Component Analysis

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Assignment Evaluation:

Item	Score (0-5)	Weight	Points	Notes
Assignment-Specific Items				
Analysis of Component 1		x2		
Analysis of Component 2		x2		
Analysis of Component 3		x2		
Bill of Materials		x6		
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 Component Analysis:

The major components that will make up Virtual Queue include a microcontroller, WiFi module, LCD Display, motion sensor, QR-code scanner, and temperature sensor. The microcontroller is the central unit where all the processing will take place. The WiFi module will communicate with the webserver to stay synchronised with the queue. The LCD display's purpose includes sharing relevant queue information to the customers outside the store. A motion sensor will be implemented to detect the motion of the customers entering and exiting the location. A QR-code scanner will scan the QR-code from a customer's device and uniquely identify each customer. Finally, the temperature sensor will take each customer's temperature and determine if he/she is healthy enough to enter the place of business.

1.1 Analysis of Component 1: Microcontroller

Due to our desire to have the device run off a battery, selecting a microcontroller with low power consumption was the first selection criteria in order to maximize our battery life. In addition, we wanted to select a microcontroller similar to one the team had experience with. As such, we landed on the STM32L family of low power microcontrollers to select from, as we had all used STM32 microcontrollers previously. In particular, we landed on the STM32L053C8, STM32L476VG, and STM32L496AG, as these are the Discovery board variants which are well suited to the flexible and rapid prototyping we anticipate occurring over the course of our project.

Microcontroller	**STM32L053C8 [1]**	**STM32L476VG [2]**	**STM32L496AG [2]**
Operating Frequency	32MHz	80MHz	80MHz
Flash Size	64kB	1024kB	1024kB
RAM Size	8kB	128kB	320kB
Timers	4 (16-bit)	11 (9 16-bit, 2 32-bit)	11 (9 16-bit, 2 32-bit)
ADC Channels	10	16	20
DACs	1	2	2

I/O Pins	37	82	134
I2C Connections	2	3	4
SPI Connections	2	3	3
UART Connections	-	2	2
USART Connections	2	3	3
Supply Current Range	0.29uA - 87uA	0.03uA – 100 uA	0.03uA – 90 uA
Operating Temperature Range	-40°C - 105°C	-40°C - 105°C	-40°C - 125°C
			Chosen

All three microcontrollers provide enough memory, a fast enough clock, and sufficient operating temperature range to be sufficient for our project. In order to further differentiate between them, we focused on the number of timers, I/O pins, various connection types, and the supply current values. Due to the large number of peripherals we plan on including in our design, a primary factor for us was the number of pins and connection types in order to be able to fully accommodate all of the devices. That, combined with the larger number of timers enabling us to have more recurring tasks, led us to select the STM32L496AG as it provided a higher degree of flexibility both in terms of hardware and software during our rapid prototyping process. However, the STM32L476VG is similar enough that it could likely be substituted if necessary.

1.1 Analysis of Component 2: WiFi module

In the past few years, the Espresif ESP8266 has been the most popular WiFi solution for MCU projects and iot devices because of the extremely affordable price compared to other WiFi solutions. It was the go to chip, however another competitor that has entered the market is the RTL8770 by Realtek.

WiFi module	Espresif ESP8266	Realtek RTL8710
Size	5x5 mm	6x6 mm
RAM	48KB available to user	36KB available to user
Flash storage	1MB	1, 2, 4, 8, or 16 MB
GPIO	Up to 21	Up to 17
I2C	Up to 3	Up to 1
UART	2x high-speed UART, 1x low-speed UART	Up to 2x UART
Power	Voltage: 3.0 to 3.6V; Current: 80 mA	
Temperature Range	-40 to 125 °C	

As can be seen from the table above, the RTL8710 is better than the ESP8266 in almost every metric and comes at a comparable price range. However, we still have decided to go with the ESP 8266 for two reasons:

- Even though the RTL8710 is better, both the devices are more than capable of handling the use case that we have in our design. Therefore, the RTL8710 does not provide us with any added benefit.
- Since ESP8266 is a very common device there is a lot of support online, which will be very helpful while working with this device.

1.1 Analysis of Component 3: Motion Sensor

Another major component is the motion sensor. Its purpose is to detect when customers are entering and exiting the store in order to keep an accurate count of the number of people inside the store and monitor for any unauthorized entry. We determined PIR sensors would be the best choice, as they would only require one sensor installation point per doorway and can differentiate based on temperature, meaning objects such as swinging doors should not interfere with a properly calibrated system.

Feature	AK9753[3]	Adafruit 189[4]
Communication Protocol	I2C	GPIO

Direction Detection	yes	no
Sensitivity Range	<3m	<6m
Power Supply	3.3V-3.63V	5V-12V
Operating Temperature	-30°C - 85°C	-20°C - 70°C
Price	$16.95	$9.95
	Chosen	

The two PIR options we decided between were the AK9753 Human Presence Sensor and the Adafruit 189 PIR Motion Sensor. While both options fit our operating temperature range, we chose the AK9753. We did so because it includes direction detection, meaning we can use just one sensor to cover entrance and exit, simplifying the mechanics of the device as well as enabling businesses with only one doorway to use it.

1.1 Analysis of Component 4: Barcode/QR codes scanner

The Barcode/QR scanner is an important piece when it comes to identifying customers. It will scan a code on the customer's phone to add them to the queue, and will scan the code again to verify the customer has reached the business when it is their turn to enter.

Feature	Waveform Barcode Scanner Module[5]	DFR0660[6]	MCR12[7]
Communication Protocol	USB/UART	USB/UART	USB
Barcode Scanning	Yes	Yes	Yes
QR code Scanning	Yes	Yes	No
Operating Voltage	5V	5V	5V
Operating Current	135mA	120mA	120mA
Standby Current	55mA	30mA	20mA
Operating Temperature	0°C - 60°C	0°C - 50°C	0°C - 50°C
Reading Angle	Pitch:±60° Skew:±65°	Pitch:±60° Skew:±65°	Pitch:±70° Skew:±60°

Price	39.99	49.90	69.95
		Chosen	

Looking at the options we found for barcode and QR code scanners, we quickly eliminated the MCR12 due to its high price, limitation to USB only, and inability to scan QR codes. The flexibility of the other scanners to use either 1D barcodes or 2D barcodes/QR codes as well as UART made them much better fits. Between the Waveform Barcode Scanner Module and the DFR0660, the main differentiator was current. The DFR0660 draws less current when operating and nearly half the current of the Waveform scanner in standby, meaning it is more energy efficient, an important consideration given our expected use of a battery. As such, we selected the DFR0660 for our preferred scanner.

1.1 Analysis of Component 5: LCD Display

The LCD display interfaces with the microcontroller to relay queue and operational information to the customer while engaging in the entry process. Its job is to notify pedestrians of current occupancy, customers at the top of the queue, and information regarding the entry procedure. The team determined that Virtual Queue's display should be LCD as opposed to an LED matrix due to size, pixel density, and availability of components. A LCD screen offers the ability to share more information on a similar-sized surface and provides a more modern and universally compatible aesthetic.

Three main LCD displays were looked at in detail. The first is the Adafruit 7.0" 40-pin TFT Display - 800x480. This screen, costing $37.50, is a "'raw pixel dot clock' display" , meaning it has no RAM, SPI or parallel type of controller. A separate driver, the Adafruit RA8875, would have to be purchased in tandem for another $34.95 in order to allow interfacing between the display and the microcontroller via 3-line or 4-line SPI in order to free up processing power and meet the timing requirements. The RA8875 eliminates the need to use more than 5 SPI pins, saving GPIO for other components. The display has 40 pin connector and 24-bit color capabilities. The Adafruit 5.0" 40-pin 800x480 TFT Display is a near identical display option, but priced cheaper due to a smaller display size. The MIKROE 7" Color Display is also quite comparable, differing mainly in the addition of touch screen capabilities, interfacing via I2C, and having a built-in driver. Otherwise all three displays encompass what we need for Virtual Queue. The Adafruit 7" display was chosen due to the size and the modularity with the driver (in the event of hardware issues).

Feature	Adafruit 7.0" 40-pin TFT Display - 800x480	Adafruit 5.0" 40-pin 800x480 TFT Display	MIKROE 7" TFT Color Display with Capacitive Touch Screen and bezel

Communication Protocol	SPI	SPI	I2C
Resolution	800x480	800x480	800x480
Screen Dimensions	154.08mm x 85.92mm	120mm x 75mm	154.08mm x 85.92mm
Analog Supply Voltage	3.3V-5V	3.3V-5V	3.3V
Backlight Voltage	9V	9V	9V
Operating Temperature	-20°C - 70°C	-20°C - 70°C	-20°C - 70°C
Price	$37.50	$29.95	$79.00
Additional Driver Required	Yes	Yes	No
	Chosen		

1.1 Analysis of Component 6: Temperature Sensor

The Temperature sensor is crucial for determining whether or not a customer can enter a business that utilizes Virtual Queue. For our application, non-contact IR sensors that measure temperature were sought out to minimize contact between customers, staff, and any intermediate surface. Two temperature sensors in particular were investigated: the TS418-1N426 and the TS305-11C55. The TS418-1N426 ($14) is used primarily for gas detection, whereas the TS305-11C55 ($8) is utilized in the medical field and climate data collection. The included tables from sources [11] and [12] (respectively) display the specifications. Both perform similarly, but the TS305-11C55 is cheaper and has a general application suited much better to Virtual Queue's needs, and thus is Team 4's choice.

TS305-11C55

PERFORMANCE SPECS

Parameter	Symbol	Value	Unit	Condition
Operating Ambient Temperature	T_{Amb}	-20 to +85	°C	permanent
Operating Ambient Temperature	T_{Amb}	-20 to +100	°C	non permanent
Package		TO-5		
Absorber Area	A	0.8 × 0.8	mm²	
Thermopile Resistance	R_{TP}	70 ± 30	kΩ	T_{Amb} = +25°C
Temperature Coefficient of Thermopile Resistance	TCR_{TP}	-0.06 ± 0.04	%/K	T_{Amb} = +25°C to +75°C
Voltage Response	V_{TP}	7.0 ± 2.1	mV	T_{Amb} = +25°C, T_{Obj} = +100°C, DC, totally filled field of view
Temperature Coefficient of Voltage Response	TCV_{TP}	-0.45 ± 0.08	%/K	T_{Amb} = +25°C to +75°C
Noise Equivalent Voltage	NEV	45	nV/Hz½	T_{Amb} = +25°C
Rise Time	τ_{63}	12 ± 5	ms	
Ambient Temperature Sensor		NTC		
Ambient Temperature Sensor Resistance	R_{NTC}	100 ± 5	kΩ	T_{Amb} = +25°C
Beta Value of NTC	β-Value	3955 ±0.3%	K	T_{Amb} = 0°C to +50°C

TS418-1N426

PERFORMANCE SPECS

Parameter	Symbol	Value	Unit	Condition
Operating Ambient Temperature	T_{Amb}	-20 to +85	°C	permanent
Operating Ambient Temperature	T_{Amb}	-20 to +100	°C	non permanent
Package		TO-18		
Absorber Area	A	1.4 × 1.4	mm²	
Thermopile Resistance	R_{TP}	180 ± 60	kΩ	T_{Amb} = +25°C
Temperature Coefficient of Thermopile Resistance	TCR_{TP}	-0.06 ± 0.04	%/K	T_{Amb} = +25°C to +75°C
Voltage Response	V_{TP}	depends on light source	mV	
Temperature Coefficient of Voltage Response	TCV_{TP}	-0.45 ± 0.08	%/K	T_{Amb} = +25°C to +75°C
Noise Equivalent Voltage	NEV	130	nV/Hz½	T_{Amb} = +25°C
Rise Time	τ_{63}	22 ± 5	ms	
Ambient Temperature Sensor		Ni-RTD		
Ambient Temperature Sensor Resistance	$R_{Ni\text{-}RTD}$	1000 ± 4	Ω	T_{Amb} = 0°C
Temperature Coefficient of Ni-RTD	$TC_{Ni\text{-}RTD}$	6178 ±150	ppm/K	T_{Amb} = 0°C to +100°C

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