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April 19, 1999

Dr. Andrew Rawicz
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Re: ENSC 370 Process Report, *Noverdose- Medication Delivery System*

Dr. Rawicz,

The attached process report concludes and wraps up Prescriptek's ENSC 370 experience. Our project was to design a machine which automatically dispenses medicine for those unable to remember when or how to take their pills.

Our process report outlines the current state of the device, deviations from our original plans, our future plans for the device and some of the budgetary constraints we came across. At the end there is a section for each group member to describe their ENSC 370 experience in Prescriptek.

Feel free to contact any member of Prescriptek at the phone number indicated above if you wish to discuss our process report.

Sincerely yours,

The Prescriptek Team:
Bryce Pasechnik
Damian Nesbitt
Derek Young
Rob Boyes
Michael Boquist

ENSC 370

Process Report
Noverdose Medication Delivery System

Team members:
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April 19th, 1999

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Introduction

Over the last four months, our team of Damian Nesbitt, Derek Young, Michael Boquist, Rob Boyes and Bryce Pasechnik have worked towards the common goal of building the Prescriptek Noverdose Automated Medicine Dispenser. Below is an account of the process in creating the device as well as some thoughts by each of the group members.

Current State of the NoverDose

The project is now officially over after the demo. The machine as described in our previous documents is an automated medication delivery system that dispenses the correct amount of medication at the correct times. A PIC microcontroller is used to access scheduling information for a particular patient's prescriptions which is stored on non-volatile FRAM. This FRAM is programmed by the pharmacist on a PC through a simple and easy to use front end. At the proper dosing time, the NoverDose takes pills from storage bins and releases them into a collection tray. This action is accomplished by servo driven foam rollers and bins that shake and release pills into the roller system. Infrared emitters and detectors sense whether the correct number of pills have been dispensed. These sensors and the servos are controlled by their own separate PIC microcontroller. If the number of pills released is OK, the pills are released into a dish for the patient to take them by a solenoid powered butterfly valve. If too many pills are dispensed, the butterfly valve dumps the pills into a reject bin. At this point the patient is alerted of there being pills in the dish via a beeper. A bump switch is attached to the cover of the final dish to determine whether or not the patient has taken their medication. If a patient fails to take their medication, or if the machine is malfunctioning, the NoverDose's master PIC will utilize a Teltone M-8888 DTMF chip to dial out to an emergency contact and an error message will be played using an ISD 33120 integrated voice chip.

Other features of the machine are: an uninterruptible power supply (UPS) powered by a 6V 4.0 A-h sealed gel cell battery for power free operation. Bright and large LED displays show the number of pills to be taken as well as the time of day. The whole machine is encased in ¼" plexi-glass and is very sturdy.

As you can see the NoverDose is a combination of many subsystems which all depend on each other for the machine to work properly. From our testing the machine's subsystems worked perfectly individually, and most of the problems occurred during final integration. By the time of the demo, the machine was working satisfactorily, but minor bugs still need to be ironed out.

Deviations from the Design Spec:

The machine went through many evolutionary changes during the actual building of it. Most of these changes were due to either misjudgments on the original parts to be used or simply time constraints. The basic use and premise of the NoverDose did not change radically, however. Below is an outline of the subsystems that underwent change between the design spec and the demo

Microcontrollers

The original design spec called for multiple PIC 16F84 chips to run the NoverDose. As it turned out, we ended up using one PIC 16C65A to run all the subsystems save the servos, pill sensors and the accept/reject butterfly valve. This PIC was used due to its 33 I/O pins, which were all used in the final product.

Mechanical Design

The major change occurred in the size of the whole machine. Instead of making the originally planned 8 bins for 8 different type pills, we decided to make only 4. This was due to monetary concerns and the NoverDose ended up being much larger than expected, especially the height. Due to the gravity feed aspect of the NoverDose, it was necessary to make the NoverDose almost 14" high. The foot print was in the general size we wanted (12" x 12") but with its imposing height, it was decided not to build it any larger.

The mechanical set up worked very well, with only the occasional stuck pill on the inclines. The gearing setup worked very well indeed, and the foam wheels were perfect for the job. For the bins, we ended up using small Rubbermaid containers which were modified to resemble a funnel at the bottom, which fed into the rollers. The infrared sensors also worked very well, after buffering their output with a Schmidt trigger to remove any jagged transient response.

PC-PIC Communications

Although our design spec originally called for serial communication between the PC and the PIC to program the final version used a parallel connection. This was due to the original testing being done using a parallel connection. Because this method of communication was already in use, we decided to keep it for the final version.

Voice Playback System

Originally the voice system was to be entirely built by us. As it turned out the FRAM that we were going to use was incapable of transferring the data quick enough to a D/A converter. It was running at one point, but the voices were only half speed. In it's place we used an ISD 33120 integrate voice chip to store and

play the messages to be sent to the emergency contact on the other end of the phone system. The method on the surface seems that it should have been easier to do, but due to the poor documentation of ISD it took much longer than expected. In the end though the voice worked and was capable of stitching together the pre-recorded error messages.

Real Time Clock / Phone System / LED Drivers

These subsystems were essentially unchanged from the design spec, save that they were all integrated on the same PIC chip.

Un-interruptible Power Supply

The UPS that was used was different from the design in the design spec. The new, simplified UPS consisted of a 12V adapter being stepped down to 6.8V using an adjustable voltage regulator. The battery that was used is a Panasonic 6V 4 A-h gel cell, that is designed to float charge at a voltage of 6.8 V. The regulator was diode protected so that it could charge the battery, but the battery would never try to charge the power supply. This system proved to be easy and worked well. Leads were connected to the terminals of the battery and the voltage from this point was stepped down again to 5V to run the PICs and all the TTL chips in the machine. The unregulated 6 to 6.8 volts from the battery are used to run the servos and solenoids as well as the LED display, as they do not require regulated voltage to run properly.

Future Plans

Although the NoverDose machine worked, it can work *better*. Some of the more important aspects to be improved upon are as below:

Physical Size/Layout

The inner workings of the machine should be simplified and shrunk. They worked well as a prototype, but the NoverDose is definitely too large at the moment.

PC User Interface

The current user interface is a simple, but effective text based C program. Due to lack of time, a GUI program was not written. For future versions a Visual C++ version of this program would be written and used.

Improved Error Handling

On future versions, the machine will have improved methods of calling out, including more sophisticated methods of determining exact error conditions.

Interior Mechanics

The current interior mechanical parts are expensive and overkill as far as robustness goes. By using custom gears and small motors the overall cost of the interior mechanics could be considerably reduced.

UPS/Power Supply

The best method for the power supply would be an internal device, which would be implemented in future versions of the NoverDose.

Extra Features

Other features that could be added easily to the machine are voice notification to take medicine and an emergency alert button for the patient to immediately contact their emergency contact in case of an emergency.

Overall

The members of the Prescriptek team see our prototype as a success and intend on following up on it. Depending on how events fair during the summer, we would eventually like to take the NoverDose or a derivative of it to market. For this, we would have to cross many bridges including huge liability issues and manufacturing processes.

Monetary Constraints

Below is a table indicating the estimated and actual costs of building the NoverDose. Some figures are omitted as they were purchased within the school, and no dollar value was assigned to them (these values are marked with asterisks)

Materials	Proposal Cost	Actual Cost
Microprocessor(s) and Programmer	$250	$350
EEPROM Memories	$20	- not used
Power Supplies (AC adapters, Batteries)	$100	$23
Mechanical Actuators	$100	$150
Misc. Electronic Components	$50	$200*
LCD's/touch pad's	$40	- Not used
Reference Material	-	$40
Voice Circuitry	-	$35
Mechanical Parts	-	$150*
Case/Housing	$30	$8*
Miscellaneous Costs	$100	-
Total	**$690**	**$956**

Personal Experiences/Thoughts on ENSC 370

Damian Nesbitt

While working in this project I learned numerous technical abilities. Starting with absolutely no transistor knowledge I have come to learn the basic of how a transistor works. I have also gained considerable experience in discrete logic. Many long nights in the lab have also given me an in depth understanding of Microchip's PIC MCU's and their associated assembly language. In trouble shooting the PIC and it's assembly code I learned that usually half an hour on the simulator will save you anywhere up to 5 hours on the breadboard. All these skills were gained through this project and will continue to be an asset to me in my engineering career.

One of the main obstructions our group came into contact with was integration of subcomponents. We found that despite every subsystem working perfectly on it's own, once vector boarded and combined trouble shooting time is increased dramatically. We had numerous deadlines broken due to over optimistic time estimations on the integrating of our subcomponents. Incremental integration along with setting well defined interfaces was key to finally producing a working system. It was extremely important for us to have excellent inter group communication so that when people weren't around we still had enough of an understanding to work with their defined interface of their subcomponent.

Personal skills were of the utmost importance in successfully working together as a team. We had to realize that people had different priorities and schedules to work around. We had to deal with group members not always being able to work on our project 100% of the time, originally these led to group conflicts, but as we came to understand each other we learned to work with these differences.

The technical knowledge gained during this course was a key factor to success in the project. I learned very quickly that no matter what your working on someone in the group will have some ideas on how it could be done best. An important skill gained was to take in all these suggestions, along with your own ideas, and come up with the best possible solution to the problem.

The final key aspect learned from this experience was group dynamics and morale when in tight situations. I found that when the pressure was on and know one had slept for long periods of time and deadlines were fast approaching that team morale often hit an extreme low. Once team morale was low production went even lower, it was a very important that the team kept each other in good working moods. Learning how to raise group morale with a simple half hour break or even with a congratulatory E-mail was perhaps the most important skill learned for group work.

In all I felt extremely privileged to work with such a devoted team of friends on such a challenging project. I feel that despite the obscene time spent in the lab over the last 4 months that this experience was more important to my engineering education than anything else thus far.

Derek Young

ENSC 370 has provided me with the opportunity to work harder on something than I every have in my entire life. The sheer enormity of the project we decided on was never apparent till the closing days of the semester with our demo date rapidly approaching. I feel that I learned a ton, and I feel good about our accomplishments.

Of the technical abilities I learned while working on the project I feel that the most important ones were PIC programming/integration and simple, practical electronic circuit design. Other skills learned and/or sharpened were AutoCAD, mechanical assembly, working with Pulse Width Modulation, using FETs and infrared sensor systems. I plan on applying these skills this summer as I have decided to build my own car alarm as a summer project.

Along with the technical knowledge, I feel much more confident in starting projects such as this. Not because I know that they will be easy to complete, but rather because I feel that I have the ability to make things work – albeit with

some concentrated effort. This is a great feeling, and it compliments the gained technical knowledge very well.

As far as group dynamics went, I really enjoyed working in my group. We are all better friends for it. Due to our huge amount of time spent in the lab together you come to appreciate the amount of effort shown by each and everyone one of my group members. I really think the guys did a great job, and I feel bad about missing the demo, but I had a plane to catch! If it wasn't for the perseverance of our group, we could never have overcome some of the enormous hurdles we encountered while attempting to integrate the final prototype. Hours and hours were poured into trouble shooting. What would be thought of as a 1 hour debug would turn into an all night session, sleeping in shifts. All nighters were routine during the final week, and they were taken as given by my group members. Now that's dedication!

The machine is done for now, and I am really proud of what we made. We had fun times and not so fun times, but it was all worth it. ENSC 370 has easily been the best and hardest course of my university career. Project courses are wonderful. I look forward to more of them, and I can't wait to start on my undergrad thesis!

Rob Boyes

I feel very fortunate to have worked with the group members of this project. This was definitely the most dedicated team I have ever worked with. All of us managed to sacrifice nearly all personal time for the good of the group. When external responsibilities closed in, the other group members were always there to pick up the slack.

Over the course of the semester, I was able to learn a great deal about DTMF telephony and PIC assembly programming. I also gained experience using opto-couplers and power FETs for electrical isolation and power driving purposes. The knowledge gained from this project has provided me with new possibilities for pet projects which I intend to pursue over the summer.

This project has taught me the advantage of "baby steps" over "big bang" design and implementation. Building large circuit or software sections at a time often led to a non-functional block that took hours or sometimes days to debug. Also, I learned to fully think through problems before attempting to implement a solution. This process increased overall efficiency and led to better working circuit blocks.

One area in particular that required a great deal of forethought and planning was the vector-boarding. I had to think ahead as to the layout of each sub-circuit on the board to ensure that enough space was allotted to each section. I also had to communicate a great deal with the other group members to understand the

operation and inter-communication of their respective sections to ensure the sections would work smoothly together.

Some of the most important lessons I learned from this project were how to work well with others. Team morale became an important factor when stress levels were mounting and obstacles seemed insurmountable. In the face of this stress, we managed to stick together and avoid backstabbing. We learned that with enough time and teamwork, any challenge can be met.

Michael Boquist

I find that I have gained many new skills after the completion of ENSC 370. Besides the technical skills that I have picked up, I have also learned many things about group dynamics in particular that proper communication is required for a successful project.

From the technical side, I have gained much experience with Microchip PIC assembly language and development tools. I have learned about the communication techniques that can be used between a microcontroller and a personal computer. Logic design and implementing a real time clock have also been part of my task.

I particularly enjoyed the mechanical aspect of this project. After weeks of brainstorming and building different models we were finally able to come up with a solution that would satisfy everyone. It was an excellent experience to be able to work with different materials to produce a mechanism that functioned as we desired. I have found that AutoCAD is an important tool for ensuring that the different components will fit together properly and it greatly decreases layout time.

Without communicating properly it became obvious that our group would not accomplish anything. We have learned that it is very important to keep focused on the task at hand otherwise our productivity greatly diminishes.

I feel very privileged to have had the opportunity to work with the Prescriptek team. Because of our varying backgrounds in programming, mechanics, and electronics we were able to complete this very diverse project. Working together allowed us to share our knowledge and learn more than if each of us focused completely on one aspect of the project.

Out of all the engineering courses that I have taken ENSC 370 has required the most work and given me the most frustration. I am satisfied with what we have accomplished this semester and I am looking forward to further developing our project and starting our first company.

Bryce Pasechnik

Now that I am finished ENSC 370, I can look back and say with out a doubt that it was the most valuable course out of my engineering schooling to date. While it required a great deal of time and effort, it is the only course that I have taken that gave us real skills and experience that we will be able to use in industry. Having already worked in a start-up company I can honestly say that the 370 experience is very similar to the life of a start-up company employee. Long hours and short deadlines are a fact of life when dealing with new technology and 370 gave me a needed refresher of what it is like.

Of all the skills I gained in this course, by far the most important was working with others. In most other project classes if one person screws up its not much effort to fix their part and move on. In ENSC 370, however, the project is of such large proportion that each person must take on an integral role. Consequently, if one person screws up, the entire group suffers. Fortunately, we were able to work well together and communicate what we were working on and how we were doing it so that this was never an issue.

Among the technical skills that I acquired, the most notable would be an expertise in PIC programming and use. I think I personally executed every mistake that you can make with a PIC and can now recognize their symptoms in circuit making debugging a great deal easier. I also had the chance to learn about interfacing a PIC microcontroller to external circuitry including I2C RAM, a D/A converter, specialized integrated voice circuitry, LED's, servos and various other components. The most valuable skill I picked up was that of doing something right the first time. I can't even remember how many times I was cursing over not installing proper connectors on our vector board from day one. It would have saved us a great deal of frustration as wires were continuously breaking off. This is but a small example of the case where if you spend an extra 10-20minutes in the first place, it will save you hours and hours in the end. Now, before I sit down and start something, I think about how I'll be using it in 2 weeks and try to design it so that modifying it will be as easy and trouble free as possible.

I'm convinced that I had the most dedicated, hard working, and skilled group members of the entire ENSC 370 class. Countless all nighters were pulled with them side by side and I can't think of a single other person who spent even half the time on their projects that any of my group members put into our project. I think that is an important lesson to be learned in this class as well: ensure you pick the right group members. Fortunately, I did in this case.