CMPE 491-O

HIGH LEVEL DESIGN REPORT

Project Name: MemorEase

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1. Introduction

1.1 Purpose of the System

   MemorEase is specifically developed to support individuals experiencing memory loss, especially those with an Alzheimer's diagnosis, by promoting cognitive engagement through tailored memory recall activities. The platform utilizes shared family memories, encompassing images, audio, and text, to foster interactive and significant experiences. This mobile application seeks to connect conventional memory care practices with contemporary technological solutions, providing a holistic approach to enhance the quality of life for both patients and their caregivers.

1.2 Design Goals

- Customized Memory Engagement: Support cognitive activities designed specifically for patients by utilizing content shared by their families.
- Data-Driven Analysis: Create reports from users' quiz answers to uncover trends in memory retention and decline, linking these trends to particular areas of the brain.
- Game-Based Motivation: Foster user involvement through reward systems and competitive rankings, improving the overall experience for users.
- Secure and Scalable Architecture: Safeguard the confidentiality of sensitive user information while managing growing numbers of users and data.

1.3 Definitions, Acronyms, and Abbreviations

- **AI:** Artificial Intelligence, which is employed for cognitive analysis and the creation of content.
- **NLP**: Natural Language Processing, facilitates interactions through text and the generation of questions.
- **GDPR**: General Data Protection Regulation, which is designed to uphold data privacy standards and ensure compliance.
- **UI/UX**: User Interface and User Experience, focusing on making digital platforms accessible and user-friendly for older adults.

1.4 Overview

MemorEase combines cognitive engagement, familial involvement, and medical analytics within a unified platform. Family members provide individualized information, including photographs and personal stories, which are analyzed using artificial intelligence to create stimulating quizzes for the patient. These quizzes are designed to test memory recall, delivering a pleasurable and therapeutic experience. Furthermore, the system generates comprehensive reports that identify cognitive strengths and weaknesses, providing essential insights for caregivers and healthcare providers. The primary aim of MemorEase is to reduce the strain on healthcare systems by facilitating proactive and tailored care, thereby enhancing the understanding of patients' cognitive health progressions.

2. Current software architecture (if any)

3. Proposed Software Architecture

3.1 Overview

MemorEase's software architecture focuses on establishing a seamless, scalable, and secure platform dedicated to memory recall and cognitive analysis. It incorporates advanced Natural Language Processing (NLP), secure cloud storage, and gamified user interactions to provide an engaging and effective experience for users. The architecture is modular, comprising distinct subsystems that promote efficient development and maintenance. Key technologies employed include Kotlin for the mobile application, Firebase for backend services, and external APIs for NLP functionalities.

3.2 Subsystem Decomposition

The system is organized into the following essential subsystems:

User Interface (UI) Subsystem: Manages the interaction between users, specifically patients and caregivers, and the application. This includes modules for engaging in quizzes, uploading memory content, and visualizing reports.

Content Management Subsystem: Oversees the storage, retrieval, and tagging of memory-related materials, such as images, text, audio, and video. It guarantees effective indexing and categorization to support quiz generation.

Quiz Engine Subsystem: Creates customized quizzes utilizing uploaded memory content and natural language processing techniques. Incorporates gamification elements, including points and leaderboards.

Analytics and Reporting Subsystem: Evaluates user responses to discern cognitive strengths and weaknesses. Produces comprehensive reports for caregivers and healthcare professionals, linking trends to specific brain regions.

Backend Services Subsystem: Delivers APIs for data synchronization, user authentication, and access control. Connects with Firebase and external NLP APIs for data processing and analysis.

Security and Compliance Subsystem: Enforces encryption and secure communication protocols. Ensures adherence to GDPR and other relevant data protection regulations.

3.3 Hardware/Software Mapping
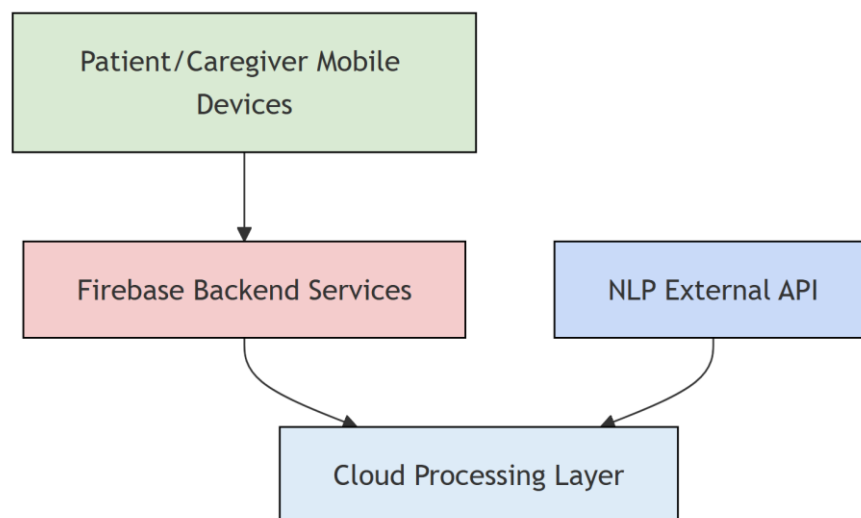
- **User Devices**: Refers to the devices utilized by patients and caregivers that operate the mobile application.
- **Cloud Services**: Utilizes Firebase to provide backend functionalities such as user authentication, data storage, and analytical services.
- **External APIs**: Incorporates integration with Natural Language Processing services for the generation of questions.

- **Processing Layer**: Comprises cloud servers that oversee quiz logic, analytics, and communications with APIs.

3.4 Persistent Data Management
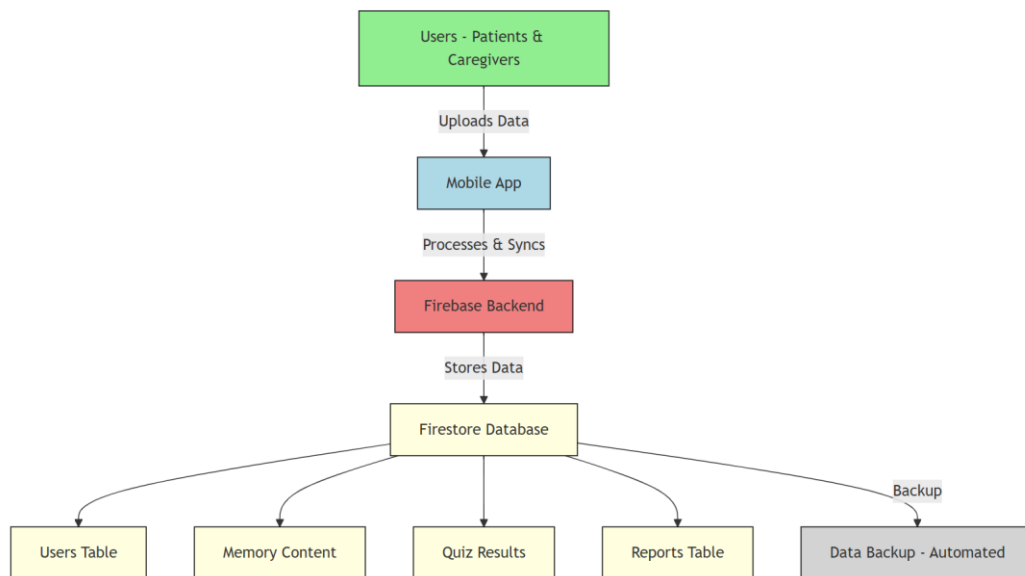
   The database system employed will be Firebase Cloud Firestore, which facilitates real-time and secure storage of user information, encompassing memory content, quiz outcomes, and generated reports.

Data Structure:

Users: This section will maintain profiles for both patients and caregivers, detailing their roles and preferences.

Memory Content: This will be organized with metadata, including tags, timestamps, and relational data.

Quiz Results: This will document patient interactions, capturing responses, timestamps, and scores.

Reports: These will be structured as JSON objects that provide analytical insights and highlight cognitive trends.

Data Backup: Automated periodic backups will be implemented in Firebase to guarantee data resilience.
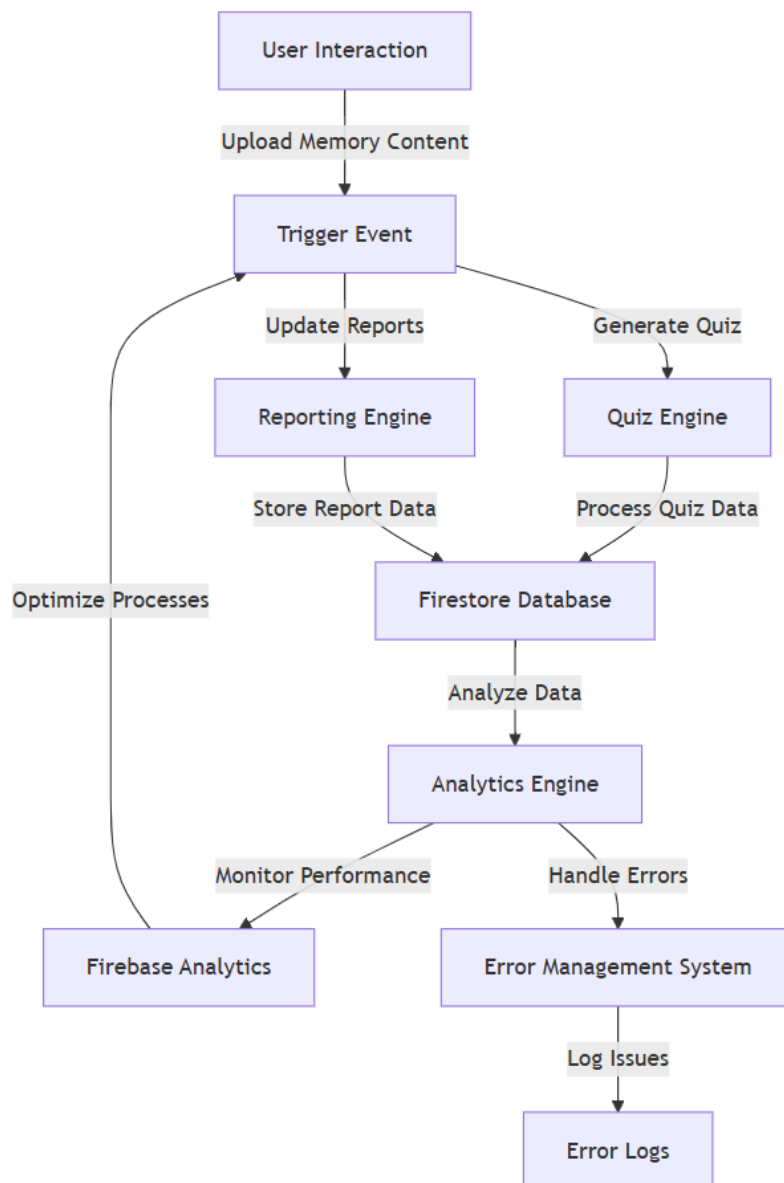
3.5 Access Control and Security

Authentication: The system will implement Firebase Authentication to facilitate secure login through email, password, or multi-factor authentication methods.

Authorization: Role-based access control (RBAC) will be employed to limit access to sensitive functionalities and information; for instance, caregivers will have the ability to upload content, while only patients will be permitted to participate in quizzes.

Encryption: All sensitive data will be protected by end-to-end encryption both during transmission and when stored.

Compliance: The system will comply with GDPR regulations, ensuring that user data is collected, stored, and processed with the explicit consent of the users.

3.6 Global Software Control

```mermaid
flowchart
    User Interaction
    --Upload Memory Content--> Trigger Event
    Trigger Event --Update Reports--> Reporting Engine
    Trigger Event --Generate Quiz--> Quiz Engine
    Reporting Engine --Store Report Data--> Firestore Database
    Quiz Engine --Process Quiz Data--> Firestore Database
    Firestore Database --Analyze Data--> Analytics Engine
    Analytics Engine --Monitor Performance--> Firebase Analytics
    Analytics Engine --Handle Errors--> Error Management System
    Firebase Analytics --Optimize Processes--> Trigger Event
    Error Management System --Log Issues--> Error Logs
```

Event-Driven Architecture: The proposed system will implement an event-driven framework to effectively manage user interactions and backend operations. For instance, the generation of quizzes will be initiated upon the upload of new content, and reports will be updated following the completion of a quiz.

Error Handling: A robust exception handling mechanism will be established to address API failures, erroneous data inputs, and network-related challenges.

Performance Monitoring: Firebase Analytics will be utilized to monitor application performance and user engagement, thereby facilitating the optimization of system responsiveness.

3.7 Boundary Conditions
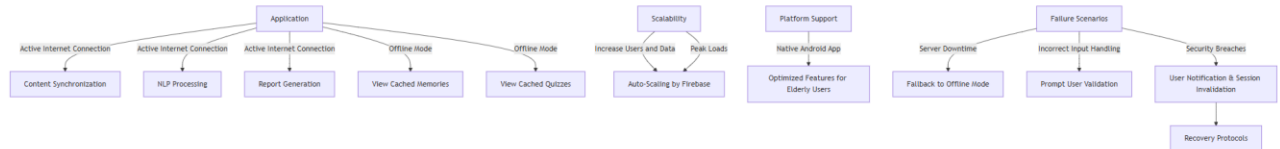
Network Dependency: The application necessitates a stable internet connection for the purposes of content synchronization, natural language processing, and report generation. Nevertheless, it will offer limited offline capabilities, including access to cached memories and quizzes.

Native Android App: The application is designed as a native Android app utilizing Kotlin. Each feature is meticulously optimized for the Android environment, guaranteeing seamless performance and a user-friendly experience specifically catered to elderly users. Cross-platform compatibility is not available.

Scalability: The system leverages the auto-scaling features of Firebase to effectively manage heightened user traffic and data demands, especially during times of peak usage.

4. Subsystem Services
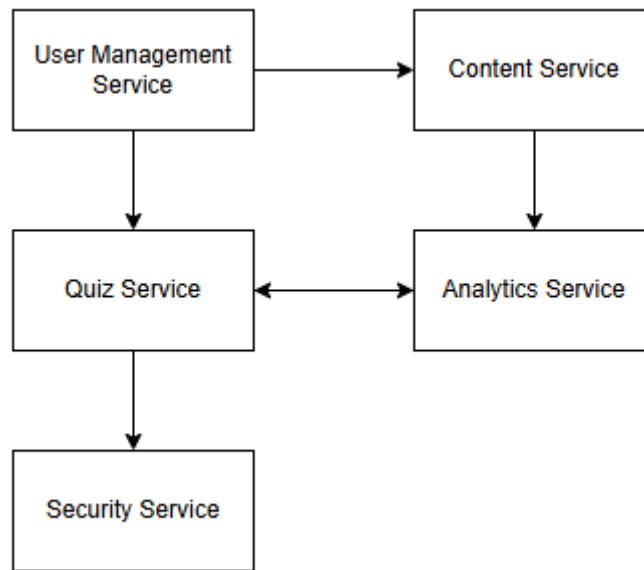
User Management Service: It enables user login and role allocation processes for all users (patients and caregivers). It ensures that:

- Users can securely log in through Firebase Authentication.
- Appropriate roles are assigned and caregiver controls content while patients answer quizzes.
- Continuous sessions are actively monitored and managed for continuous user experience.

Content Service: It is responsible for management of patient memory multimedia data. This subsystem enables:

- Uploading of images, audio, videos, and text by caregivers.
- Metadata tagging for efficient indexing and categorization.
- Secure storage and real-time retrieval of content from Firebase.

Quiz Service: It produces custom, personalized and dynamic quizzes on the content uploaded. It incorporates:

- Dynamic question generation using Natural Language Processing (NLP).
- Evaluation of patient responses with immediate feedback.
- Gamification elements, such as scoring systems and leaderboard updates.

Analytics Service: It processes user input to extract data about cognitive trends. This subsystem provides:

- Aggregation and analysis of patient responses to quizzes to identify patterns.

- Comprehensive reports linking memory trends to specific brain regions.
- Graphical and textual summaries for caregivers and healthcare professionals.

Security Service: It's subsystem guarantees confidentiality and integrity of user data at every stage of the lifecycle. This is achieved through:

- End-to-end encryption for data in transit and at rest.
- Role-based access control (RBAC) to restrict permissions.
- Compliance with GDPR and other relevant data protection standards.

5. Glossary

Alzheimer's Disease: A progressive neurological disorder characterized by memory loss and cognitive decline.

Gamification: The application of game-design elements and principles to non-game contexts to enhance user engagement.

Temporal Lobe: The part of the brain involved in processing sensory input, language comprehension, and memory formation.

Tagging: The process of assigning descriptive metadata to content, such as photos and videos, to improve organization and retrieval efficiency.

NLP (Natural Language Processing): A field of AI that enables systems to understand and generate human language, critical for creating quizzes based on uploaded content.

Firebase: A comprehensive backend-as-a-service platform used for authentication, database management, and analytics in the project.

GDPR (General Data Protection Regulation): A regulatory framework ensuring the protection of personal data and privacy in the EU, adhered to by MemorEase.

Data Encryption: A security measure to protect sensitive information by converting it into a code to prevent unauthorized access.

6. References

- Alzheimer's Association. "2024 Alzheimer's Disease Facts and Figures." Alzheimer's & Dementia, 2024.
  URL: https://www.alz.org

- Anderson, J., et al. "AI in Alzheimer's Care: Memory and Cognitive Support Applications." *Journal of Healthcare AI*, 2022.

- Smith, R., and Liu, T. "Natural Language Processing for Memory Care Applications: Techniques and Use Cases." *Artificial Intelligence in Medicine*, 2023.

- Harvard Health Publishing. "AI Applications in Alzheimer's Disease Management." Harvard Health Publishing, 2024.

- IEEE Transactions on Mobile Computing. "Memory Recall Enhancement Through Mobile Apps." IEEE Transactions on Mobile Computing, 2023.