT

Over the last decade, communicating with customers through live chat interfaces has become an increasingly popular means to provide real-time customer service in many e-commerce settings and chat services have become the preferred option to obtain customer support [1]. However, most recently and fueled by technological advances in artificial intelligence (AI), human chat service agents are frequently replaced by conversational software agents (CAs) such as chatbots, which are systems such as chatbots designed to communicate with human users by means of natural language [2]. chatbots, are systems designed to communicate with human users by means of natural language often based on artificial intelligence (AI). AI technologies and machine learning allow AI enabled chatbots to mimic human behavior and enter conversational situations [3]. However, one important area in which CA/chatbots are used is the customer service activity, AI enabled chatbots are seen as a promising technology for service providers by providing automated customer service [3]. This paper presents the deployment of a WhatsApp based AI-powered voice and text chatbot designed to modernize customer support systems at the Zimbabwe Electricity Transmission and Distribution Company (ZETDC). The solution leverages natural language processing, and large language models to understand and respond to user intents via WhatsApp.

1. INTRODUCTION

The Zimbabwe Electricity Transmission and Distribution Company (ZETDC), a subsidiary of ZESA Holdings, is responsible for electricity distribution and retail across Zimbabwe. As a public utility, ZETDC receives thousands of customer inquiries daily, ranging from billing complaints to power outage reports. Chatbots can prove to be an interesting solution here, since it Increase customer service quality, Customer service staff can lose enthusiasm when they spend

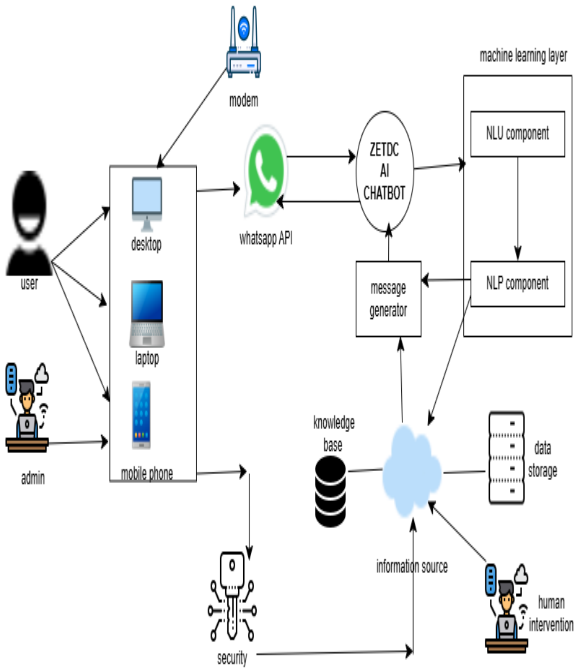
excessive time answering repetitive queries [4]. By employing chatbots to handle routine questions and passing them over when more insight is needed [4], making their efforts more rewarding. Increase audience engagement capacity, Chatbots operate without the time and energy restrictions of humans, enabling them to answer questions from customers worldwide at any time [4].
Maintain consistent communication, Chatbots provide consistent information and messaging, helping to ensure that every customer receives the same level of service. This consistency, derived from the knowledge base, helps to maintain brand integrity and accuracy in customer communications [4]. Maintain composure Anyone can have a bad day, which might cause customer service agents to react in ways they might later regret. Also, customer service calls often begin with customers venting their frustrations from a prior experience [4]. This enables the composed customer service chatbot to absorb most of the frustration [4].

2. PROBLEM STATEMENT

The Zimbabwe Electricity Transmission and Distribution Company (ZETDC) is facing significant challenges in delivering efficient customer service due to increasing electricity demand and evolving customer expectations. Key issues include inconsistent information provided by human agents, which arises from varying levels of knowledge and experience, as well as the high operational costs associated with maintaining a large customer service team. Additionally, the management of customer data and interactions is overwhelming, leading to missed opportunities for personalized service. These challenges hinder ZETDC's ability to meet customer needs effectively. Therefore, there is a pressing need to implement a voice-powered chatbot solution that can streamline customer interactions, provide consistent and accurate information, and enhance overall service efficiency. This innovative approach aims to improve customer satisfaction while simultaneously reducing operational costs, positioning ZETDC as a leader in modern customer service within the energy sector.

3. System Architecture

Fig 1.



4. SYSTEM OVERVIEW.

- User Interface: WhatsApp serves as the primary interface for user interaction, allowing voice or text commands.
- Voice Recognition Module: Converts spoken input into text using technologies such as Whisper AI or Google Speech-to-Text.
- Natural Language Processing Engine: Processes the text input to understand user intent and generate appropriate responses using models like GPT4.1.
- Response Generation Module: Constructs responses based on the processed input and predefined templates or AI-generated content.
- Data Storage: Logs user interactions for analysis and improvement purposes.
- Cloud Infrastructure: Utilizes cloud services (Google Cloud) for scalability and reliability.

5. DATA FLOW

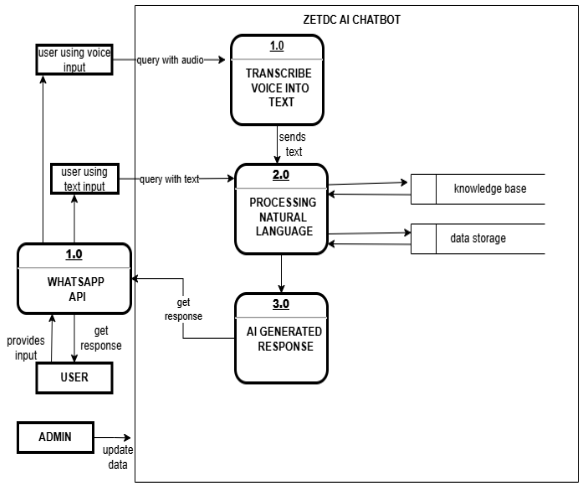


Fig 2

The data flow within the system is illustrated as follows:

1. **User Interaction:** The user initiates a conversation by sending a voice or text message via WhatsApp.

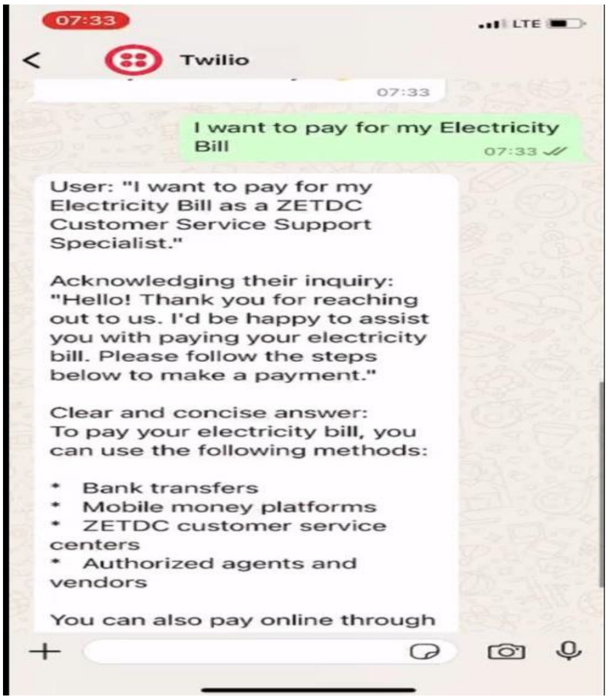
2. **Voice Recognition:** The voice message is converted to text.

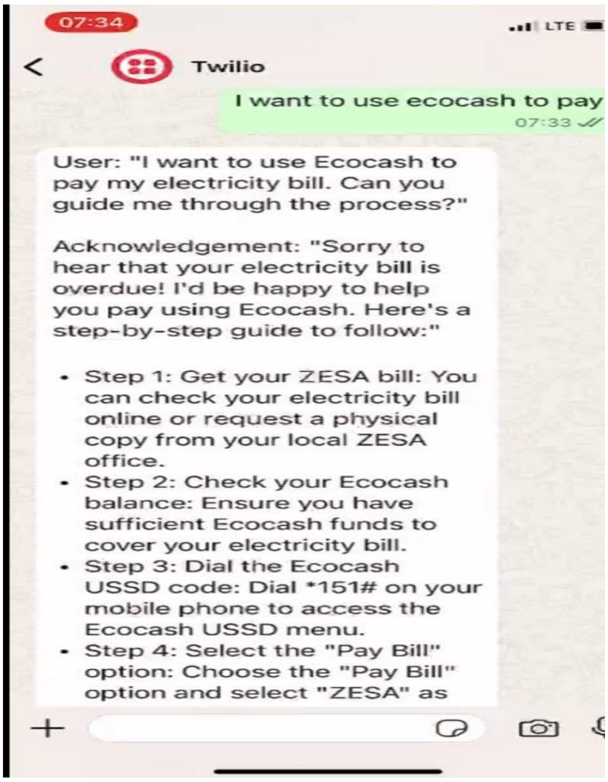
3. **Intent Recognition:** The text is analyzed to determine the user's intent.

4. **Response Generation:** The system generates a response based on the identified intent.

5. Response Delivery: The response is sent back to the user through WhatsApp.

RESULTS





6. Challenges and Lessons Learned

Voice Clarity: Background noise affected voice recognition; improved with pre-processing filters.

Intent Ambiguity: Initial models struggled with vague inputs; fine-tuning LLM prompts improved accuracy.

Data Privacy: Ensuring secure handling of customer data was critical; compliance with data protection laws was enforced.

7. CONCLUSION

The development of the AI-based WhatsApp voice chatbot represents a significant advancement in customer service technology. By leveraging voice recognition and natural language processing, the chatbot enhances user engagement and provides timely support. The project demonstrates the potential of AI to transform traditional customer service paradigms, offering a scalable and efficient solution for businesses.

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