15 April 2009

Patrick Leung
School of Engineering Science
Simon Fraser University
Burnaby, BC
V5A 1S6

Re: ENSC 440 Post Mortem for the D-Tech Reminding System

Dear Professor Leung:

The document included is the post mortem for goldfish Technologies' D-Tech Reminding System. For our project we designed and built a system that will scan a person as they are leaving their home in order to alert them of items that they have forgotten to bring with them.

This report describes the functionality of our current product, encountered problems or digressions from the original design and thoughts on future development. The report also details the state of our budget and timeline, as well as a brief reflection on the project from each team member.

goldFish Technologies is built of five motivated and skilled fifth year engineering science undergraduates: Owen Lin, Sami Nguyen, Sharika Salim, Jeremy So, and Christopher Yao. If you have any questions or concerns please feel free to contact us at ensc-goldfish@sfu.ca.

Sincerely,

Sharika Salim
Chief Executive Officer
goldFish Technologies

goldFish Technologies

# Post Mortem:

## RFID-Based Reminder System


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### Submitted to:

Mr. Patrick Leung
Mr. Steve Whitmore


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# Glossary

| | |
|---|---|
| GUI | Graphical User Interface |
| LCD | Liquid Crystal Display |
| PIR | Passive Infrared |
| RFID | Radio Frequency Identification |
| UART | Universal Asynchronous Receiver/Transmitter |
| USB | Universal Serial Bus |

# 1. Introduction

Our goal was to create a reminder system that would seamlessly integrate into a user's life. As a user leaves their home, this device installed at the household's door would notify the user of forgotten items, as well as to-do tasks for that day. Using Radio Frequency Identification (RFID) technology as our basis, we would develop a fully integrated project that involves the use of a web application, an embedded PC, a motion sensor and most importantly, an RFID reader.

Our final prototype product, named the D-Tech Reminder system, incorporates all of our proposed and desired functionality. Using our system, a user can add reminder items by tagging them with SmartTags and entering them into our database either through the use of our web form application, the Anywhere Access Form, or our embedded PC graphical user interface (GUI), the D-Tech Central Unit. Our D-Tech and Scan unit is then able to scan a user as they are leaving their home and display relevant information such as reminders, to-do tasks, weather updates and messages to a Liquid Crystal Display (LCD). Extra features such as image display and audio messages are also incorporated to enhance the final usability of our overall project.

# 2. Anywhere Access Form: Web Application Form

## 2.1. Accomplishments

The D-Tech System Anywhere Access Form is an available online portal for users to add tagged item and tasks to their D-Tech Central Unit database. This web application acts similarly to a survey or questionnaire, asking the users for relevant information. Users can use the form to remotely enter tasks, items and messages to the home database. The simplistic design allows the form to be extremely intuitive, as shown in Figure Figure 2.1.

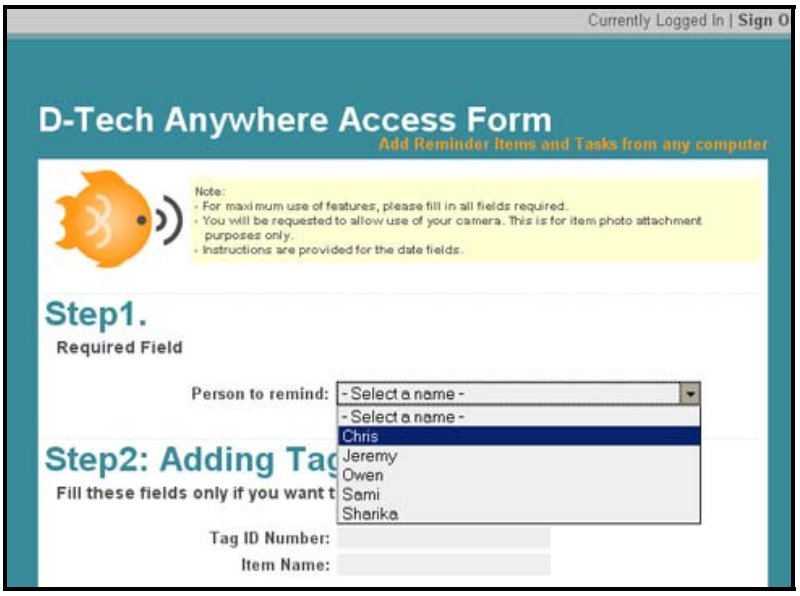


**Figure 2.1: Anywhere Access Form Entry Page**

This form includes many features that make the process of entering data into the system easily accessible, secure and fun! The Anywhere Access form website is hosted on an actual web server, allowing it to be accessed by any computer with internet access. The form also implements file security to prevent private data from being public, as well as access security that require users to login in order to enter data. In addition, a webcam feature is built in to give users the option of taking a picture of an object to associate with their reminder.

To increase usability, the application also features built-in instructions, data field checking, drop down menus, and pop-up calendars for date selection.

## 2.2. Issues

The main issue with creating the web form was the initial learning curve of learning new web scripting languages such as PHP, JavaScript and Flash. Because we had general knowledge of developing websites, we had a base to work with. With time, we became comfortable with the languages and were able to not only meet our initial feature requirement but we were also able to add additional features using the same knowledge. This includes one feature we are extremely proud of: the current weather condition display feature. This additional feature, though not part of the web form, is created on the same server and uses the same storing and updating algorithm.

### 2.3. Future Plans

Since the internet has become very integrated into people's lives via portable net-book laptops, MP3 players, and cell-phones, this simple web application can be extended for all sorts of uses. With additional time, we would make the application designed for mobile phone use as well. This allows the user or their friends and family to text-message reminders and notes to their D-Tech System. In order to support this feature, it would also be ideal to allow users to create separate accounts for their friends or distant relatives for adding reminders and messages to their system. This extends the applications of our project as users can have their doctors remind them of medication they have to take, or their dentist reminding them that they have an appointment.

# 3. D-Tech Central Unit: GUI and Physical System

### 3.1. Accomplishments

The D-Tech Central Unit processes data from the RFID reader, the Anywhere Access Form and the GUI. As such, the development board that we used needed to allow serial port communication, connection to the internet and provide touch screen LCD capabilities.

A huge amount of software was produced in order to provide full GUI and data synchronization functionality. Our Central Unit database consisted of multiple linked lists to store data for each user. In addition, data was stored into text files to backup the local linked list database. Entries acquired from the web were added to the database as well as the backup files. Similarly synchronization between the database and the backup files were preserved when an entry was edited or deleted so that the database could be generated from the backups if needed.

The GUI allowed users to add and view users and add entries for each user. Furthermore, entries can be viewed, edited and deleted. Items that were added through the Anywhere Access Form with a picture are displayed graphically in addition to being listed through text. Also, on top of our original plans we were able to add a couple of extra features. One such feature being that it displays current weather conditions on the home page. Additionally, our system allows users to leave messages for other users through the GUI or the Anywhere Access Form. This message will then be displayed to the user as they walk through the door.

### 3.2. Issues

One of the major obstacles that we faced was in communication between the development board and the RFID reader. We initially assumed that the RFID reader could connect to the board through USB; however, we quickly learned that the development board could not support USB hosting. We had to work around this problem by the use of a laptop to act as a wire between the USB connection of the RFID reader and the serial port of board. Another issue was the fact that the board couldn't support permanent storage due to the fact that it was a development board. Although it had ports for a Secure Digital (SD) card and a memory stick, there was no driver support available for it. Hence for our prototype, our design generated backup files for all users. Currently, we can only simulate it as being stored permanently as such implementation isn't actually supported. Another problem that we ran into was the fact that our board could only connect to the internet via an Ethernet connection. This made testing nearly impossible, as the university's Ethernet ports were locked to students. We solved this problem by buying an Ethernet bridge that allowed us to connect into the school's wireless network instead.

### 3.3. Future Plans

For future development, we recommend packaging to be more compact while enlarging the size of the LCD screen to make the product easier to use. Additionally, we would like to make communication between the RFID reader and the Central Unit wireless, allowing for more flexibility in use. With this modification, essentially the central unit could even be integrated into a cell-phone, making reminders easily accessible and will allow for greater user flexibility. Another feature that we could incorporate is text-to speech-conversion. Thus, when a use walks out their door, the missing reminder items and tasks will be announced to them on top of being displayed and listed on the GUI.

## 4. D-Tech and Scan Unit: RFID Reader and Motion Sensor

### 4.1. Accomplishments

The D-Tech scan unit can successfully read and identify up to sixteen unique tags at any given time. It is seamlessly integrated with the embedded PC via a laptop acting as data transfer wire. While we originally planned to connect the RFID reader directly to the embedded PC, we decided to install a laptop as a medium; the reason will be explained in the issues section. Because our project places emphasis on overall product size, we could not use the hardware driver provided by Texas Instruments and had to create our

own. The driver was developed by using the original PC driver as a reference, and is written in such a way so that collision in tag reading can be avoided. This allowed the RFID reader to accurately read and transfer tag data to the embedded PC without trouble. To integrate the passive infrared (PIR) sensor to the RFID reader, we designed a switch and placed it in the path of the voltage lines between the RFID reader and the power source (which, at this time, is the USB port of the laptop containing our communications driver). When the PIR sensor detects motion, it would activate a mechanical relay, connecting the power lines and activating the RFID reader. This worked incredibly well and our reader was able to turn on and read tags very quickly once motion is sensed.

## 4.2. Issues

The TRF7960 RFID evaluation board proved to be a challenge to integrate with our embedded PC unit. The universal asynchronous receiver/transmitter (UART) to USB converter chip on the TRF7960 prevented us from directly connecting the output signal of the RFID reader to a serial connection input on the embedded PC, and due to technical limitations, where the embedded PC cannot act as a host USB device, we decided that the best solution was to use a laptop to act as a wire that would take USB input from the RFID reader and convert the exact same data to a serial output.

Because the antenna on the RFID reader is built in, the reading range of passive tags is limited to a maximum distance of 10 cm. The size of the antenna also limits the reading range, and while the option of adding an external antenna to the reader is viable, due to budget and technical constraints it was not pursued.

Originally, a switching circuit was to be designed using only discrete electronics. However, during testing, we found that transistor switches were not able to provide enough current or voltage to a load, such as our RFID reader. Our solution to this was the use of a mechanical relay, as a physical short would completely solve any current or voltage level issue provided that the relay is capable of handling the required levels without being damaged. Transistors are still used in our design. However, their purpose is only to pull up the output signal of the PIR sensor.

## 4.3. Future Plans

In the future we plan to find an embedded PC that can act as an USB host device and remove the laptop completely. This will not only move us closer to the “embedded device” goal but also reduce the cost of the production.

We also plan to add external antennas to the RFID reader so passive tags can be read from a much further range. We hope to include an affordable external antenna that can be installed around the doorframe of a household so that any user walking out of their house will be scanned.

In terms of size, the D-Tech and Scan unit has quite a large profile. We plan to reduce this in the future to reduce material costs as well as to reduce visibility of the product when it is installed. To accomplish this, a new switch using only discrete components will be designed. A redesigned switch will also remove the clicking sound that is heard when the mechanical relay is activated. Furthermore, the scan unit size can be greatly reduced if it only contained the motion sensor switch and the antenna. It is very possible to incorporate the reader circuitry into the D-Tech Central Unit and simply have it connected to the antenna via cable. In fact, we can further reduce size and part count by redesigning the reader circuitry to directly send its information to the D-Tech Central Unit (with proper drivers) instead of having to use a separate microcontroller to translate the reader signals into USB format.

# 5. Budget and Timeline

## 5.1. Budget

The table below illustrates the components purchased to be used on the prototype along with their respective price. The total incurred cost is $780.00.

**Table 5.1: Comparison between estimated and actual project costs**

| Components | Estimated Cost | Actual Cost |
|---|---|---|
| *RFID* | | |
| RFID scanner | $250.00 | $350.00 |
| RFID antenna | 60.00 | - |
| RFID tags | 40.00 | 70.00 |
| Controller | 40.00 | - |
| Controller power supply | 20.00 | - |
| *Sensor* | | |
| Motion sensor | $50.00 | $20.00 |
| Sensor power supply | 20.00 | 30.00 |
| *Central system* | | |
| Console and display | $300.00 | - |
| Console power supply | 25.00 | - |
| Webcam | 30.00 | - |
| *Miscellaneous* | | |
| Cable connections | $10.00 | $30.00 |
| Fabrication and casing | 10.00 | 60.00 |
| Circuitry | 10.00 | 15.00 |
| *Non-proposed Components* | | |
| Ethernet bridge | - | $105.00 |
| Laptop (the wire) | - | 100.00 |
| **Total** | **$865.00** | **$780.00** |

Since the actual prototype utilizes a RFID evaluation kit that includes a scanner, antenna, and controller, the costs were combined into the RFID scanner cost. The goldFish team was also able to combine the cost of the RFID module into two sub-components, RFID scanner and RFID tags. In addition, the team was able to obtain an embedded PC evaluation kit from Lucky One, thus the budget for the Central System's console and display were allocated to purchasing an Ethernet bridge and a laptop computer (due to the lack to functionality on the embedded PC evaluation kit).

The group received $740 from the Engineering Science Student Endowment Fund (ESSEF), hence leaving $40 to be covered by the team.

## 5.2. Timeline

The Gantt Chart in Table Table 5.2 below illustrates the comparison of timeline of proposed schedule and actual project schedule. The only major task extensions belong to Central Unit software implementation, GUI, and debugging. This is due to hardware limitation of the embedded PC, which was discovered during later stages of implementation, and the integration of additional features. Overall the project adhered to the proposed schedule and completion deadline. This success was due to the effective delegation of work and willing of each team member to help those in need.

**Table 5.2 Gantt chart of proposed timeline versus actual timeline**

| Tasks | Duration *(Estimated in days)* | January | | | | February | | | | March | | | | | April | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4 | 11 | 18 | 25 | 1 | 8 | 15 | 22 | 1 | 8 | 15 | 22 | 29 | 5 | 12 | 19 |
| **Research** | | | | | | | | | | | | | | | | | |
| Initial Project Idea | 7 | | | | | | | | | | | | | | | | |
| Preliminary Research | 14 | | | | | | | | | | | | | | | | |
| Technical Research | 35 | | | | | | | | | | | | | | | | |
| **Hardware Implementation** | | | | | | | | | | | | | | | | | |
| RFID Module | 35 | | | | | | | | | | | | | | | | |
| Motion Sensor Module | 21 | | | | | | | | | | | | | | | | |
| Central Unit Console | 35 | | | | | | | | | | | | | | | | |
| **Software Implementation** | | | | | | | | | | | | | | | | | |
| Graphic User Interface | 35 | | | | | | | | | | | | | | | | |
| Drivers | 35 | | | | | | | | | | | | | | | | |
| **Integration** | | | | | | | | | | | | | | | | | |
| Hardware Integration | 14 | | | | | | | | | | | | | | | | |
| Software Integration | 14 | | | | | | | | | | | | | | | | |
| Full Integration | 35 | | | | | | | | | | | | | | | | |
| **Testing and Debugging** | | | | | | | | | | | | | | | | | |
| Component Testing | 35 | | | | | | | | | | | | | | | | |
| Integration Testing | 35 | | | | | | | | | | | | | | | | |
| Debugging | 56 | | | | | | | | | | | | | | | | |
| Final Acceptance Testing | 21 | | | | | | | | | | | | | | | | |
| | | Proposed Timeline | | | | | | | | Actual Timeline | | | | | | | |

# 6. Individual Experiences

## 6.1. Sharika Salim

This project has been a challenging but rewarding experience. I was involved in the software development of our system and hence had the opportunity to program for an embedded environment. In this position, I was required to program in a Windows CE environment using use Microsoft Foundation Class Library (MFC) for the first time. MFC proved to have a sharp learning curve, but was very useful and flexible for the means of our project especially in terms of developing a user friendly GUI. One of the most challenging aspects of our system's software development was the limitations of our development board and specifically because it runs Windows CE. Much of the common and desired functionality available through MFC was unavailable for Windows CE, thus making our life harder as we now had to find "creative" work-arounds!

In terms of group dynamics, I must say I am pretty pleased with dedication and work ethics of my team. Each member had something unique to bring to the table in the case of technical as well as soft skills. Although we all had individual responsibilities, we all helped each other find solutions to problems when needed and collaboratively worked on certain areas together. I enjoyed working with my group and I know that the quality of our group dictated the quality and rewards of what could have been a very frustrating and painful experience!

## 6.2. Chris Yao

At the beginning of the project I was assigned to the development of the RFID component. Through the past 13 weeks I've grasped the basics of USB and serial communications between different hardware. It was an extremely valuable learning experience for me to be able to work on driver development and trouble shooting. While there were a lot of problems and frustrations, the feeling of accomplishment when I see the end product working makes all the hardships trivial. Over the course of the project I understood more about the RFID technology and its impact on the technological world; I've also realized the difficulties when working with an embedded system and trying to integrate two hardware components together. Overall the technical experiences I got out of this project were well worth the time spent.

Working with my group, I found it extremely comforting that everyone was hard working and keen on completing the project ahead of the deadline. This not only allowed us to stay ahead of our schedule but also made it so that we would not be trapped in a state of panic when nearing the end. I felt the entire group had a very good

working relationship with each other and we would try to do our best to resolve any problem we encounter together.

Overall I've found this project to be a very enjoyable learning experience. It involved areas in software, hardware and firmware, it was challenging yet fun, and it was a product that could be useful for the general public. I've had a great time working with my group and I would not hesitate to work with them again in the future.

## 6.3. Jeremy So

One of the most important attributes I learned from this is the ethics of teamwork. The concept of "divide and conquer" was demonstrated and proved successful while working with the goldFish Technologies team. Learning to allocate your knowledge and skill to difference parts of the project was also crucial.

From a technical perspective, I significantly increased my knowledge of programming embedded Window systems using MFC. Inadvertently, I also learned to program using Visual Basic 5 but soon learn that, Windows CE does not support such language. In addition to software knowledge, I learned a great deal regarding RFID technology during the research phase.

To conclude, I found contents learned from this course and project to be most applicable and practical towards my career as an engineer. I highly enjoyed working and learning from this group of future engineers.

## 6.4. Owen Lin

Throughout the course of the project, my role gradually moved from hardware development straight into software development. Originally, I was assigned to obtain a suitable RFID reader to use and designed a switching circuit to control it. After the switching circuit design was completed, I was tasked with developing serial communication drivers for both our laptop medium and our development board, then straight into development of our control software. Through the course of this project, I have been able to learn about analog and digital circuit design, communication protocols between different devices and also a heavy dose of MFC programming. I learned the importance of choosing features before finalizing component selection so we don't have to design workarounds when we discover a component lacks a needed feature. The programming experience I acquired will also no doubt be very useful to me in the future.

My group was very hard working and I found working with them to be a pleasure. We were able to stay on task and more or less maintain our project timeline. With any huge

problem encountered during our project, everyone would contribute to solve it so that we may continue as quickly as possible.

Overall, this course was a very valuable learning experience. It gave us a sense of what a project development environment is like and also provided us with certain technical knowledge that we may otherwise not have obtained through regular course work.

## 6.5. Sami Nguyen

My main contribution in this project was in the designing and development of the Anywhere Access Form web application. Because I had a background in web design, I was assigned this initial task. However, creating the form itself required more work than I had initially thought. I had to continuously make changes to the application throughout the course of semester to support synchronization with the Central unit database. However, from this experience I learned many new scripting languages such as PHP, JavaScript and Flash in addition to gaining an understanding of how web server security works. This project allowed to me explore a completely different area of programming, which allowed to me to further broaden my educational background.

Aside from working on the web form, I continuously contributed in other areas of the project by developing features and trouble-shooting for the GUI using C++. Because I didn't have much background in C++ programming, this proved to be difficult yet worthwhile learning experience. I learned everything from MFC programming to flashing of development boards. Though there were many issues to overcome during the software development process of our project, the entire team was very supportive and was always willing to combine efforts to solve problems.

Overall, the experience of working on this project was very positive. This was mainly due to the good team work and dedicated members of our team. With anticipation that this course would be work intensive, our team worked hard throughout the semester to avoid any end of semester stress. I feel very appreciative of my group and would be happy to work with them again.

# 7. Conclusion

Overall we've accomplished all the goals we set for ourselves. We followed the schedule set during our initial planning stages and worked as a group to overcome the challenges along the way. Our project is functioning as intended and we've even added extra features. We would like to offer special thanks to Patrick, Jason, Jamie, Steve, Lucky, Fred, Ash and the team members of SonarSense for their continuous support in the course of the development of our project. We all believe this was a valuable learning experience in both team building as well as technical research/development.