Software Design Document(SDD)

Topic : Health Monitoring System

Team : SmartSpark

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1. Introduction

1. 1. Purpose

This software design specification (SDD) was written to define the design of “Smart Health Monitoring (SHM)”. This document presents the system design of an IoT-based healthcare management application for elderly single-family homes, and aims to support developers to systematically implement the project during the development process. The design was written with maintainability and expandability in mind.

1. 2. Scope

SHM is a system that monitors the health status and daily life of the elderly in real time and supports managers to respond quickly in case of an emergency. The key stakeholder is the elderly and the caregiver who remotely manages their health, and this system provides the following new values.

This system provides the elderly with an environment where they can receive prompt help through real-time health monitoring and automatic notifications in case of an emergency. The elderly can continuously track their steps, heart rate, medication, and outing status using sensors that collect health data, allowing them to effectively manage their health.

Caregivers can check the health information of seniors through mobile applications and receive immediate notifications when abnormalities occur, allowing them to respond quickly.

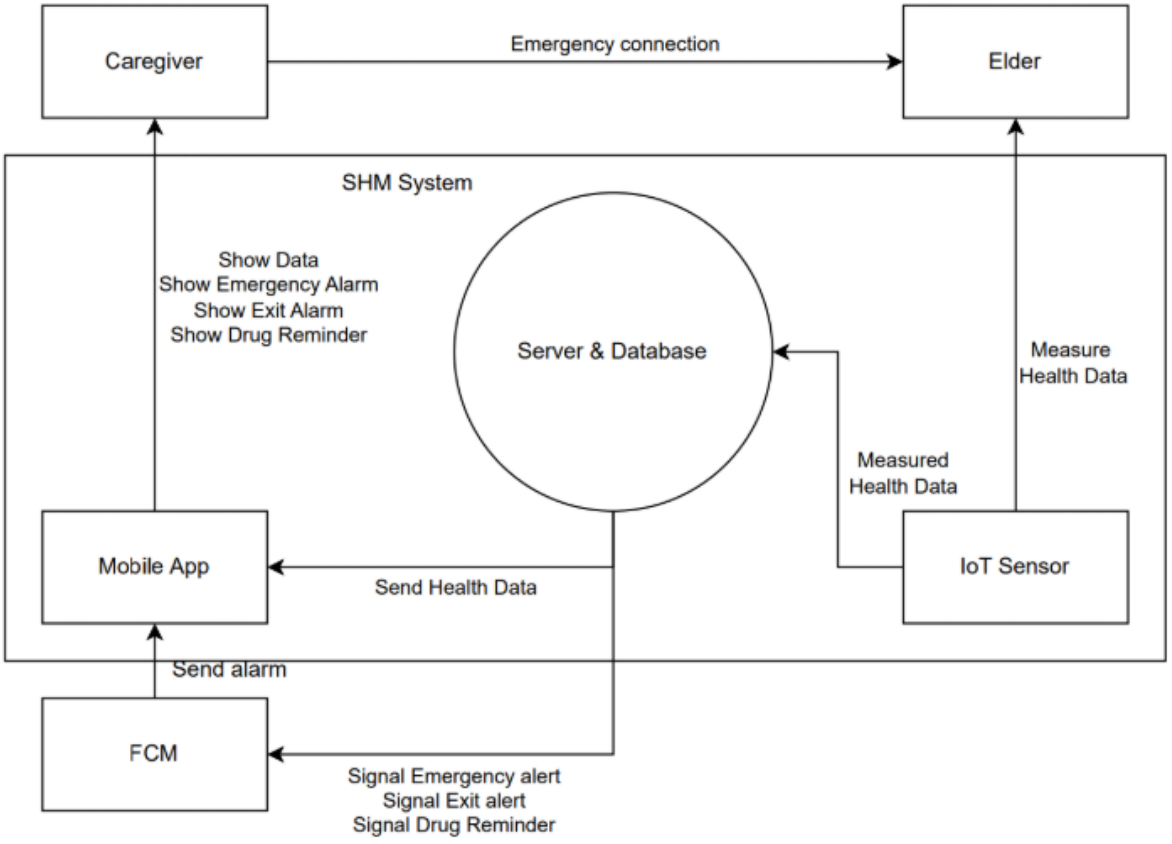
In this way, SHM is a system that provides real value to the lives of seniors and their caregivers, and focuses on creating an environment where health and safety can be managed more effectively.

1. 3. Context

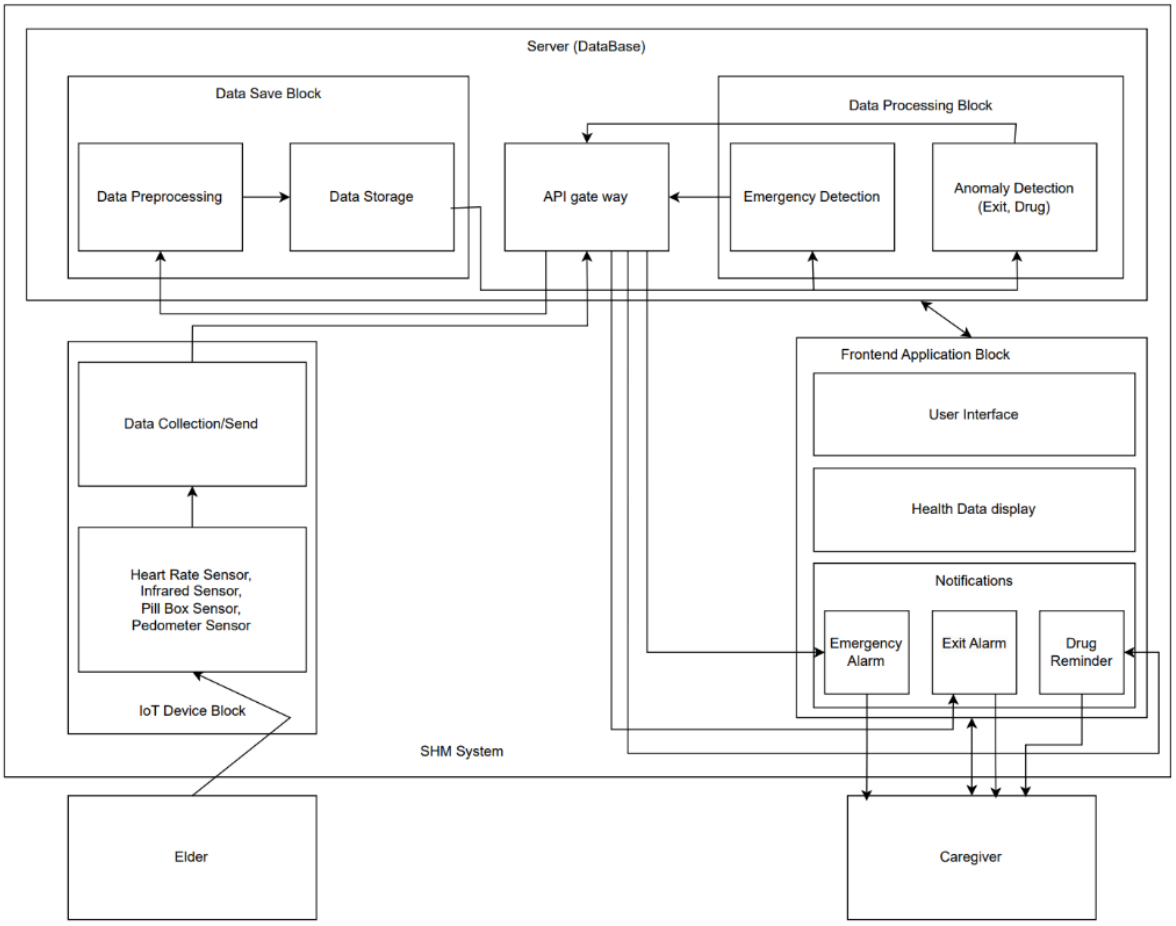
1. 3. 1. System Overview

Smart Health Monitoring System (SHM) is an IoT-based application designed to monitor the health and safety of elderly single-family homes. The system collects real-time health data of the elderly, such as heart rate, number of steps, medication status, and whether or not they go out, through IoT sensors. The collected data is transmitted to the server, processed, and stored, and the caregiver can check it through a mobile application and respond quickly to emergency situations. The system requires real-time monitoring, secure data processing, and seamless communication between components.

1. 3. 2. Context Diagram



1. 3. 3. Block Diagram



1. 3. 4. Data Flow and Communication

The SHM system measures data such as the elderly's heart rate, number of steps, medication, and outing status through IoT sensors, and transmits this data to the server for processing. If the network connection is lost, the data is temporarily stored locally, and when the connection is restored, it is transmitted to the server to prevent data loss.

Data is processed step by step to support real-time monitoring and long-term data analysis. The data of the last 10 minutes is streamed in real time to provide the caregiver with real-time status check, and after 10 minutes, it is converted into data sampled at 5-minute intervals, cached, and maintained for 1 hour. After 1 hour, the sampled data is transferred to the server storage to help the caregiver efficiently perform long-term health management and abnormal condition detection of the elderly.

1. 3. 5. Key Design Considerations

The SHM system is designed based on the constraints below and aims for stable and efficient system operation.

1. 3. 5. 1. Hardware limitations

- A variety of sensors are required, each with different data formats and transmission methods, requiring additional hardware or protocol support to integrate them.

1. 3. 5. 2. Interfaces to other applications

- The communication protocol must be provided as a RESTful API to support integration with other applications so that data collected from sensors can be efficiently integrated and transmitted.

1. 3. 5. 3. Reliability requirements

- Since older people are not accustomed to operating apps, the system must be highly reliable. In particular, it must be designed to minimize the possibility of errors and to respond quickly when they occur.

1. 3. 5. 4. Criticality of the application

- Internet connectivity is essential for critical functions such as emergency notifications to function smoothly. This is a critical constraint of the system, as the functions may not function properly if the Internet is disconnected.

1. 3. 5. 5. Safety and security considerations

- Personal outing and health information is considered sensitive information, and security measures must be put in place to protect privacy. Strong security measures are needed to prevent data leakage.

2. Definitions, acronyms, and abbreviations

Term	Definition
SHM (Smart health monitoring)	The name of the healthcare management application for the elderly living alone. It supports caregivers in monitoring the elderly's health status and receiving emergency alerts.
Elderly	The primary user of the healthcare management application who is monitored for health and safety. Typically, this refers to elderly individuals living alone who may require health monitoring and emergency assistance.
Caregiver	The user responsible for remotely monitoring the elderly’s health status and responding promptly in case of emergencies.
IoT	Internet of Things. A technology where multiple devices interact by exchanging data over a network. In this project, sensors use IoT to collect and transmit health status data.

Term	Definition
GPS	Global Positioning System. A satellite-based location tracking system, used to provide the caregiver with the elderly person’s location during an emergency.
JWT	JSON Web Token. An authentication method used to enhance API request security and access control. The token is encrypted, includes an expiration time, and is periodically renewed.
Real-Time Data Streaming	A feature that provides caregivers with updated data on the elderly person’s status every second, covering the last 10 minutes.
Sampled Data	Data older than 10 minutes is sampled at 5-minute intervals and stored in the cache for memory efficiency. This data is permanently stored on the server after 1 hour.
Push Notification	A function that sends real-time alerts to caregivers when the elderly’s health status is abnormal or in case of an emergency.
Infrared Sensor	A sensor installed near the door to detect exits. When an outing is detected, an alert is sent to the caregiver.
Gyroscope Sensor	A sensor that detects tilt and acceleration changes to determine if a fall has occurred.
Heartbeat Sensor	A sensor used to monitor the elderly’s heart rate, providing data for detecting abnormal heart conditions or emergencies.
Pedometer Sensor	A sensor used to track the number of steps taken by the elderly, helping caregivers monitor physical activity levels.
Health Monitoring	The function of tracking and analyzing health data such as heart rate, steps, and medication intake to ensure the well-being of the elderly.
Emergency Alert	A system feature that detects critical health abnormalities or accidents (e.g., falls) and promptly notifies the caregiver with relevant information, including GPS location.
Historical Data	Long-term stored data that allows caregivers to view health trends and patterns over daily, weekly, and monthly periods.

3. References

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- **The Role of JWT**

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- **IEEE 1016-2009, titled IEEE Standard for Information Technology—Systems Design—Software Design Descriptions**

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- **Examples of professional SDD - Atlanta Regional Commission**

  https://www.its.dot.gov/research_archives/msaa/pdf/MSAA_SystemDesignFINAL.pdf
- **Examples of professional SDD - U.S. Government Printing Office**

  https://www.govinfo.gov/media/FDsys_Architecture.pdf
- **Examples of professional SDD - PuppyIR**

  https://cordis.europa.eu/docs/projects/cnect/7/231507/080/deliverables/001-PuppyIRD42DesignReportv10.pdf
- **Example of student-generated SDD**

  https://senior.ceng.metu.edu.tr/2014/such/documents/SDD.pdf

4. Body

4. 1. Identified stakeholders and design concerns

4. 1. 1. Identified Stakeholders

The key stakeholders of this system are elderly people living alone and their caregivers who monitor their health and safety. Each stakeholder's characteristics and requirements were reflected as important considerations in the design.

4. 1. 1. 1. Characteristics of elderly

- Elderly people often suffer from adult diseases due to their advanced age, so continuous health monitoring is necessary. It is necessary to periodically measure the amount of exercise through heart rate and number of steps, and take immediate action if abnormalities occur.
- Older people are likely to be less familiar with smartphones and apps. Therefore, the interface should be simple and intuitive for them to use, and buttons and fonts should be large for many people with poor eyesight.
- Elderly people with poor health tend to forget to take their medications because they have to take many medications. Therefore, a system is needed to prevent medication from being missed.
- Because it is difficult for elderly people living alone to respond to emergencies on their own, a notification should be sent to their caregivers in the event of an emergency to help them respond.

- If a senior living alone does not return home until too late, there may be an accident. To find out, a system that sends out/return notifications to the caregiver is needed.
- Because older adults may dislike anything complicated or inconvenient, installing health monitoring sensors should be simple enough for older adults to do.

4. 1. 1. 2. Characteristics of caregiver

- Caregivers need to remotely monitor the health and safety of elderly people living separately and be notified quickly in the event of an emergency so they can call the elderly person or report to 119. A real-time push notification system is required for this purpose.
- Because the health information that seniors need to manage can be so varied, it should be summarized and presented in an easy-to-read format. It is also important to check overall health trends, so data history should be available to identify trends.
- Caregivers should be able to adjust alarm conditions and frequencies based on the health characteristics or lifestyle of the elderly person. For example, if the patient needs to take medication three times a day, the medication failure detection should occur three times a day.

4. 1. 2. Design Concerns

4. 1. 2. 1. Design Concerns for elderly

- The sensor should be designed in a way that does not interfere with the elderly's activities. In addition, the sensor should be used naturally while minimizing the weight and size.
- The system should be able to automatically detect emergency situations and send alerts to caregivers without requiring any additional actions from the elderly. Additionally, the sensor must continuously collect data to detect changes in the elderly's environment.
- Medication adherence and outdoor activity status should be automatically recorded and managed through the sensor without requiring any additional input from the elderly.
- Alerts for going out and returning home should be sent to caregivers in real time if the outdoor status persists beyond a specific duration or if abnormal behavior is detected.
- The sensor should be designed to minimize psychological discomfort, ensuring that the elderly do not feel inconvenience or resistance when wearing or using it.

4. 1. 2. 2. Design Concerns for caregivers

- The system must automatically detect the elderly's health status and emergencies, ensuring that caregivers receive alerts immediately. The alerts should be designed to convey critical information clearly and without omission.
- Caregivers should be able to view data such as the elderly's heart rate, step count, medication adherence, and outdoor status at a glance. The data should be presented through intuitive graphs or charts.
- The system should allow caregivers to easily monitor and manage changes in the elderly's health status through long-term data analysis.
- Caregivers should be able to adjust specific health parameters (e.g., heart rate thresholds, outdoor time limits, number of medications taken, etc.).
- Even if the network connection is lost, the system should securely store data locally and automatically sync with the server when the connection is restored.
- Emergency alerts must be sent within 1 minute, and the system must ensure high reliability to prevent any service disruptions.

4. 1. 3. Related Requirements

4. 1. 3. 1. Functional Requirements

- The system must send real-time emergency notifications to caregivers whenever an anomaly or emergency is detected in the elderly's health status.
- The system must notify caregivers in real time when the elderly leave their designated area, based on data from the infrared sensor.
- The system must alert caregivers if the elderly fail to take their medication, as detected by the medicine container sensor.
- The system must ensure that notifications for emergencies, going out, and missed medication are sent promptly and accurately to caregivers' devices.

4. 1. 3. 2. Non-functional Requirements

4. 1. 3. 2. 1. Caregivers

- Emergency alerts must be sent within 30 seconds and have an accuracy rate of 99% or higher.
- The data accessible to caregivers must always be up-to-date(reflected within 30 seconds).
- The user interface must be intuitive and easy to use.

4. 1. 3. 2. 2. System Administrators

- The system availability must be at least 99.9%, with recovery within 5 minutes in case of a failure.
- Logging and monitoring should be implemented to track system status and quickly address any issues.
- The system should also be able to operate smoothly despite an increase in users and data expansion.

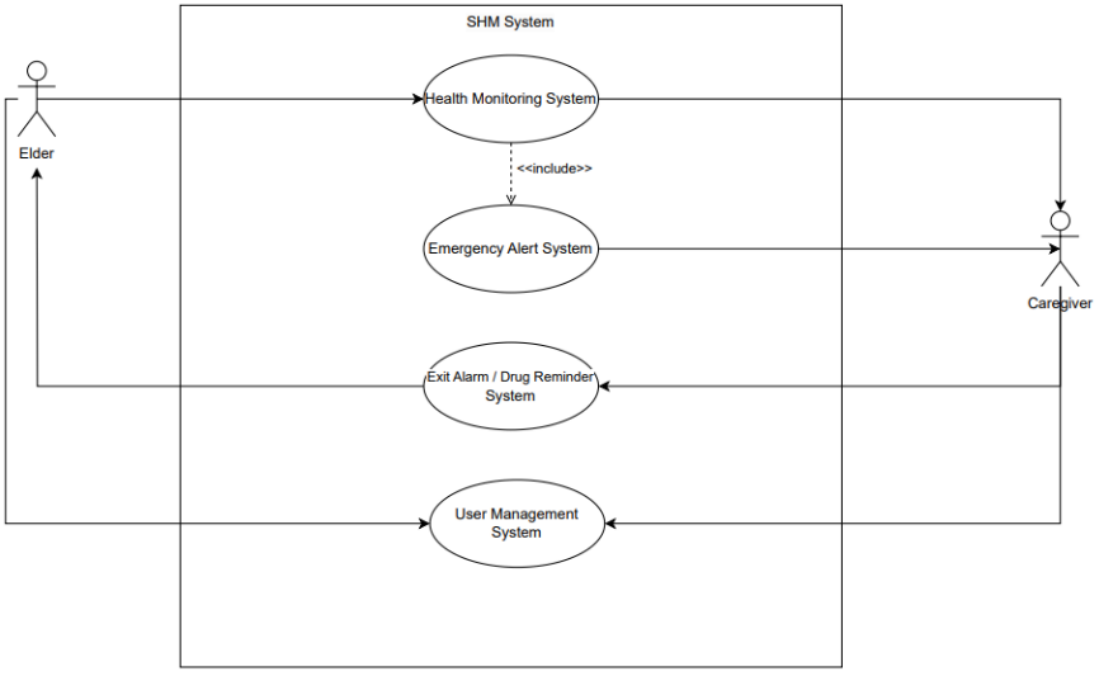
4. 1. 3. 2. 3. End Users (Eldery)

- The system must comply with privacy protection laws, ensuring that data is safeguarded from unauthorized access.
- Data transmission should be encrypted through HTTPS, and access permissions must be strictly managed.

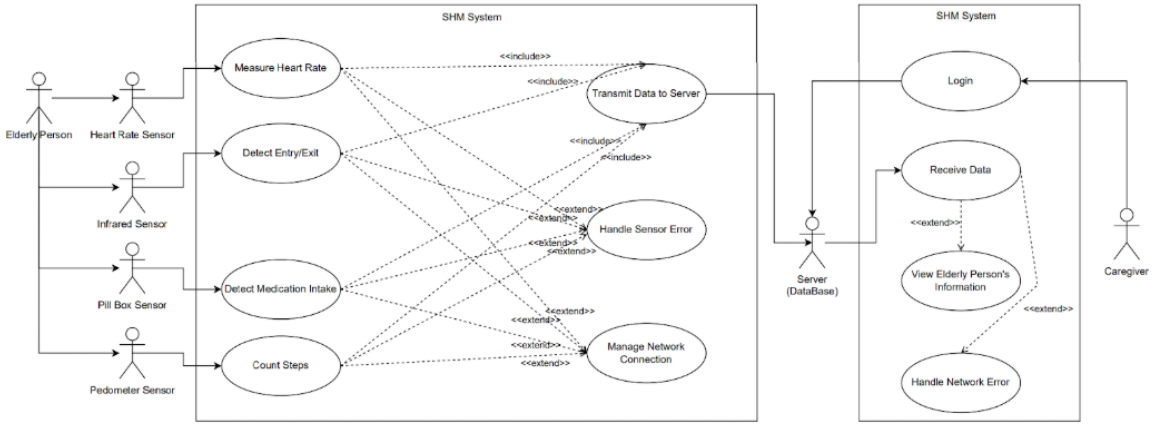
4. 2. Contextual viewpoint

4. 2. 1. Use case diagrams for the entire system

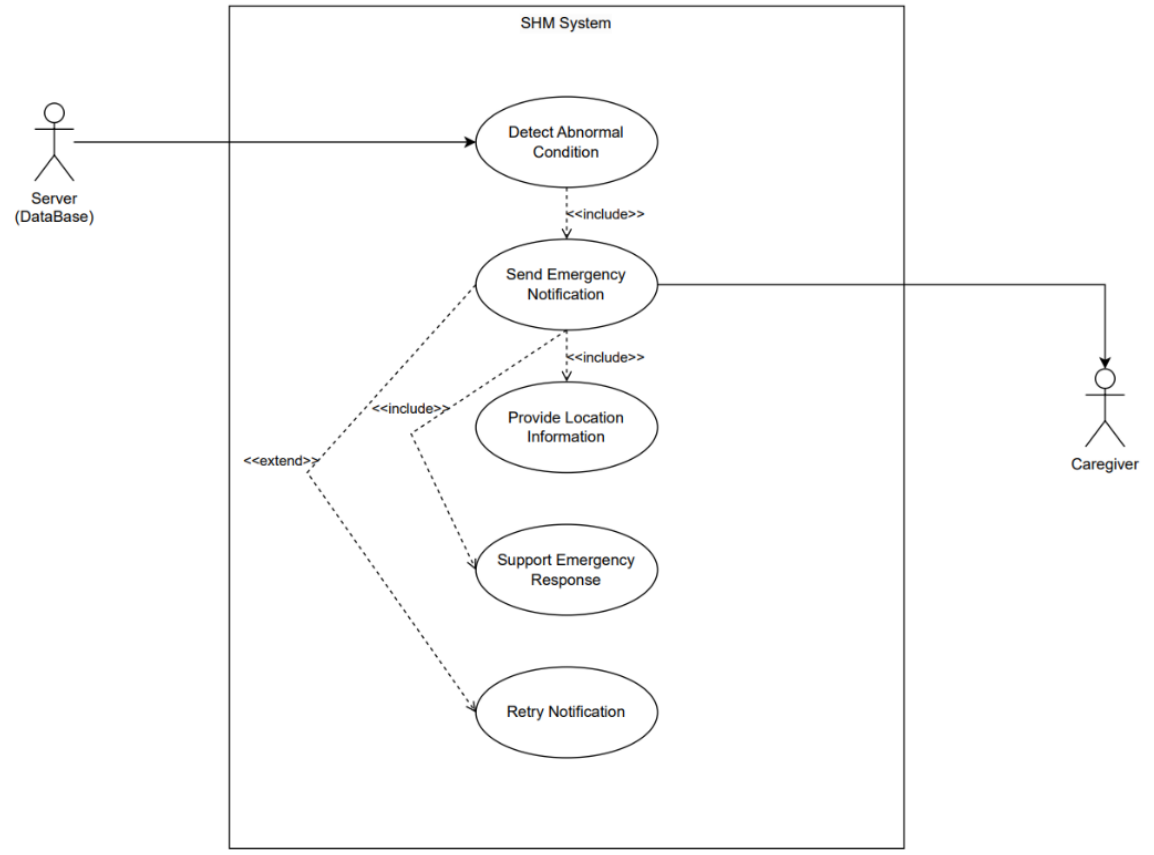
4. 2. 1. 1. Use case diagram of entire system



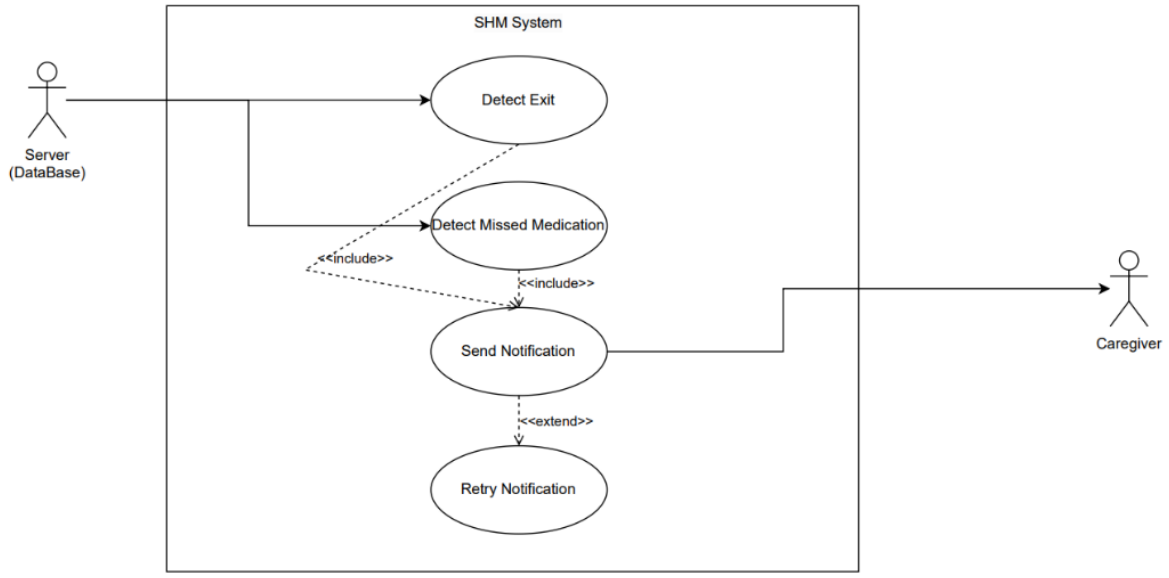
4. 2. 1. 2. Use case diagram of health monitoring system



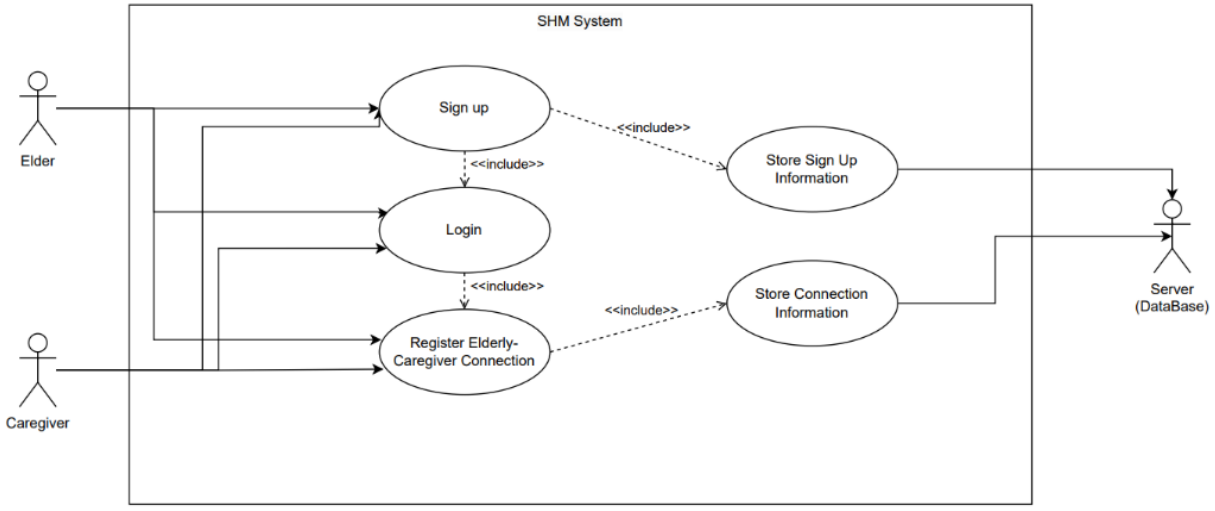
4. 2. 1. 3. Use case diagram of emergency alert system



4. 2. 1. 4. Use case diagram of daily life reminder system



4. 2. 1. 5. Use case diagram of user management system



4. 2. 2. Design concerns

- Real-time monitoring
  - The health status of the elderly must be monitored in real-time, and the data should be quickly accessible to the caregiver.
  - Real-time data transmission and emergency alerts must be provided with minimum delay.
- Security and privacy
  - Personal health data collected from sensors must be secured, and sensitive information should only be accessible to authorized users.

    - Personal information, such as ‘go out signal’ records and heart rate, should be encrypted for storage to minimize the risk of data breaches.
- Simplicity for elderly users
    - Considering that elderly users may not be familiar with smartphones, most interactions should be automated through IoT sensors, requiring no additional manual operation.
- Accessibility for caregivers
    - Caregivers should be able to intuitively check both real-time and summarized data and receive instant notifications in case of emergencies.
    - Data records should be provided by periods to analyze long-term health patterns.

4. 2. 3. Relevant requirements

4. 2. 3. 1. Functional requirements

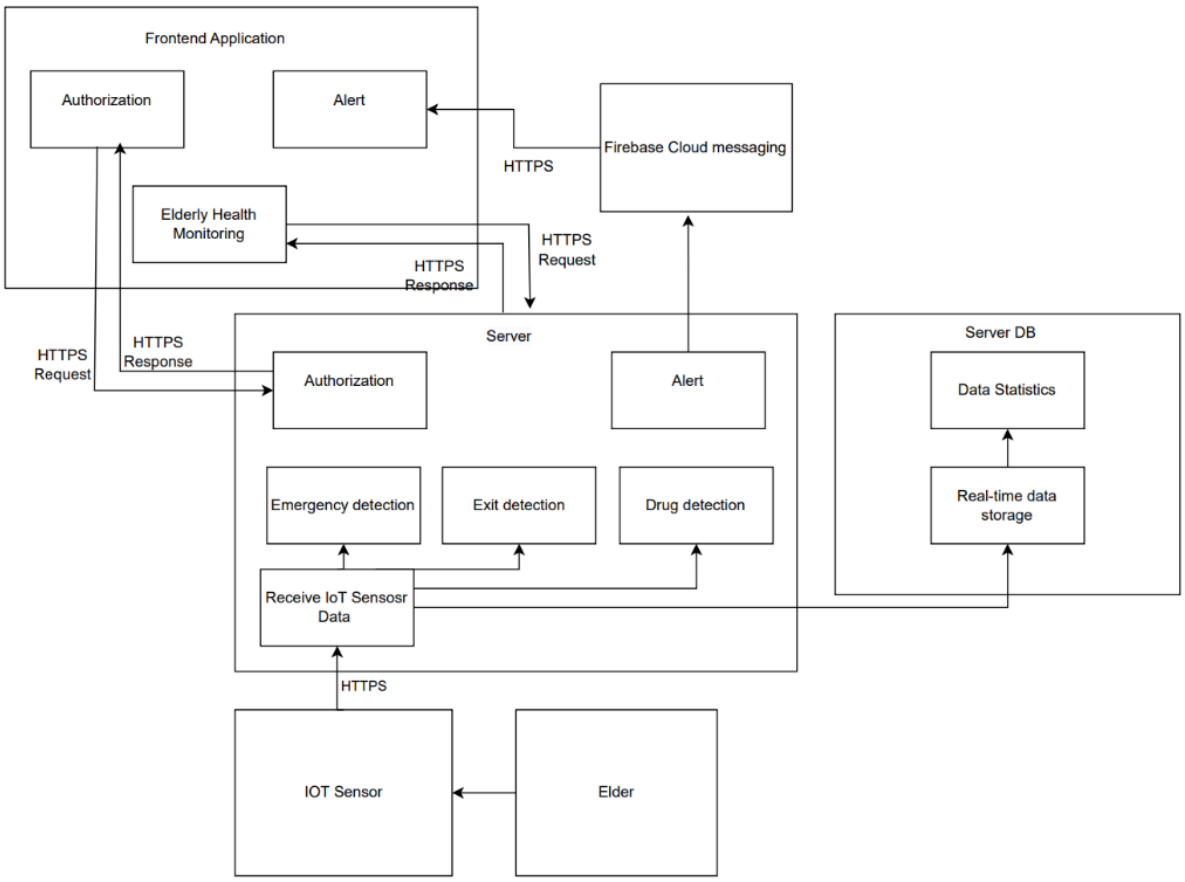
- The system must collect and transmit data using sensors efficiently.
- The system must process real-time data and send emergency notifications when necessary.
- The system must provide administrators with tools for data visualization and analysis.

4. 2. 3. 2. Non-functional requirements

- Data transmission delays must be kept within 1 minute.
- User data must be encrypted using HTTPS and stored in a secure repository.
- Notifications must be sent within 30 seconds with an accuracy of over 99%.
- Information provided to caregivers must be updated with the latest data within 30 seconds.
- The system must maintain 99.9% availability.
- In case of a failure, the system must be restored within 5 minutes.

4. 3. Composition viewpoint

4. 3. 1. Architecture diagrams for the entire system and sub-systems



4. 3. 2. Design concerns

- Modular architecture
  - The SHM system should be designed with a modular architecture, where each component operates independently and can be easily expanded.
  - The system should be designed to minimize the impact on the existing system when adding specific sensors or features.
- Data flow between components
  - Data collected from IoT sensors is transmitted to the server through an API gateway.
  - The server processes the data and generates emergency alerts when necessary, which are then sent to the mobile application.
  - The data flow should support both real-time processing and long-term storage.
- Scalability and reliability
  - The server should be designed to handle more than 100 concurrent users, ensuring no performance degradation even during data overload.

    - In case of network disconnection, the data should be stored locally and synchronized once the connection is restored.
- Security
    - All communication must be encrypted through the HTTPS protocol, and the system should be designed so that only authenticated users can access the data.
    - Personal health data should be encrypted during storage to minimize security risks.

4. 3. 3. Relevant requirements

4. 3. 3. 1. Functional requirements

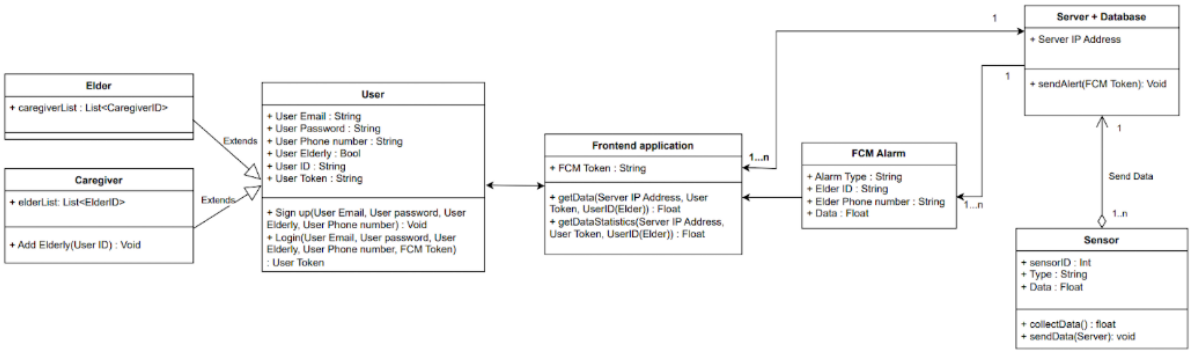
- The system must collect real-time data from IoT sensors and transmit it to the server.
- The system must process the data on the server to detect anomalies and send the results to the mobile application.
- The system must deliver emergency notifications to caregivers in real time.

4. 3. 3. 2. Non-functional requirements

- The system should support easy addition of new sensors through a modular design.
- Core functionalities such as secure access, database searches, record additions/updates/deletions must always be operational.
- Local storage should be used to prevent data loss in case of network disconnection.
- Components and subsystems must provide logging and monitoring capabilities to track performance and quickly diagnose issues.

4. 4. Logical viewpoint

4. 4. 1. Class diagrams for the entire system and sub-systems



4. 4. 2. Design concerns

- Clear data representation
  - To systematically manage the health data of the elderly, each data type should be defined as a class to provide a clear data structure.
  - The interactions and relationships between data must be efficiently represented.
- Maintainability and scalability
  - Class design should allow for minimal changes to the existing structure when adding new features or data.
  - Reduce coupling and increase cohesion between classes to improve maintainability.
- Security and privacy
  - Health data and user information must have access control, with sensitive data stored and transmitted in an encrypted state.
- Real-time and historical data management
  - Real-time data and long-term data should be managed in separate classes but must be accessible in an integrated manner when needed.
  - The system must support time-based sorting and filtering of data.

4. 4. 3. Relevant requirements

4. 4. 3. 1. Functional requirements

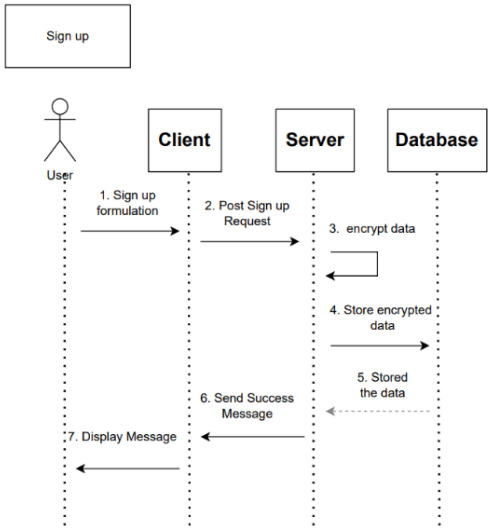
- Create, modify, and delete user accounts
- Storage, process, and manage notifications for health data
- Distinguishing and processing real-time and long-term data

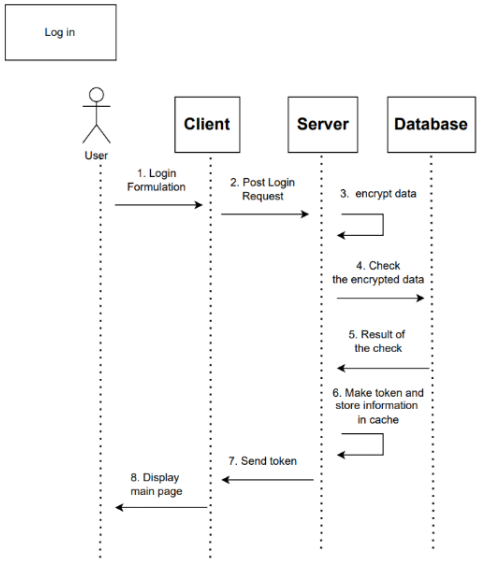
4. 4. 3. 2. Non-functional requirements

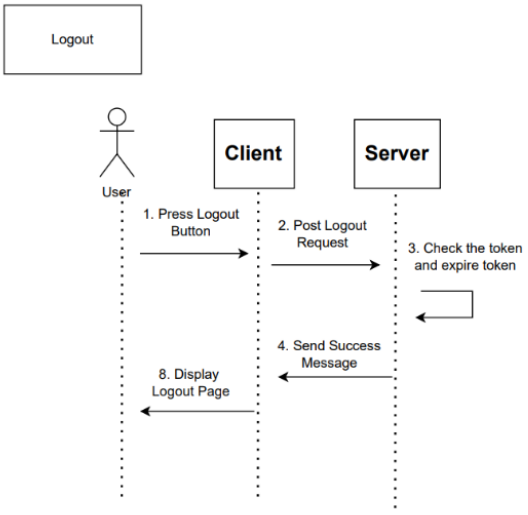
- The class structure must ensure maintainability and scalability.
- The security and privacy of sensitive data must be guaranteed.
- The system must comply with personal data protection laws and prevent unauthorized data access.
- Personally identifiable information should only be retained for the minimum necessary period and securely deleted when no longer needed.
- Data transmission must be encrypted using HTTPS.

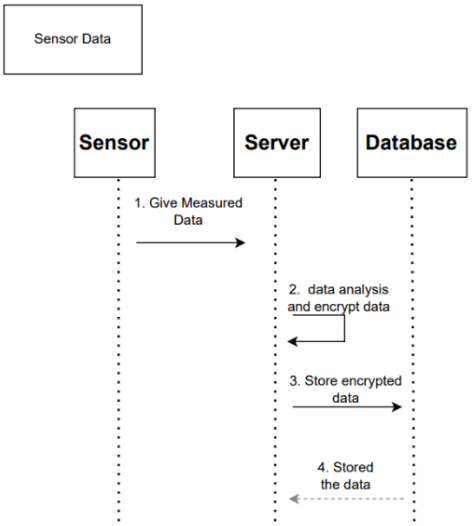
4. 5. Interaction viewpoint

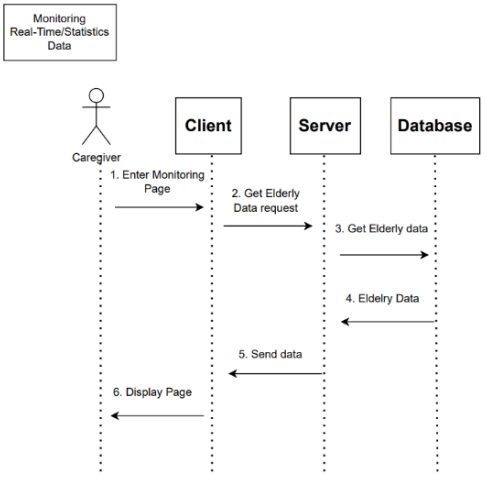
4. 5. 1. Activity and/or sequence diagrams for the entire system and sub-systems

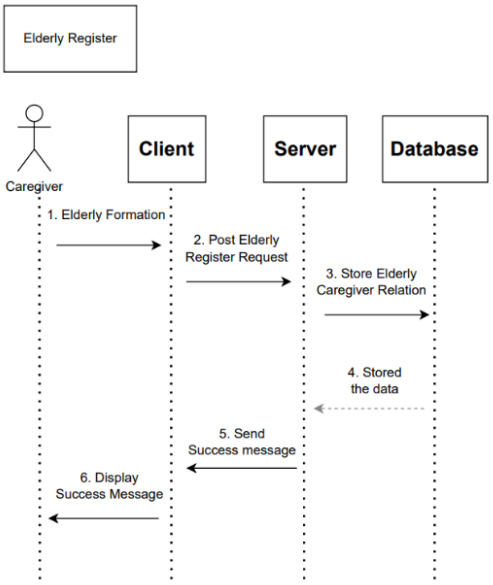


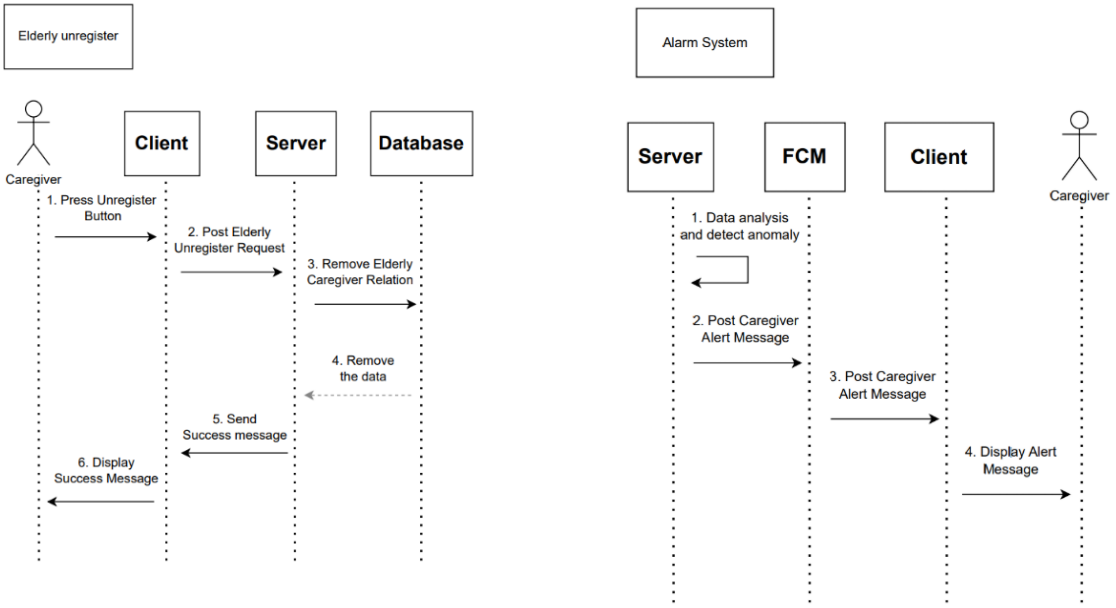



Logout
User
Client
Server
1. Press Logout Button
2. Post Logout Request
3. Check the token and expire token
4. Send Success Message
8. Display Logout Page


Sensor Data
Sensor
Server
Database
1. Give Measured Data
2. data analysis and encrypt data
3. Store encrypted data
4. Stored the data


Monitoring Real-Time/Statistics Data
Caregiver
Client
Server
Database
1. Enter Monitoring Page
2. Get Elderly Data request
3. Get Elderly data
4. Eldelry Data
5. Send data
6. Display Page


Elderly Register
Caregiver
Client
Server
Database
1. Elderly Formation
2. Post Elderly Register Request
3. Store Elderly Caregiver Relation
4. Stored the data
5. Send Success message
6. Display Success Message



4. 5. 2. Design concerns

- Real-time interaction
  - Data collected from IoT sensors must be transmitted in real time to servers and clients, and caregivers must be notified immediately in the event of an emergency.
- Seamless communication
  - All components within the system must communicate seamlessly without data loss, and in case of network failure, data must be stored locally and automatically synchronized after the connection is restored.
- Data flow transparency
  - The flow of data must be clearly defined so that it can explain how data is processed and transmitted at each step.

4. 5. 3. Relevant requirements

4. 5. 3. 1. Functional requirements

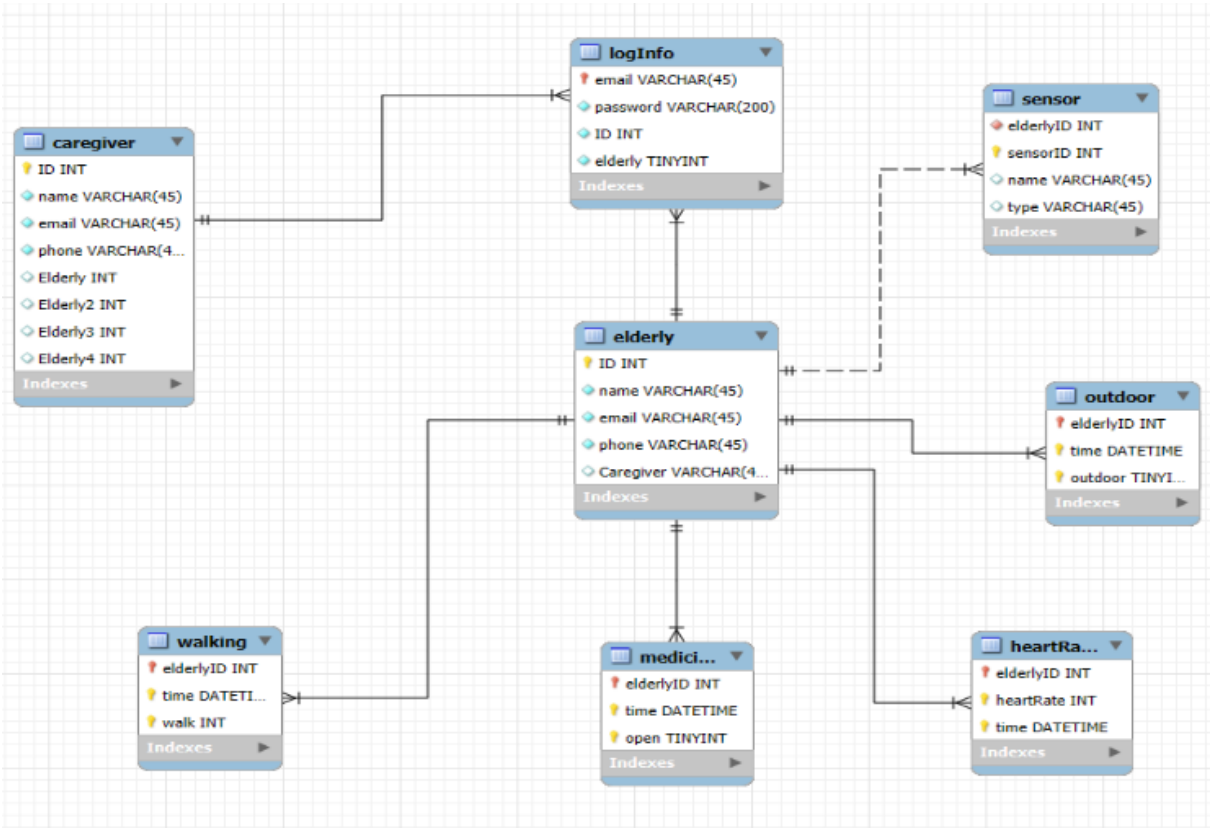
- Send alerts to caregivers when abnormal conditions occur after analyzing sensor data.
- Sending real-time data to the server at 1-second intervals
- In case of network failure, data is stored locally and then recovered and synchronized to the server.

4. 5. 3. 2. Non-functional requirements

- Data processing and notification delivery must be done in real time.
- The user interface should be intuitive, easy to use, and continuously improved through feedback.
- When performing system maintenance, procedures must be provided to notify users in advance and minimize the impact.
- The system must be able to handle more than 1,000 concurrent users.

4. 6. Information viewpoint (ER diagram)

4. 6. 1. Entity-Relationship Model



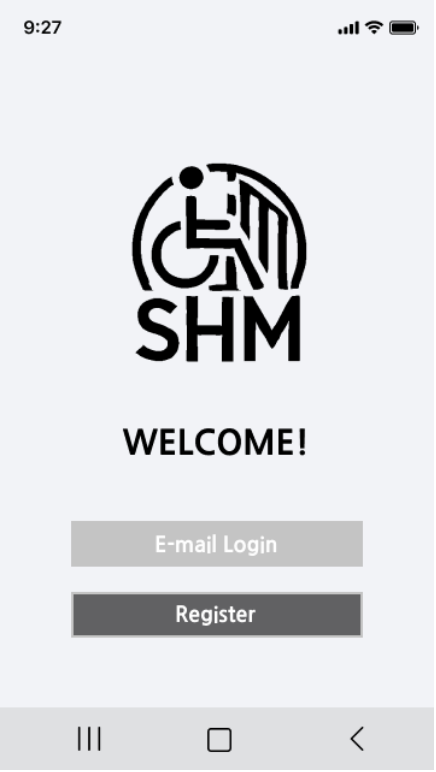
4. 6. 2. Design concerns

- Eliminates duplication and omission through unique constraints and not null constraints.
- Increases efficiency in input/output by accessing using ID columns.
- Access is possible through IDs between each entity, and data consistency is maintained using foreign key constraints.

5. Appendix

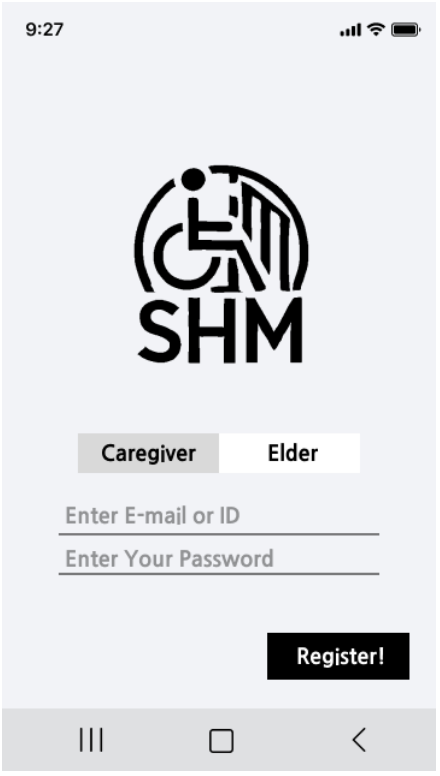
5. 1. Software prototype design

5. 1. 1. Welcome Screen

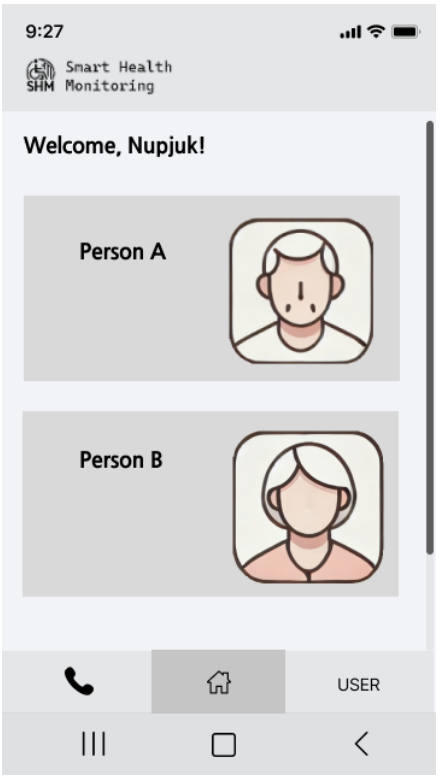


5. 1. 2. Login Screen

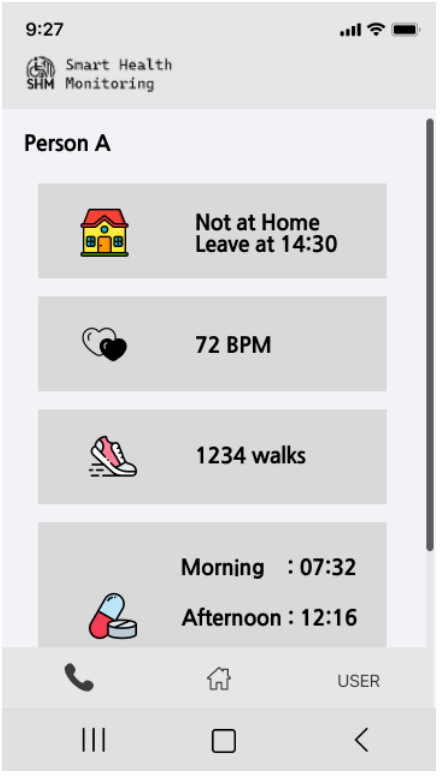
5. 1. 3. SignUp Screen



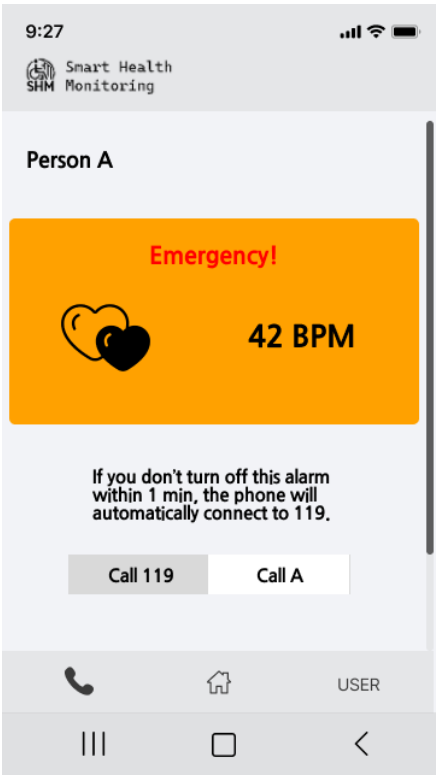
5. 1. 4. Home Screen



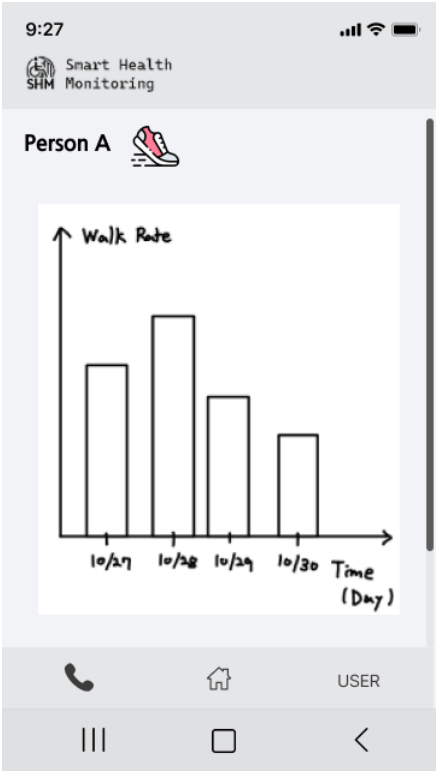
5. 1. 5. Elderly Health Monitoring Screen



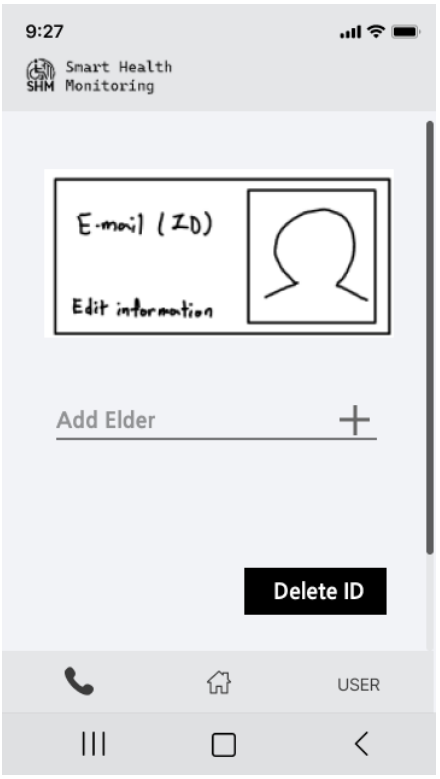
5. 1. 6. Heart Rate Statistics Screen



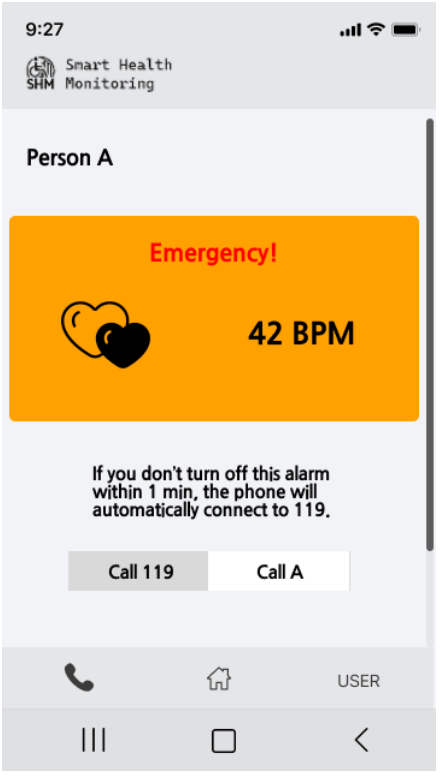
5. 1. 7. Step Count Statistics Screen



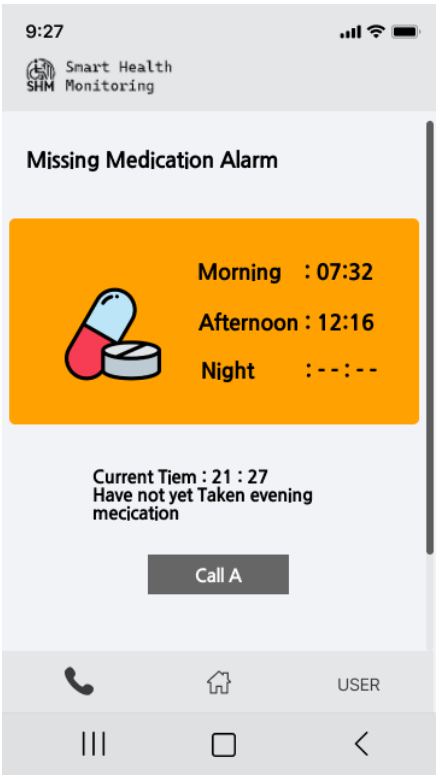
5. 1. 8. User Tab Screen



5. 1. 9. Heart Rate Emergency Screen



5. 1. 10. Missed Medication Alarm



5. 1. 11. Exit Alarm