Schafer's Wafers

Clean Room ID System
High Level Design Document

Barbara Raynal
Matt Schueler
Rob Maurer
John Plunkett

Table of Contents

1. Introduction

The addition of Stinson-Remick and a new class 100 cleanroom to the College of Engineering's resources has created a lot of excitement among students and faculty. Additions are still being made in order to enhance this crown jewel of the engineering department. With this purpose and with the users in mind, Professor Seabaugh suggested the idea of creating a system that displays a list of users who are currently working in the cleanroom. Knowing who is in the lab in case of an emergency is essential for the user's safety. Being able to quickly identify the users would be very useful for the emergency responders. Also, students and faculty are often looking for someone, and it is hard to distinguish between people while they are wearing the coveralls. The display will not only serve safety purposes, but it will also allow students, faculty, and visitors to know who is currently utilizing the cleanroom.

2. Problem Statement and Proposed Solution

The cleanroom at Notre Dame is used by students, faculty, and technicians on a regular basis. Cleanroom users are required to wear hoods and coveralls, which make them difficult to quickly identify from the lobby. This is not only inconvenient, but it is also a safety hazard. In an emergency situation, it is important to be able to quickly locate users.

To address this problem, we will implement an electronic display that will show cleanroom user information. This will allow people in the lobby to quickly identify who is in the lab at any given time. As a user enters the cleanroom, their name will be added to a list of current users shown on an LCD in the foyer of Stinson-Remick.

Another issue with the cleanroom is that users often find themselves waiting on machinery to become available and functional. The lab staff emails the users when a machine breaks down or is repaired, but the quantity of notifications each day makes it difficult to keep track of which machines are currently functional and as such, the majority of these notifications are promptly forgotten.

A secondary function of the display system would address this issue by displaying the status of equipment in the lab (upon request from the user). The system will interface with a cleanroom system called CORAL that keeps track of when equipment is being used and when equipment is under repair. Since the user information has been deemed more important, the display may only show the equipment statuses when a button by the display is held down.

3. System Description and Block Diagram

The system will have four main inputs (RF ID Scanners, Administrator Access, CORAL, and display selection button) and one output (LCD). All of the logic in the system will take place in the embedded ARM processor. The binary information from the RF ID scanners uses Wiegand protocol (26 bits for each scan). The information will be sent through a Y-cable, which sends it to both the lock shop server and a Bluetooth transmitter for our system. This way, the display can see cleanroom user information without compromising the security of the information in the lock shop server. The Wiegand binary data will be received by the processor through a wireless USB module with Wi-Fi and Bluetooth capabilities. The processor will receive the binary code, and reference a look-up table to figure out which person is scanning in or out of the cleanroom. That person's name will be added to a list of current users, and the LCD will be notified to display the updated list.

The data from the CORAL can be accessed using the same USB module's Wi-Fi capabilities. The module will remain in a sleep mode until it sees that the data from the CORAL was changed or if it receives data from the RF ID scanners. An administrator will be able to access the look-up table through the USB module over the internet. This way, users can be readily added or deleted from the system. There will be one button by the display that will send one bit of information to the processor. If the button is being pressed, the processor will receive a 1, and it will show the equipment statuses until the button is released, and the bit is changed to a 0. This allows the secondary feature to be useful without taking away from the primary feature of displaying user information as conveniently as possible. Finally, the processor will connect to the LCD through an HDMI cable.

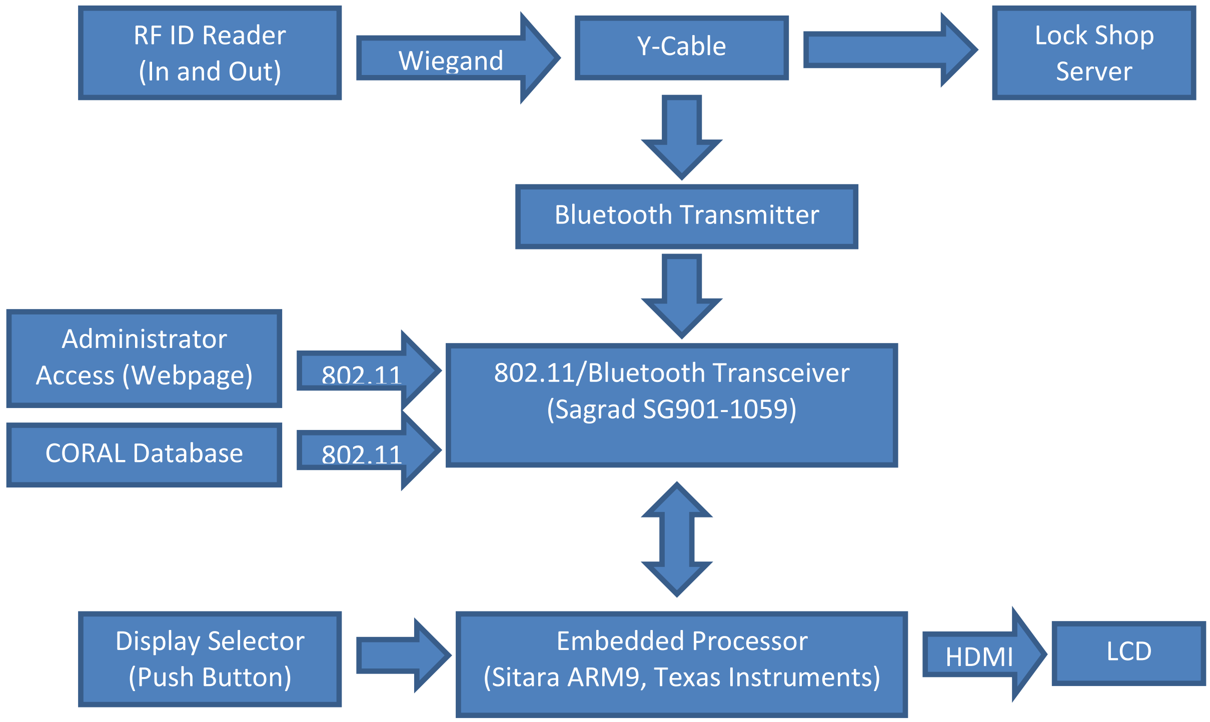

Figure 1: Block diagram

4. System Requirements

4.1 Overall system requirements

Overall System Requirements	
Purpose	Display information about the cleanroom users at all times
Power	Display screen must be powered 24 hours a day. To meet this requirement, the screen will be powered through an outlet.
Information Acquisition	Embedded processor must have constant access to the swipe card information about cleanroom users, as well as CORAL to get machine statuses.
Bluetooth	User information from the scanner on the cleanroom door must be transferred to the embedded processor.
Wireless Internet (Wi-Fi)	The administrator and CORAL system must be able to communicate with the embedded processor.

Inputs	Embedded processor must receive information from the display selector, CORAL, RFID reader, and the administrator
Adjustable Settings	The administrator should be able to edit the information displayed on the screen, as well as the list of current lab users. What information is retrieved from the server can be adjusted by the administrator as well. There is no need to slow down the system by retrieving information that is not being used at the moment.

4.2 Subsystem and Interface Requirements

Subsystem and Interface Requirements	
LCD Screen Setup	The screen will be on a stand so as not to damage the cleanroom walls
Power	Since the screen is powered by an outlet it must be placed near one
Bluetooth	Only needs to work in a small range
Wireless	A chip that provides Wi-Fi access for the microcontroller is necessary.
Display Selector	It must be accessible and allow the user to shift the information displayed on the screen
RFID Reader	Must be modified by inserting a Y-cable so that the user information will travel undisturbed to the lock shop as well as to our transmitter.
Administrator	A webpage that allows the administrator to change settings should be available and accessible from any computer
Software	The code must allow the embedded processor to understand the information extracted from the RFID reader and assign it to a specific user to be able to display the user's name

Software (continued)	The time at which the user enters the cleanroom is also acquired and the processor will keep track of how long the user has been inside the cleanroom so that this information can be displayed as well.
	The software must allow the administrator to easily add/remove lab users.
	There must be a series of interrupts in the embedded arm processor so that it can detect the changes in the input to keep the information on the display up to date.

4.3 Future enhancement requirements

Future Enhancement Requirements	
Software must make it easy for new features to be added as needed. Some extra features are suggested in this table	
Background/font colors	Change them periodically to prevent burn-in damage to LCD
Top cleanroom users	Display the names of the top users per week/month/all time.
Top machinery/bench users	May require adding more buttons for the user to choose what information to display on the screen
Customizable slide show	The administrator would be able to create a slide show for special occasions, such as dinners in the Stinson-Remick lobby.
iPhone Application	This would allow users to check who is in the cleanroom at any given moment from their iPhone. It would also contain information about machine availability, top users, and current research undertaken.

5. High Level Design Decisions

The main project components are the embedded processor, USB Wi-Fi module, LCD screen, and the Y-cable. The current processor choice is from the Sitara ARM9 family of processors from Texas Instruments. This family has a built-in LCD controller feature and USB capabilities. We will need to figure out the RAM requirements of the software before we choose the exact model. The USB module can be a Sagrad SG901-1059, which has both Bluetooth and Wi-Fi capabilities. The Wi-Fi feature can be used to access data from the CORAL system, while the Bluetooth can be used to transfer the binary information from the RF ID system. The LCD can be driven by an HDMI cable from the microprocessor.

The system will be powered by an outlet near the entrance to the cleanroom. We will use a surge protector and plug in both the LCD and the embedded processor. In order to power the embedded processor with DC power, we will need to use an AC to DC converter.

5.1 RFID Reader System

The RFID readers are manufactured by the company Lenel. They operate using the protocol Wiegand. This involves sending 1 parity bit, 8 bits of facility code, 16 bits of ID code, and a trailing parity bit. This code is split in the Y-cable: one version is sent to the lock shop server as before, while the other is sent to our Bluetooth transmitter. The 16 bit ID code can be decoded at the embedded processor connected to our LCD so that we can keep track of the users currently in the cleanroom. Two Y-cables are necessary: one for users swiping into the lab and one for users swiping out. Bluetooth was selected due to the fact that the data needs to be transmitted only a short distance from the card swipe to the display module, and Bluetooth systems require low power. Additionally, the wireless transceiver chip selected for our display module operates using both 802.11 and Bluetooth, meaning that a separate Bluetooth chip is not necessary here.

5.2 CORAL System

In order to retrieve the machine status information, the embedded processor needs to get the data from the appropriate database. A read-only role was set up in the database so that we can access the information needed without accidentally making any changes to any of the information stored in the database.

PostgreSQL is an object-related database management system that is used to manage all the data in the CORAL system. The command-line utility ‘psql’ is used to access the desired information. Procedural languages other than SQL, such as C can be used to execute commands. By typing a specific command, different tables can be called depending on what kind of information the user is interested in.

For the Cleanroom ID System, the kind of information needed is machine statuses and the name of the user who has each machine enabled. For this purpose, a table that lists all enabled machines could be called. Basically, all the information needed is there. It is just a matter of calling the right table and sorting out the information. This is something that the embedded processor will have to take care of. Part of the code will have to be dedicated to sorting the information provided by the tables acquired from the database.

The information will have to be filtered so that only the relevant information remains and is put in the right place so that it is ready to be displayed on the display screen.

5.3 Administrator Access

The administrator access feature will involve creating a website and interfacing it with the embedded processor. The website will be written using HTML, and the applets used to edit display options and access the user look-up tables will be written with Java. The website will be run through Notre Dame's local network, and will require an administrator password to access it.

When the administrator page is updated, the data will be sent to the processor with the USB module's Wi-Fi feature. The processor will receive the data and will have to use a C program to correctly apply the administrator commands to the look-up table or to the display.

5.4 Display Module in Lobby

The display module is the main component of our system, as it is how the information regarding current users is conveyed. There are three major parts of the display module: the LCD screen, the embedded processor, and the wireless transceiver chip.

5.4.1 LCD Screen

The LCD screen is the most important element because it is what the user will interact with. All of the other project elements work together so that the right information is available to the public through the display screen. The LCD should be of reasonable size so that the information can be comfortably read by any person interested in cleanroom activities. It should also have an HDMI port that allows it to communicate with the processor. The limiting factor when selecting the LCD is cost. We plan to purchase the largest LCD possible based on our budget and the money provided by the electrical engineering department.

5.4.2 Embedded Processor

Several considerations need to be made when selecting a processor for the display. The most important is whether or not it is compatible with the LCD as well as Wi-Fi/Bluetooth. The processor needs to have enough memory to store the list of current lab users so that it is able to decode the information provided by the RFID reader, as well as sort and filter the machine information provided by the CORAL system and drive the LCD. At the moment, we have selected a processor from the ARM 9 Sitara family of Texas Instruments. This processor is attractive due to its built-in LCD controller, with documentation. It also supports access to a Wi-Fi connection through USB2.0, and allows for connections to external memory, if it becomes necessary. Finally, it has a built-in operating system, simplifying code development.

5.4.3 802.11/Bluetooth Transceiver

The specific wireless USB module that will be used is the Sagrad SG901-1059. This is a high speed transceiver that supports Windows and Linux OS.   This element is a key factor of the project. It allows the RFID reader to send information to the processor as well as the administrator and CORAL system. The RFID reader sends user information via Bluetooth and because this information is only transferred from the cleanroom door to the Stinson-Remick foyer, the Bluetooth capability does not need to work over a large range. The administrator and CORAL communicate with the processor through a wireless connection (ND-Secure, nomad). Because it is high speed, all data can be transferred without making the system slow and troubling the user.

5.4.4 Display Selector

A push button is needed to provide the user the option of changing the information available on the LCD. The default screen will display the names of the users currently inside the cleanroom. When the user decides to press the button, the processor will receive a 1, and it will show the equipment statuses until the button is released, and the bit is changed to a 0. The button should be accessible to an average-height person so that anyone can benefit from this added feature.

6. Open Questions

As of right now, we are unsure if we can get a Y-cable installed at the output of the card readers due to the fact that the RFID readers would need to be taken apart. If we are unable to use this method, we may have to add either another card reader or a keyboard where users can enter their netID as they enter the lab. Ideally, we can use a Y-cable so that users won't have to go through an extra step while entering the cleanroom.
We still need to finalize the model of embedded processor as well. Once this is done, we can figure out if we need more memory to run the system. In that case, we will need to install an SD card to add more memory that can support the user database.

We do not yet know the logistics of the administrator access feature. This will probably be done through internet access and the USB module. It is possible that we will have to write a program to allow easy modifications of the lab user list and the display settings. Finally, we still do not know how large and expensive the LCD will be. If we are granted supplementary funding from the department, a larger screen can be acquired. Otherwise, a small screen that allows us to stay within budget will be purchased.

7. Major Component Cost

Component	**Initial Selection**	**Cost**
LCD screen		$200 -?
Wireless chip (802.11/Bluetooth)	Sagrad SG901-1059	$31.04
Bluetooth transmitter (for Y-cable)		
Embedded processor	Sitara ARM9	$13.00
Surge protector		$10.00 - $30.00
Y-cable (x2)		$2.00 - $20.00 each

8. Conclusion

The implementation of this project will help solve the problem of quickly finding students and lab staff who are in the cleanroom. The display will provide both convenience and serve as a safety precaution as it will show who is in the cleanroom at any given time in the case of a fire or other accident. It also has the added benefit of serving as a point of interaction between the cleanroom and visitors.

We have ideas for how to design the system, and we have alternative solutions for any of the parts that turn out to be unfeasible. The heavy use of software in the design allows us a lot of freedom in designing extra features and programs. As described in section 6, there are still some unanswered questions. We are confident, however that we can get the project working.

We have received support from several members of the Notre Dame community, who deserve acknowledgement: Mike Young, Andrew Tripp, Mike Thomas, Prof. Seabaugh. We thank them for their time and willingness to collaborate with us.