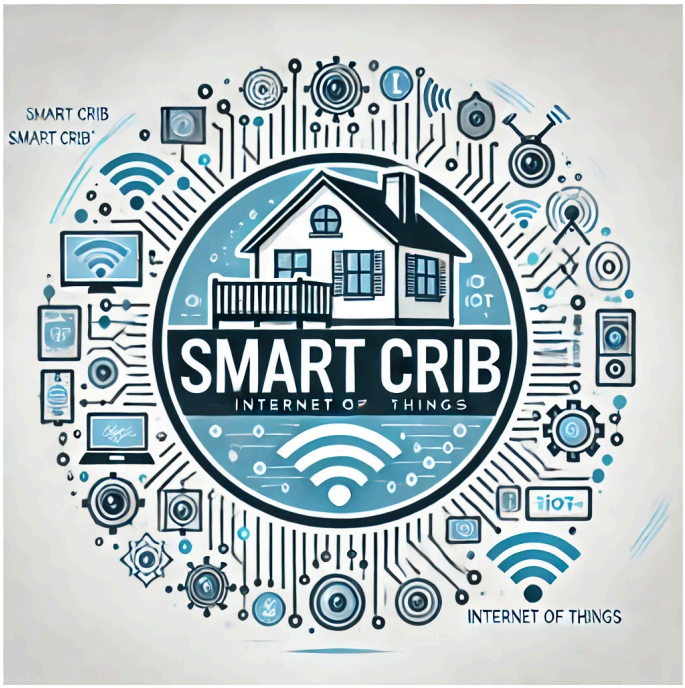
DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING THE
UNIVERSITY OF TEXAS AT ARLINGTON

SYSTEM REQUIREMENTS SPECIFICATION

CSE 4316: SENIOR DESIGN I

Summer 2024



SMARTCRIB

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REVISION HISTORY

Revision	Date	Author(s)	Description
0.1	07.14.2024	Don Dang, Luis Del Rio Carrillo, Zait Martinez, Pranav Pujar	document creation
1.0	07.15.2024	Don Dang	Complete Product Concept
1.1	07.15.2024	Don Dang	Complete Product Description
1.2	07.15.2024	Don Dang	Complete Customer Requirements
2.0	07.16.2024	Zait Martinez	Complete Package Requirements
3.1	07.17.2024	Don Dang	Completed Performance Requirements
3.2	07.18.2024	Luis Del Rio	Completed Safety Requirements
4.0	07.18.2024	Don Dang & Zait Martinez	Completed Maintenance & Support Requirements
4.1	07.18.2024	Pranav Pujar & Don Dang	Completed Other Requirements
4.2	07.19.2024	Don Dang	Completed Future Items
5.0	07.21.2024	Don Dang	Final document edit

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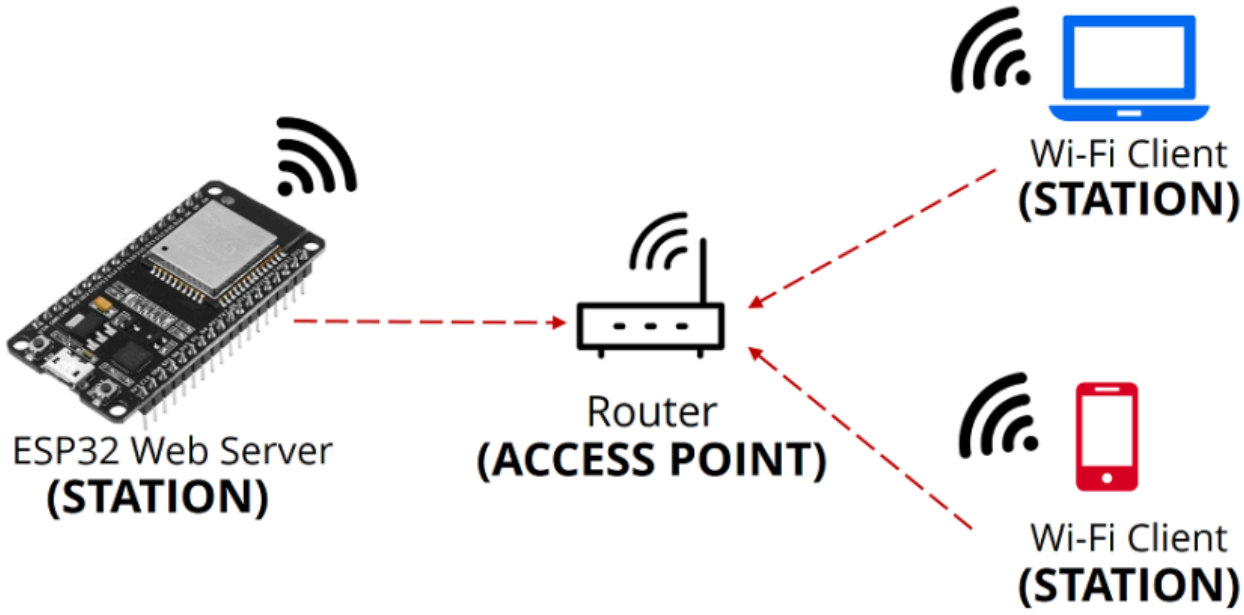
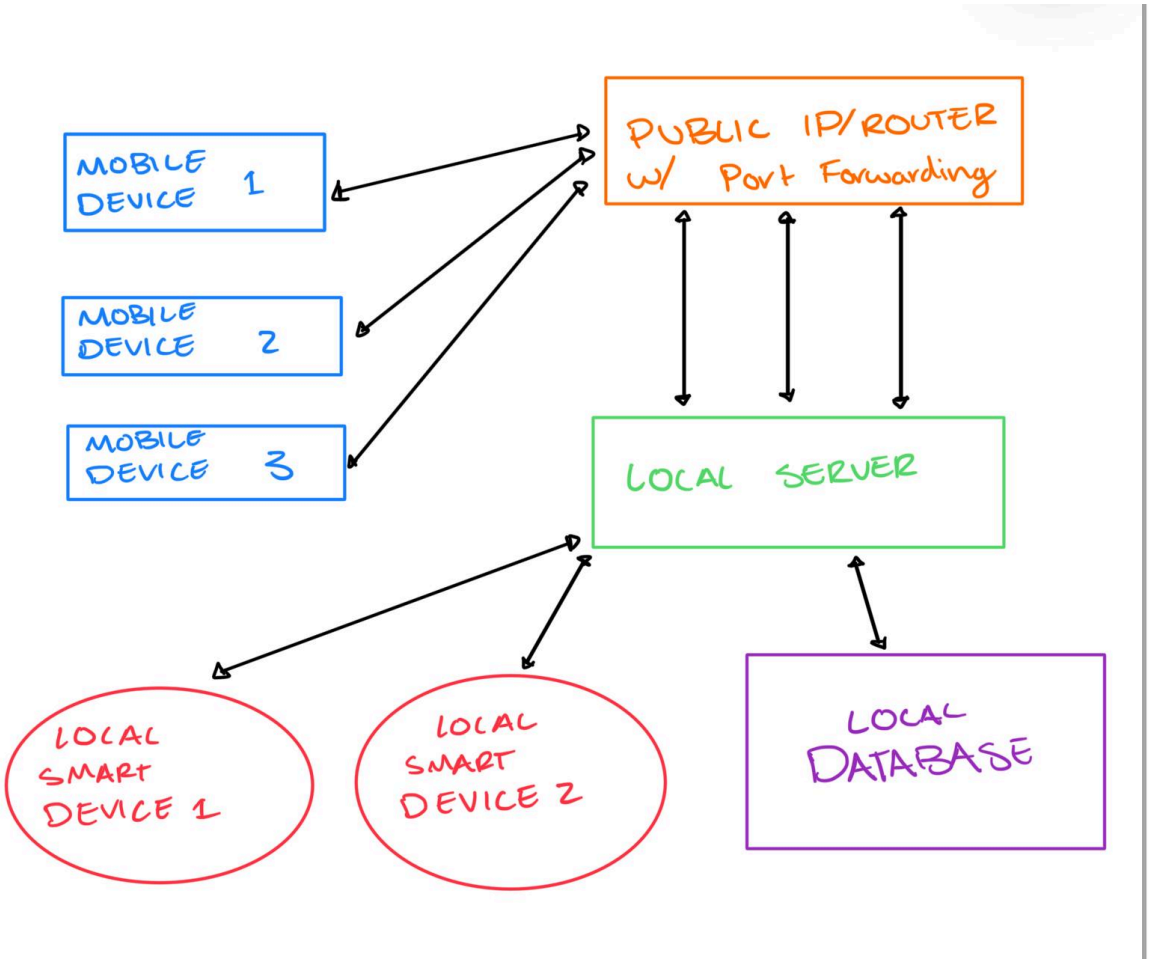
LIST OF FIGURES

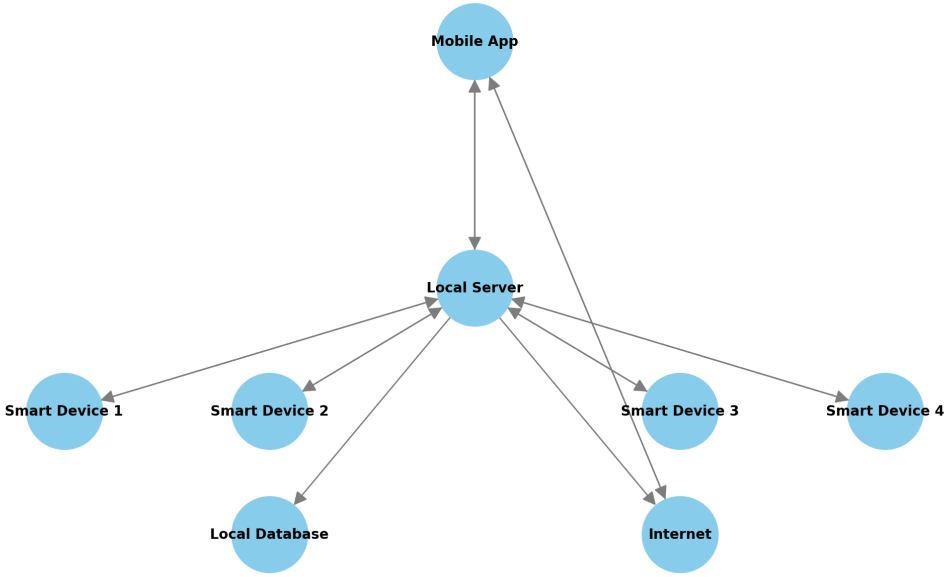
- Direct Control To Device Through Local Network Connection For Prototyping UI Application and Features.



-Centralized Server & Database Connecting All Localized Devices for Easier Device Expandability, with Internet Access Mobile Application allowing for Multiple Users



Conceptual Diagram of Smart Home System



1 PRODUCT CONCEPT

Our Product is a Smart Home system which will be built on multiple systems working together. This includes the user's Mobile application, a home wifi network, smart devices that connect to the local wifi network, and a local server along a local database. The Goal is to have a central server that is local, this will access both the database which contains data of all devices around the house, and the devices themselves. Through this local server the devices will be able to communicate with one another having access to the data on other devices will allow each and every device to adapt and change accordingly to make the home automation system a smooth operation where all devices are aware of any data that could be important to them. The local server will have internet access allowing Users to use a Mobile App to access all important data from the database. The user will then be able to adjust individual devices as desired. The system will allow for multiple users and multiple devices to be added. The design will make integration of new devices and features to further expand your home automation experience.

1.1 PURPOSE AND USE

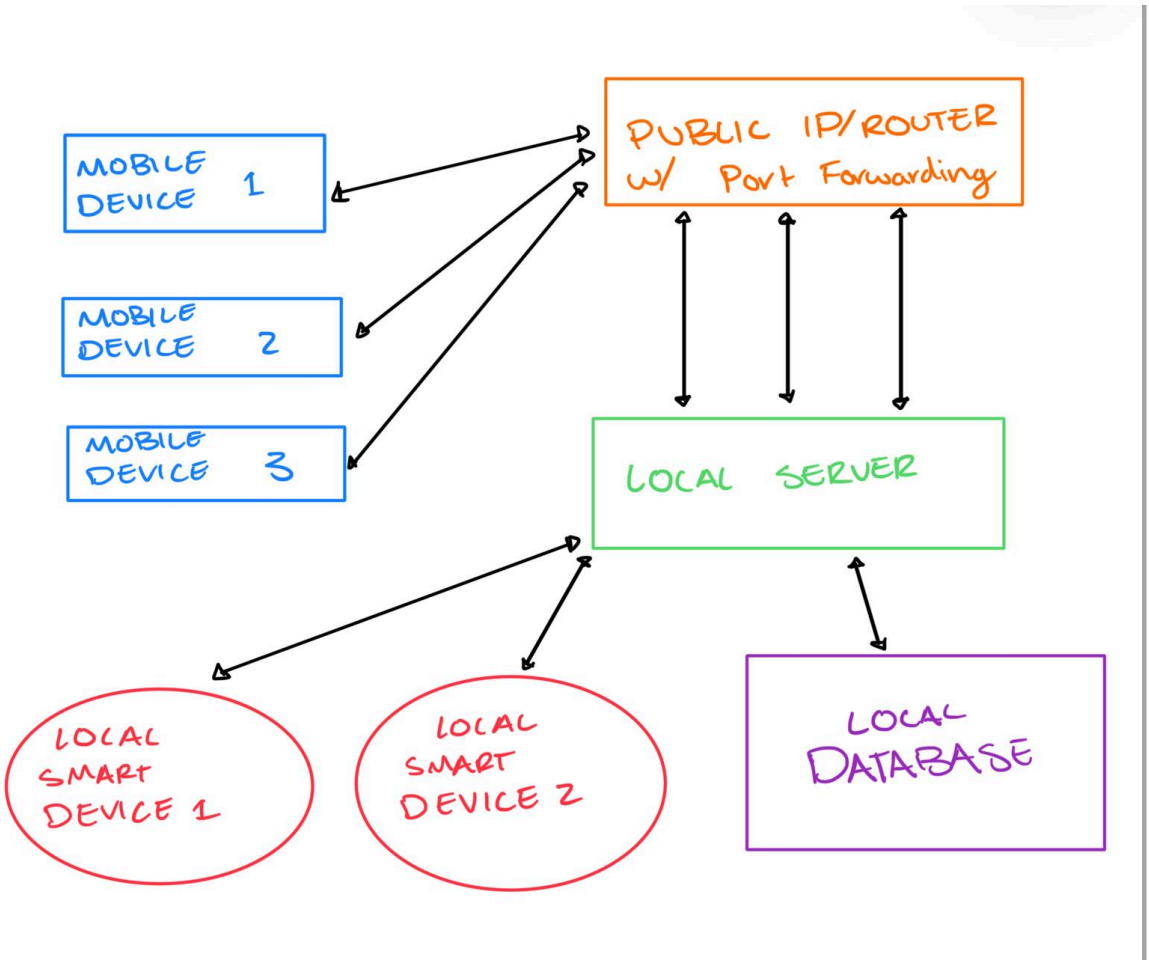
This is where you describe in a brief, yet clear and concise, manner what your product should do and how you expect it should be used.

The purpose of our System is to have a centralized/localized home automation network where all devices can communicate with one another shared data and even ask other devices to do things without the need for an internet connection (local wifi connection still necessary). Things will be automated and control of this system will be accessible through the local network or Via internet connection. However the goal is to rely as little as possible on the user for any tasks. It is meant to be a smooth coherent system to make the users day to day life easier, not to give the user the responsibility of controlling and orchestrating all the devices to work together which is what we see in today's smart home applications.

1.2 INTENDED AUDIENCE

The intended Audience is any homeowner or person living within the household. It is intended to be easy to use through a Mobile Phone app. The goal is to have a centralized Application where everything is located and controlled. Initial build will be general use but with the use of open source components it will allow others who are more tech savvy to possibly add their own custom devices.

Figure 1: Smart Light Device


MOBILE DEVICE 1
MOBILE DEVICE 2
MOBILE DEVICE 3
PUBLIC IP/ROUTER w/ Port Forwarding
LOCAL SERVER
LOCAL SMART DEVICE 1
LOCAL SMART DEVICE 2
LOCAL DATABASE

2 PRODUCT DESCRIPTION

The Smart Light Automation System is an innovative IoT solution designed to seamlessly integrate and control smart light bulbs in residential and commercial settings. This system allows users to automate lighting based on schedules, motion detection, and ambient light levels, providing optimal energy efficiency and convenience.

2.1 FEATURES & FUNCTIONS

Our Smart Home system is designed to create a seamless and automated home environment through the integration of various smart devices and a centralized local server.

Features:

- **Centralized Local Server:** Acts as the brain of the system, managing communication between devices and storing data locally.
- **Mobile Application:** Provides a user-friendly interface for users to monitor and control their smart home devices.
- **Smart Devices Integration:** Supports various smart devices (e.g., lights, thermostats, security cameras) that connect to the local Wi-Fi network and communicate with the central server.
- **Local Database:** Stores data from all connected devices, allowing the system to adapt and respond based on real-time information.
- **Internet Access:** Enables remote access and control of the system through the mobile application.

Functions:

- **Device Communication:** Allows devices to share data and execute commands based on information from other devices.
- **User Control:** Users can adjust device settings and automate routines via the mobile app.
- **Automation:** Automates tasks based on user preferences and device interactions, minimizing the need for manual intervention.

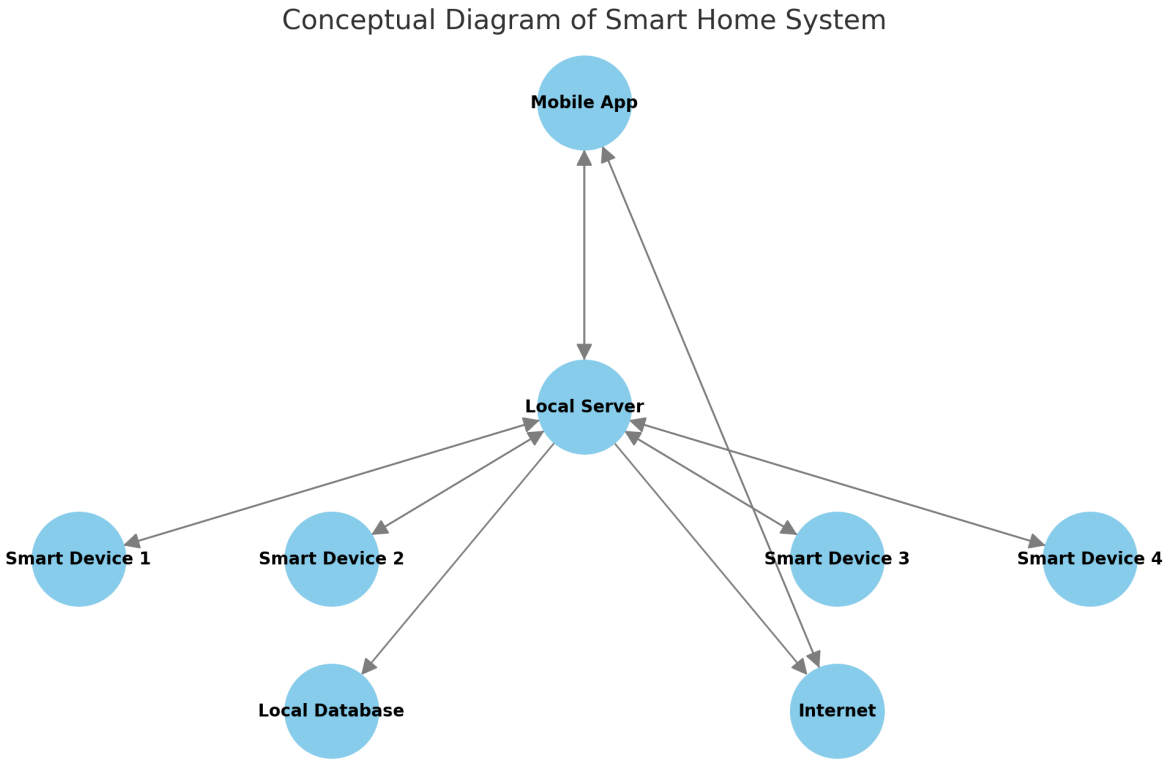


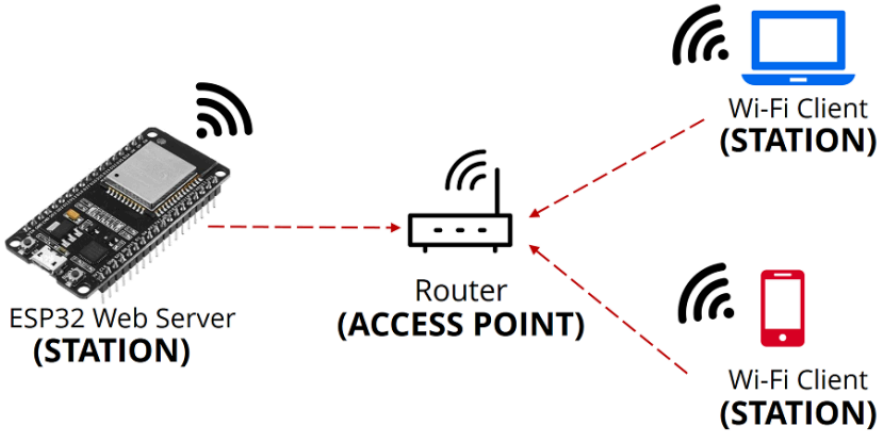
Diagram Explanation:

- **Central Server:** Local server managing data flow and device communication.
- **Smart Devices:** Includes lights, thermostats, cameras, etc. (the smart home component devices) connected via the local Wi-Fi network.
- **Mobile Application:** Interface for user interaction accessible locally or remotely.
- **External Elements:** Internet access for remote control, potential integration with third-party services.

2.2 External Input & Outputs

Name	Description	Use
User Commands	Instructions from the mobile app	Adjust device settings, trigger actions
Device Status	Real-time data from smart devices	Monitor device status, automate actions
Environmental Data	Sensor data (temperature, motion, etc.)	Trigger automated responses
Notifications	Alerts and updat es to the mobile app	Inform users of important events
Remote Commands	Instructions sent via the internet	Enable remote control
Device Data Logs	Historical data stored in the local database	Analyze trends, improve automation

2.3 Product Interface



The operational interfaces provide a user-friendly experience for end-users, administrators, and maintainers.

End-User Interface:

1. **Mobile Application Dashboard:** Displays an overview of all connected devices, current status, and controls for each device.
2. **Control Panels:** Interface for adjusting device settings, creating automation routines, and viewing notifications.
3. **Server Management Console:** Provides tools for managing the local server, monitoring system health, and troubleshooting.**Maintainer Interface:**
    1. **Maintenance Dashboard:** Interface for maintaining and updating the system, including device firmware updates and network management.
    2. These interfaces are designed to provide a seamless and intuitive user experience, ensuring that users can easily manage and control their smart home environment.

3 Customer Requirements

Customers require a Smart Light Automation System that offers seamless integration with existing smart home ecosystems, providing intuitive and user-friendly control via mobile apps or voice commands. They seek energy-efficient solutions with automated scheduling, motion detection, and ambient light sensing to enhance convenience and reduce electricity consumption. Additionally, robust security, regular software updates, and reliable customer support are essential to ensure a hassle-free and secure user experience.

3.1 Requirement Name

Centralized Local Server

3.1.1 Description

The central server will act as the primary hub for all device communications and data management within the Smart Home system. It will store data locally, ensuring that devices can operate independently of internet connectivity. The server will facilitate device-to-device communication, enabling seamless integration and automation of tasks.

- The server will be a dedicated hardware unit with sufficient processing power and storage capacity to handle multiple devices.

- It will have an intuitive user interface for system administrators to manage and configure the network.
- The server will be able to interface with the local database and mobile application, providing real-time updates and control options to the user.

3.1.2 Source

Customer feedback and requirements were gathered through brainstorming and collecting feedback on ideas from home owners and families, primarily from homeowners interested in home automation.

3.1.3 Constraints

Economic: The cost of the server hardware should be kept within budget constraints to ensure affordability.
Environmental: The server should have a low power consumption design to minimize the environmental footprint.
Social: The system should be user-friendly and accessible to all household members.
Political: Compliance with local and international data privacy regulations is mandatory.
Health & Safety: The server should meet safety standards to prevent overheating and electrical hazards.
Manufacturability: The server design should allow for scalable production.
Sustainability: Use of recyclable materials in the server's construction is encouraged.

3.1.4 Standards

- **IEEE 802.11:** For Wi-Fi communication.
- **IEEE 802.3:** For Ethernet connections.
- **NIST SP 800-53:** For data security and privacy controls.
- **UL 60950-1:** Safety standards for information technology equipment.

3.1.5 Priority

Critical (must have or product is a failure)

3.2 Requirement Name

Mobile Application Interface

3.2.1 Description

The mobile application will serve as the primary user interface for interacting with the Smart Home system. It will provide users with real-time control and monitoring capabilities over their smart devices. The app will be compatible with both iOS and Android platforms.

- The app will feature a dashboard displaying the status of all connected devices.
- Users will be able to configure and control individual devices, set up automation routines, and receive notifications.
- The interface will be intuitive and user-friendly, designed with accessibility in mind.

3.2.2 SOURCE

Customer feedback and requirements were gathered through brainstorming and collecting feedback on ideas from home owners and families, primarily from homeowners interested in home automation.

3.2.3 CONSTRAINTS

Economic: Development and maintenance costs must be managed to stay within the project budget.
Social: The app should be accessible to users with varying levels of technical proficiency.
Health & Safety: The app must be designed to prevent unauthorized access and ensure data security.
Manufacturability: The app should be developed using cross-platform frameworks to streamline updates and maintenance.

3.2.4 STANDARDS

ISO 9241-210: Ergonomics of human-system interaction.
WCAG 2.1: Web Content Accessibility Guidelines for ensuring app accessibility.
ISO/IEC 27001: Information security management standards.

3.2.5 PRIORITY

High (very important to customer acceptance, desirability)

4 PACKAGING REQUIREMENTS

The packaging requirements for Smart Crib focus on ensuring the hardware and software components are protected, reliable, and user-friendly following constraints and standards.

4.1 Hardware/Electronics

4.1.1 DESCRIPTION

The physical components for Smart Crib will include sensors, microcontrollers, communication modules, power supplies, and enclosures. These components must be packaged in a way that ensures durability, ease of installation, and protection against environmental factors e.g moisture, temperature, pressure, vibration, and chemicals

4.1.2 SOURCE

Components will be sourced from reputable suppliers known for high-quality electronics and IoT devices. Preferred suppliers include Mouser Electronics, Adafruit, Digi-Key, Vilros, Cana Kit, Micro Center

4.1.3 CONSTRAINTS

- Compliance: All components must comply with relevant safety and electromagnetic compatibility (EMC) standards
- Environmental Protection: The packaging must protect the hardware from dust, moisture, and potential physical damage.
- Size and Weight: The packaging should be compact and lightweight to facilitate easy deployment and handling.
- Heat Dissipation: Adequate ventilation or heat sinks should be included to manage heat generated by the electronics

4.1.4 STANDARDS

- IP (Ingress Protection) Ratings: Ensuring that the enclosures meet IP65 standards for dust and water resistance.
- RoHS (Restriction of Hazardoues Substances): Compliance with RoHS to limit the use of hazardous materials in the electronics
- UL (Underwriters Laboratories) Certification: Ensuring that components are UL certified for safety.

4.1.5 PRIORITY
High

4.2 Software

4.2.1 Description

The software component of Smart Crib includes the firmware for the devices, the backend server software, and the user interface. It must be developed and packaged to ensure security, scalability, and ease of deployment.

4.2.2 Source
Software tools and libraries will be sourced from trusted open-source communities and reputable software vendors. Primary sources include GitHub for open-source software and AWS or Azure for cloud services.

4.2.3 Constraints
- Security: The software must include robust security features to protect against unauthorized access and data breaches
- Scalability: The software architecture should support scaling to accommodate an increasing number of devices and data volume.
- Compatibility: The software must be compatible with various operating and hardware platforms.
- Licensing: Compliance with all software licensing agreements, particularly for open-source components

4.2.4 Standards
- ISO/IEC 27001: Information security management standards to ensure data protection.
- IEEE 802.15.4: Standards for low-rate wireless personal area networks to ensure reliable communication protocols.
- OWASP (Open Web Application Security Project): Best practices for secure web application development

4.2.5 Priority
High

5 PERFORMANCE REQUIREMENTS
The key performance requirements for Smart Crib include real-time processing to guarantee immediate data input responses, low power consumption to extend time in service and reduce maintenance costs, and high reliability to maintain continuous operation without failures. Strong connectivity is essential for seamless communication between devices and the central server, while scalability ensures the system can handle growth in devices and data volume.

5.1 Real-Time Processing

5.1.1 DESCRIPTION
The IoT system must process and respond to data inputs in real-time to ensure timely decision-making and actions. This is crucial for applications requiring immediate updates and responses.

5.1.2 SOURCE
Real-time processing is driven by the need for immediate system feedback and actions in dynamic environments.

5.1.3 CONSTRAINTS

- Latency: The system must ensure latency is minimized
- Data Throughput: The system should handle high data throughput without significant delays or data loss.

5.1.4 Standards
- IEEE 802.15.4: Standard for low-rate wireless personal area network ensuring reliable real-time communication
- ISO/IEC 27001: Ensuring real-time data security and integrity

5.1.5 Priority
High

5.2 Low Power Consumption

5.2.1 Description
The Individual devices must operate on low power to extend battery life and reduce maintenance costs. This is particularly important for sensors and devices deployed in remote or hard-to-reach areas.

5.2.2 Source
The requirement for low power consumption is driven by the need to minimize maintenance and operational costs, ensuring devices remain functional for extended periods without frequent battery replacements.

5.2.3 Constraints
- Energy-Efficient Components: Use of low-power microcontrollers and sensors.
- Power Management: Implement power-saving modes and energy-efficient communication protocols.

5.2.4 Standards
- Energyg Star: Standards for energy efficiency.
- IEEE 802.15.4: Ensuring low-power communication protocols

5.2.5 Priority
High

5.3 Reliability

5.3.1 Description
The system must be highly reliable to ensure continuous operation without failures. This is essential for maintaining accurate and consistent performance in critical applications.
-
5.3.2 Source
Reliability requirements originate from the need to provide consistent and dependable service, reducing the risk of operation disruptions and data inaccuracies.

5.3.3 Constraints
- Redundancy: Incorporate redundant systems to handle hardware or software failures.
- Error Handling: Robust error detection and correction mechanisms.

5.3.4 Standards
- ISO 9001: Quality management systems ensuring reliable processes.
- ISO/IEC 27001: Ensuring data reliabilit and security

5.3.5 Priority
High

5.4 Connectivity

5.4.1 Description

The IoT system must maintain reliable connectivity between devices and the central server. This includes handling different types of network connections and ensuring seamless data transmission.

5.4.2 Source
Connectivity requirements are based on the need for seamless communication and data exchange between IoT devices and the central system to provide real-time updates and control.

5.4.3 Constraints
- Network Protocols: Support for multiple communication protocols e.g Wi-Fi, Bluetooth, and Zigbee
- Signal Strength: Ensure strong signal strength and coverage, especially in large or obstructed areas.

5.4.4 Standards
- IEEE 802.11 Standards for Wi-Fi connectivity
- IEEE 802.15.4 Standards for low-rate wireless personal area networks

5.4.5 Priority
High

5.5 Scalability

5.5.1 Description
Smart crib must be scalable to accommodate an increasing number of devices and data volume as the project or deployment grows.

5.5.2 Source
Scalability requirements are driven by the need to support future growth and increased operational complexity without compromising performance

5.5.3 Constraints
- Modular Architecture: Design the system with a modular architecture to facilitate easy expansion.

5.5.4 Standards
- ISO/IEC 20000: IT service management standards ensuring scalable services

5.5.5 Priority
High

6 Safety Requirements

Include a header paragraph specific to your product here. Safety requirements might address items specific to your product such as: no exposure to toxic chemicals; lack of sharp edges that could harm a user; no breakable glass in the enclosure; no direct eye exposure to infrared/laser beams; packag-ing/grounding of electrical connections to avoid shock; etc.

Home automation system where a localized network has control over all devices around the house such as smart lights etc. Systems will be accessible to users through a mobile app, all systems will be able to communicate with one another and possibly function without internet connection as long as all devices are within the localized network.

6.1 Laboratory equipment lockout/tagout (LOTO) procedures

6.1.1 Description

Any fabrication equipment provided used in the development of the project shall be used in accordance with OSHA standard LOTO procedures. Locks and tags are installed on all equipment items that present use hazards, and ONLY the course instructor or designated teaching assistants may remove a lock. All locks will be immediately replaced once the equipment is no longer in use.

6.1.2 Source

CSE Senior Design laboratory policy

6.1.3 Constraints

Equipment usage, due to lock removal policies, will be limited to availability of the course instructor and designed teaching assistants.

6.1.4 Standards

Occupational Safety and Health Standards 1910.147 - The control of hazardous energy (lockout/tagout).

6.1.5 Priority

Critical

6.2 National Electric Code (NEC) wiring compliance

6.2.1 Description

Any electrical wiring must be completed in compliance with all requirements specified in the National Electric Code. This includes wire runs, insulation, grounding, enclosures, over-current protection, and all other specifications.

6.2.2 Source

CSE Senior Design laboratory policy

6.2.3 Constraints

High voltage power sources, as defined in NFPA 70, will be avoided as much as possible in order to minimize potential hazards.

6.2.4 STANDARDS

NFPA 70

6.2.5 PRIORITY

Critical

6.3 RIA ROBOTIC MANIPULATOR SAFETY STANDARDS

6.3.1 DESCRIPTION

Robotic manipulators, if used, will either housed in a compliant lockout cell with all required safety interlocks, or certified as a "collaborative" unit from the manufacturer.

6.3.2 SOURCE

CSE Senior Design laboratory policy

6.3.3 CONSTRAINTS

Collaborative robotic manipulators will be preferred over non-collaborative units in order to minimize potential hazards. Sourcing and use of any required safety interlock mechanisms will be the responsi-bility of the engineering team.

6.3.4 STANDARDS

ANSI/RIA R15.06-2012 American National Standard for Industrial Robots and Robot Systems, RIA TR15.606-2016 Collaborative Robots

6.3.5 PRIORITY

Critical

7 MAINTENANCE & SUPPORT REQUIREMENTS

For the product we intend to roll out, below are the maintenance and support requirements we have identified:-

7.1 Firmware and Software Updates

7.1.1 Description

Regular updates to ensure security patches and feature enhancements. Over-the-Air (OTA) update capability to simplify the update process for end-users.

7.1.2 Source

Device manufacturers, software developers.

7.1.3 Constraints

- Limited bandwidth for OTA updates.

- User acceptance for automatic updates.

7.1.4 Standards

- IEEE 802.11 for Wi-Fi updates.
- MQTT for IoT communications.

7.1.5 Priority

High

7.2 Device Monitoring

7.2.1 Description

Continuous monitoring for device health and performance. Use of dashboards and alerts for proactive issue detection and resolution.

7.2.2 Source

Network management tools, IoT platforms.

7.2.3 Constraints

- Real-time data processing capabilities.
- User privacy considerations.

7.2.4 Standards

- ISO/IEC 27001 for information security management.
- ANSI/TIA-942 for data center management.

7.2.5 Priority

High

7.3 Network Management

7.3.1 Description

Ensuring reliable and stable connectivity. Regular checks and updates to network configurations and protocols.

7.3.2 Source

Network administrators, IoT platform providers.

7.3.3 Constraints

- Network infrastructure limitations.
- Interference from other devices.

7.3.4 Standards

- IEEE 802.3 for Ethernet.
- IEEE 802.11 for Wi-Fi.

7.3.5 Priority

High

7.4 Battery Management

7.4.1 Description

For battery-operated devices, regular checks and optimizations for battery life. Notifications for low battery levels and potential replacements.

7.4.2 Source

Device manufacturers, IoT platform providers.

7.4.3 Constraints

- Battery capacity and technology.
- Environmental factors affecting battery life.

7.4.4 Standards

- IEC 61960 for rechargeable batteries.
- UL 1642 for lithium batteries.

7.4.5 Priority

Medium.

8 OTHER REQUIREMENTS

For the product we intend to roll out, below are the other requirements we have identified:-

8.1Training and Onboarding

8.1.1 Description

Providing onboarding assistance for new users. Offering training sessions or tutorials to help users understand and utilize all features.

8.1.2 Source

Training teams, user experience designers.

8.1.3 Constraints

- Availability of training resources.
- User engagement and retention.

8.1.4 Standards

- ADDIE model for instructional design.
- ISO/IEC 40180 for IT user training.

8.1.5 Priority

Medium

8.2 Scalability and Future-Proofing

8.2.1 Description

Ensuring the system can scale with the number of devices and users. Planning for future upgrades and technology advancements.

8.2.2 Source

System architects, technology forecasters.

8.2.3 Constraints

- Infrastructure limitations.
- Budget for future upgrades.

8.2.4 Standards

- ISO/IEC 25010 for system and software quality requirements.
- TOGAF for enterprise architecture.

8.2.5 Priority

High

9 Future Items

9.1 Automatic Window Blinds Control

9.1.1 Description

This requirement involves implementing automatic control for window blinds, allowing users to open and close blinds via the SmartCrib app or based on predefined schedules and environmental conditions (e.g., sunlight intensity, time of day).

9.1.2 Source

User feedback, market research, and competitor analysis.

9.1.3 Constraints

- **Budget**: Limited funds to purchase and integrate motorized blinds.
- **Time**: Insufficient time to develop and test this feature within the project timeline.
- **Skills**: The team lacks expertise in motor control and integration with IoT systems.
- **Technology**: Need for reliable and compatible motorized blinds that can integrate with the existing SmartCrib system.

9.1.4 Standards

IEEE 802.15.4: Standard for low-rate wireless personal area networks (LR-WPANs) applicable to Zigbee/Thread communication.
IEC 62368-1: Safety standards for electronic equipment.

9.1.5 Priority

The priority is scaled medium as we are trying to automate lights first.

9.2 Smart Thermostat

9.2.1 Description

Integrating a smart thermostat with the SmartCrib system to allow users to control home heating and cooling remotely, set schedules, and receive energy usage reports.

9.2.2 Source

Market demand analysis and user feedback.

9.2.3 Constraints

- **Budget:** Cost constraints prevent the purchase and integration of smart thermostats.
- **Time:** Development and integration would extend beyond the project deadline.
- Skills: Team members do not have sufficient experience with HVAC systems and their integration with IoT.
- **Feasibility Analysis:** Preliminary analysis suggests significant complexity and potential compatibility issues with existing HVAC systems.

9.2.4 Standards

ASHRAE Standards: Standards for heating, ventilation, air conditioning, and refrigeration systems.

ISO 16484-2: Building automation and control systems (BACS) standards.

9.2.5 PRIORITY

The priority is high as we will integrate this after automating lights.

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