Project Documentation

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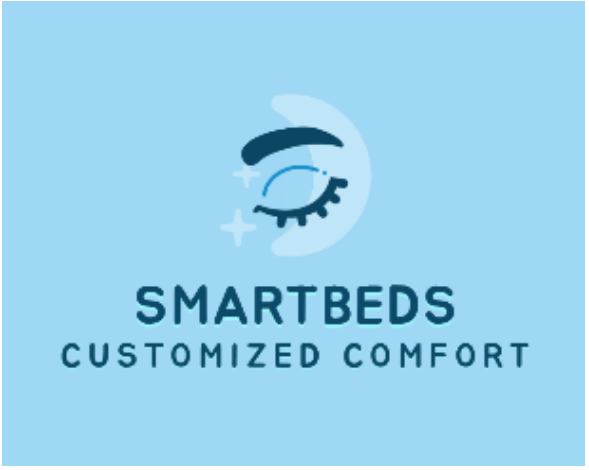

List of Content

1. Formal Content

1.1 Topic

Development of an intelligent bed system with multifunctional smart home integration to increase sleeping comfort and quality of life.

1.2 Purpose

The project aims to improve users comfort and sleep quality by offering individual temperature regulation and other smart functions. This system is intended to serve as an innovative smart home product to meet the needs of the modern market.

1.3 Workshare list

- Dennis Nickolay
    - Writing and merging project documentation
    - Correction of the description of the domain context of BBs business
    - Team project stakeholders
    - Relationships between team project stakeholders
    - Description of the team project domain and context
    - Possible constraints of the team project
    - Cross reference list
    - Requirements
        - REQ-001, REQ-001.1, REQ-001.2, REQ-001.3
        - REQ-002, REQ-002.1, REQ-002.2, REQ-002.3
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- Can Yilmaz
    - Use cases
    - DFD diagram
    - UML Use case diagram
    - Requirements
        - REQ-004, REQ-004.1, REQ-004.2, REQ-004.3

- Jonas
    - UML State diagram
    - UML Activity diagram
    - UML Class diagram
    - Requirements
        - REQ-006, REQ-006.1, REQ-006.2

- Marius Ureche
    - Stakeholder of the BBs business
    - Relationship between the stakeholders of the BBs business
    - Description of the domain context of the BBs business
    - Personas
    - Poster
    - Goal of the stakeholders
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        - REQ-005, REQ-005.1, REQ-005.2
- Stephane Sandevski
    - Prototype (with user flow)
    - UI Prototype description
    - Kano evaluation of key requirements
    - Requirements
        - REQ-003, REQ-003.1, REQ-003.2

2. Context of BB Business

2.1 Stakeholders

- Bob Builder (Owner and Decision Maker)
- Construction Company (BBB)
- Business Consultant
- IT Service Provider
- Central Facility Management
- Suppliers
- Customers (Buyers of luxury houses and luxury hotels)
- Competitors

2.2 Relationship of the stakeholders

- **Bob Builder** is the decision-maker and leads the construction company.
  He has the vision to integrate smart home solutions into buildings and engages the business consultant as well as the team of software requirements engineers.
- **The Business Consultant** advises Bob Builder on implementing his vision and conducts cost-benefit analyses.
- **The IT Service Provider** is hired by Bob Builder to deliver the necessary software and hardware for smart home solutions.
- **Central Facility Management** oversees the smart home system (SHS) equipment.
- **Suppliers** are responsible for providing building materials and other resources.
- **Customers** are the buyers of luxury houses and luxury hotels.
  Their needs and requirements for smart home solutions are crucial for the success of BB's business.
- **Competitors** influence the market and push BB to offer innovative solutions

2.3 Context and Domain description

Domain Description

BB Business is a company specializing in the construction of luxury properties including exclusive homes and hotels in Central Europe. The company places great emphasis on high-quality materials, modern design and first-class amenities to serve an affluent and discerning clientele. The focus is on creating luxurious living and vacation experiences that combine the highest levels of comfort and innovative technologies.

Context

In recent years, BB Business has seen declining profits due to increasing competitive pressures and technological innovations. In order to stand out and increase the attractiveness of its properties, the company relies on the integration of smart home solutions. These are intended to raise luxury standards, improve user comfort and increase both customer satisfaction and profit margins through technologies such as intelligent heating and cooling systems and connected devices.

3. Context of the team project topic

3.1 Stakeholders

Internal

- **SmartBeds** is responsible for the development of the Smart Bed system, including the technical and functional requirements.
- **Project Manager** coordinates activities and ensures that the project is carried out according to plan and requirements.
- **Marketing and Sales Team** develops marketing strategies and promotions for the Smart Bed.
- The **Technical Team** is responsible for implementing the software and hardware components of the Smart Bed system.

External

- **BB Business** is the hotel company that wants to integrate the smart bed system into its hotels in order to stand out from competition.
- **IT service provider** offers technical support in software development and integration of the smart bed system.
- **Smart Home Solution Provide**r delivers compatible devices required for smart bed technology.
- **Customers** are the end users of the Smart Bed system in BB Business hotels.
- **Regulatory authorities** ensure that all legal requirements are met, for example regarding data protection and technical standards.

3.2 Relationships of the stakeholders

Internal

- **SmartBeds and Project Manager**:
    - **Relationship**: The Project Manager coordinates the activities of the SmartBeds team and ensures that the project is carried out according to plan, requirements, and timelines. They ensure effective collaboration between all internal stakeholders.The Project Manager coordinates the activities of the SmartBeds team and ensures that the project is carried out according to plan, requirements, and timelines. They ensure effective collaboration between all internal stakeholders.

- **SmartBeds and Marketing and Sales Team**:
    - **Relationship**: The Marketing and Sales Team works closely with SmartBeds to develop appropriate marketing strategies and promotional activities for the Smart Bed. The Marketing Team relies on input from SmartBeds regarding the product features and unique selling points (USP).The Marketing and Sales Team works closely with SmartBeds to develop appropriate marketing strategies and promotional activities for the Smart Bed. The Marketing Team relies on input from SmartBeds regarding the product features and unique selling points (USP).

- **SmartBeds and Technical Team**:
    - **Relationship**: The Technical Team is responsible for implementing the software and hardware components of the Smart-Bed system. SmartBeds provides the functional and technical requirements, while the Technical Team brings the product vision to life.

External

- **BB Business and SmartBeds**:
    - **Relationship**: BB Business commissions SmartBeds to develop a custom Smart-Bed system for their hotels. BB Business provides the requirements and works closely with SmartBeds to ensure the system meets their objectives and delivers value to hotel guests.

- **BB Business and IT Service Provider**:
    - **Relationship**: BB Business collaborates with the IT service provider to ensure the smooth technical integration of the Smart-Bed system into their hotels. The IT service provider supports the software development and provides necessary infrastructure components.

- **BB Business and Smart Home Solution Provider**:
    - **Relationship**: BB Business sources smart home devices from external providers, which are needed for the Smart-Bed technology. The Smart Home Solution Provider ensures compatibility between their devices and the system developed by SmartBeds.

- **SmartBeds and Customers**:
    - **Relationship**: The customers (hotel guests) are the end users of the Smart-Bed system. SmartBeds designs the product based on the needs and expectations of hotel guests to maximize comfort and satisfaction.

- **BB Business and Customers**:
    - **Relationship**: BB Business provides the Smart-Bed system to its hotel guests to enhance their sleep quality and overall guest experience. Satisfied customers lead to increased customer loyalty and, in turn, higher revenue for BB Business.

- **BB Business and Regulatory Authorities**:
    - **Relationship**: BB Business ensures that all legal requirements, including data protection regulations and technical standards, are met for the Smart-Bed system. Regulatory authorities oversee compliance and ensure that the product adheres to necessary standards.

- **SmartBeds and Regulatory Authorities**:
    - **Relationship**: SmartBeds must ensure that all components and systems of the Smart-Bed comply with applicable legal requirements, particularly regarding data privacy, security, and technical standards.

3.3 Goals of the stakeholders

Stakeholder 1: Bob Builder (Owner/CEO)

- **Goal 1:** Increase company profits by expanding the product portfolio to include Smart-Beds.
- **Goal 2:** Establish the company as a leading provider of luxury apartments and hotels with innovative smart home solutions in Central Europe.

Stakeholder 2: Customers

- **Goal 1:** Enhance sleep comfort and quality through the personalized features of the Smart-Bed.
- **Goal 2:** Ensure simple and intuitive operation of the Smart-Bed via a user-friendly app.

3.4 Context and Domain description

Domain Description

The project domain is the Smart Home System, an area focused on integrating intelligent technologies into the home environment to improve comfort, convenience, and quality of life. This domain encompasses various technologies that automate and optimize tasks within a home, such as temperature regulation, security, and health monitoring. Smart homes use interconnected devices that communicate with each other, often through a central system or app, allowing users to control and monitor their living space remotely.

Context

In the specific context of our team project, the product we developed is called “SmartBed”. This product was developed as part of a project commissioned by BB Business, a hotel company facing increasing competition and declining profits. To differentiate itself from competitors and enhance guest experiences, BB Business wanted to integrate a Smart Home solution into their hotels. The SmartBed system was designed to provide personalized sleep comfort by integrating temperature-regulating functions into the mattress, controlled via a user-friendly app. This app allows guests to adjust the mattress temperature to their preference and also includes a profile system that enables multiple users to have personalized settings. Additionally, the SmartBed system offers a range of features aimed at improving sleep quality, including detailed sleep analysis to help guests monitor and optimize their rest.

3.5 Personas

Persona 1: Walter Schwarz

- **Age:** 35 years
- **Hobbies:** Reading, relaxing
- **Challenges:** Insomnia, dissatisfaction with standard mattresses
- **Goals:** Improve rest and sleep quality
- **Reason for development:** This Person fits well in the profile of our product SmartBed, as they suffer from insomnia, which our product can effectively counteract.

Persona 2: Anna Becker

- **Age:** 42 years
- **Hobbies:** Yoga, keeping up with tech trends
- **Challenges:** Increased sensitivity to temperature changes
- **Goals:** Achieve maximum sleep quality and monitor health metrics
- **Reason for development:** This Person fits well in the profile of our product SmartBed, because of her issues with temperature sensitivity, which our product can effectively counteract.

Persona 3: Markus Klein

- **Age:** 50 years
- **Hobbies:** Commuting for work, wellness activities
- **Challenges:** Back pain caused by improper sleeping posture
- **Goals:** Obtain ergonomic support during sleep
- **Reason for development:** This Person fits well in the profile of our product SmartBed, because of his back pain. Our product provides an adjustable position of the mattress which counteracts his back pain.

3.6 Possible constraints

Technological limitations: Integrating precise temperature sensors and heating / cooling elements into the mattress could be complex and expensive.

Ease of use: Developing an app that is easy to use yet offers comprehensive controls requires careful UX design.

Safety Requirements: Electrical components in a mattress must meet strict safety standards to prevent overheating or short circuits.

Energy consumption: The continuous cooling and heating function could cause increased electricity consumption, which could contradict the sustainability goals of the smart home system.

3.7 Poster

Smart Beds is a pioneering company dedicated to enhancing sleep through advanced technology. Our mission is to create innovative sleep solutions that improve health and well-being.

Objectives

- Enhance Sleep Health: Promote better sleep patterns and recovery.
- Elevate User Experience: Create a seamless, enjoyable sleep environment.
- Increase Market Share: Capture a larger segment of the sleep tech market.
- Drive Customer Loyalty: Build a community of satisfied users through exceptional service.

Solutions

- Smart Technology: Features sleep tracking, temperature control, and automatic adjustments for optimal comfort.
- Comfort Features: Customizable firmness levels to cater to individual preferences.
- User-Friendly App: Offers personalized insights, sleep scores, and recommendations for improvement.
- Sustainability: Utilizes eco-friendly materials and sustainable production practices.

4. Requirements for the team project topic

4.1 System Level 0 Requirements

ID: REQ-001
Title: Mattress Synchronization via App (Sleep Connect)
Requirement: The SmartBed system shall synchronize with the other mattresses in the network to provide a consistent sleep experience through the "Sleep Connect" feature in the app.

ID: REQ-002
Title: Wake-Up Function via Integrated Speaker
Requirement: The SmartBed system shall activate the integrated speaker to play an alarm sound to wake up the user.

ID: REQ-003
Title: Adjustable Mattress Temperature Function
Requirement: The SmartBed system shall adjust the mattress temperature to provide the user-specified level of warmth or cooling when the desired temperature is set through the app.

ID: REQ-004
Title: SmartBed Height Adjustability
Requirement: The SmartBed system shall adjust the height of the SmartBed in response to user input, ensuring precise and customizable elevation control.

ID: REQ-005
Title: Control mattress settings via the app
Requirement: The SmartBed system should enable the user to adjust mattress settings such as firmness, temperature, and other comfort features via the app.

ID: REQ-006
Title: Visualization of sleep data
Requirement: The SmartBed system should display the user’s collected sleep data, such as sleep duration, sleep stages, and heart rate, in the app.

4.2 System Level 1 Requirements

ID: REQ-001.1
Title: Mattress Synchronization Control
Requirement: The Bed Synchronization subsystem shall manage the connection and synchronization process between the SmartBed and other mattresses in the network to ensure consistent sleep settings through the “Sleep Connect” feature.

ID: REQ-001.2
Title: Communication Protocol Handling
Requirement: The Bed Synchronization subsystem shall implement communication protocols (Bluetooth and Wi-Fi) to establish and maintain secure, stable connections between the SmartBed and other mattresses in the network.

ID: REQ-001.3
Title: Sleep Setting Consistency Enforcement
Requirement: The Bed Synchronization subsystem shall enforce consistent sleep-related settings (e.g., firmness, temperature, and position presets) across all connected mattresses to provide a unified sleep experience through the “Sleep Connect” feature.

ID: REQ-002.1
Title: Alarm Sound Playback
Requirement: The Wake Mechanism subsystem shall play the configured alarm sound through the integrated speaker when the wake-up time is reached to wake up the user effectively.

ID: REQ-002.2
Title: Wake-Up Time Monitoring
Requirement: The Wake Mechanism subsystem shall monitor the configured wake-up time and activate the alarm sound playback when the specified time is reached.

ID: REQ-002.3
Title: User Alarm Configuration Handling
Requirement: The Wake Mechanism subsystem shall support user configuration of alarm parameters, including sound type, volume, and wake-up time, and save these settings for activation at the specified time.

ID: REQ-003.1
Title: Temperature Adjustment
Requirement: The Temperature Regulation subsystem shall adjust the mattress heating or cooling elements to achieve the user-defined temperature setting.

ID: REQ-003.2
Title: Temperature Monitoring and Maintenance
Requirement: The Temperature Regulation subsystem shall monitor the mattress temperature and dynamically regulate the heating or cooling elements to maintain the user-specified temperature consistently.

ID: REQ-003.3
Title: User Temperature Configuration Handling
Requirement: The Temperature Regulation subsystem shall allow users to configure and save their desired mattress temperature settings via the mobile app and adjust the mattress temperature accordingly.

ID: REQ-004.1
Title: Height Adjustment Subsystem Control
Requirement: The subsystem shall accept height adjustment commands via the mobile app and manual controls.

ID: REQ-004.2
Title: Obstacle Detection and Safety
Requirement: The Height Adjustment subsystem shall detect potential obstacles in the adjustment path and automatically stop or reverse the adjustment to prevent damage or injury.

ID: REQ-004.3
Title: Height Adjustment Feedback
Requirement: The Height Adjustment subsystem shall provide real-time feedback to the user through the app, indicating the current height of the SmartBed and confirming when the desired height adjustment has been successfully achieved.

ID: REQ-005.1
Title: Mattress Settings Adjustment Interface
Requirement: The Smart Control subsystem should provide an intuitive interface in the app that enables the user to adjust mattress settings such as firmness, temperature, and other comfort features.

ID: REQ-005.2
Title: Real-Time Adjustment Feedback
Requirement: The Smart Control subsystem should provide real-time feedback in the app to confirm successful adjustments to mattress settings such as firmness and temperature.

ID: REQ-005.3
Title: User Preference Storage
Requirement: The Smart Control subsystem should store user-configured mattress settings, such as firmness and temperature, to automatically apply them during future sessions or upon system activation.

ID: REQ-006.1
Title: Data Collection and Transmission
Requirement: The Sleep Data subsystem should collect the user's sleep data, such as sleep duration, sleep stages, and heart rate, from the SmartBed sensors and transmit it to the app for visualization.

ID: REQ-006.2
Title: Data Visualization and Display
Requirement: The Sleep Data subsystem should display the collected sleep data in an easy-to-read format (graphs, charts, or numbers) on the app to allow the user to review their sleep performance.

ID: REQ-006.3
Title: Sleep Data Update
Requirement: The Sleep Data subsystem should automatically update the app's display with the latest sleep data after each completed sleep phase to ensure users have up-to-date information.

Cross reference list

System Level 0 ID	System Level 1 IDs
REQ-001	REQ-001.1, REQ-001.2, REQ-001.3
REQ-002	REQ-002.1, REQ-002.2, REQ-002.3
REQ-003	REQ-003.1, REQ-003.2, REQ-003.3
REQ-004	REQ-004.1, REQ-004.2, REQ-004.3
REQ-005	REQ-005.1, REQ-005.2, REQ-005.3
REQ-006	REQ-006.1, REQ-006.2, REQ-006.3

4.3 Use cases

1. Use Case
   - **Use Case Title**: 002 Wake User
   - **Goal in Context**: Activate the integrated speaker to wake the user with an alarm sound at the set time.
   - **Primary Actor**: User
   - **Scope**: Smartbed System
   - **Level**: Primary Task
   - **Story**: The user sets an alarm through the app. At the specified time, the system activates the integrated speaker to play the alarm sound, waking the user.
   - **Priority**: High
   - **Frequency**: Daily
   - **Open issues**: Should the system offer volume control or alternate wake-up sounds?

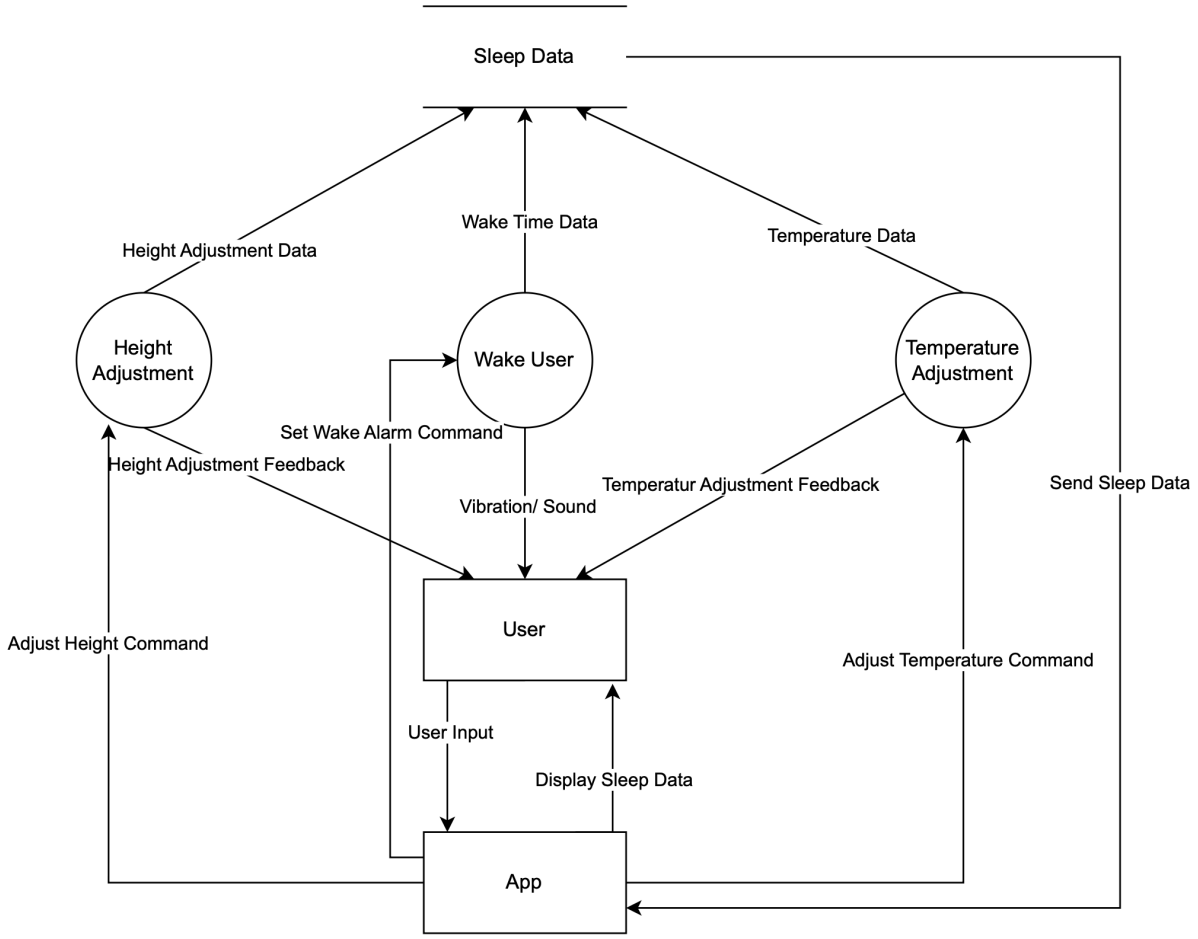
2. Use Case
   - **Use Case Title**: 002 Adjust Bed height
   - **Goal in Context**: Allow users to customize the bed height for comfort or accessibility.
   - **Primary Actor**: User
   - **Scope**: Smartbed System
   - **Level**: Primary Task
   - **Story**: The user navigates to the height adjustment feature in the app and sets their preferred height. The system adjusts the bed accordingly to achieve precise elevation.
   - **Priority**: High.
   - **Frequency**: Daily.
   - **Open issues**: Should the height adjustment be lockable to prevent accidents? What is the minimum and maximum range of the height adjustment?

3. Use Case
   - **Use Case Title**: 003 Adjust Bed temperature
   - **Goal in Contex**t: Provide the user with a personalized sleeping temperature
   - **Primary Acto**r: User
   - **Scope**: Smartbed System
   - **Level**: Primary Task
   - **Story**: The user opens the app and selects their desired Bed temperature. The system adjusts the Bed to the specified warmth or cooling level.
   - **Priority**: High.
   - **Frequency**: Daily.

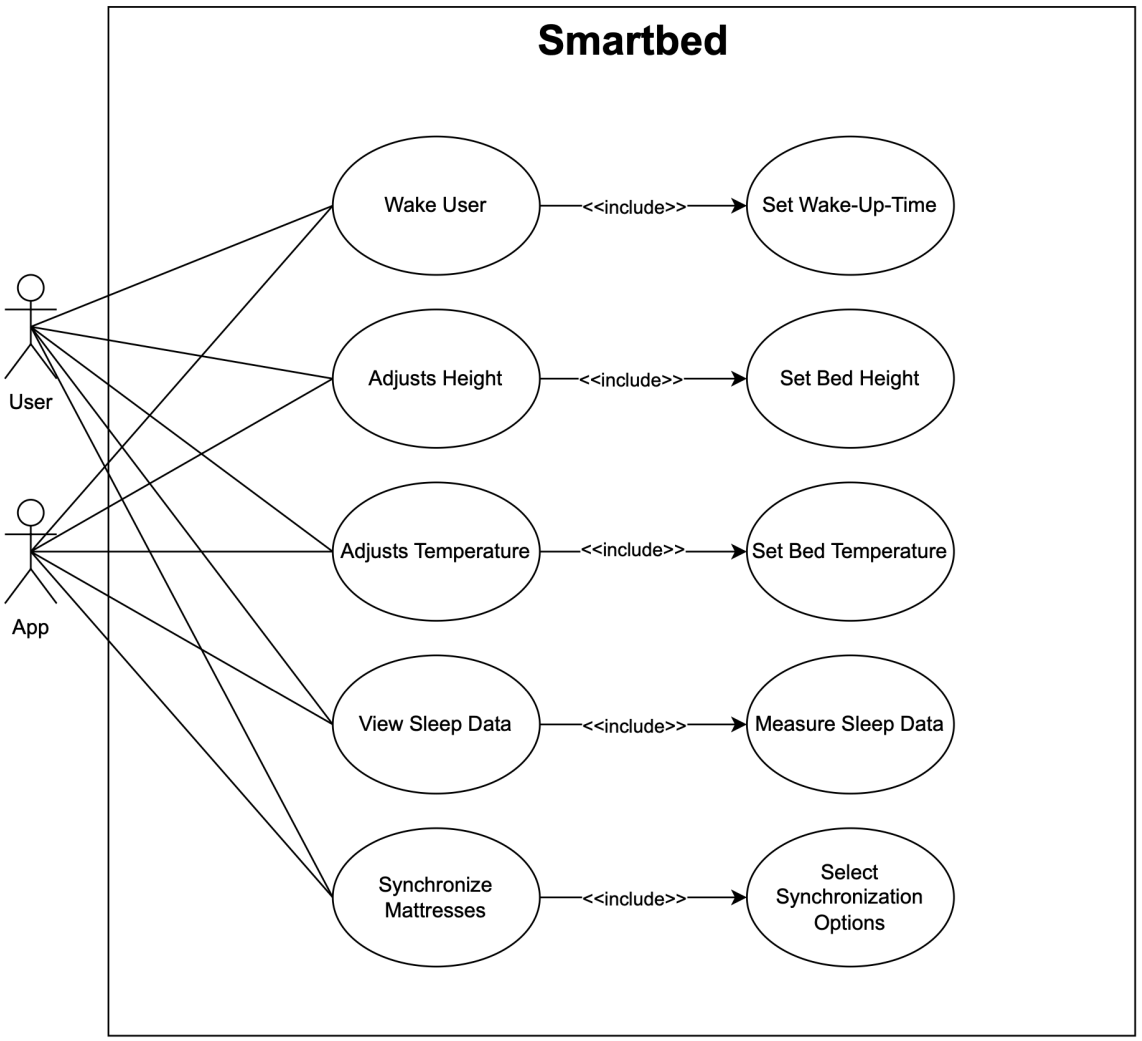
- **Open issues**: How does the system respond if the temperature setting conflicts with external conditions, such as extreme room temperatures?

5. Models and Diagrams

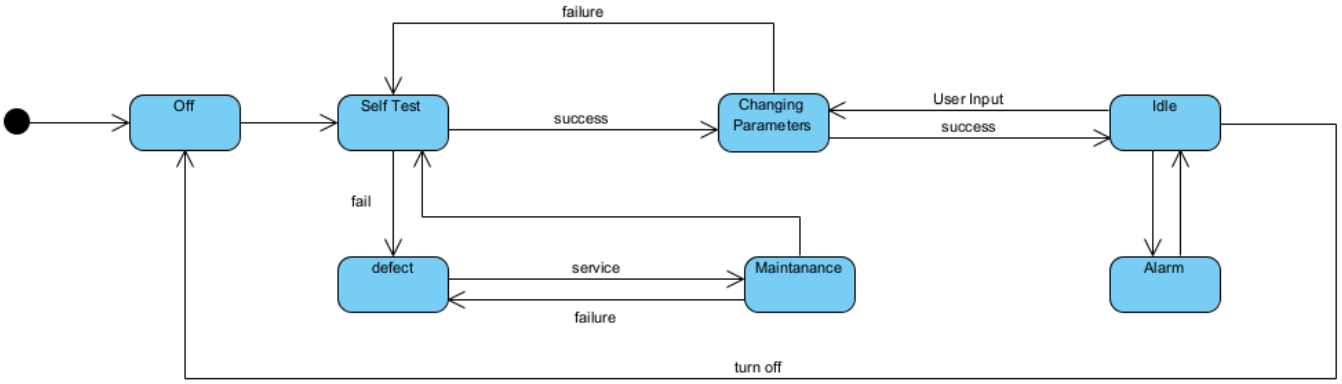
5.1 DFD (Data Flow) diagram



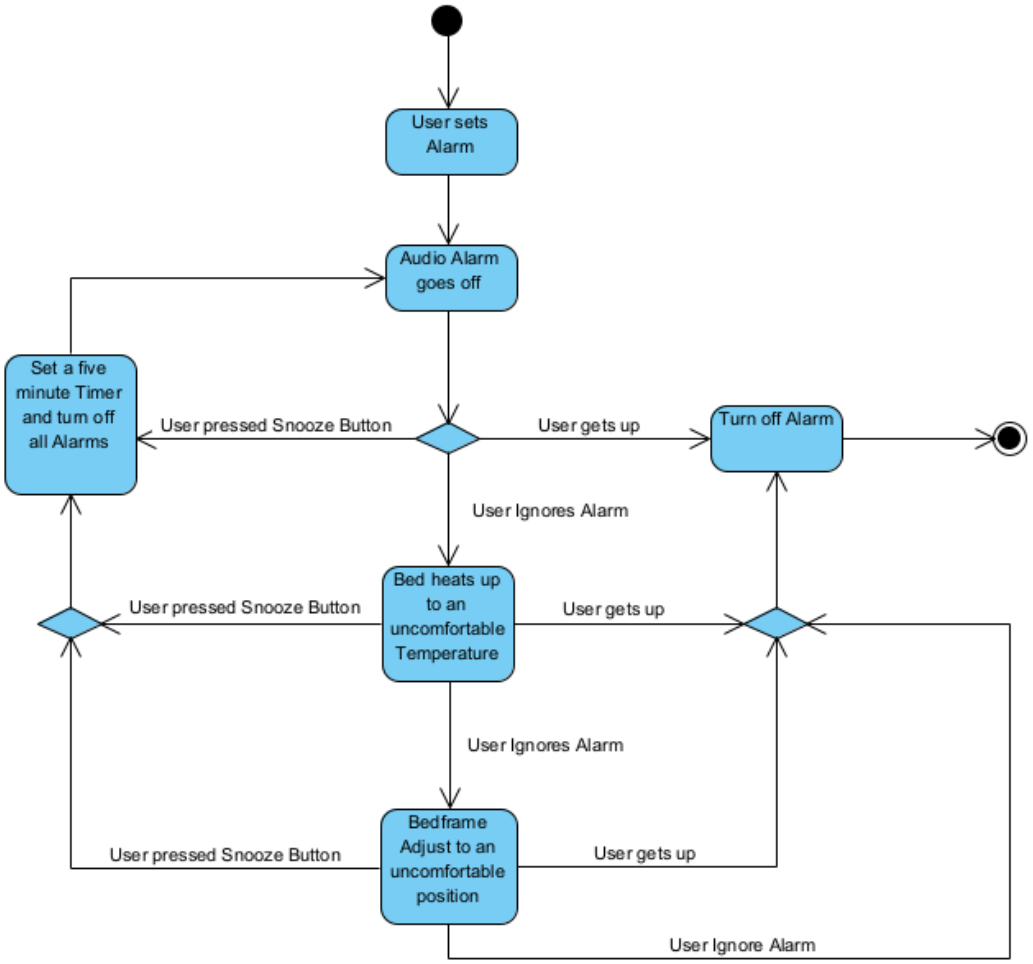
5.2 UML Use case diagram



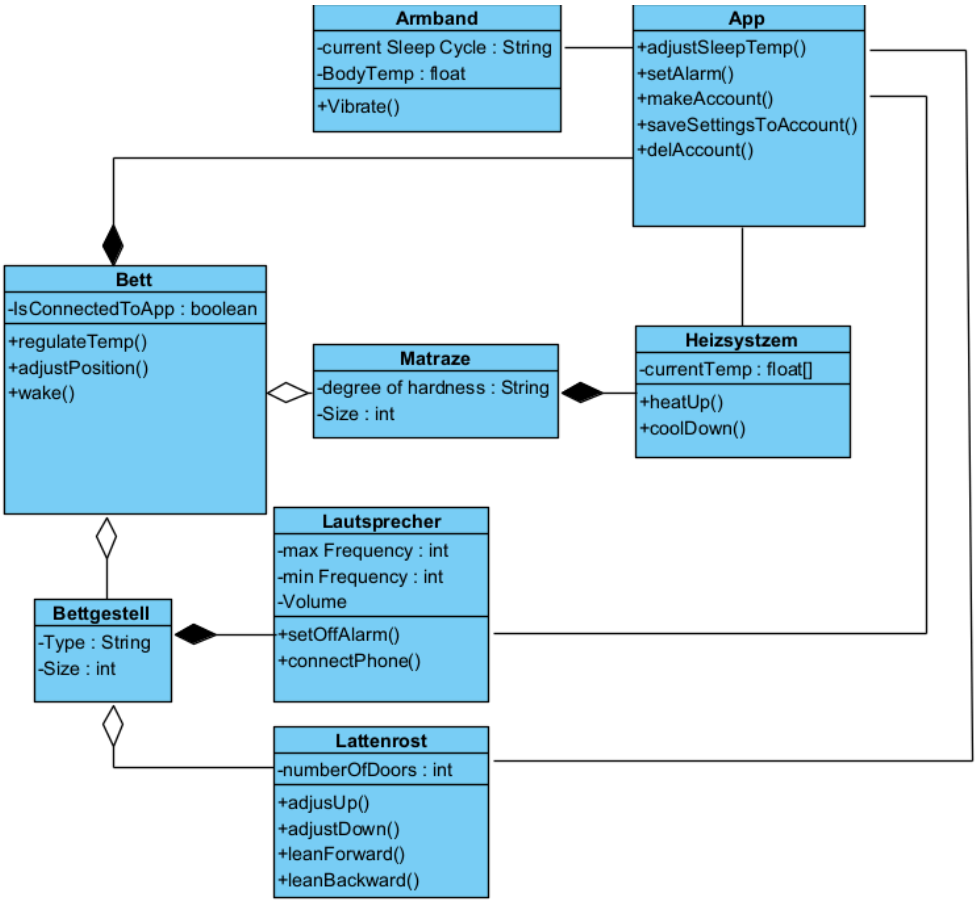
5.3 UML State diagram



5.4 UML Activity diagram

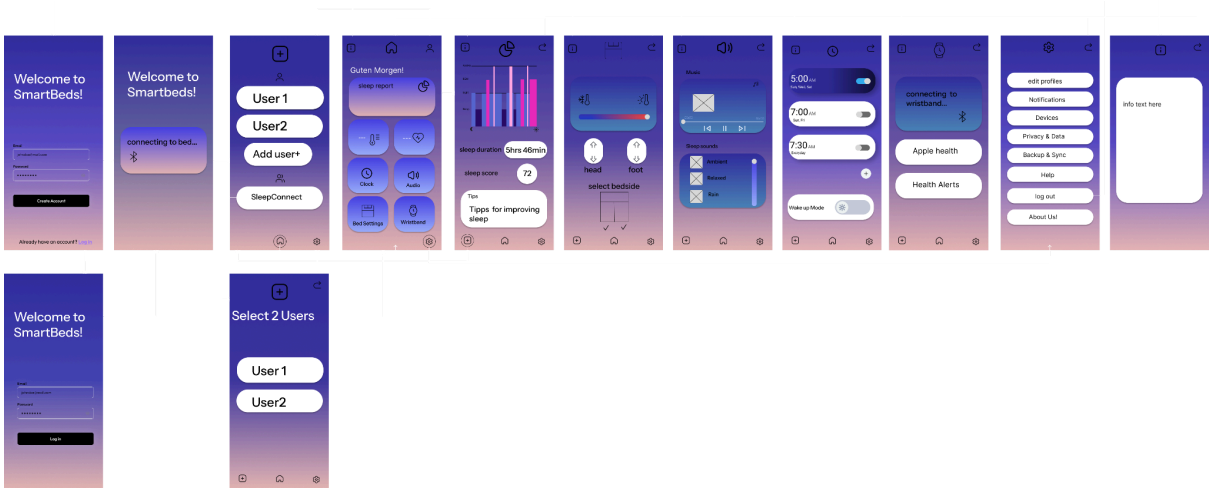


5.5 UML Class diagram



6. Prototype

6.1 Wireframe depiction of the User Interface



UI Prototype Description

Upon opening the SmartBeds app, the user is prompted to register. If they already have an account, they can log in directly. After logging in, the app connects to the SmartBed. Once the connection is established, the user can create profiles, which serve as default preferences. The *SleepConnect* option allows two users to share the same bed, so each side of the bed can have its own settings. To use this feature, the user simply selects two profiles and assigns them to the respective sides of the bed.

After setting up the preferences, the user enters the main menu, which combines all system functions. The options here include:

Sleep Report

The Sleep Report provides the user with detailed information about their sleep cycle through a graph.

Sleep Score: A value that shows the efficiency of sleep, with a scale from 1 to 100.

Sleep Duration: Indicates how long the user slept.

Tips: Offers suggestions on how to optimize sleep based on collected data.
The upper right arrow takes the user back to the main menu.

Bed Settings

The Bed Settings allow the user to select options for the bed itself.

Slide Bar: Adjusts how much the bed should be heated.

Head Elevation: Adjusts the angle of the head area for raising or lowering.

Foot Elevation: Adjusts the angle of the foot area for raising or lowering.

Select Bedside/Whole Bed: Allows the user to apply settings to the whole bed or just one side.
The upper right arrow takes the user back to the main menu.

Audio Settings

The Audio Settings enable the user to control the built-in speakers in the bed. Here, the user can select between playing their own music or pre-installed sleep sounds designed to aid in sleep optimization and relaxation.
The upper right arrow takes the user back to the main menu.

Clock

The Clock feature allows the user to set an alarm, which will be played through the SmartBed speakers.
The *Wake Up Mode* option can be toggled on or off. When enabled, it will trigger the alarm and also vibrate the wristband and raise the head elevation.
The upper right arrow takes the user back to the main menu.

Wristband Settings

The Wristband Settings allow the user to connect their wristband or smartwatch to the SmartBed app. This enables the measurement of heart rate, which is important for the Sleep Report. The User can also connect the Wristband with Apple Health and can enable Health Alert.
The upper right arrow takes the user back to the main menu

Settings

Settings include various functions that are important for the user:

Edit Profiles: Allows the user to edit or delete profiles.

Notifications: The user can decide whether they want to receive notifications.

Devices: Shows the connected devices.

Privacy & Data: The user can control whether their data can be used.

Backup & Sync: Setup for backup and synchronization.

Log Out: Allows the user to log out of the app.

About Us!: Provides information about the development team.

Information

The *Information* button provides specific details about each function in the app. When the user selects this button in any tab, it displays a unique information text that explains the respective feature in more detail.

6.2 Kano evaluation of the key requirements

User Requirement:
"As a user, I want to adjust the temperature of the bed according to my preference to ensure optimal sleep."

Functional Requirement:
"The system should allow the user to control the bed temperature at will using an app."

Basic Needs (Must-Have):
User Requirement: Temperature control is a must-have feature for a smart bed, especially since users expect a comfortable sleeping environment. The absence of this functionality would lead to significant dissatisfaction.
Functional Requirement: The basic functionality of a temperature control slider is considered essential. If users cannot adjust the temperature of the bed, it would negatively impact the app's usability and comfort.

Performance Needs (One-Dimensional):
User Requirement: Users expect the bed's temperature control to be precise and responsive. More refined control, such as setting specific temperatures (e.g., 18°C or 22°C), would lead to higher satisfaction.
Functional Requirement: A temperature range that includes both heating and cooling is a performance requirement. The more precise the control and the faster the temperature adjustment, the greater the user satisfaction.

Excitement Needs (Delighters):
User Requirement: An intelligent auto-regulation system that adjusts the bed's temperature based on the user's body temperature or the room's environment (e.g., detecting when the user feels too hot or cold and automatically adjusting the bed temperature).
Functional Requirement: Integration with weather conditions or adaptive sleep cycles could delight users. For example, the bed could automatically adjust its temperature based on external factors or personal preferences, providing a pleasant surprise for users.

User Requirement:

“As a user, I want the SmartBed to adjust its height smoothly and precisely according to my input via the app, ensuring safety and comfort, with the bed staying within predefined height limits."

Functional Requirement:

“The height Adjustment Subsystem shall adjust the height of the SmartBed in response to user input via the app, ensuring smooth, precise and safe elevation changes within predefined limits”

Basic Needs (Must-Have):

User Requirement:The SmartBed must be able to adjust the height of the head and foot areas based on user input through the app. This feature is a must-have, as it enables the user to customize the beds position for comfort or specific needs.
Functional Requirement: The system must accept user input from the app and adjust the height of the beds head and foot areas accordingly.

Performance Needs (One-Dimensional):

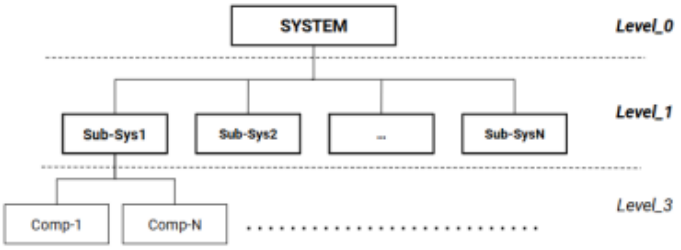
User Requirement:Users expect the beds height adjustment to be precise and responsive. The adjustment should occur without noticeable delays.
Functional Requirement: The system should allow precise control over the height, with the bed moving smoothly within a range of angles. The adjustment should occur quickly and quietly.

Excitement Needs (Delighters):

User Requirement: While not expected, it would be delightful for the bed to feature intelligent adjustments that consider user references, time of day, or external factors. For instance, the SmartBed could offer an automatic wake-up feature, when activated, the alarm goes off to wake the user up, and the head area of the bed is automatically raised to help the user ease into the day.
Functional Requirement: The system shall include an optional wake-up mode that, when activated, triggers an alarm to wake the user and simultaneously raises the head area of the bed.

7. Appendix

7.1 Glossary

Term	Definition
BB (Bobs Builder)	BB is an imaginary stakeholder of the team project.
SmartBeds	SmartBeds is an imaginary company which develops Smart-Home-Systems
REQ-XXX.n	Identification tag for requirement
System level 0	
System level 1	

7.2 Bibliography and sources

- Lectures L1-L11