SANTA CLARA UNIVERSITY
DEPARTMENT OF COMPUTER ENGINEERING

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

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ENTITLED

Doorbell for the Hearing Impaired

BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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Thesis Advisor

Department Chair

Doorbell for the Hearing Impaired

by

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Dominic Magdaluyo

Submitted in partial fulfillment of the requirements
for the degree of
Bachelor of Science in Computer Science & Engineering
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Santa Clara University

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ABSTRACT

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Chapter 1

Introduction

1.1 Problem and Motivation

Doorbells and knocking are often useless for those that are audibly impaired. Someone with hearing impairments needs to depend on other residents to answer the door for them or purchase expensive equipment to send them phone notifications. Depending on the neighborhood, the ability to know there's a visitor at the door is essential for quality of life including package delivery and community involvement.

1.2 Current Solutions

Current solutions are limited in supporting these individuals. Louder doorbells are useless to those that are completely deaf and can be annoying for housemates that are not hearing impaired. Current light systems are not integrated into the house and must be carried around the house (or multiple installments are needed, thereby increasing the cost). Furthermore, the light systems may be easily missed if not facing the device or if in a well-lit room. Video doorbells are expensive and require a smartphone to interface with it. The notifications may be missed during the time frame where a person is at the door. A useful alternative is smart wearables but those are limited in battery life. For example, the Apple Watch Series 4 is advertised to last 18 hours on average use which is not useful for a person when sleeping. Designing a low-cost solution was important to the team, as unemployment among deaf individuals is high at 47%. Generally, hard of hearing individuals are senior citizens who do not have much money. A simple and affordable solution would improve their lives greatly. The hearing impaired community already struggle enough and providing an affordable option to doorbells is essential in keeping them aware of their surroundings and being part of their communities.

1.3 Solution

To tackle these issues, our solution would aim at integrating a system into the entire household by using Philips Hue light fixtures or, as a cheaper alternative, providing LED strips, removing the need for a portable device that may be easily forgotten. Furthermore, the system will give the user options on a configuration that works best for their home. On top of that we will provide a low power vibration bracelet solution. This would be sleek so that it can be worn while sleeping while providing a gentle but noticeable vibration. The bracelet could be charged while away from the house, so a user will always be able to use it once in the house. Together, our system will be low cost while providing more functionality towards the hearing impaired.

Chapter 2

Requirements

2.1 Description

In this chapter, we list the functional and nonfunctional requirements prioritizing them from top to bottom. In section 2.2, we list functional requirements by critical, recommended, and suggested and these describe what the system will do. In section 2.3, we list non-functional requirements in the same way and these describe how the system will perform. Lastly, in section 2.3, we discuss our design constraint and how it affects the scope of this project.

2.2 Functional Requirements

- Critical
  - Doorbell will activate light system
- Recommended
  - Doorbell will activate vibration system
  - Doorbell is integratabtle with other light/vibration devices available
  - The System will be low power
- Suggested
  - Doorbell will not communicate over WiFi

2.3 Non-Functional Requirements

- Critical
  - The system will be cheap, ideally $50 or less for a full house integration
- Recommended

  - The system will be able to connect to various types of devices to allow preferred devices per user

- Suggested

  - The system has an appealing aesthetic

2.4 Constraints

The constraint of our design is that we are not building from the ground up. This makes achieving our goal of an affordable system very difficult as we will be using already built parts. As such is the case, we will have to design this system as a proof of concept.

Chapter 3

Use Case Diagram

3.1 Description

The use case diagram (Figure 3.1) shows the potential functions of our system for two actors: the Resident and the Visitor. Our use cases are listed in the following section by which actor is allowed the action and what preconditions, postconditions, and/or exceptions are there for the specific use case in our system.

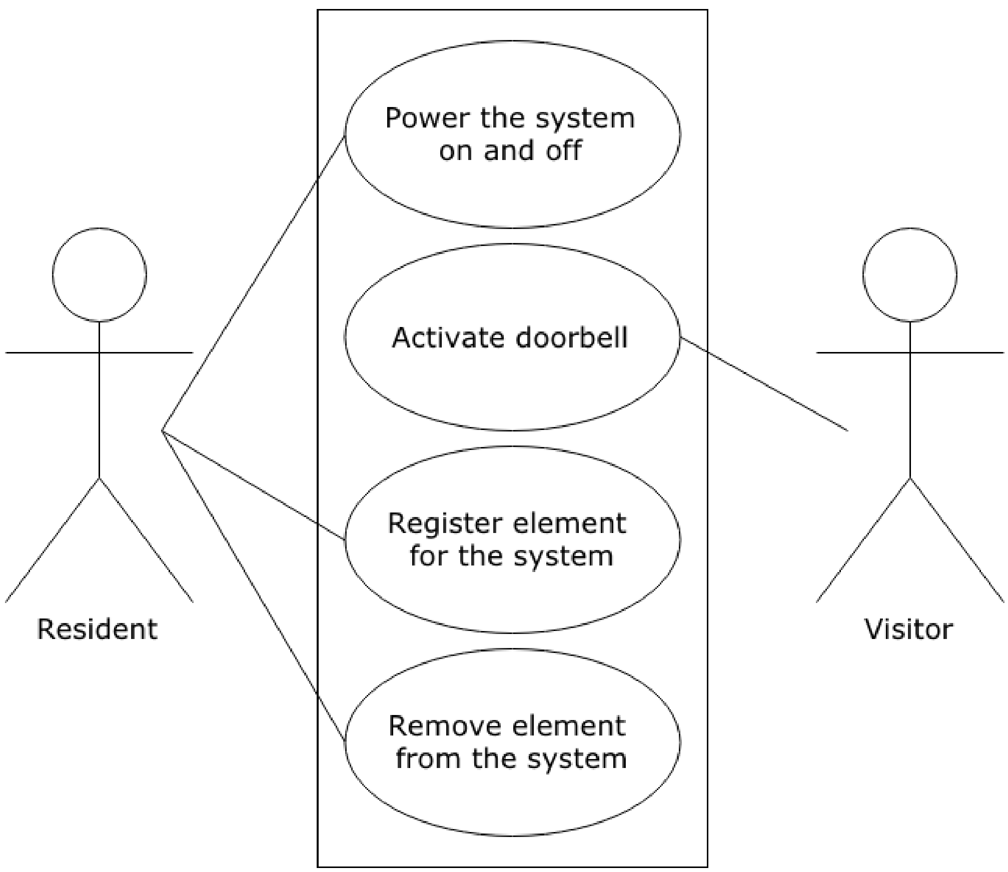

Figure 3.1: Use Case Diagram

3.2 Functionality

3.2.1 Power System On and Off

Actors Resident

Goal Setting up system and personalizing it

Postcondition System should safely shut off or turn on with previous settings

3.2.2 Activate Doorbell

Actors Visitor

Goal Alert the Resident, that someone is at the door

Precondition System is successfully activated with a device paired to it

Postcondition Alert the Resident through their connected device(s)

Exceptions Nothing happens if System is not active or device is disconnected

3.2.3 Register Element to the System

Actor Resident

Goal Connect a device so Resident may be alerted of Visitor at door

Precondition: System is powered on successfully

Postcondition Device is registered successfully to system and will be activated once prompted

Exception Unsuccessful device registration and prompt user of error in pairing

3.2.4 Remove Element from the System

Actor Resident

Goal Unregister device from the system when no longer using it

Precondition System should be on

Postcondition Device successfully unregistered

Chapter 4

Activity Diagrams

4.1 Description

The activity diagrams show the potential paths of actions a user may take with the system. For the Resident actor (Figure 4.1), upon turning on a system, the user may register or remove devices. The system will be then available and a user may receive a response when the doorbell is pressed. From any of these actions a user may take, they may also power the system off.

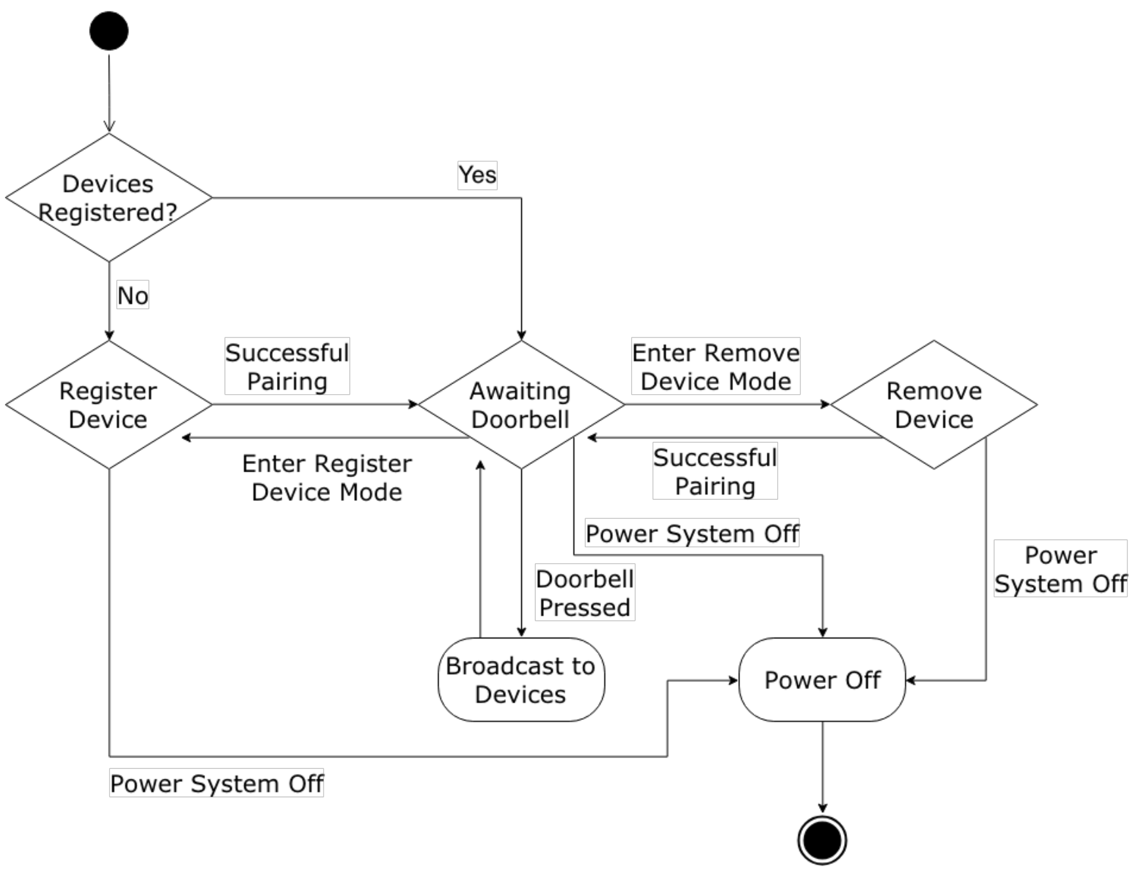

Figure 4.1: Resident Activity Diagram

For the Visitor actor (Figure 4.2), when the system is on, the user will be able to activate the doorbell by a button and have one of the connected devices respond to the Resident actor.

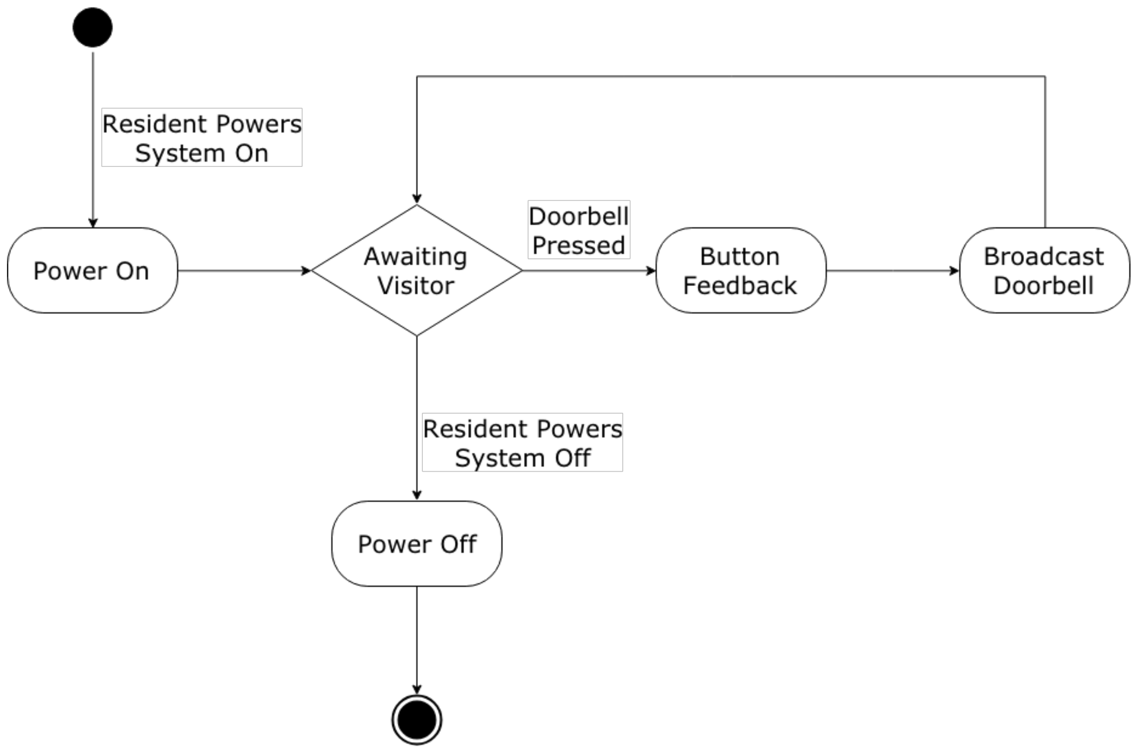

Figure 4.2: Visitor Activity Diagram

Chapter 5

Architecture Diagram

5.1 Description

Chapter 6

Technology Used and Design Rationale

6.1 Description

In this chapter, we discuss the necessary devices and technology needed for this system and why they were chosen in our design.

6.2 Technology

The main computer of the system will be a raspberry Pi Zero W. Potential devices that can be connected to the system will be Philips Hue Lights, LED strips with RF sensors, bone conduction ear buds, and a FitBit watch. Technologies used in this system will be Bluetooth and WiFi.

6.3 Design Rationale

The main computer of this System will be the Raspberry Pi Zero W. The Raspberry Pi Zero W is a low cost IoT board with WiFi capabilities and is part of a widely used open source project. This will allow us to find solutions to various problems we may encounter in development. Furthermore, if we come up with unique issues, the community is very responsive and hopefully minimize any delays.

We want this to be an open platform that multiple types of devices can be connected to. As such we will provide high cost and low cost solutions. Philips Hue Light bulbs are popular in IoT solutions for lighting in houses. Furthermore, they have an open API which will help development be smoother. The LED strips are our answer to a low cost light solution. LEDs are cheap and could be spread out across a house with minimal extra costs.

Furthermore, we will provide vibration solutions to the doorbell system. We will use FitBit as our high end solution which has an open API making development easy. We will be developing with a higher cost FitBit so that we can interact with a screen. For a low-cost vibration solution, we will be using bone conduction ear buds which are designed to hang around an individual's head at all times and can be simply interacted with by using bluetooth.

Overall, we will be experimenting with both WiFi and Bluetooth. We would like to possibly stay away from WiFi in case a low income household didn't have a router. Both are standard forms of communication between devices and are available with our chosen devices. We will also be able to set up the Raspberry Pi Zero W with hostapd (host access point daemon) to make the board function like a router. Most likely, this will lead to more power consumption so it is not an ideal solution.

Chapter 7

Conceptual Model

7.1 Description

The system will use the Raspberry Pi Zero as the main computer. A router will be necessary in communicating to other devices in the household. The router can be performed by the Raspberry Pi Zero if necessary. The button of the doorbell will be attached to the Raspberry Pi Zero.

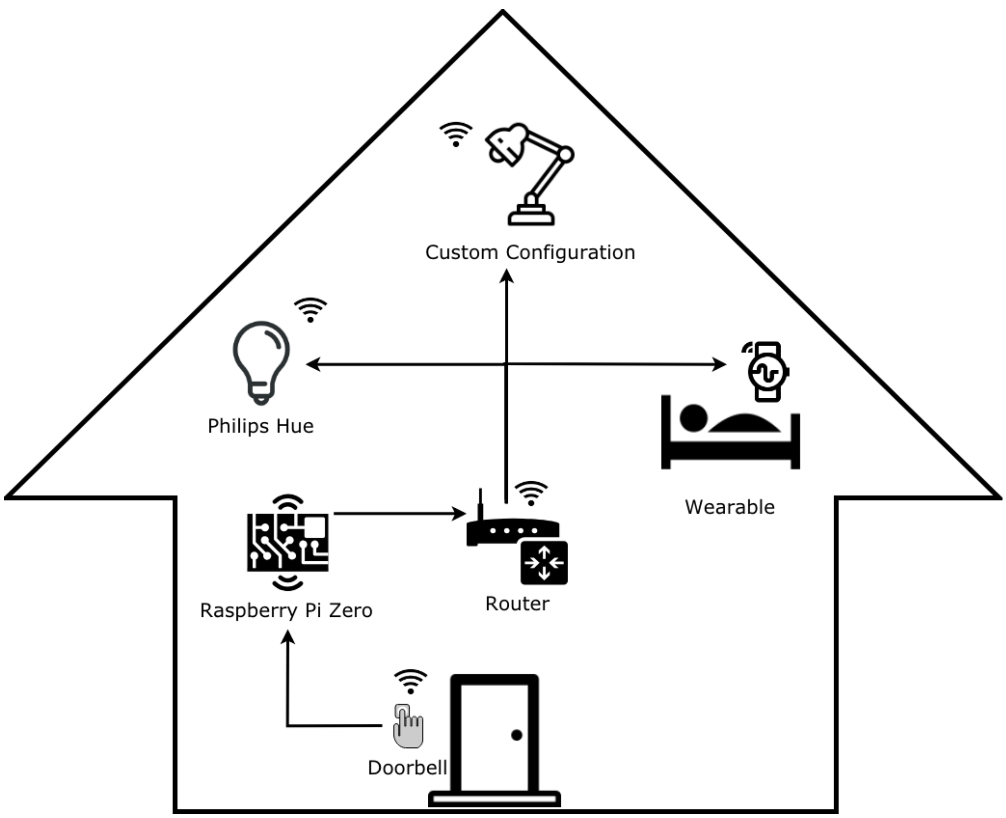

Figure 7.1: Conceptual Model

Chapter 8

Test Plan

8.1 Description

This chapter discusses methods by which we plan to test our system from unit testing to system testing

8.2 Unit Testing

We will be testing our system in small individual processes. These would be things such as if an individual script performs properly in our system. We would also have to verify that devices work as we expected.

8.3 Functional Testing

We will be testing our system in small units. This will have to do with verifying that a device can be activated to notify the Resident actor or that a button triggers a software action properly.

8.4 Component Testing

We will be testing our system by use cases. We expect to put together multiple functional components such as a device turning on and a button interrupt triggering the device.

8.5 System Testing

Finally, we will test the system as a whole. We would set it up in a house and verify that all the use cases perform properly.

Chapter 9

Risk Analysis

9.1 Description

Risk Name	Consequences	Probability	Severity (0-10)	Impact	Mitigation Strategies
Time	Behind on deadlines.	0,7	9	6.3	Follow the development timeline.
Compatibility Issues	Will delay the development of the system. Spend unnecessary money.	0.6	7	4.2	Research technologies and their compatibility in full. Discuss with advisor in approaches to resolving issues.
Network Issues	Will delay the development of the system.	0.35	9	3.15	Work with the IT department to resolve issues. May need to focus on bluetooth.

Table 9.1: Risk Analysis.

Chapter 10

Development Timeline

10.1 Description

Task Name	Duration	Start	ETA	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Quarter Break
Fall Quarter														
Problem Statement	14 days	18.09.22	18.10.05											
Funds Proposal	14 days	18.10.06	18.10.19											
Design Report (Rough Draft)	28 days	18.10.20	18.11.16											
Design Report (Final)	5 days	18.11.26	18.11.30											
Minor Development (Base System)	50 days	18.11.17	19.01.06											
Winter Quarter														
Initial Operating System	67 days	19.01.07	19.03.15											
Design Review	18 days	19.01.07	19.01.25											
Design Report (Revised)	7 days	19.01.26	19.02.01											
Testing	21 days	19.02.23	19.03.15											
Spring Quarter														
Recommended Requirements	28 days	19.04.01	19.04.28											
Demo System	11 days	19.04.29	19.05.09											
Testing	18 days	19.04.15	19.05.02											
Design Presentation	18 days	19.04.22	19.05.09											
Project Report	28 days	19.05.10	19.06.07											
Final Implementation	28 days	19.05.10	19.06.07											

Table 10.1: Development Timeline.