📄 CSYE 7380 - Final Project Documentation: Simplified Digital Twin for a Customer Support System

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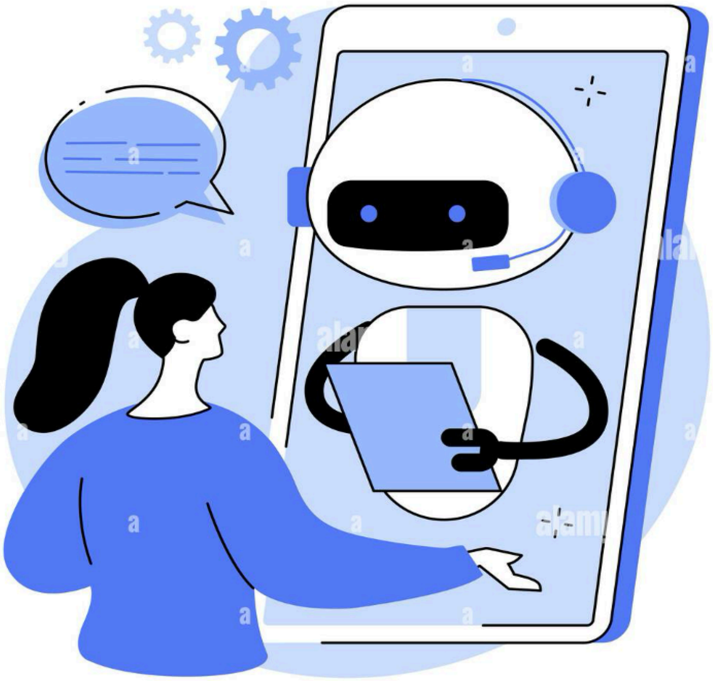
📌 1. Introduction



The Simplified Digital Twin for a Customer Support System is a project designed to automate and simulate the process of handling customer support tickets. The system uses a **Large Language Model (LLM)** to:

- Categorize tickets based on user descriptions.
- Generate automated responses to support queries.
- Incorporate a feedback loop to improve the quality of responses over time.
- Enhance responses with Retrieval-Augmented Generation (RAG) for additional context.

This digital twin acts as a virtual representation of a real-world support system, reducing manual intervention and improving response efficiency.

🎯 2. Project Goals

1. **Automate Ticket Categorization:** Classify support tickets using an LLM.
2. **Generate Initial Responses:** Provide relevant, automated responses to user queries.
3. **Simulate Support Workflow:** Develop a digital twin that mirrors real-world support processes.

4. **Incorporate RAG:** Enhance response accuracy using external knowledge sources.
5. **Implement a Feedback Loop:** Collect user feedback to iteratively improve responses.

🏢 3. Business Process Definition

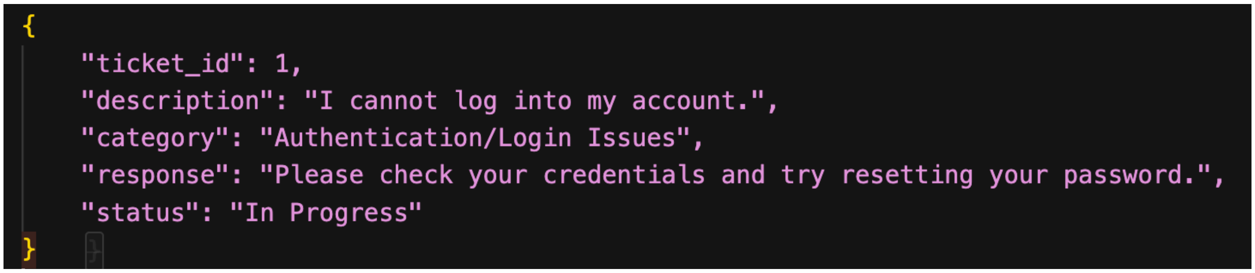
The customer support ticket system involves the following steps:

1. **Receiving a Ticket**: The user submits a support ticket with a description of their issue via the frontend interface.
2. **Categorizing the Ticket**: The LLM categorizes the ticket based on the description (e.g., Authentication Issues, Payment Issues).
3. **Generating an Initial Response**: The LLM provides an initial response tailored to the category of the ticket.
4. **Updating Ticket Status**: The system updates the status of the ticket (e.g., In Progress, Resolved) after processing.

🗄️ 4. Data Representation

Ticket Data Structure

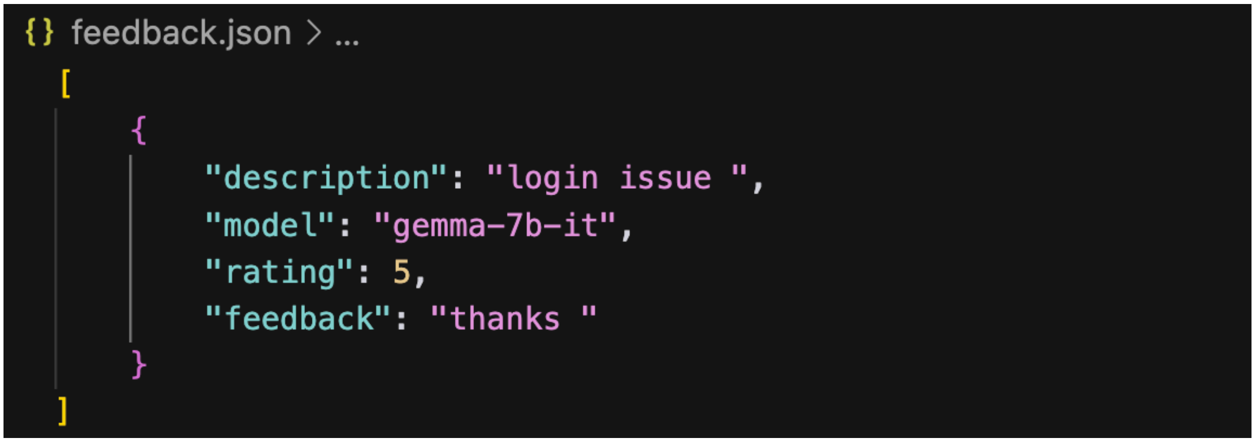
Tickets are represented as Python dictionaries:



```
{
    "ticket_id": 1,
    "description": "I cannot log into my account.",
    "category": "Authentication/Login Issues",
    "response": "Please check your credentials and try resetting your password.",
    "status": "In Progress"
}
```

Feedback Data Structure

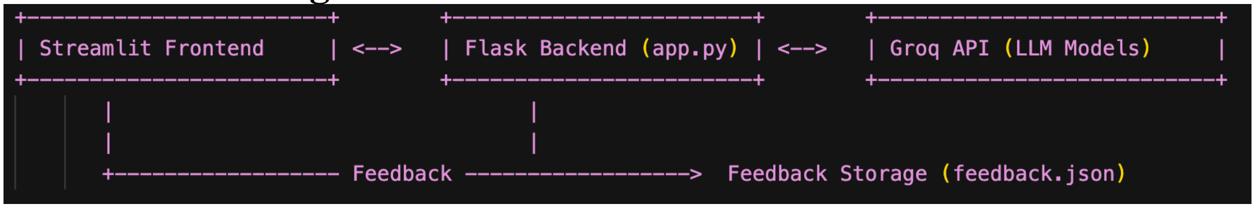
Feedback data collected from users and stored in: feedback.json.



```
{} feedback.json > ...
[
    {
        "description": "login issue ",
        "model": "gemma-7b-it",
        "rating": 5,
        "feedback": "thanks "
    }
]
```

🏗️ 5. System Architecture

Architecture Diagram



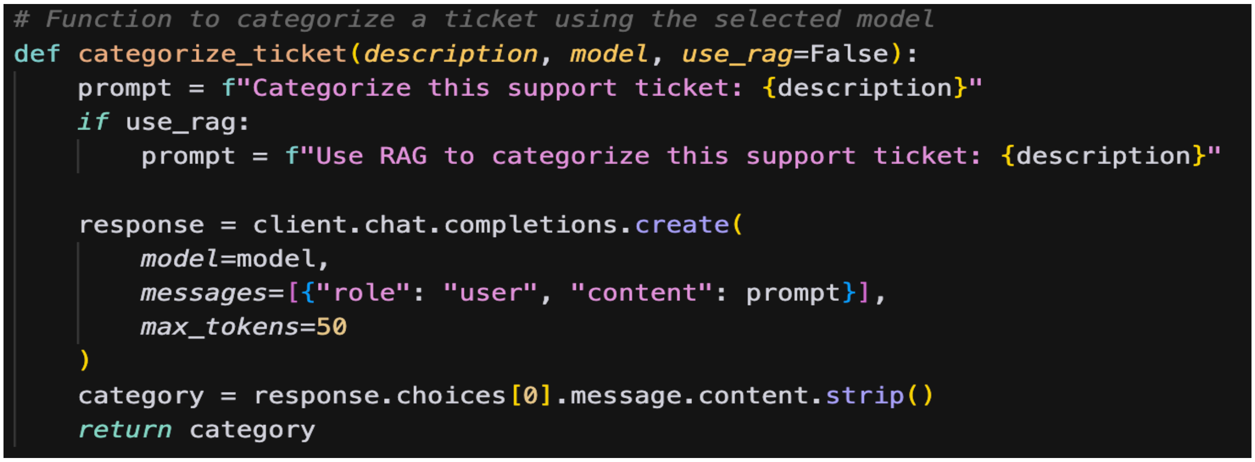
```
+------------------------+        +-------------------------+       +---------------------------+
| Streamlit Frontend     | <-->   | Flask Backend (app.py) | <-->   | Groq API (LLM Models)     |
+------------------------+        +-------------------------+       +---------------------------+
       |                                 |
       |                                 |
       +------------------ Feedback ------------------>  Feedback Storage (feedback.json)
```

Components

- **Frontend (Streamlit):** User interface for submitting tickets, selecting models, and providing feedback.
- **Backend (Flask):** Handles processing requests, categorization, response generation, and storing feedback.
- **Groq API (LLMs):** Provides LLMs like gemma-7b-it and llama3-8b-8192 for processing.
- **Feedback Storage:** Collects user feedback in feedback.json for future improvements.

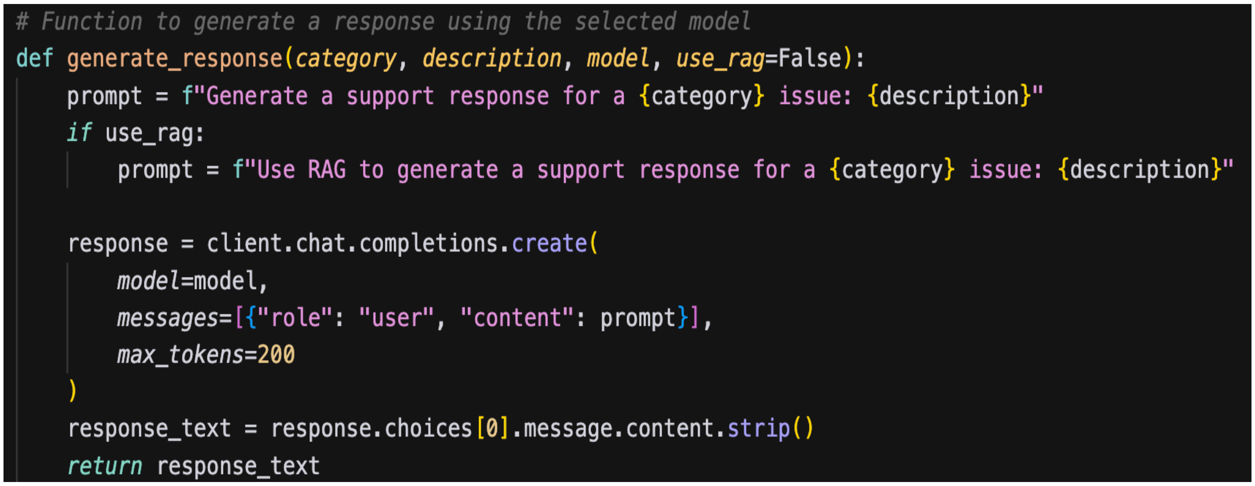
🤖 6. LLM Integration

Categorization Function



```python
# Function to categorize a ticket using the selected model
def categorize_ticket(description, model, use_rag=False):
    prompt = f"Categorize this support ticket: {description}"
    if use_rag:
        prompt = f"Use RAG to categorize this support ticket: {description}"

    response = client.chat.completions.create(
        model=model,
        messages=[{"role": "user", "content": prompt}],
        max_tokens=50
    )
    category = response.choices[0].message.content.strip()
    return category
```

Response Generation Function



```python
# Function to generate a response using the selected model
def generate_response(category, description, model, use_rag=False):
    prompt = f"Generate a support response for a {category} issue: {description}"
    if use_rag:
        prompt = f"Use RAG to generate a support response for a {category} issue: {description}"

    response = client.chat.completions.create(
        model=model,
        messages=[{"role": "user", "content": prompt}],
        max_tokens=200
    )
    response_text = response.choices[0].message.content.strip()
    return response_text
```

🧪 7. Digital Twin Simulation

The backend functions (categorize_ticket and generate_response) act as the core components of the digital twin.

These functions simulate:

1. Ticket Categorization
2. Response Generation
3. Feedback Collection

🚀 8. Using the Digital Twin

Workflow Simulation

1. **Submit a Ticket**: Users describe their issue in the Streamlit frontend.
2. **Categorize & Respond**: The backend categorizes the ticket and generates a response.
3. **Review & Feedback**: Users provide feedback on the response, which is stored for improvement.

🌐 9. Frontend and Backend Interaction

The **Customer Support Chatbot** leverages a **Streamlit frontend** and a **Flask** backend to handle user interactions and process support tickets.

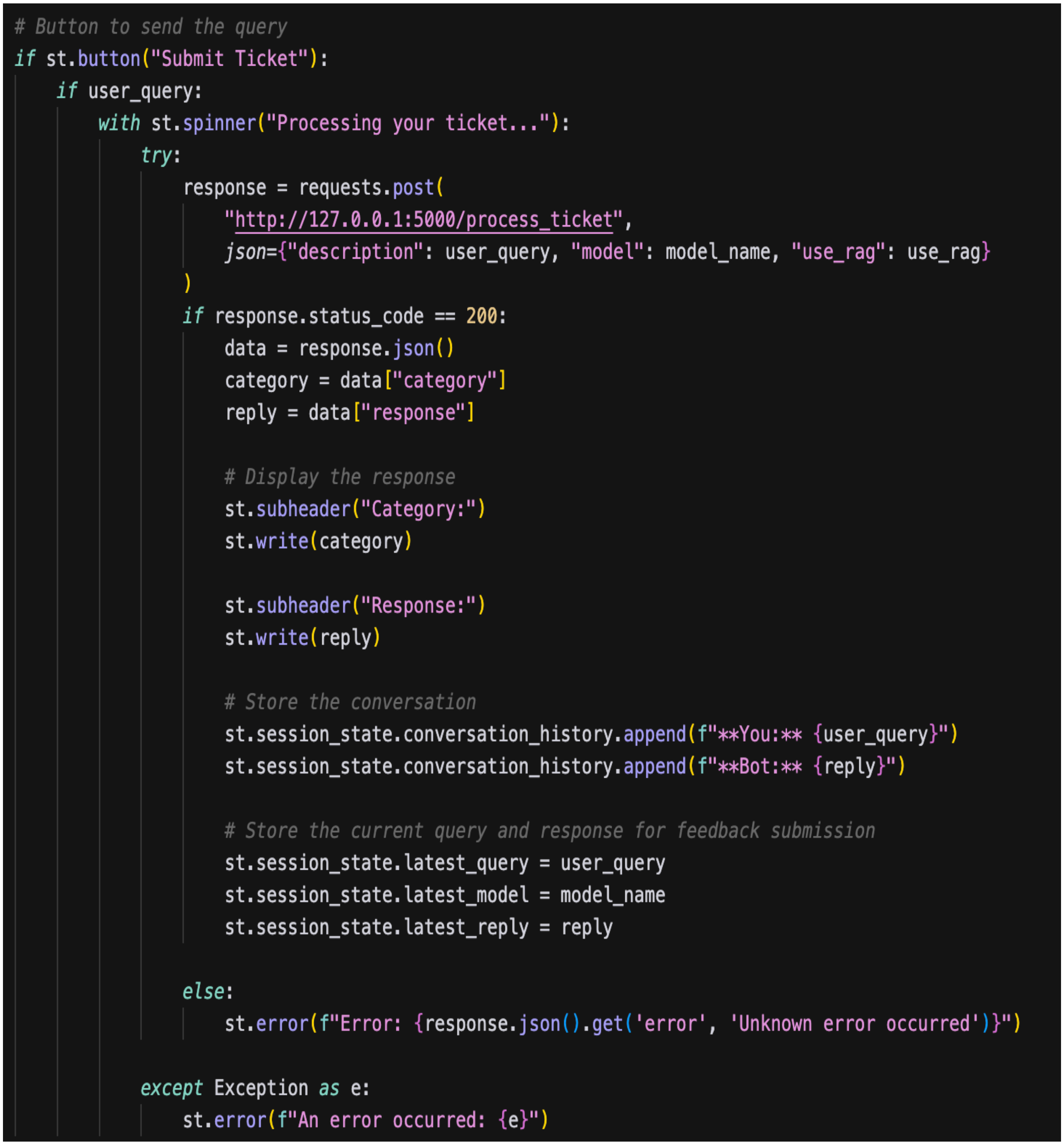
The interaction flow is as follows:

1. **Frontend (Streamlit):**
    - The user inputs a ticket description, selects a model, and optionally enables RAG mode.
    - Sends a POST request to the Flask backend (/process_ticket endpoint) with the ticket description and model details.
    - Displays the category and generated response received from the backend.
    - Allows users to submit feedback, which is sent to the backend (/submit_feedback endpoint).

2. **Backend (Flask):**
    - Receives the ticket data, categorizes the ticket, and generates a response using the selected LLM model.

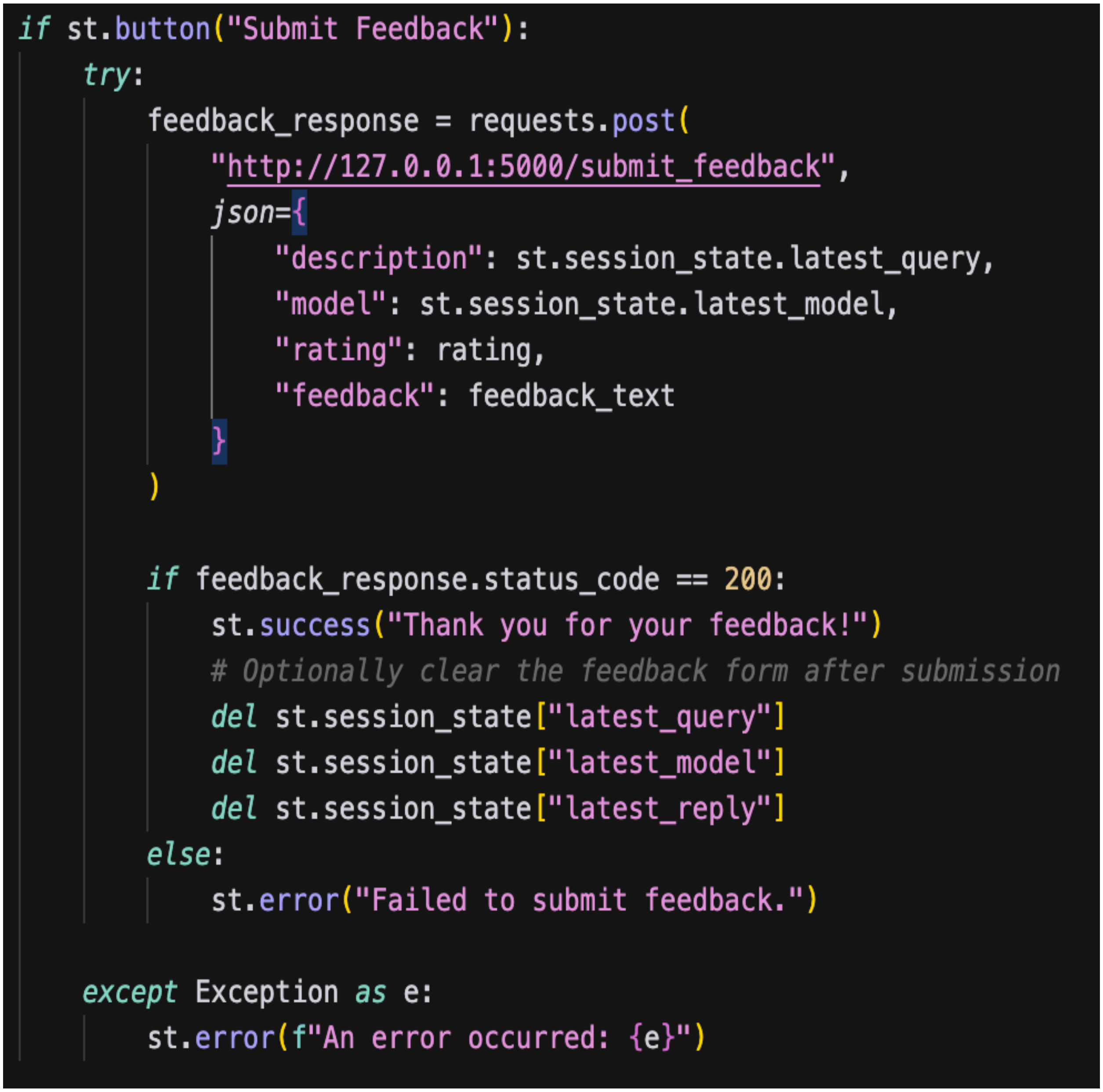
  - Saves feedback into feedback.json when submitted.
  - Handles communication with the Groq API for LLM processing.

Frontend Interaction (Streamlit)



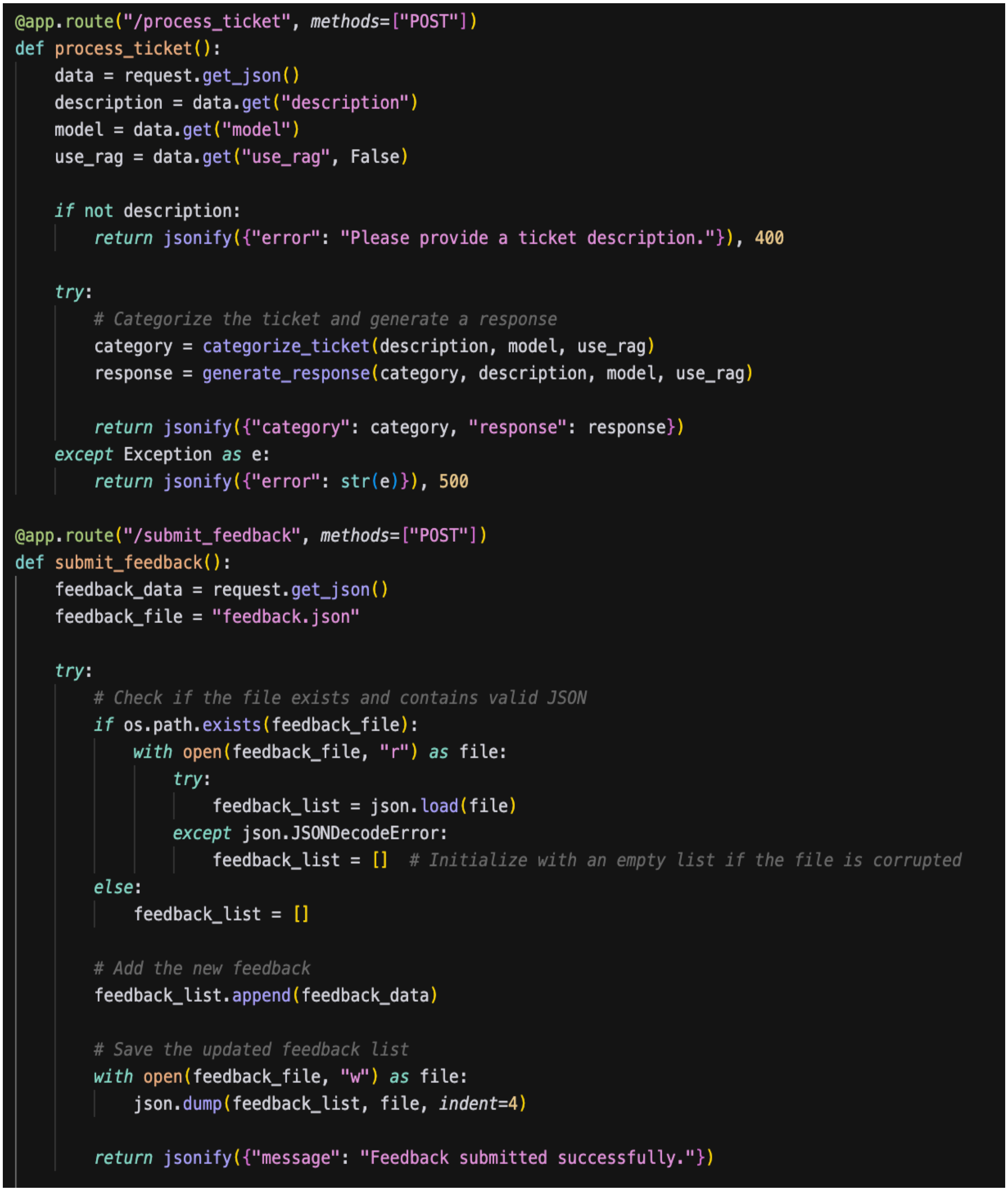
```
# Button to send the query
if st.button("Submit Ticket"):
    if user_query:
        with st.spinner("Processing your ticket..."):
            try:
                response = requests.post(
                    "http://127.0.0.1:5000/process_ticket",
                    json={"description": user_query, "model": model_name, "use_rag": use_rag}
                )
                if response.status_code == 200:
                    data = response.json()
                    category = data["category"]
                    reply = data["response"]

                    # Display the response
                    st.subheader("Category:")
                    st.write(category)

                    st.subheader("Response:")
                    st.write(reply)

                    # Store the conversation
                    st.session_state.conversation_history.append(f"**You:** {user_query}")
                    st.session_state.conversation_history.append(f"**Bot:** {reply}")

                    # Store the current query and response for feedback submission
                    st.session_state.latest_query = user_query
                    st.session_state.latest_model = model_name
                    st.session_state.latest_reply = reply

                else:
                    st.error(f"Error: {response.json().get('error', 'Unknown error occurred')}")

            except Exception as e:
                st.error(f"An error occurred: {e}")
```

Feedback Submission Interaction



```python
if st.button("Submit Feedback"):
    try:
        feedback_response = requests.post(
            "http://127.0.0.1:5000/submit_feedback",
            json={
                "description": st.session_state.latest_query,
                "model": st.session_state.latest_model,
                "rating": rating,
                "feedback": feedback_text
            }
        )

        if feedback_response.status_code == 200:
            st.success("Thank you for your feedback!")
            # Optionally clear the feedback form after submission
            del st.session_state["latest_query"]
            del st.session_state["latest_model"]
            del st.session_state["latest_reply"]
        else:
            st.error("Failed to submit feedback.")

    except Exception as e:
        st.error(f"An error occurred: {e}")
```

Backend Endpoints (Flask)



```
@app.route("/process_ticket", methods=["POST"])
def process_ticket():
    data = request.get_json()
    description = data.get("description")
    model = data.get("model")
    use_rag = data.get("use_rag", False)

    if not description:
        return jsonify({"error": "Please provide a ticket description."}), 400

    try:
        # Categorize the ticket and generate a response
        category = categorize_ticket(description, model, use_rag)
        response = generate_response(category, description, model, use_rag)

        return jsonify({"category": category, "response": response})
    except Exception as e:
        return jsonify({"error": str(e)}), 500

@app.route("/submit_feedback", methods=["POST"])
def submit_feedback():
    feedback_data = request.get_json()
    feedback_file = "feedback.json"

    try:
        # Check if the file exists and contains valid JSON
        if os.path.exists(feedback_file):
            with open(feedback_file, "r") as file:
                try:
                    feedback_list = json.load(file)
                except json.JSONDecodeError:
                    feedback_list = []  # Initialize with an empty list if the file is corrupted
        else:
            feedback_list = []

        # Add the new feedback
        feedback_list.append(feedback_data)

        # Save the updated feedback list
        with open(feedback_file, "w") as file:
            json.dump(feedback_list, file, indent=4)

        return jsonify({"message": "Feedback submitted successfully."})
```

💡 10. Potential Enhancements

- **Complex Ticket States:** Add states like Escalated, Pending Review.
- **Priority Levels:** Implement priority handling and SLA tracking.
- **Real-Time API Integration:** Connect to external APIs like Zendesk.
- **Advanced Feedback Loop:** Automatically adjust LLM prompts based on feedback.

🛠️ 11. Technologies Used

- Backend: Flask
- Frontend: Streamlit
- Models: Gemma-7b-it, LLaMA3-8b-8192
- API: Groq API
- Environment: Python 3.9, dotenv for environment variables

⚙️ 12. Setup and Installation

Follow these steps to set up and run the project on your local machine:

Prerequisites

1. Python 3.9 or higher
2. Dependencies listed in requirements.txt
3. Groq API Key (set in the .env file)

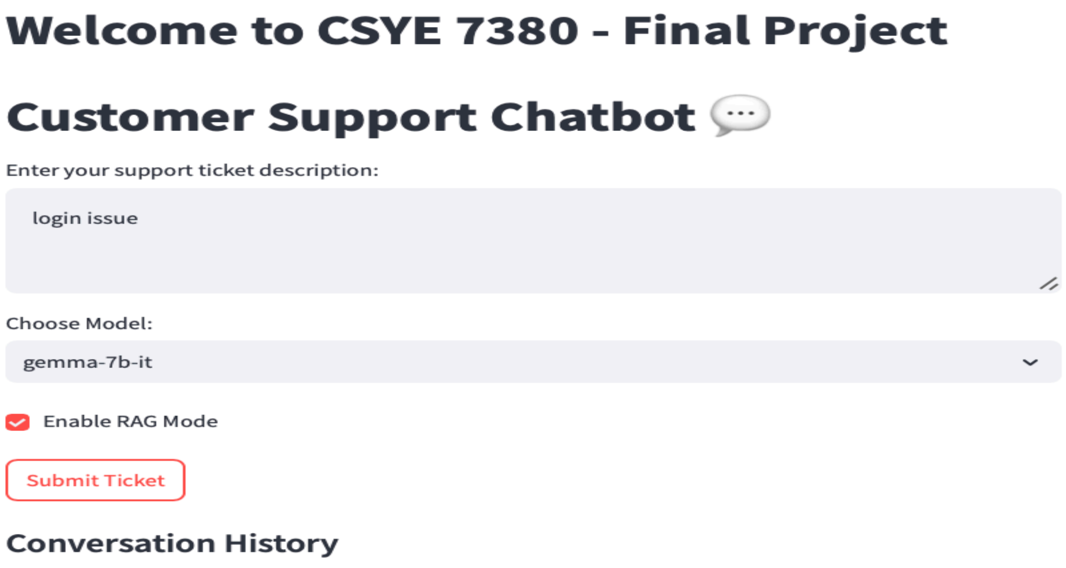
```
project-root/
|-- app.py               # Flask backend
|-- frontend.py          # Streamlit frontend
|-- run_chatbot.py       # Script to run both frontend and backend
|-- requirements.txt     # List of dependencies
|-- sample_tickets.json  # Sample ticket data
|-- feedback.json        # Stores user feedback
└── .env                 # Environment variables (GROQ API key)
```

Installation Instructions 💻

```
git clone <[your-repo-url](https://github.com/Nehagopinath15neu/GenAIFinal-Project.git)>
cd <[your-repo-directory](https://github.com/Nehagopinath15neu/GenAIFinal-Project.git)>

Create and Activate a Virtual Environment
- python3 -m venv myenv
- source myenv/bin/activate

Install Dependencies
- pip install -r requirements.txt

Set Up Environment Variables
- GROQ_API_KEY=<your-groq-api-key>

Run the Project
- python run_chatbot.py

Access the Frontend
- http://localhost:8501
```

🚀 13. Demonstration Steps

1. Submit a Support Ticket:
   - Enter a brief description of your issue.
   - Select the "gemma-7b-it" or "llama3-8b-8192" model.
   - Optionally, enable RAG Mode.
   - Click "Submit Ticket."



Welcome to CSYE 7380 - Final Project

Customer Support Chatbot 💬

Enter your support ticket description:

login issue

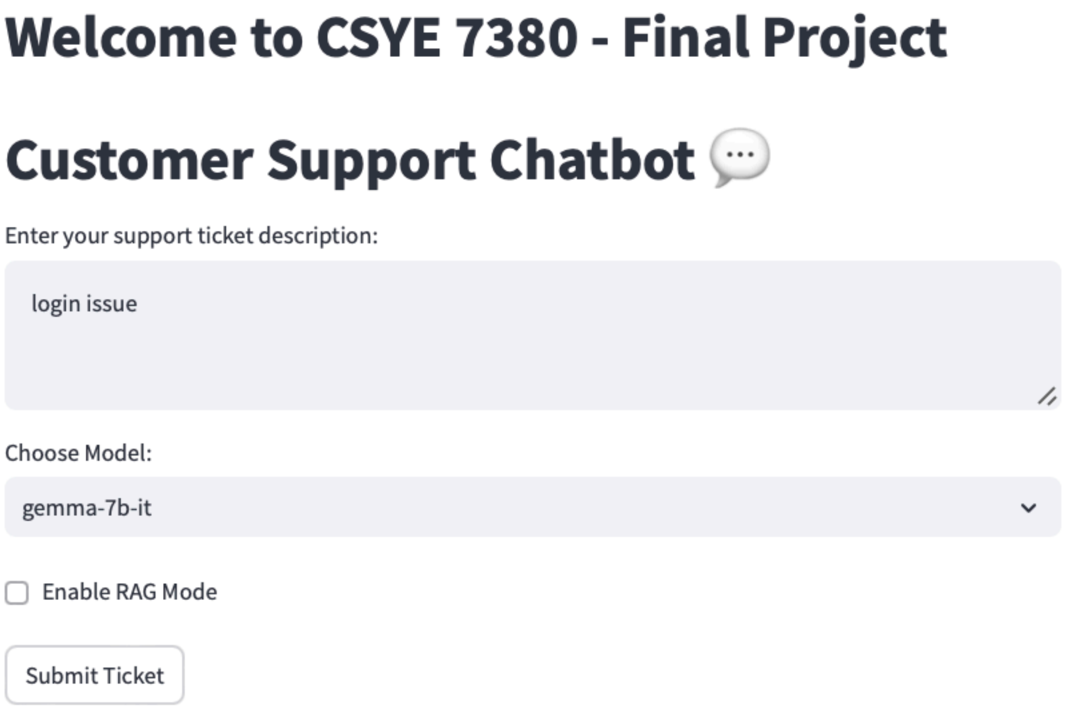
Choose Model:

gemma-7b-it

☑ Enable RAG Mode

Conversation History

With disabled RAG Mode


Welcome to CSYE 7380 - Final Project

Customer Support Chatbot 💬

Enter your support ticket description:

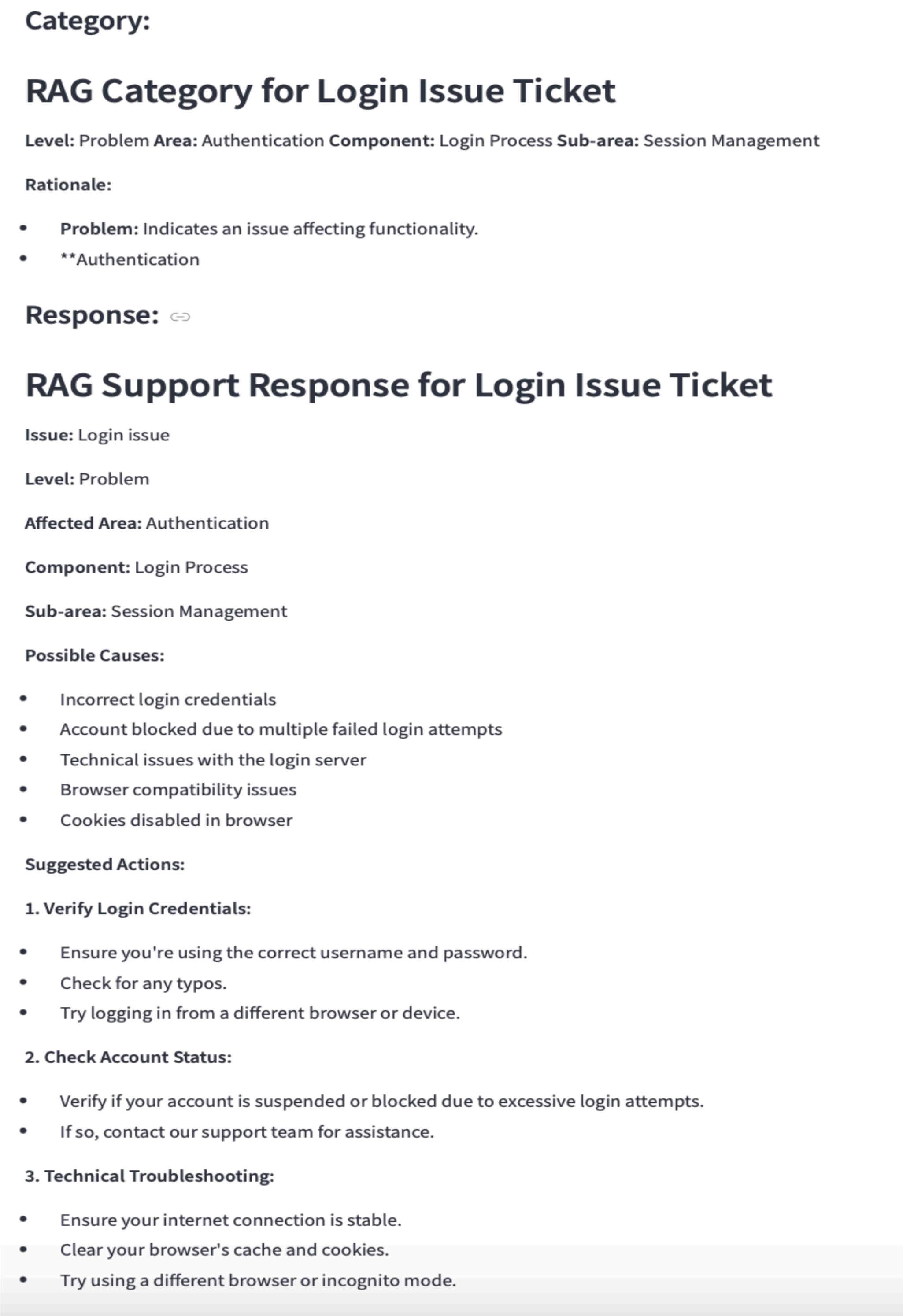
login issue

Choose Model:

gemma-7b-it

☐ Enable RAG Mode

2. View the Response:
    - The system will display the category and response generated by the LLM.



Category:

RAG Category for Login Issue Ticket

Level: Problem **Area:** Authentication **Component:** Login Process **Sub-area:** Session Management

Rationale:

- **Problem:** Indicates an issue affecting functionality.
- **Authentication

Response:

RAG Support Response for Login Issue Ticket

Issue: Login issue

Level: Problem

Affected Area: Authentication

Component: Login Process

Sub-area: Session Management

Possible Causes:

- Incorrect login credentials
- Account blocked due to multiple failed login attempts
- Technical issues with the login server
- Browser compatibility issues
- Cookies disabled in browser

Suggested Actions:

1. Verify Login Credentials:

- Ensure you're using the correct username and password.
- Check for any typos.
- Try logging in from a different browser or device.

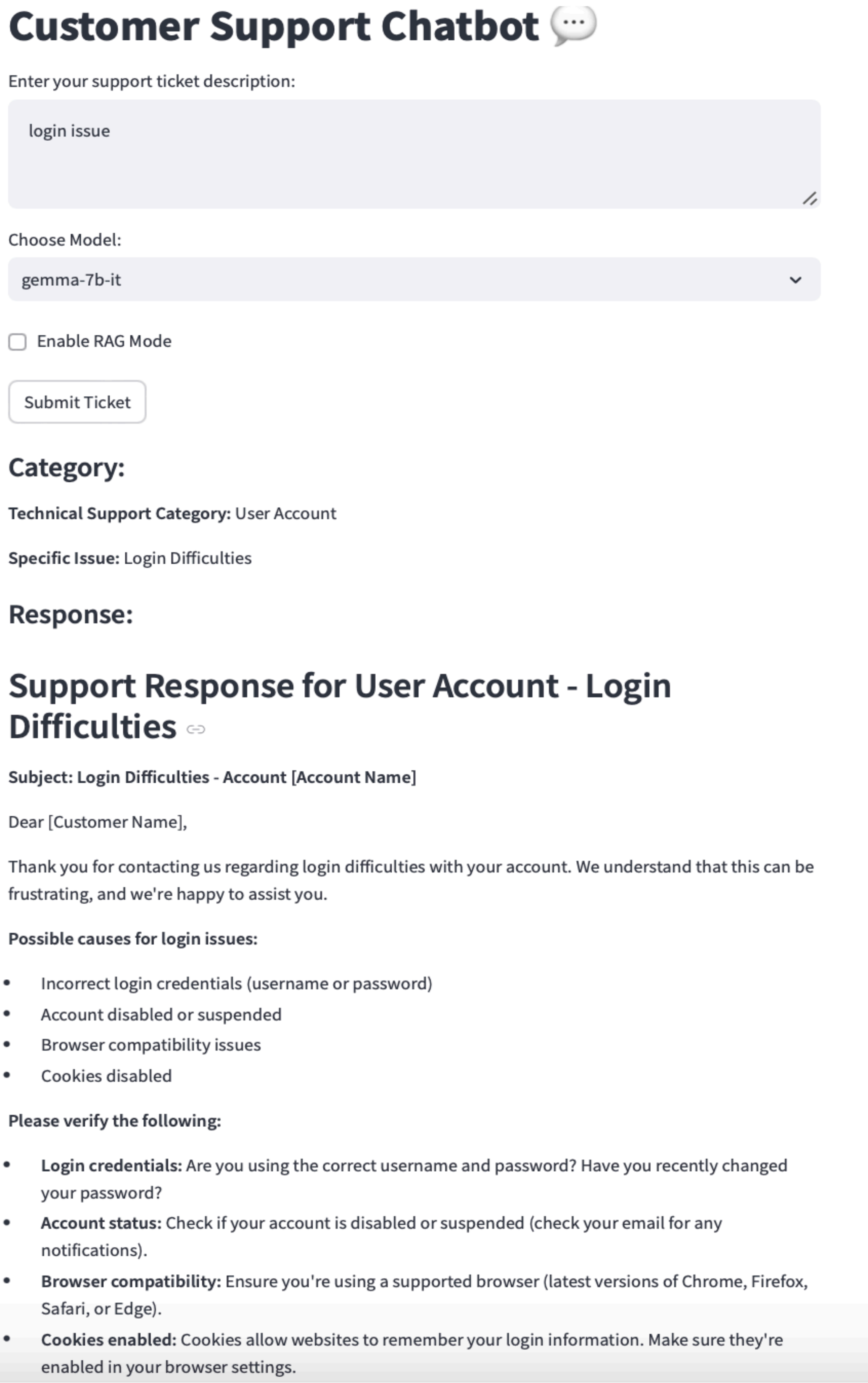
2. Check Account Status:

- Verify if your account is suspended or blocked due to excessive login attempts.
- If so, contact our support team for assistance.

3. Technical Troubleshooting:

- Ensure your internet connection is stable.
- Clear your browser's cache and cookies.
- Try using a different browser or incognito mode.

Disabled RAG Mode Response



Customer Support Chatbot 💬

Enter your support ticket description:

login issue

Choose Model:

gemma-7b-it

☐ Enable RAG Mode

Category:

Technical Support Category: User Account

Specific Issue: Login Difficulties

Response:

Support Response for User Account - Login Difficulties

Subject: Login Difficulties - Account [Account Name]

Dear [Customer Name],

Thank you for contacting us regarding login difficulties with your account. We understand that this can be frustrating, and we're happy to assist you.

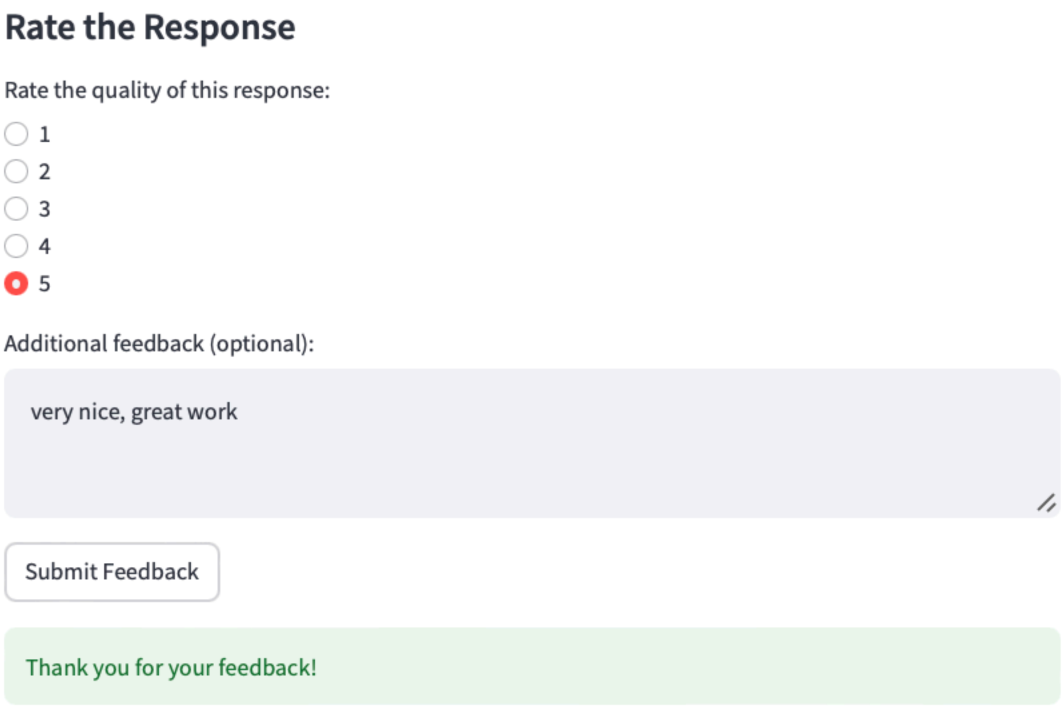
Possible causes for login issues:

- Incorrect login credentials (username or password)
- Account disabled or suspended
- Browser compatibility issues
- Cookies disabled

Please verify the following:

- **Login credentials:** Are you using the correct username and password? Have you recently changed your password?
- **Account status:** Check if your account is disabled or suspended (check your email for any notifications).
- **Browser compatibility:** Ensure you're using a supported browser (latest versions of Chrome, Firefox, Safari, or Edge).
- **Cookies enabled:** Cookies allow websites to remember your login information. Make sure they're enabled in your browser settings.

3. Provide Feedback:
    - Rate the response and add additional comments.
    - Click "Submit Feedback" to save the feedback.



Rate the Response

Rate the quality of this response:

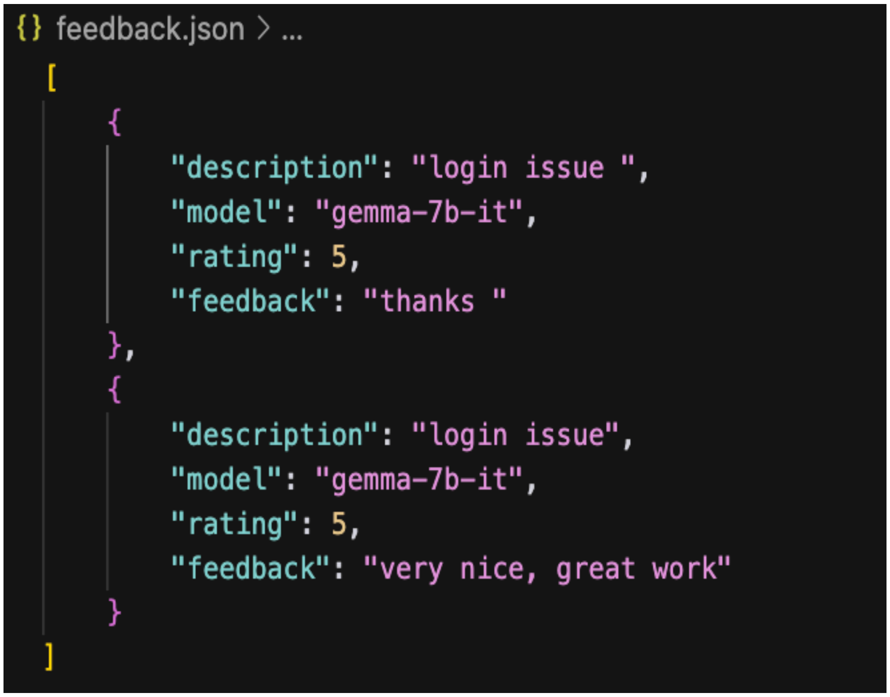
○ 1
○ 2
○ 3
○ 4
● 5

Additional feedback (optional):

very nice, great work

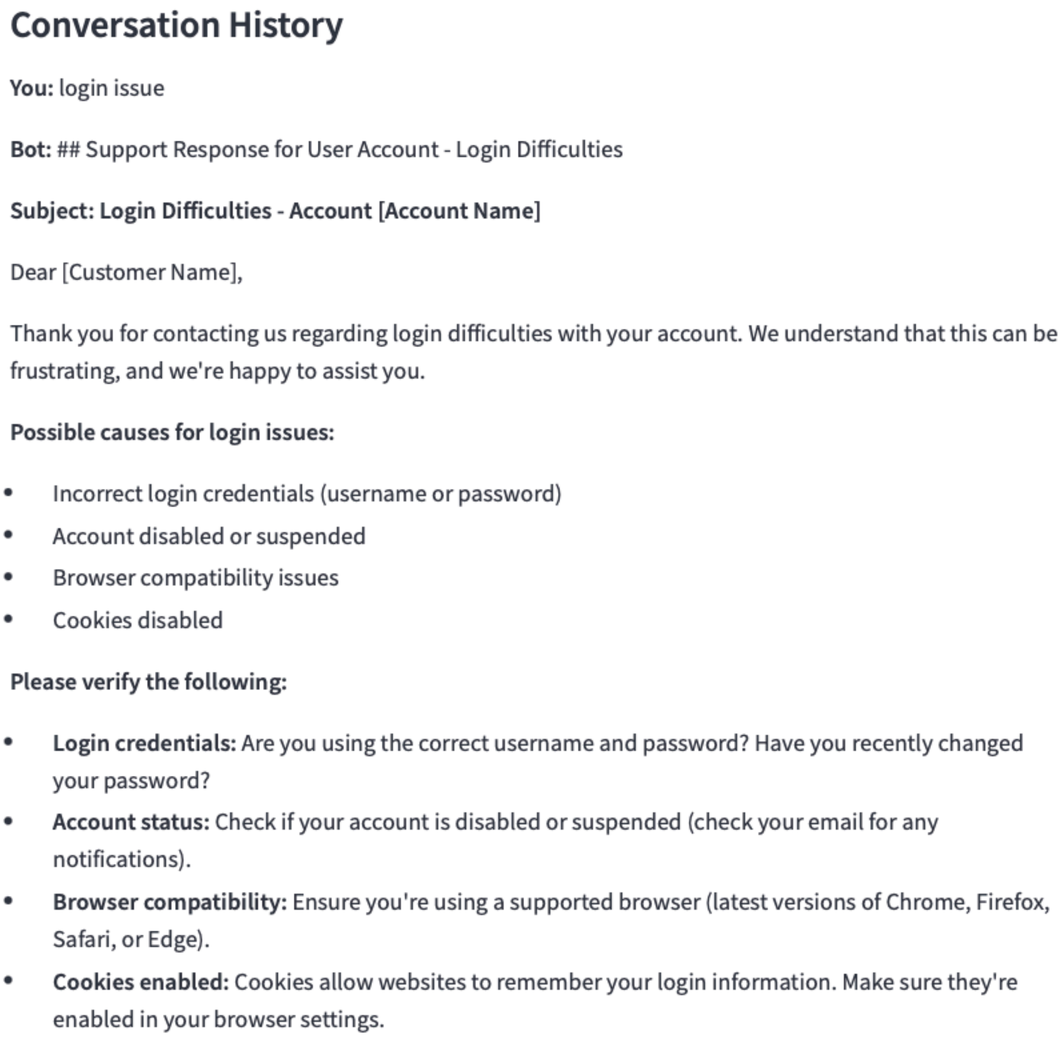
Thank you for your feedback!

Backend Feedback saving



```json
[
    {
        "description": "login issue ",
        "model": "gemma-7b-it",
        "rating": 5,
        "feedback": "thanks "
    },
    {
        "description": "login issue",
        "model": "gemma-7b-it",
        "rating": 5,
        "feedback": "very nice, great work"
    }
]
```

4. View Conversation History:
   - Previous conversations are displayed below the input form.



Conversation History

You: login issue

Bot: ## Support Response for User Account - Login Difficulties

Subject: Login Difficulties - Account [Account Name]

Dear [Customer Name],

Thank you for contacting us regarding login difficulties with your account. We understand that this can be frustrating, and we're happy to assist you.

Possible causes for login issues:

- Incorrect login credentials (username or password)
- Account disabled or suspended
- Browser compatibility issues
- Cookies disabled

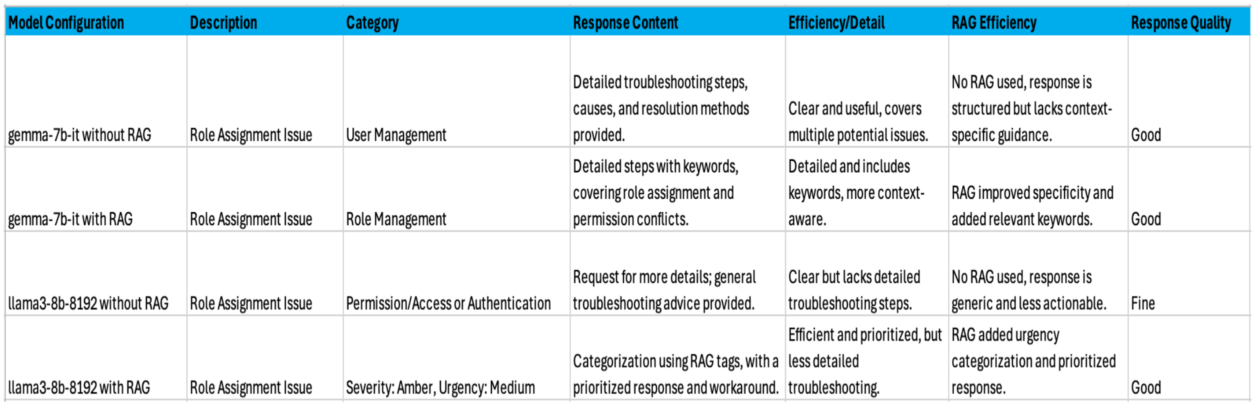
Please verify the following:

- **Login credentials:** Are you using the correct username and password? Have you recently changed your password?
- **Account status:** Check if your account is disabled or suspended (check your email for any notifications).
- **Browser compatibility:** Ensure you're using a supported browser (latest versions of Chrome, Firefox, Safari, or Edge).
- **Cookies enabled:** Cookies allow websites to remember your login information. Make sure they're enabled in your browser settings.

Note – I have created another document “Final Project-Response document” where I tried for non-domain specific as well and also as I did a lot of testing not everything is captured in it to give you proper understanding on the efficiency I have added some responses and created an efficiency table and wrote summary on it – now here as it will be to many pages, so adding only tables and conclusion for the table here.

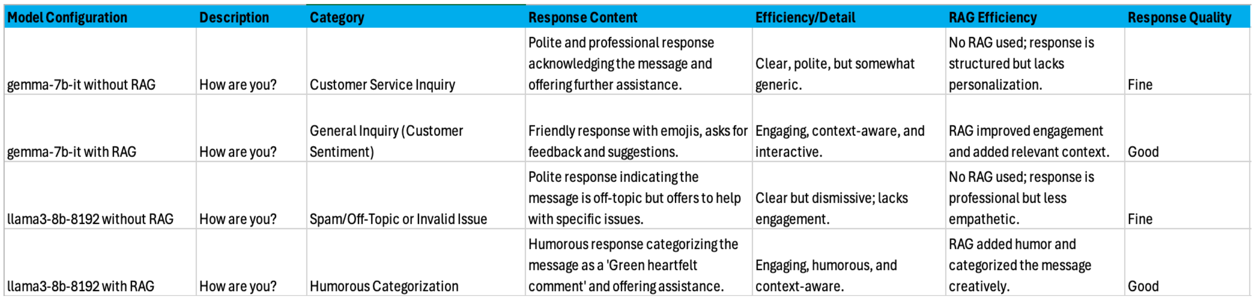
Comparison Table on responses efficiency

Domain Specific



Model Configuration	Description	Category	Response Content	Efficiency/Detail	RAG Efficiency	Response Quality
gemma-7b-it without RAG	Role Assignment Issue	User Management	Detailed troubleshooting steps, causes, and resolution methods provided.	Clear and useful, covers multiple potential issues.	No RAG used, response is structured but lacks context-specific guidance.	Good
gemma-7b-it with RAG	Role Assignment Issue	Role Management	Detailed steps with keywords, covering role assignment and permission conflicts.	Detailed and includes keywords, more context-aware.	RAG improved specificity and added relevant keywords.	Good
llama3-8b-8192 without RAG	Role Assignment Issue	Permission/Access or Authentication	Request for more details; general troubleshooting advice provided.	Clear but lacks detailed troubleshooting steps.	No RAG used, response is generic and less actionable.	Fine
llama3-8b-8192 with RAG	Role Assignment Issue	Severity: Amber, Urgency: Medium	Categorization using RAG tags, with a prioritized response and workaround.	Efficient and prioritized, but less detailed troubleshooting.	RAG added urgency categorization and prioritized response.	Good

Non-Domain Specific



Model Configuration	Description	Category	Response Content	Efficiency/Detail	RAG Efficiency	Response Quality
gemma-7b-it without RAG	How are you?	Customer Service Inquiry	Polite and professional response acknowledging the message and offering further assistance.	Clear, polite, but somewhat generic.	No RAG used; response is structured but lacks personalization.	Fine
gemma-7b-it with RAG	How are you?	General Inquiry (Customer Sentiment)	Friendly response with emojis, asks for feedback and suggestions.	Engaging, context-aware, and interactive.	RAG improved engagement and added relevant context.	Good
llama3-8b-8192 without RAG	How are you?	Spam/Off-Topic or Invalid Issue	Polite response indicating the message is off-topic but offers to help with specific issues.	Clear but dismissive; lacks engagement.	No RAG used; response is professional but less empathetic.	Fine
llama3-8b-8192 with RAG	How are you?	Humorous Categorization	Humorous response categorizing the message as a 'Green heartfelt comment' and offering assistance.	Engaging, humorous, and context-aware.	RAG added humor and categorized the message creatively.	Good

Response Efficiency Conclusion

The evaluation of both domain-specific and non-domain specific responses highlights the significant benefits of using **RAG (Retrieval-Augmented Generation) mode**. Across different models (**gemma-7b-it** and **llama3-8b-8192**), RAG mode consistently enhances the quality, context, and engagement of responses.

- **For Domain-Specific Questions**:
  RAG mode improves the specificity and relevance of responses, providing better categorization, troubleshooting steps, and prioritization. This results in clearer and more actionable support for users.

- **For Non-Domain Specific Questions**:
  RAG mode adds personalization, humor, and interactive elements, transforming generic responses into more engaging and context-aware interactions.

In conclusion, integrating **RAG mode** with language models improves the overall user experience by making chatbot responses more accurate, engaging, and tailored to user needs. This approach ensures that both technical support and general inquiries are handled effectively, enhancing customer satisfaction and service efficiency.

🛠️ 14. Challenges and Solutions

Challenges Faced

- **Model Compatibility**:
  - Some models like llama2-13b-4096 and claire-3b-256 were not accessible due to API restrictions.
- **Feedback Storage**:
  - Implementing a reliable method to store feedback without overwriting existing data.
- **SSL Compatibility**:
  - The warning related to LibreSSL required suppressing with NotOpenSSLWarning.

Solutions Implemented

- **Working Models**:
  - Selected models like **"gemma-7b-it"** and **"llama3-8b-8192"** that were verified to work with the Groq API.
- **Feedback Loop**:
  - Feedback is appended to feedback.json to ensure data is not lost.
- **Suppressing Warnings**:
  - Added code to suppress NotOpenSSLWarning to avoid unnecessary terminal warnings.

📝 15. Conclusion

The **Simplified Digital Twin for a Customer Support System** effectively demonstrates the integration of LLMs for automating ticket categorization and response generation.

The system includes:

- **Automated Categorization and Responses**.
- **Retrieval-Augmented Generation (RAG)** for enhanced responses.
- **User Feedback Loop** for continuous improvement.
- **Streamlit Frontend** and **Flask Backend** for seamless user interaction.

This project showcases how AI can streamline customer support workflows, reducing the need for human intervention while maintaining efficiency.

Useful Links

- Groq API Documentation - https://console.groq.com/docs/api-reference#chat
- Streamlit Documentation - https://docs.streamlit.io/
- Flask Documentation - https://flask.palletsprojects.com/en/stable/

GitHub Repository - https://github.com/Nehagopinath15neu/GenAIFinal-Project

YouTube video Link - https://youtu.be/tzClwyW-xiA