Schafer's Wafers
Clean Room ID System
Low Level Design Document

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1 Introduction

The addition of Stinson-Remick hall and the new Notre Dame Nanofabrication Facility has created a lot of excitement among the students and faculty in the electrical engineering department. The new cleanroom has been in use for 8 months, and the transition towards becoming a functional, full-time research facility is nearly complete. In the class 1000 and class 100 areas of the cleanroom, users are required to wear masks, coveralls, booties, and gloves to prevent the dispersion of particles and other contaminants. The downside of this is that it makes it difficult for faculty members to identify who is in the cleanroom without going through the gowning procedure. With this in mind, Professor Seabaugh proposed that a display system be designed, built, and mounted in the foyer of Stinson-Remick Hall that posts the current users for people to see from the lobby. It can also be used to tell people in the lobby which machines are reserved, in use, or broken. The display system will serve as a safety precaution, as users will be able to be quickly located and evacuated in case of an emergency. It will be a fun and convenient way for users to plan out their lab time, and it will increase efficiency by minimizing the number of times users need to enter and exit 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. The processor will intermittently poll a cleanroom system called CORAL that keeps track of when equipment is being used or is under repair. Since the user information has been deemed more important, the display may only show the equipment status off to the side of the screen, or when prompted by an additional input (android app).

3 System Description and Block Diagram

The system will have 3 main inputs (the lock shop Server, the administrator website access, and the CORAL software). All of the logic in the system will take place in the Zotac MAG board. The lock shop server keeps a database of cleanroom users based on binary information that it receives from the card scanners at the entrance to the lab. The lock shop has promised that it will implement a program that will send an email to a designated email address (ndnfinfo@nd.edu) each time a user enters or exits the cleanroom. The assumed format of the email will provide the name of the user, whether they have just entered or exited the lab, and the time. A C-Program that runs on the Zotac MAG board will be used to access the email account and keep track of which registered users are currently logged into or out of the cleanroom in a matrix. The names that are "logged into" the cleanroom at any given time will be shown on the display. There will also be a log kept that records the total time each user has spent in the cleanroom each week so that additional features, such as a "top ten users" function.

The CORAL system is accessed through the Zotac MAG board's Wi-Fi 802.11n chip. The information from CORAL is acquired via a read-only account setup by Mike Young for CORAL's remotely accessed database. The program will intermittently poll the CORAL database to see if anything has changed since the last poll. The CORAL information, including who is currently using each machine, and the status of each machine, will be displayed alongside the current user information. The display graphics will be interfaced to an LCD from the Zotac MAG board through a VGA cable.

The ndnfinfo website will be accessible directly from ND's EE department website. This will allow users to see the information from the display system from their own computers. The website also will have a password-protected administrator access that will allow someone to add or remove names from the list of registered cleanroom users. The administrator will also be able to edit the website using Dreamweaver software combined with ndnfinfo AFS access, and to modify the display options on the main LCD. The website will have a link to the remote CORAL access program so that users can more easily reserve or check on machines and equipment. If time permits, we will try to have the CORAL program run on a GUI interface directly on the website, so that users won't have to download the program to reserve machines remotely.
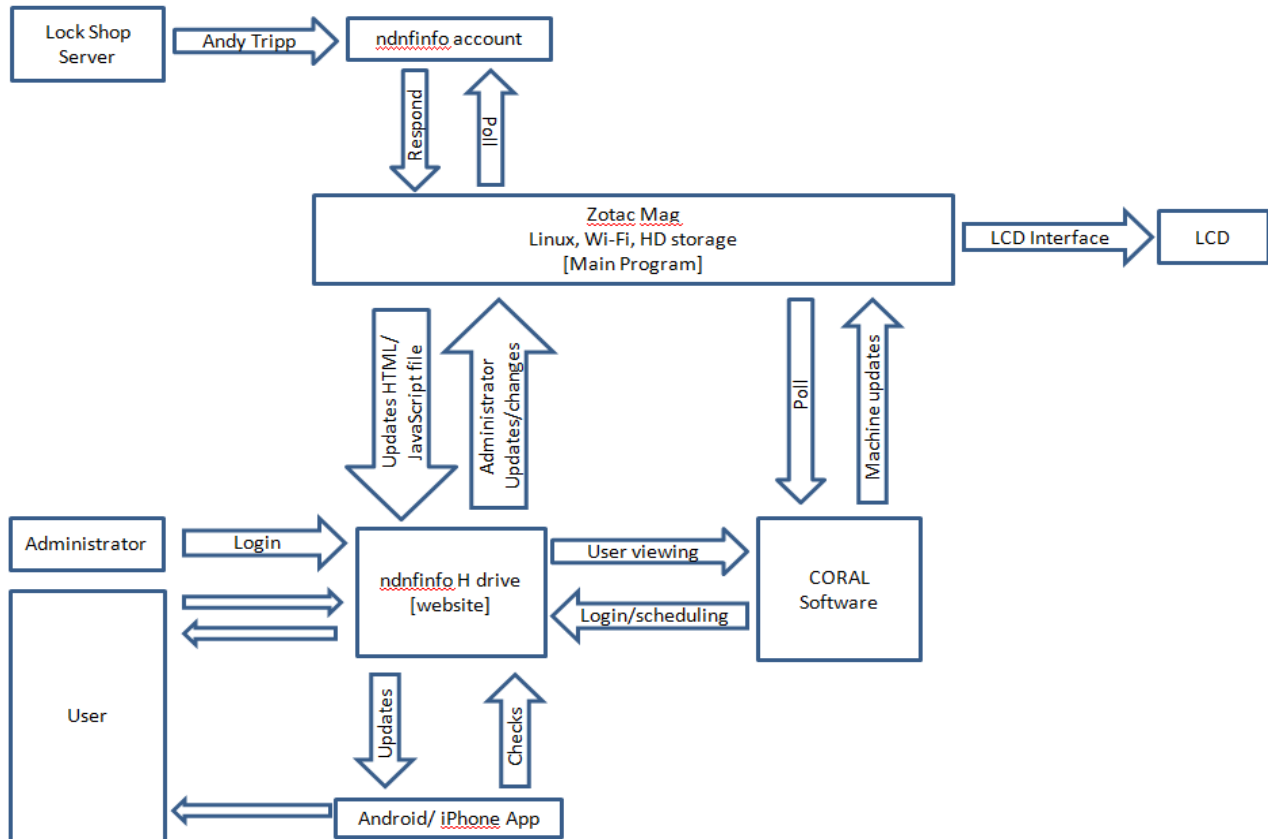
Figure 1. Overall system block diagram.

4 System Requirements

4.1 Overall System:

Overall System Requirements	
Purpose	Display information about the cleanroom users at all times giving the user the option to view machine statuses instead.
Power	Display screen must be powered 24 hours a day. To meet this requirement, the screen as well as the Zotac single board computer will be powered through an outlet. A power cable will be connected from the nearest outlet to the board.
Information Acquisition	Zotac single board computer will have constant access to the swipe card information about cleanroom users via emails from the lock shop, as well as access to the CORAL database to get machine statuses through a psql script.

Wireless Internet (Wi-Fi)	Zotac single board computer has wireless card to allow the administrator to communicate with it. The single board computer must also be able to constantly pull information from the ndnfinfo email account as well as the CORAL database.
Inputs	Zotac single board computer must receive information from CORAL, the lock shop server, and the administrator
Extra Features	There will be a website where users can log in to check current users and machine reservations as well as make their own.
Adjustable Settings	The administrator should be able to edit the format of the information displayed on the screen, as well as the list of allowed lab users. Department information on the website can be modified as well. 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 Requirements:

Subsystem and Interface Requirements	
LCD Screen Setup	The screen will be on a stand so as not to damage the cleanroom walls. The Zotac single board computer will be mounted on the back of the LCD screen.
Power	Since the screen and single board computer are powered by an outlet it must be placed near one, or an extension cord must be used.
Wireless	Zotac single board computer has a Wi-Fi card that allows it to poll and receive information necessary for the display.
RFID Reader	An e-mail account is set up so that the information gathered by the RFID reader about user activity is available to the single board computer. The program running on the single board computer is able to poll the server and obtain the information it needs for the display from the ndnfinfo

	email account.
Administrator	All the software that will run the display is stored on the ndnfinfo AFS account, allowing the administrator to change settings from any computer. Only the administrator will know the password.
Web Page	The .htaccess (password) file is easily accessible through the AFS shared filespace to allow the administrator to easily add/remove users that are allowed to access the web page.
	Users are able to check reservations made by other users for any machine as well as making their own through the link provided.
Software	The code reads the names of users from the emails sent from the lock shop and displays them on the LCD screen.
Software (continued)	The time at which the user enters the cleanroom is also acquired, and the program will keep track of how long the user has been inside the cleanroom so that this information can be displayed as well.
	The program checks for new emails every 5 seconds. If there are new emails, it reads them and updates the user activity. If no new emails are present then it checks the psql database in order to update machine statuses. The screen and webpage are updated and the process begins again.

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 cycle functionality to Android app 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.
Android application connection	This would allow users to connect to the display from there Android smartphones to cycle through which information is displayed on the screen.
iPhone application	This could extend all the benefits provided by the Android application to an iPhone application.

5 Low Level Design

The main project components are the Zotac Mag single board computer combined with the Wi-Fi module, the LCD screen, the CORAL software, the ndnfinfo website and Gmail account, and the android app.

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 use the AC to DC converter provided with the board.

5.1 Main Program

The Main Program is written in C++. It begins by populating the matrix of registered cleanroom users from a file in the ndnfinfo AFS space. Each user is assigned a "0" indicating that they are currently out of the cleanroom. Every 5 seconds, the program polls the Gmail servers through the Wi-Fi connection. If there is a new email that contains cleanroom user information, it will be retrieved. If the email indicates that a user has entered the cleanroom, the user's assigned value will be changed to a "1", and their name will appear on the displayed list of current users. If the email indicates that a

person has logged out of the cleanroom, their value will be changed to "0" and their name will be removed from the list. After an email is registered, it is automatically deleted. The time that each user enters the cleanroom will be tracked as a personal variable in the matrix, as well as the total time that each person spends in the cleanroom over the course of the week.

Since the program is designed to run 24 hours a day, there must be a way to update the matrix of users (in case a new user is added to the system) while the program is running. With this in mind, we will make the main matrix dynamically appendable. Since it will not be critical to update the list of users every 5 seconds, we will have the program check the user file on the AFS space and update the list of total users every 12 or 24 hours. To add a new user to the list, the administrator can simply open the file on the ndnfinfo AFS space and add the user to the end. A program can be written to automate this task later if necessary.

It should also be noted that when the program is launched, it will say that nobody is in the cleanroom, and neglect people who are already inside until they log out and then log back in. An example of what the main program matrix might "look" like is below:

User	In (1) or Out(0)	Time logged in	Total Time this week
User 1	1	11:12:09	5:06:48
User 3	1	13:10:43	7:41:24
User 5	0	0	3:20:03

In this case, if a new user, User 4, is added to the system, a new row will be added to the matrix, and he will take the bottom row. Then if User 3 was deleted from the system, User 5 and User 4 would be shifted up so that there are not blank spots in the matrix. Individual parts of the main program can be tested by commenting out the bulk of the program to single out a particular function, and then compiling it and running the executable from the Zotac MAG board.

The main program is also responsible for accessing the CORAL database for machine updates. This is listed below in section 5.3.

5.2 Ndnfinfo Account/RFID information retrieval

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. The original plan was for the code to be split by a Y-cable: one version was to be sent to the lock shop server, while the other was to be sent to our Bluetooth transmitter. Due to the lock shop's objection to using this method, the new design consists of the lock shop sending emails to the ndnfinfo email account with user activity information. The main program continuously polls the email account and updates the information displayed on the LCD screen and website.

5.3 CORAL System

In order to retrieve the machine status information, the Zotac MAG needs to get the data from the appropriate database. A read-only account 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.

From the main program, a system call is used to execute the 'psql' command and initiate the psql command line interface. Several flags are set in order to simplify the process of extracting the information. One flag specifies that the password should be extracted from a designated file in the current directory, since there is no user present to type it in. Another flag tells psql to execute commands from a file, as opposed to from user commands entered in the terminal, which again is used for automation purposes. Finally, a third flag tells psql to pipe the output of the commands into a file, named 'machines.txt', which is later accessed by the main program to display the list of currently used machines. Since the format of the data obtained from the database is known, the program recognizes a certain character that precedes important information (the newline character). This fact is exploited to easily load the information into the program.

5.4 Ndnfinfo Website

A website was created with the purpose of making the cleanroom user and machine status information available to all users from any computer. The files that contain the website information are located in the www folder on the ndnfinfo h-drive. To access all the website files the administrator only needs to access the ndnfinfo h-drive by providing the username (ndnfinfo) and password (WafersD11). The index.html file is the main file that controls the website. The website has restricted access so that only students and faculty that have cleanroom access can enter the site. To make this possible there is a second file called .htaccess which contains the netIDs of the allowed users. This makes it easy for the administrator to edit the file to add or remove allowed users.

The ndnfinfo website has links to the EE department as well as the NDnano website. A special feature is that the website will act as the Remote CORAL app. Users will be able to check machine statuses and reservations people have made on machines up to a week in advanced. The goal is for users to be able to make their own reservations through our website.

5.5 Display Module Hardware

The display module in the lobby of Stinson Remick will consist of the Zotac Mag and an LCD screen.

5.5.1 Zotac Mag

The Zotac Mag provides both the embedded processor and the wireless transceiver chip. The Zotac Mag has an Intel ATOM 330 dual-core CPU, 2GB of RAM, and a 160GB Hard Drive, so it has enough memory to store the list of current lab users, decode the information provided by the lock shop server thought the Gmail server, as well as sort and filter the machine information provided by the CORAL system. The Zotac Mag also has VGA and HDMI ports so we will be able to drive an LCD screen. The Zotac Mag did not have a preloaded operating system, so we were able to load the Ubuntu Linux distribution. The Zotac Mag has an 802.11n Wi-Fi module which would allow the Zotac Mag to get information from the lock shop server through the Gmail server. The administrator and CORAL also communicate with the processor through a wireless connection (ND-Secure or nomad). Because it is high speed, all data can be transferred without making the system slow and troubling the user.

5.5.2 LCD Screen

All of the other project elements work together so that the right information is available to the public through the LCD screen outside of the cleanroom. 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 a VGA port that allows it to communicate with the Zotac Mag. Currently we plan to use a screen from the learning center for the final demonstration. 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.

5.6 Android App

Another helpful tool for users on the go provides quick access to the list of current cleanroom users and the machines used. This allows the users to see whether or not the lab is crowded and to judge if they should go in then or at a later time. A smartphone application is a convenient way to manifest this tool, and this will first be implemented as an Android app due to the fact that the Eclipse development software is available for a variety of operating systems. A future feature of the project could be an iPhone app to provide usage for people who own these devices.

Initially, the app will have basic functionality, simply listing the current lab users and their log in times in a listview format. The app will get this information by accessing the website and loading this information into the program. Users will also be able to see

the machines currently used by clicking on a tab. This information is obtained from the website in a similar fashion. Future features could include connecting the app to the display module in Stinson-Remick to control cycling through different views using commands from the smartphone.
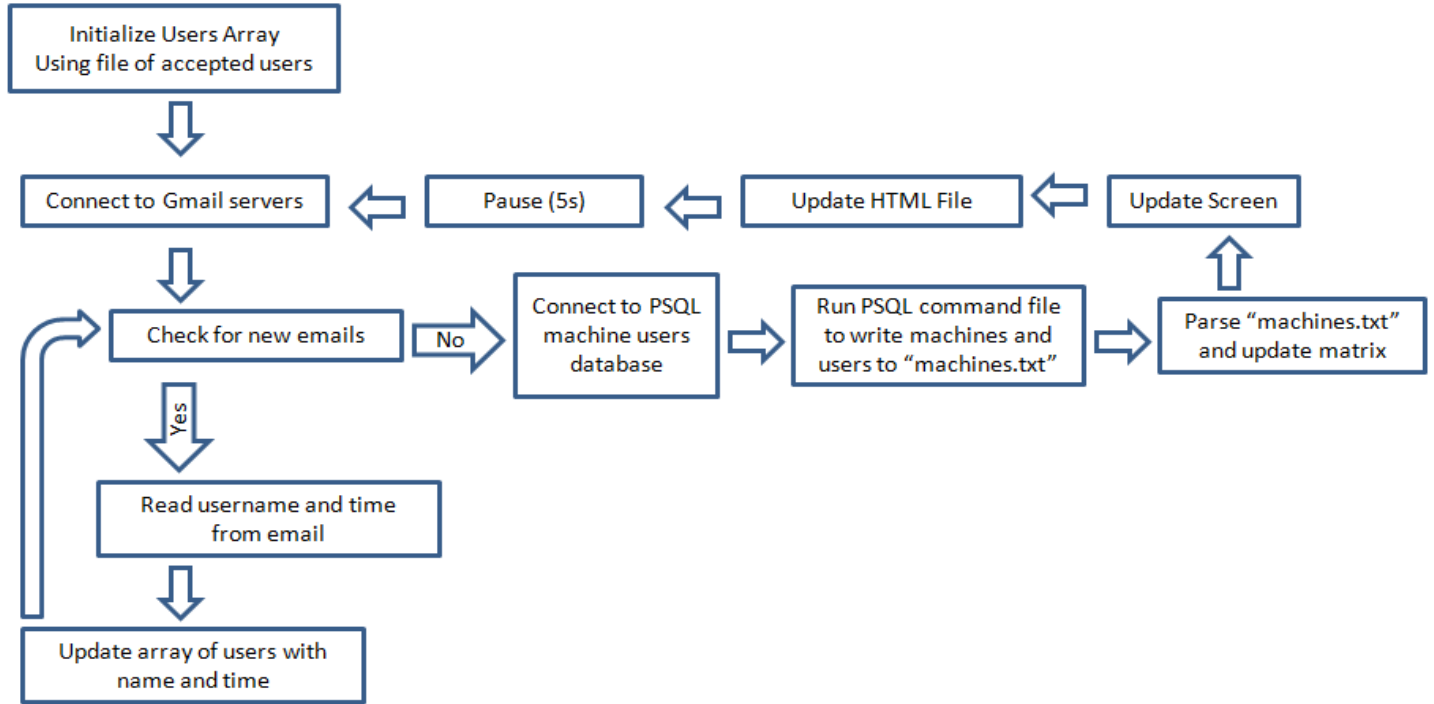

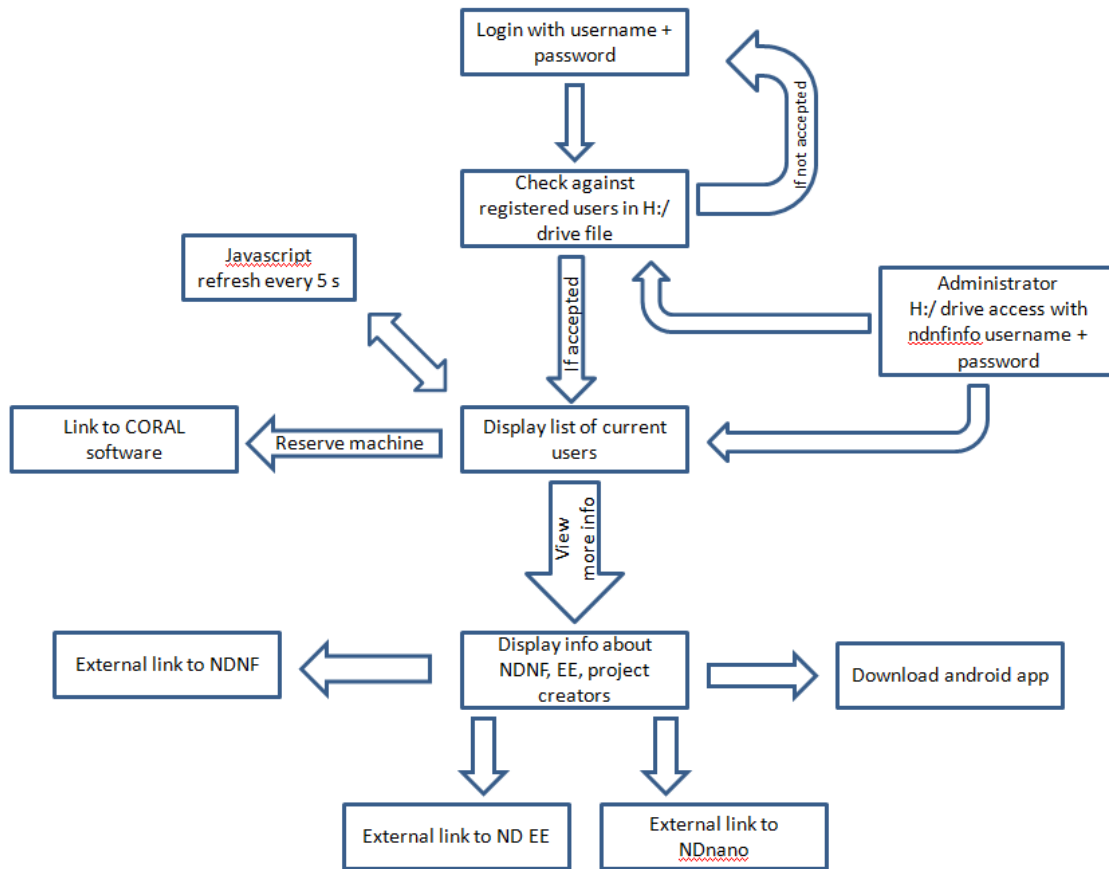Figure 2. Main program block diagram.

Figure 3. Website block diagram.

6 Bill of Materials

Zotac MAG: Ordered from Amazon for $268.00 + tax

7 Conclusions

This project will increase safety and efficiency in the cleanroom, and it will make it much easier for faculty to find their students quickly. We are confident that we will be able to fulfill the primary requirements of the system, and the heavy use of software in the design of the system allows for a great deal of secondary features and customization. Several additional features, such as an iPhone app, smartphone connection to the display, and a CORAL log in from the website could extend the functionality of our project. We believe that the implementation of this system will be a useful tool that users can enjoy for years after we have left Notre Dame.

8 References

http://www.zotac.com/index.php?option=com_wrapper&view=wrapper&Itemid=100082&lang=us

http://download.intel.com/design/processor/datashts/320528.pdf