Department of Computer Science & Engineering The University of Texas at Arlington

Project Charter
CSE 4316: Senior Design I
Summer 2024

Smart Crib

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Revision History

Revision	Date	Author(s)	Description
0.1	07/05/2024	Don Dang	Added logo, project title, partners
0.2	07/05/2024	Don Dang	Updated table of contents, revision history
1.0	07/05/2024	Luis Del Rio Carrillo	Completed Problem Statement
1.1	07/06/2024	Luis Del Rio Carrillo	Completed Methodology
2.1	07/06/2024	Don Dang	Completed Value Proposition
2.2	07/06/2024	Pranav Pujar	Completed Development Milestones
2.3	07/06/2024	Zait Martinez	Completed Background
3.1	07/07/2024	Zait Martinez	Completed Related Work
3.2	07/07/2024	Zait Martinez	Completed System Overview
3.3	07/07/2024	Don Dang	Completed Roles and Responsibilities
3.4	07/07/2024	Don Dang	Completed Cost Proposal
4.1	07/07/2024	Don Dang	Completed Facilities & Equipment
4.2	07/07/2024	Don Dang	Completed Assumptions
4.3	07/07/2024	Pranav Pujar	Completed Constraints
4.4	07/07/2024	Don Dang, Pranav Pujar, Zait Martinez	Completed Risks
5.0	07/08/2024	Don Dang,Pranav Pujar, Zait Martinez	Completed Documentation & Reporting

Contents

1 Problem Statement

Numerous smart home devices come with their corresponding mobile applications, designed to be seamless, reliable, and secure. These devices transform our daily experiences, affecting how we live, work, and relax. However, the various communication and connectivity protocols often require users to navigate different administrative platforms, hindering the goal of a truly seamless experience.

2 Methodology

The purpose of the Smart Crib is to integrate various technologies and proprietary solutions to provide seamless interaction between different vendors of smart devices. Our approach includes developing custom devices when necessary to ensure comprehensive device administration, edge processing, and secure connections.

We plan on implementing a cross-platform mobile application that can control various hardware systems within a household. This application also needs to be able to communicate with the hardware devices (light, speakers, etc) through appropriate interfaces.

3 Value Proposition

Our system creates an environment where all your smart home devices can work together seamlessly, allowing users to enjoy the benefits of their favorite devices on a single, unified platform. Instead of competing with other brands, we aim to complement and integrate them, fostering an ecosystem that enhances the overall smart home experience.

4 Development Milestones

This list of core project milestones should include all major documents, a demonstration of major project features, and associated deadlines. Any date that has not yet been officially scheduled at the time of preparing this document may be listed by month.

Provide a list of milestones and completion dates in the following format:

- Project Charter first draft - July 2024
- System Requirements Specification - July 2024
- Architectural Design Specification - July 2024
- Detailed Design Specification - August 2024
- CoE Innovation Day poster presentation - Spring 2025
- Final Project Demonstration - December 2024

5 Background

An in-depth explanation of the problem, including the "business case". What is wrong with the status-quo or what opportunity exists that justifies undertaking this project (expanding upon the problem statement)? If you have a clear customer or sponsor, why do they want you to work on this? What is the existing relationship, if any, between the development team and the customer? This section should occupy 1/2 - 1 full page.

There are numerous smart home devices, each with its own mobile application, which should be seamless to use, reliable, and secure. These devices transform our daily experiences—how we live, work, and unwind. However, the different communication and connectivity protocols require users to navigate various administration platforms, hindering a seamless experience.

Our solution aims to unify these systems, enabling them to work together as a coordinated team rather than as individual systems requiring user intervention. By designing an intuitive user interface and providing clear documentation and support, we ensure our IoT solution is simple to install, configure, and use.

To address security concerns, we will implement strong encryption protocols, secure boot processes, and timely software update notifications. Additionally, as the number of devices on a user's network grows, managing and scaling the platform becomes challenging. By collaborating with companies in the Connectivity Standards Alliance, we ensure compatibility and integration with a wide range of products, creating a seamless smart home experience.

6 Related Work

The IoT landscape has significantly improved and advanced in recent years, which offers us a breadth of opportunities to learn from existing research, PoCs, and commercial implementations.

Edge computing in IoT systems is still relatively new and still in the research stages. Edge computing's application in IoT lies in exploring how it can enhance systems by processing data closer to the source. This would massively reduce latency in many important and prevalent IoT systems, as well as bandwidth usage. [1] -2

As for prototypes and Proof-of-Concept implementations, the IoT landscape has given rise to one of the most diverse sets of use cases for enthusiasts to experiment on. DIY Home Automation Systems have been thoroughly explored and continue to be explored, primarily using development platforms like Arduino and Raspberry Pi. They often can provide basic automation and remote control capabilities, as well as a wide array of sensing capabilities. [2] - 3

Wearable Tech is also a key domain powered by IoT by hobbyists. This is mostly applications in the healthcare industry with devices such as wearable health monitors in the form of health watches, and other portable gadgets. Vital signs such as heart rate and temperature can be measured using off-the-shelf sensors and microcontrollers. [3] - 4

Commercially available products using IoT again target the home automation consumer sector in the form of Smart Home Devices. Companies like Google, Amazon, and Philips offer complete smart home solutions that allow users to set up ecosystems of smart, IoT-powered devices. All devices in an ecosystem are automated and have remote control usually through mobile apps. Devices such as Nest, Echo, and Hue are the most successful examples. [4] - 5

Limitations of existing solutions:
High-end commercial solutions may be too costly for individual customers or small businesses to afford. For example, extensive IIoT platforms necessitate large infrastructure investments and continuous maintenance expenses. [5] - 6

Since many commercially accessible goods are a part of closed ecosystems, integrating devices made by multiple manufacturers can be difficult. Customers trying to create a unified IoT system may find this lack of compatibility to be a major obstacle. [6] - 5

7 System Overview

Explain, at a high level, how you will implement a solution to the problem. Include a diagram of the major components of the system (not a full architectural design, but a high-level overview of the major system components and how a user or external system might interface). Avoid specific implementation details (operating system, programming languages, etc.). This section should occupy at least 1 full page.

Our Internet of Things project seeks to combine multiple different systems—such as smart home monitoring, smart agriculture, and smart lighting control—into a unified ecosystem that improves user convenience, effectiveness, and sustainability. The main elements of each system are described below, along with how they function together within the larger Internet of Things architecture. These systems can have common devices and overlapping domains and access structures.

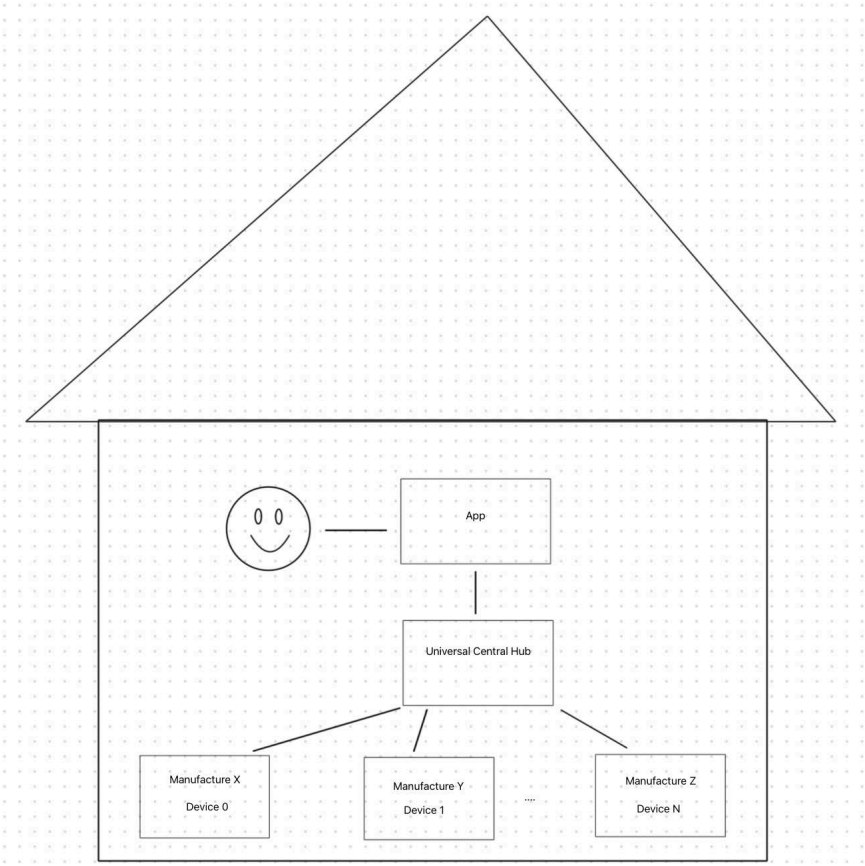
Smart Lighting Control System: This system's main goal is to give residential and business buildings effective, adaptable lighting options. It consists of dimmers, light switches, and smart bulbs that can be operated from a distance via a mobile or online application. In accordance with occupancy or ambient light levels, users can establish automated rules, timetables, and brightness adjustments. This technology lowers electricity usage and expenses by ensuring lights are only turned on when necessary, improving energy efficiency.

Smart Agriculture System: By automating and monitoring critical activities, the smart agriculture system is intended to maximize farming practices. It has actuators for automatic fertilization and watering, as well as sensors for temperature, moisture content, and nutrient levels. These sensors gather data in real-time, which is then analyzed to reveal information about the growth and health of the crop. Enhancing crop production and resource management, users can remotely monitor soil conditions and receive notifications for irrigation demands or potential problems.

Smart Home Monitoring System: By keeping an eye on and managing several facets of home security, this system improves convenience and security. This covers smart devices including motion sensors, door locks, security cameras, and garage door openers. Remotely monitoring their home security systems, receiving notifications for unwanted entry, and even granting visitors access are all available to users.

This system offers a complete smart home experience by integrating easily with agriculture and smart lighting control systems.

High-level system design:



8 Roles & Responsibilities

Who are the stakeholders of the project? Who will be the point of contact from the sponsor or customer side? Who are the team members, and what will be their areas of responsibility? Will your team maintain the product owner and scrum master for the whole project, or will that role change periodically? This section should occupy 1/2 - 1 full page.

The stakeholders of the SmartCrib project include us the students whose skills and knowledge will be on showcase, homeowners seeking to enhance their living experience through automation, technology enthusiasts interested in IoT solutions, and potential investors or companies in the home automation market. The primary point of contact from the sponsor or customer side will be the project sponsor, typically a representative from a company or organization funding the project or a faculty advisor overseeing the capstone. The team members consist of Don Dang, Luis Del Rio, and Pranav Pujar who will oversee software development and integration, Zait Martinez will handle hardware implementation, Luis Del Rio Carillo will handle user interface design, and the team as a whole will manage project documentation and testing. The team will maintain the roles of product owner and scrum master

throughout the project, ensuring consistency in leadership and project management. These roles may be assigned to team members with the most relevant experience and rotated periodically to provide leadership opportunities and ensure a well-rounded understanding of all project aspects. Regular meetings and agile practices will be adopted to ensure smooth collaboration and progress tracking.

9 Cost Proposal

This section contains the approximate budget for the project, where that money will come from, and any other support.

The primary expenditure will be on the central hubs. As the project scales the cost range of devices will vary based on the functionality and complexity of the device. Our software approach uses an open-source code base to develop our platform. On a smaller scale, various sensors and communication modules will be used along with their corresponding power supplies and batteries. Lastly, enclosures and mounting apparatuses along with prototyping and testing material will be used.

9.1 Preliminary Budget

Include a high level budget table for components, fabrication, software licensees, development hardware, etc. This should be in a tabular format broken up into appropriate line items.

- Arduino	$28
- Raspberry PI Zero	$25
- Dimmable LED Pack	$5
- PCB board	$9
- prototyping Jumper Wires	$6
- Wifi Router & Extender	$34
- Thermostat	$25
- Speakers	$10
- TOTAL	$142

9.2 Current & Pending Support

What are all of the funding sources for the project, and are there any potential funding sources that haven't been secured yet? List all funding sources (including the default funding amount provided by the CSE department) and their dollar amounts.

CSE Department: $800

10 Facilities & Equipment

What lab space, testing grounds, makerspaces, etc. will you need to complete the project? Will you require any specific equipment, and if so, where will you get it (borrow, lease, purchase, outsource, already present in the lab, etc.).

We will need access to the necessary hardware (Arduino/microcontrollers) to connect IoT devices to an application. We might also require wifi routers/extenders. We can make use of the makerspace in Nedderman Hall and the Grounds & IoT lab in ERB 203. Appropriate IoT devices must be made available for use in the project.

11 Assumptions

An assumption is a belief of what you assume to be true in the future. You make assumptions based on your knowledge, experience, or the information available on hand. These are anticipated events or circumstances that are expected to occur during your project's life cycle.

Assumptions are supposed to be true but do not necessarily end up being true. Sometimes they may turn out to be false, which can affect your project significantly. They add risks to the project because they may or may not be true. For example, if you are working on an outdoor unmanned vehicle, are you assuming that testing space will be available when needed? Are you relying on an external team or contractor to provide a certain subsystem on time? If you are working at a customer facility or deploying on their computing infrastructure, are you assuming you will be granted physical access or network credentials?

This section should contain a list of at least 5 of the most critical assumptions related to your project. For example:

The following list contains critical assumptions related to the implementation and testing of the project.

- We will have the necessary hardware required to allow for smart lights to communicate with each other
- The light bulbs along with the microcontrollers/arduinos will be able to seamlessly communicate with our mobile application with no hardware limitations coming in the way.
- There will be sufficient computational resources to allow us to create a mobile app that can accommodate multiple lights, speakers, etc.

12 Constraints

Constraints are limitations imposed on the project, such as the limitation of cost, schedule, or resources, and you have to work within the boundaries restricted by these constraints. All projects have constraints, which are defined and identified at the beginning of the project.

Constraints are outside of your control. They are imposed upon you by your client, organization, government regulations, availability of resources, etc. Occasionally, identified constraints turn out to be false. This is often beneficial to the development team since it removes items that could potentially affect progress.

This section should contain a list of at least 5 of the most critical constraints related to your project. For example:

The following list contains key constraints related to the implementation and testing of the project.

- Final prototype demonstration must be completed by Nov 1st, 2024

- The time constraint might make us have to downsize on project specifications.
- A budget of $800 will have to be kept in mind while spending on hardware.

13 Risks

This section should contain a list of at least 5 of the most critical risks related to your project. Additionally, the probability of occurrence, size of loss, and risk exposure should be listed. For size of loss, express units as the number of days by which the project schedule would be delayed. For risk exposure, multiply the size of loss by the probability of occurrence to obtain the exposure in days. For example:

The following high-level risk census contains identified project risks with the highest exposure. Mitigation strategies will be discussed in future planning sessions.

Risk description	Probability	Loss (days)	Exposure (days)
Availability of necessary IoT hardware	0.50	20	10
Outdoor testing grounds are not available	0.20	14	2.8
Internet access not available at installation site	0.30	9	2.7
Delays in app development due to unforeseen issues/bugs	0.30	30	2.0
Work delays due to inclement weather/international travel	0.15	10	1.5

Table 1: Overview of highest exposure project risks

14 Documentation & Reporting

14.1 Major Documentation Deliverables

These deliverables are major grade components of the course. Completing these documents should generally be the sprint goal during the applicable sprint period. Refer to current and previous course syllabi and schedules to estimate the due dates of these items. Remove this explanatory paragraph from your draft, but leave the heading.

14.1.1 Project Charter

Describe how this document will be maintained and updated (how often, under what circumstances, etc.). When will the initial version be delivered? When will the final version be delivered?

Once a month.

14.1.2 System Requirements Specification

Describe how this document will be maintained and updated (how often, under what circumstances, etc.). When will the initial version be delivered? When will the final version be delivered?

Initial version will be delivered on July 8 2024. Subsequent revisions to this Project Charter document will be made once a month.

14.1.3 Architectural Design Specification

Describe how this document will be maintained and updated (how often, under what circumstances, etc.). When will the initial version be delivered? When will the final version be delivered?

We will have weekly meetings as a group, and will dedicate a portion of these meetings to discuss potential revisions to the project charter and implement the same.

14.1.4 Detailed Design Specification

14.2 Recurring Sprint Items

14.2.1 Product Backlog

How will items be added to the product backlog from the SRS? How will these items be prioritized? Who makes the decision (product owner, group vote, etc.)? What software will be used to maintain and share the product backlog with team members and stakeholders?

We will be using Excel to note down tasks in the backlog. This backlog will then be used to delegate tasks to team members depending on how their existing skillset matches with the backlog description.

14.2.2 Sprint Planning

How will each sprint plan be planned? How many sprints will there be (you need to look at the schedules for this course and previous Senior Design II courses during the appropriate semesters to figure this out).

Sprint Planning is at the first day of each sprint. Since each Sprint lasts 2 weeks, we will have roughly 4 sprints in the Summer, counting the current and past sprint. We will have about 6 sprints in the Fall.

14.2.3 Sprint Goal

Who decides the sprint goal? How will you involve your customer in this process?

The Sprint Goal is brainstormed by the whole team based on team needs, backlog items remaining, and carryover items. In addition to planned goals to stick to our general project timeline, we will adjust sprint goals based on changing feedback and parts of the project that we think need more/less attention.

14.2.4 Sprint Backlog

Who decides which product backlog items make their way into the sprint backlog? How will the backlog be maintained (collaboration software, a "scrum board", etc.)?

During the weekly meetings, a portion of the time will be allocated to discussing individual sprint backlog items, which will be entered into an Excel sheet in decreasing order of priority.

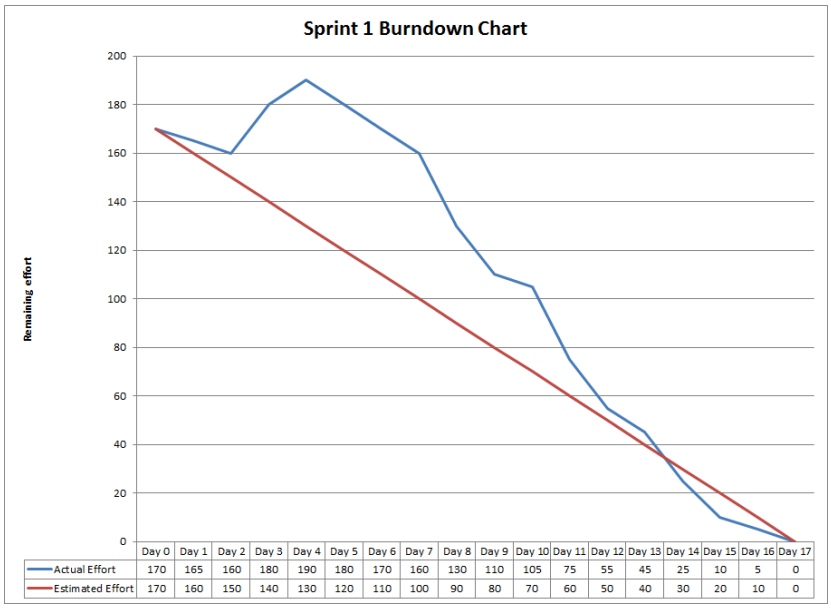
14.2.5 Task Breakdown

How will individual tasks be assigned from the sprint backlog? Will it be up to each team member to voluntarily claim a task, or will it come from the product owner? How will time spent on tasks be documented?

There will be backlog task matching based on individual skills. In situations where there are multiple team members capable of taking on one backlog task, that task will be assigned on a volunteer basis.

14.2.6 Sprint Burn Down Charts

Who will be responsible for generating the burn down charts for each sprint? How will they be able to access the total amount of effort expended by each individual team member? What format will the burn down chart use (include an example burn down chart below).



Sprint 1 Burndown Chart

Pranav Pujar will handle the making of Burndown Charts for the sprints. This will be done by tracking effort points completed each day of the sprint by team members when communicated to the team conversation (Discord). Each PBI's work items will have assigned persons and efforts which will make it easy to track efforts from each person towards the sprint goals. Burndown chart will have total effort points (of work items) on the vertical axis, and days into the sprint on the horizontal axis.

14.2.7 Sprint Retrospective

How will the sprint retrospective be handled as a team? When will this discussion happen after each sprint? What will be documented as a group and as individuals, and when will it be due?

The sprint retrospective will be discussed during the weekly team meetings. The documentation will be reviewed and modifications will be made as and when deemed necessary during the meetings. It will be due by the end of every month.

14.2.8 Individual Status Reports

What sort of status will be reported by each individual member, and how often will it be reported? What key items will be contained in the report?

The progress of individual sprint backlog items that have been undertaken by every teammate will be documented in the individual sprint reports. This will be reported at then end of every 2-week sprint.

14.2.9 Engineering Notebooks

How often will the engineering notebook be updated, at a minimum, by each team member? What is the minimum amount of pages that will be completed for each interval, and how long will that interval be? How will the team keep each member accountable? Who will sign of as a "witness" for each ENB page?

At a minimum engineering notebook will be updated once a week, and anytime a teammate finds, solves, or attempts to solve a significant problem or requirement. Each interval is about two weeks and at least two pages should be completed at each interval. As a witness we have had really good communication so teammates must demonstrate progress to the group who can then sign off when updating the notebook.

14.3 Closeout Materials

The following materials, in addition to major documentation deliverables, will be provided to the customer upon project closeout. Remove this paragraph from your draft, but leave the heading.

14.3.1 System Prototype

What will be included in the final system prototype? How and when will this be demonstrated? Will there be a Prototype Acceptance Test (PAT) with your customer? Will anything be demonstrated off-site? If so, will there be a Field Acceptance Test (FAT)?

For the final system prototype we plan on having a minimized replica cut out of a house model, with various systems installed, this home cutout will allow us to demonstrate how our systems work together in their real life use setting while also allowing us to transport the prototype. This prototype is something we can add features to as we go and it is very possible to be able to demonstrate this during the end of the second course. There could be a PAT depending on customer needs, as of right now it is just a product with many customers in mind not an individual's requirements and needs. There most likely won't be an offsite demonstration as this requires the use of an actual house which would not be reasonable as of right now.

14.3.2 Project Poster

What will be included on the poster, what will be the final dimensions, and when will it be delivered?

The poster shall include key points of our system, the goal, the use, etc. We shall also include images representing the overall functionality of the system to demonstrate how everything comes together as one system.

14.3.3 Web Page

What will be included on the project web page? Will it be accessible to the public? When will this be delivered? Will it be updated throughout the project, or just provided at closeout (at a minimum, you need to provide a simple web page at the end).

Web page will be provided at closeout and accessible to the public, it will include progress pictures, demonstrations and explanation of the project as well as possibilities for future additions/features.

14.3.4 Demo Video

What will be shown in the demo video(s)? Will you include a B-reel footage for future video cuts? Approximately how long will the video(s) be, and what topics will be covered?

Demo video will be a walkthrough of our project hands-on use. Demonstrating how a customer would use the system and how the system interacts or responds.

14.3.5 Source Code

How will your source code be maintained? What version control system will you adopt? Will source code be provided to the customer, or binaries only? If source code is provided, how will it be turned over to the customer? Will the project be open sourced to the general public? If so, what are the license terms (GNU, GPL, MIT, etc.). Where will the license terms be listed (in each source file, in a single readme file, etc.).

Source Code will be maintained using git and github, source code will not be provided to the customer as of right now that is not the idea for the project however this could change, if we decide to create a system where current devices from other companies could integrat their own device then it could be necessary to release source code.

14.3.6 Source Code Documentation

What documentation standards will be employed? Will you use tools to generate the documentation (Doxygen, Javadocs, etc.). In what format will the final documentation be provided (PDF, browsable HTML, etc.)?

Aside from simple commenting during regular version updates, it will be necessary to document the big idea on subdivision of our sourcecode, this will be the task of whoever works on said subdivision and they must do so efficiently in order for the whole team to understand their work. Final documentation will be PDF.

14.3.7 Hardware Schematics

Will you be creating printed circuit boards (PCBs) or wiring components together? If so, list each applicable schematic and what sort of data it will contain (PCB layout, wiring diagram, etc.). If your project is purely software, omit this section.

We will most likely not be creating anything from scratch as the main goal of our system is a network of individual pieces of hardware, we plan on reusing systems that already exist where applicable. There will however be wiring of components together and this will have to be documented in order to be replicated and understood by both the rest of the team and future teams or personnel.

14.3.8 CAD files

Will the project involve any mechanical design, such as 3D printed or laser-cut parts? If so, what software will you use to generate the files and what file formats will you provide in your closeout materials (STL, STEP, OBJ, etc.). If your project is purely software, omit this section.

The project is not based on any mechanical features however we could have the ability to add mechanical systems as features to our system. In that case Fusion360 will be used and files will be in stl format.

14.3.9 Installation Scripts

How will the customer deploy software to new installations? Will you provide installation scripts, install programs, or any other tools to improve the process? Will there be multiple scripts provided (perhaps separate scripts for the graphical front end and back end server software)?

Software will be embedded in hardware. The new installation goal is to be plug and play

14.3.10 User Manual

Will you customer need a printed or digital user manual? Will they need a setup video? Decide now what will be provided and discuss.

The easiest way for a new customer to understand how to use our system is by watching the system walkthrough video. Here any customer accessible feature will be demonstrated in a hands on fashion by one of our teammates.

References

[1] Kenneth S Rubin. *Essential Scrum: A Practical Guide to the Most Popular Agile Process*. Addison- Wesley Professional, 1st edition, 2012.

[2] Zhang, Y., & Qiu, M. (2019). Edge Computing for IoT: A Comprehensive Survey. *IEEE Access*, *7*, 94463–94479.

[3] Brown, A., & Smith, B. (2018). DIY Smart Home Automation Systems. *Proceedings of the 2018 International Conference on Consumer Electronics (ICCE)*, 45–49.

[4] Lee, J., & Lee, K. (2019). Wearable Health Monitoring Systems Using Arduino. *Proceedings of the 2019 IEEE International Conference on Wearable and Implantable Body Sensor Networks (BSN)*, 1–4.

[5] Johnson, S. (2020). Smart Home Devices: A Market Analysis. *Journal of Smart Technologies*, *12*(3), 30–35.

[6] Kumar, R., & Tiwari, S. (2021). Industrial IoT Platforms: An Overview. *IEEE Transactions on Industrial Informatics*, *17*(1), 234–246.