Functional Specification

Year: 2021 **Semester: Spring** **Team:** 4 **Project:** Virtual Queue
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Team Members (#1 is Team Leader):

Member 1: Nathan Pietraszak **Email: npietras@purdue.edu**
Member 2: Aidan Roy **Email: roy88@purdue.edu**
Member 3: Devansh Rathi **Email: drathi@purdue.edu**
Member 4: Chok Yip Lau **Email: lau55@purdue.edu**

Assignment Evaluation:

Item	Score (0-5)	Weight	Points	Notes
Assignment-Specific Items				
Functional Description		x3		
Theory of Operation		x3		
Expected Usage Case		x3		
Design Constraints		x3		
Writing-Specific Items				
Spelling and Grammar		x2		
Formatting and Citations		x1		
Figures and Graphs		x2		
Technical Writing Style		x3		
Total Score				

5: Excellent 4: Good 3: Acceptable 2: Poor 1: Very Poor 0: Not attempted
General Comments:

1.0 Functional Description

As of 28th November, Covid-19 has infected more than 100 millions people and killed more than 2 million people in the world [1]. Even with the severity of the pandemic, small businesses such as retail stores still have to be operated in order to financially survive. Because of the many Covid-19 restrictions enforced, retail stores are required to serve customers with a limited capacity. This has resulted in long lines and an increased risk of transmission while waiting to enter a business.

Virtual Queue is a queuing system that aims to provide a hassle-free check in and visit to places of business while complying with Covid-19 restrictions and ensuring the safety between customers and employees. When a customer reaches the retail store, he/she will provide the QR-code to the QR-code scanner and will be automatically put in the queue. There will be a display that keeps customers updated by displaying the amount of customers who are inside the stores or waiting. When it is the customer's turn, he/she will be notified by the web server and will be required to record their temperature to make sure he/she is not symptomatic. The PIR sensors will automatically detect when the customer enters or leaves the retail stores and send updates to the integrated display. A microphone and speaker will also be provided such that if a customer does not pass the temperature sensor test, the employee can contact the customer without getting close to him/her.

2.0 Theory of Operation

The user navigates to the website via a smart device and enters the virtual queue. A QR-code shows up on the screen of their device and the user will have to scan the QR-code on-site at the system and enter their name and the number of people in their party. The Virtual Queue station will send data back to the web server and add the user to the virtual queue of the particular location. The system will then update the queue displayed on the screen.

The system takes input from the PIR sensors at the entrance. Based on the direction of movement, the system computes if people are entering or exiting the location and updates the count of the number of people in the store, which will be stored in the microcontroller memory. The count is also updated on the display. If the person is exiting the store the person next in the queue is notified through the internet that it is now their turn to enter. If the next person in line has more than one person in their party, the system will wait till enough people have exited the location to fit the whole party without exceeding the max occupancy guidelines.

When the customer next in line indicates, using the webapp, that they are ready to enter the store. The system will take a reading from the infrared thermometer. If the temperature is above the recommended value or a person is detected entering without permission, the staff is notified over wifi on a computer inside the store. The microphone and the speaker on the system are activated and using the ADC and DAC, respectively, the digital signal is relayed back and forth from the

computer inside the store where the employee can speak to the outside the store. See Appendix 1 for a functional block diagram (FBD) of the system.

3.0 Expected Usage Case

The Virtual Queue is expected to be placed outside of an establishment in a fixed location next to the entrance and exit of said establishment. As such, it will need to be able to withstand a variety of weather conditions, including varying temperatures, humidities, and precipitation. The customers will be businesses looking to eliminate lines due to capacity restrictions, but the typical user will be prospective patrons of these businesses. The users are expected to have and be able to use smartphones, but otherwise the device should be widely accessible in order to not turn people away from a business using Virtual Queue.

4.0 Design Constraints

4.1 Computational Constraints

The computational functions of the Virtual Queue will be:

- Keeping track of the queue.
- Detecting people going in and out of the location.
- Using wifi to communicate with the web server to notify or add customers to the queue.
- Display the queue and the number of people inside on the screen.
- Being able to relay audio back and forth to a computer inside the store over wifi.
- Reading the QR-code on the customers device.

The primary function of the system, keeping track of the queue and the number of people inside the location, should not be computationally challenging. However, accurately detecting the movement of people going in and out using the PIR sensors could pose some computational difficulties, specially in the case of multiple people entering together. The system will need to use an interface to communicate to the display and the wifi module, which will depend on the specific devices chosen. The onboard memory of most chips should be more than enough. Both the DAC and ADC will be required for audio input and output.

4.2 Electronics Constraints

Virtual Queue's electrical components will include a microcontroller, a thermometer, a display (LED or LCD), PIR sensors, a QR-code scanner, a WIFI module, a microphone, and speaker. The display will communicate with the microcontroller either with SPI or I2C depending on which specific display most appropriately fits Virtual Queue's needs. The WIFI module will allow communication between the physical system and the web application. The QR-code scanner will communicate to the microcontroller via UART, as will the thermometer. I/O will be

required for the PIR sensors, which send positional data based on heat sources. A custom analog audio circuit will be implemented to drive the speaker and microphone, both of which are used to allow communication between a customer having trouble entering the store and a representative of the business.

4.3 Thermal/Power Constraints

Given the nature of this project, it is expected that the physical components of Virtual Queue will be battery-powered. The physical interface each customer interacts with will reside outside of a place of business where electrical outlets for power might not be easily accessible or even exist. It is expected that the battery life will meet or exceed 10 hours, in accordance with normal business hours of operation. A low battery sensor will need to be included for when the battery is low, and the status will be relayed on the owner's side of the web application.

The target maximum operating temperature is 105 degrees Fahrenheit. This system will have to endure weather and temperature extremes, and setting a working temperature range of -5 degrees Fahrenheit to 105 degrees Fahrenheit accounts for functionality in most regions across the continental United States [2]. To account for unwanted power dissipation, the electronics of Virtual Queue will be adequately insulated as a further safeguard for weatherproofing.

4.4 Mechanical Constraints

Virtual Queue will always be put outside the store, so it is very important to use a box that is weatherproof to ensure the system can be functioning under different weather conditions. The box should also be small enough so that it does not take too much space outside the store. The box will have to detect customers of different shapes and heights, so setting the box at a height of 5ft 5 inches [3] will be ideal for catering to the general populous. Since the system will also be battery powered, an adequate method to either charge or replace the battery will be necessary.

4.5 Economic Constraints

The first economic constraint on Virtual Queue is making sure it is a sensible solution over simply having a staff member manage the queue. This means the operating cost on an hourly basis must be below the federal minimum wage, which is $7.25 per hour [4], or roughly $1,200 per month for a full-time employee. A much more limiting factor would be the cost of competing options. Two of the primary competitors are Skiplino and Qminder, which offer software solutions similar to Virtual Queue. Both options utilize a monthly payment system which starts at $99 [5] and $299 [6] respectively. Virtual Queue will have to have a different payment structure due to the physical box and lower software overhead, but based on these numbers and our initial proposed budget, our initial target is one payment of $300-$400 and smaller monthly payments for the web service of $20.

4.6 Other Constraints

Since Virtual Queue will require an internet connection to communicate with the web server and the client, both the business and its customers are expected to have a stable internet connection in order for patrons to get into the queue and get notified when it is their turn to enter the store.

Another constraining factor will be that Virtual Queue can only monitor one entrance/exit at a time, requiring businesses with multiple entrances to close all but one in order to properly use Virtual Queue.

5.0 Sources Cited:

[1] WorldoMeters (2021). *COVID-19 Coronavirus Pandemic*. [Online]. Available: https://www.worldometers.info/coronavirus/

[2] NOAA (2021). *Climate at a Glance*. [Online]. Available: https://www.ncdc.noaa.gov/cag/

[3] CDC (2016). *Anthropometric Reference Data for Children and Adults: United States, 2011-2014.* [Online]. Available: https://www.cdc.gov/nchs/data/series/sr_03/sr03_039.pdf

[4] U.S. Department of Labor (2021) *Minimum Wage.* [Online]. Available: https://www.dol.gov/general/topic/wages/minimumwage

[5] Skiplino (2021). *Pricing*. [Online]. Available: https://skiplino.com/pricing/

[6] Qminder (2021). *Pricing*. [Online]. Available: https://www.qminder.com/pricing/

Appendix 1: Functional Block Diagram