Electronic Badge for Career Fairs

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ECE 445 Design Document - Spring 2020

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1. Introduction

1.1 Objective

Career fairs are an excellent place for students to connect with recruiters from a variety of companies and pursue roles that interest them in the most direct way possible. However, most students spend the majority of their time waiting in long lines for the more popular and well-known companies, which causes them to miss out on other promising companies [1]. This aspect hinders a student's ability to get as much benefit from a career fair as he or she should be able to. Additionally, as lion share of time goes away in standing in line for big companies, several promising but small companies get discouraged due to lower student volume at their stall. Another time consuming aspect of career fairs is the requirement of companies for the students to fill out electronic forms regarding necessary contact information for employment. This process is something that is repeated every time the student stands in line for a different company. Another issue many people overlook with regards to career fairs is the massive amount of paper that is printed for resumes [2]. Students can carry up to twenty resumes and so career fairs spawn tens of thousands of papers a lot of which get unused and wasted. In general, career fairs are plagued with a variety of problems which stem from inefficiencies in different facets.

Our main goal is to reduce a major portion of these inefficiencies by tackling the biggest problem which we consider to be the long lines and wasted time. Our solution involves building an electronic badge that students can carry around in career fairs that allows them to be placed in a virtual queue for a given company. This will grant students tremendous flexibility and allow them to be more productive with their time.

1.2 Background

As traditional career fairs struggle with inefficiencies, there has been a rise of virtual career fairs. They reduce paper wastage, have virtual queue systems and easy to apply interface for the candidates. This makes them a great alternative to traditional career fair. However, they suffer from lack of physical interaction, which is considered a key element in networking. Body language describes several qualities about a candidate and recruiters use it as a strong metric for selection [3]. Overall, in person interactions facilitate higher information richness and makes traditional career an essential aspect for recruiting. Hence, our solution to implement virtual queues aims to aid the traditional career and make it par with virtual career fairs.

Overall, virtual queues are becoming much more popular as more people are beginning to experiment with the concept. An example of this is amusement parks, which have adopted this idea by allowing visitors to queue up to different rides through a wearable [4]. This provides visitors flexibility to enjoy more rides and improves overall experience. Although easily available in other industries, the virtual queue technology isn't widely adopted at career fairs which suffers from the same problem as amusement parks. If the virtual queue system is implemented in a traditional career fair, it could have several benefits for students and companies. Career fairs are sponsored by companies and if companies witness increased efficiencies, career fairs can charge higher prices and attract more companies. On the student side, it can increase the probability of getting through the company recruiting processes, which can result in higher employment/internship rate for university. Although seemingly simple, virtual queues can provide sustainable value to career fairs.

1.3 High-level Requirements

1. Electronic badge must be able to connect to the receiver with a tap (within 1 inch), and the student should be added on the virtual queue of the company.

2. Electronic badge must display current positions for a student for 3 virtual queues, alert them when the position is <10, and allow the student to remove himself/herself from the queue.

3. The receiver must maintain and process a virtual queue of upto 999 students, and send each badge the student's position every 2 minutes.

2. Design

2.1 Electronic Badge

2.1.1 Block Diagram

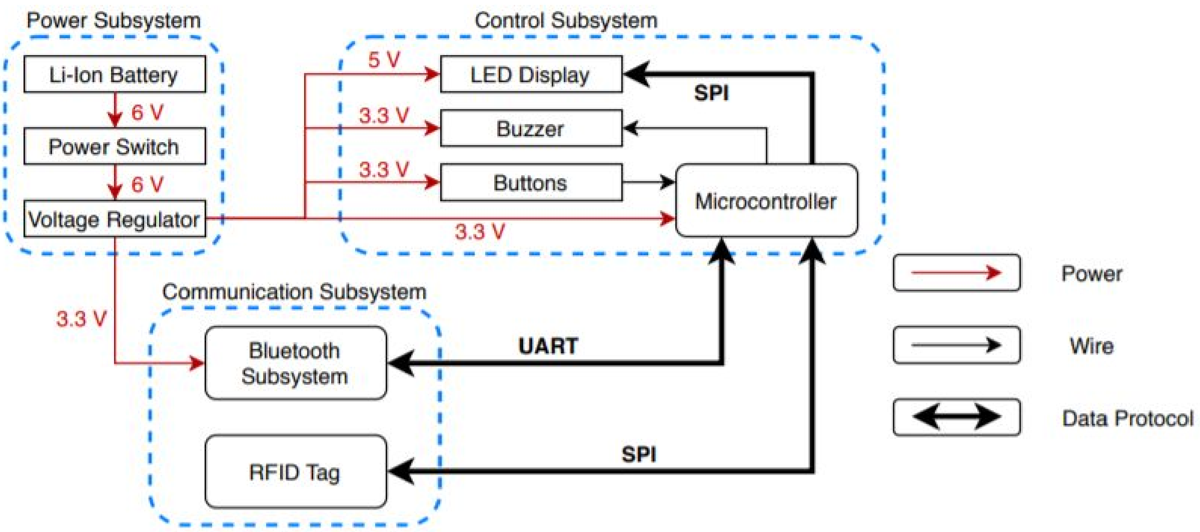

Figure 2.1: Block diagram

2.1.2 Physical Diagram

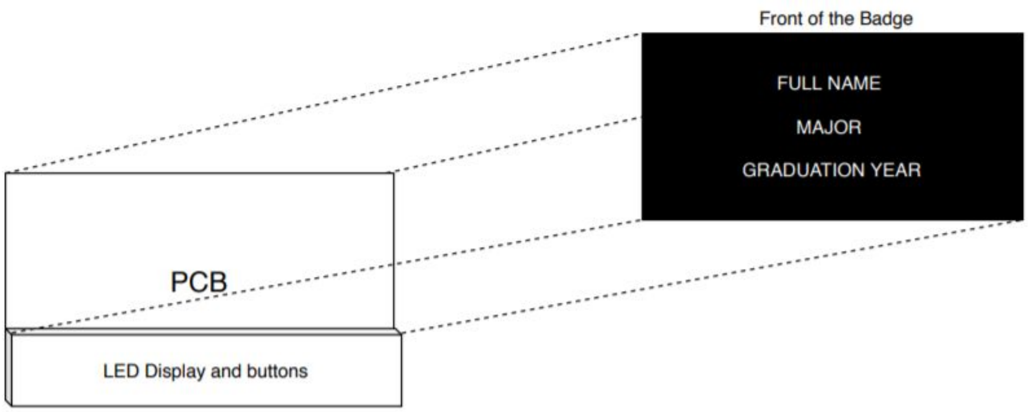

Figure 2.2: Block diagram

The black part will be hooked on the PCB and will cover the PCB board. It will be placed above the LED display and buttons.

2.1.3 Power supply

Li-ion battery

The lithium-ion battery must be able to keep the circuit continuously powered when switched on, and should be lightweight and small to fit on the electronic badge and not make it heavy. Additionally, it will need to last throughout the day in the career fair as we don't want students to go change the battery in the middle or keep it for charging.

Requirement(s)	Verification
Requirement 1: Battery should be able to provide a voltage output of 4.5-6 V for 5-6 hrs.	A multimeter will be used to check if the voltage output is equal to the specified values. Use an oscilloscope to check if the voltage signal is steady.
Requirement 2: Battery should be able to store 1500-2000 mAh.	1. Connect a fully-charged lithium-ion battery with VDD and GND. 2. Put a resistor with LED across in parallel and let 250 mAh drain for 5-6 hrs. 3. Put the Voltage meter across the VDD & GND, and check for the voltage levels till the end. 4. If the LED lights up till the end, the battery could store 1500 mAh.

Power switch

We don't want the device to run indefinitely, and would like to switch it off after use. Thus, we need a switch which disconnects the voltage regulator from the battery when switched off.

Requirement(s)	Verification
Requirement 1: A switch which disconnects the voltage regulator from battery when off and provides very less voltage (<= 0.2 Volts) drop when switched on.	1. Connect the switch across the battery and put a voltage meter right below the switch. 2. Turn on the switch and note the voltage. 3. Turn the switch off and if the switch works, the circuit will get disconnect and the value should be close to 0 V.

Voltage regulator

Different components in subsystems would require different voltages. Additionally, battery voltage drops over time, whereas various subsystems would need constant stable voltage. Hence, a voltage regulator would be needed to ensure stable and correct voltage is provided throughout the badge.

Requirement(s)	Verification
Requirement 1: Can output stable 3.0 - 3.3V from an input of 4.5V to 6V battery.	A. Connect battery parallely with a resistor and connect the voltage regulator with GND and VDD across battery. B. Use an oscilloscope to measure the output across the voltage regulator.
Requirement 2: Maintains thermal stability below 125°C.	During 1A, use an IR thermometer to ensure that temperature stays below 125°C.

2.1.4 Control Unit Subsystem

Micro-controller

The microcontroller should be compatible with bluetooth module, RFID tag, LED display, and the vibrating buzzer. It must communicate with the Bluetooth module via UART and the RFID tag via SPI (Serial Peripheral Interface). Whenever it receives an updated position for the queues via bluetooth, it must update the LED display via SPI. It must trigger the vibration of the buzzer when any of the current positions are < 10. Lastly, if the button is pressed, it must send a request to the receiver via bluetooth to remove the user from the queue.

Requirement(s)	Verification
Requirement 1: The microcontroller must be able to communicate over UART protocol with the bluetooth module.	Communication via UART: 1. Connect microcontroller to a USB-UART bridge, like CP2102. 2. Using a terminal, send data via the UART bus and verify whether this is the same as the data echoed back
Requirement 2: The microcontroller must be able to communicate over SPI protocol simultaneously with 2 systems (LED display and RFID tag)	Communication via SPI: 1. Connect microcontroller to a USB-SPI bridge, like MCP 2210. 2. Using a terminal, send data via the

	SPI bus and verify whether this is the same as the data echoed back

LED Display

The LED would display to the student his/her current position on the 3 virtual queues.

Requirement(s)	Verification
The LED must clearly display the 3 current positions of maximum 3 digits each.	1. Connect the LED display to the microcontroller. 2. Using the SPI communication procedure, seen above, send data and verify this data is displayed on the LEDs.

Buzzer

The vibrating buzzer soldered on the underlying PCB should be able to alert the student when his/her current position on any of the 3 queues is < 10.

Requirement(s)	Verification
The vibrations should be strong enough to be recognized by the user, but not too strong. The vibrating mini motor disk should work with 2V-5V input voltage, which would be adjusted based on the required strength of vibration.	

Buttons

There should be 3 buttons (one for each virtual queue), which when pressed, should allow the student to remove himself/herself from the corresponding queue.

Requirement(s)	Verification
Buttons should be easy to press but should not be too sensitive to touch.	

2.1.5 Communication Subsystem

Bluetooth module

The bluetooth module must be BLE (Bluetooth low energy eg. RN4871). This means it would have low power consumption, few milliseconds of connection time and high data rate. This module must be able to establish a connection with the receiver every 2 minutes to:

1. receive the updated position of the user on the queues and send them to the microcontroller.
2. send a signal to remove the user from the queue when commanded by the microcontroller.

Requirement(s)	Verification
Requirement 1: The module must be BLE (low-energy bluetooth) with an input voltage requirement of ~3.3V.	
Requirement 2: Must establish a connection with the receiver's bluetooth module every 2 minutes, and thus must be long-range bluetooth (50-100 m).	
Requirement 3: Must communicate with the microcontroller using UART to send the updated positions, and receive commands for removal from queue.	

RFID Tag

The RFID tag should be able to activate when close enough to the receiver and send relevant information (UIN) to it, to allow students to be put on the virtual queue. It should have fast detection time (thus fast data transmission) and should only work within a close range as we would prefer the system system to only work when the badge is in close proximity of the receiver.

Requirement(s)	Verification

Requirement 1: RFID tag's read range should be at most 10 cm of the receiver.	Move the tag increasingly far from the reader to determine the maximum range. Reduce power to the reader accordingly.
Requirement 2: Should have >100 bits to store the UIN of the user and the unique bluetooth ID and must be reprogrammable	The tag is a purely passive device. We should be able to use the user programmable memory on the tag, and read the serial output from the SPI pin of the reader.
Requirement 3: The operating frequency should be ~13.56 MHz for appropriate data transmission as low frequency tags reduce the speed of data transmission.	The reader should also operate at the same frequency, and the status LED on the receiver should light up when a tag is detected in this frequency range.

2.2 Electronic Receiver

2.2.1 Block Diagram

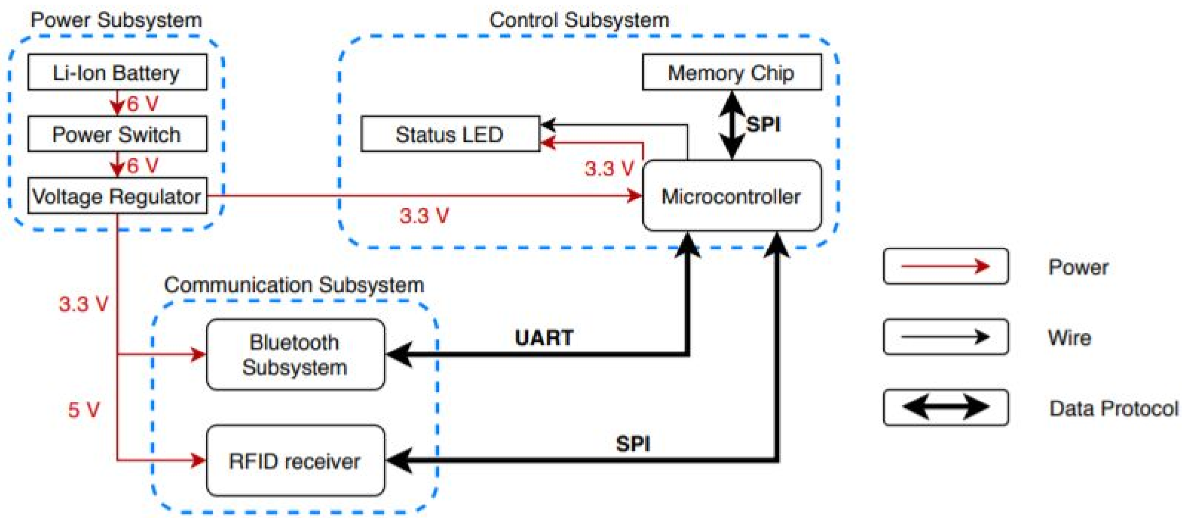

Figure 2.2: Block diagram for Electronic Receiver

2.2.2 Power Supply

Li-ion battery

The lithium-ion battery must be able to keep the circuit continuously powered over a long period of time.

Requirement(s)	Verification
***Requirement 1*:** Battery should be able to provide a voltage output of 4.5-6 V for 5-6 hrs.	A multimeter will be used to check if the voltage output is equal to the specified values. Use an oscilloscope to check if the voltage signal is steady.
Requirement 2: Battery should be able to store 1500-2000 mAh.	1. Connect a fully-charged lithium-ion battery with VDD and GND. 2. Put a resistor with LED across in parallel and let 250 mAh drain for 5-6 hrs. 3. Put the Voltage meter across the VDD & GND, and check for the voltage levels till the end. 4. If the LED lights up till the end, the battery could store 1500 mAh.

Voltage regulator

Different components in subsystems would require different voltages. Additionally, battery voltage drops over time, whereas various subsystems would need constant stable voltage. Hence, a voltage regulator would be needed to ensure stable and correct voltage is provided throughout the badge.

Requirement(s)	Verification
Requirement 1: Can output stable 3.0 - 3.3V from an input of 4.5V to 6V battery.	C. Connect battery parallely with a resistor and connect the voltage regulator with GND and VDD across battery. D. Use an oscilloscope to measure the output across the voltage regulator.
Requirement 2: Maintains thermal stability below 125°C.	During 1A, use an IR thermometer to ensure that temperature stays below 125°C.

Power switch

We don’t want the device to run indefinitely, and would like to switch it off after use.

Requirement(s)	Verification
Requirement 1: A switch which disconnects the voltage regulator from battery when off and provides very less voltage (<= 0.2 Volts) drop when switched on.	1. Connect the switch across the battery and put a voltage meter right below the switch. 2. Turn on the switch and note the voltage. 3. Turn the switch off and if the switch works, the circuit will get disconnected and the value should be close to 0 V.

2.2.3 Control Unit Subsystem

Micro-controller

The microcontroller should be compatible with bluetooth module, RFID reader and status LED. It must communicate with the Bluetooth module via UART and the RFID reader via SPI (Serial Peripheral Interface). Whenever it receives information regarding a new tap from RFID reader, it must add the student to the stored queue, and inform the student that he/she has been added via the status LED. Additionally, it must send the updated positions of each badge through bluetooth, and must remove any student from the queue if it receives the command through bluetooth. Lastly, when a student whose position on the queue is < 10 taps again, the student must permanently be removed from the queue.

Requirement(s)	Verification
Requirement 1: The microcontroller must be able to communicate over UART protocol with the bluetooth module.	Communication via UART: 1. Connect microcontroller to a USB-UART bridge, like CP2102. 2. Using a terminal, send data via the UART bus and verify whether this is the same as the data echoed back
Requirement 2: The microcontroller must be able to communicate over SPI protocol simultaneously with 2 systems (LED display and RFID tag)	Communication via SPI: 1. Connect microcontroller to a USB-SPI bridge, like MCP 2210. 2. Using a terminal, send data via the SPI bus and verify whether this is the same as the data echoed back

***Requirement 3*:** Must have memory chip storage of at least 10kB for accommodating a virtual queue of a 1000 students and logic for maintaining it. Must also have read and write speeds of ~ 4.5Mbps.	

2.2.4 Communication Subsystem

Bluetooth Module

The bluetooth module must be BLE (Bluetooth low energy eg. RN4871). This means it would have low power consumption, few milliseconds of connection time and high data rate. This module must be able to establish a connection with each electronic bade every 2 minutes to:

1. Send the updated position of each user on the queue to each badge.
2. Receive a signal to remove any user from the queue and forward the command to the microcontroller.

Requirement(s)	Verification
Requirement 1: The module must be BLE (low-energy bluetooth) with an input voltage requirement of ~3.3V.	
Requirement 2: Must establish a connection with the receiver's bluetooth module every 2 minutes, and thus must be long-range bluetooth (50-100 m).	
Requirement 3: Must communicate with the microcontroller using UART to send the updated positions, and receive commands for removal from queue.	

RFID Receiver

We need the receiver to activate RFID tags and receive UIN information. It should also be able to send this information to the microcontroller so that the system can maintain the virtual queue.

Requirement(s)	Verification
Requirement 1: RFID receiver activates RFID tag within at most 10 cm range.	Move the tag increasingly far from the reader to determine the maximum range. Reduce power to the reader accordingly.
Requirement 2: Connects to microcontroller and can successfully send the received UIN and Bluetooth ID over SPI protocol.	The tag is a purely passive device. We should be able to tap the device on the reader, and read the serial output from the SPI pin of the reader.
Requirement 3: The operating frequency should be ~13.56 MHz for appropriate data transmission as low frequency tags reduce the speed of data transmission.	The tag must also operate at the same frequency, and the status LED on the receiver should light up when a tag is detected in this frequency range.

2.3 Tolerance Analysis

One important subsystem which should operate during the entire career fair duration is the power-supply module. Every student would add themselves to virtual queues and wait accordingly; however, if the electronic badge system turns off during the career fair not only student lose will his/her spot in the career fair, he/she won't be able to add themselves in any further lines. This would result in the entire career fair day being wasted and is something which has to be absolutely avoided. We will model the power supply subsystem for tolerance analysis. To begin, we would need mAH requirement for normal operations in the system.

We have 5 main components on the badge side which would consume power:

a. Power regulator: Using a linear regulator we would modify any incoming input to a smooth 3-3.3V output. This means, we can calculate the tolerance based on other 4 elements and an input of 3-3.3Vs
b. LED display: 15mAh for a Monochrome 128x32 I2C OLED graphic display
c. Micro-controller: 0.5 mAh for ATmega328p at 1 Mhz at 1.8V. However, we would need to operate at moderate throughout so 10 Mhz resulting at 5 mAh. However, we operate at 3.3 V and then we will have 10 mAh of consumption.
d. Bluetooth module: 2.23mA during connected test mode with 18.75 ms interval
e. Buzzer: 10 mAh for medium vibrations.

Every hour we would need 48 mAh, for normal operations which would result in 300 mAH consumption, which is less than stated requirement for batter power.

However, we will assume the battery has error of 20% and the subsystems:

1. Buzzer might be frequently used: 30-40 mAh

2. Micro-controller at peak 20 Mhz range would result in 20 mAH
3. LED display would use every pixel: 80 mAh
4. Bluetooth module is already considered at max but we would give another 10% leeway

This would result in a new power requirement of ~145 mAh. Assuming a 10% burnout throughout circuit, would bring this to 160 mAh. Battery with 20% error can have in worst case only 1200 mAh power (1500 * 0.8).

Using the extremes of tolerances, we still get 7.5 hrs of work time, more than needed for a 6 hr career fair. Hence, our system would work given the extremes of the tolerances and will achieve the needed result.

3. Cost Analysis

The labor costs can be calculated by the formula seen below, using an hourly rate of 50$, 12 hours per week for 10 weeks:

$$Labor\ Costs\ =\ 2.5\ \times\ (group\ size)\ \times\ (hourly\ cost)\ \times (hours\ per\ weeks) \times\ \ (\#\ of\ weeks)$$

Inputting the values:

$$Labor\ Costs\ =\ 2.5\ \times\ 3\ \times\ 50\ \times\ 9\ \times\ 10$$

Therefore we have:

$$Labor\ Costs\ =\ \$45,000$$

4. Schedule

5. Safety and Ethics

When considering the ethics of our project we made sure to consult the IEEE code of ethics which consist of 10 different guidelines. Based on these guidelines, our project doesn't have any significant issues to breach the outlined ethical code, but there are some things that are worth talking about.

Some of these ethical issues relate to the eighth listed guideline of the IEEE code of ethics which says “to treat fairly all persons..” [5]. In certain cases, some of the parts which are used in our project, like the LED display or bulb could stop working due to overuse or other unknown reasons. This could result in some students not being able to use an electronic badge of their own to take advantage of the virtual queue system. We will therefore have to make sure we are aware of this as we build our badge and focus on using good quality parts. Another ethical issue which could unfairly impact some people is if they are talking to a certain recruiter and their position comes up for another virtual queue causing them to miss their place in the other queue. To counter this issue, we decided to have the badge alert them when they are tenth in the queue so that they have enough lag time to make their position. Another ethical issue could arise if the cost of the badge is placed on the students which could result in some students missing out on the product. Ideally this issue would not be present given the badges are handed free of cost from ECS itself.

The first and ninth listed guidelines of the IEEE code of ethics are also very important which say “to hold paramount the safety, health, and welfare of the public...” and “to avoid injuring others...” respectively [5]. These guidelines connect well with safety problems that could arise for our project which will be further elaborated upon. The two biggest safety issues for our project involve the Li-ion battery and the badge design. When it comes to the Li-ion battery, these can overheat with a lot of usage and when this goes to extreme levels, it has the potential to catch fire [6]. Although this is very rare, it is an important safety hazard and definitely something we have to be mindful with regards to the usage for both the electronic badge and receiver. Another safety issue is if a student drops the badge by accident, which could cause damage to the badge for future use and result in the parts being scattered across the floor. It is therefore very important that the badge is made to be as sturdy and durable as possible to avoid such a safety hazard.

6. References

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