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*e*AR Inc.

*e*AR™ Process Report

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Date April 2, 1999

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*e*AR Inc.

April 6, 1999

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, BC
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RE: ENSC 370 Project *e*ARä Process Report

Dear Dr. Rawicz:

The attached document is the Design Specification for an assistive device for the hearing impaired. This project is to design a pager that uses vibration to notify hearing impaired people in cases of doorbell ring, incoming phone calls or even in case of fire or toxic gas.

This document summarizes the current state of the device, deviation from our original plans and our future development plan for the device. It also includes details about the budgetary and time constraint throughout the development. In the end, each team member tells his interpersonal and technical experience from the project.

eAR™ Inc. is a team of five creative, motivated, gregarious, versatile SFU engineering students. They are George Tsai; Minhong Zhou; Rick Liu; Daniel Tang; Aaron Lee. Regarding to any questions or concerns about our project, please contact me by phone at 294-2290 or by email at ctsaia@sfu.ca.

Sincerely,

George Tsai
CEO of ***e***AR Inc.

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Introduction

After thirteen straight weeks of hard work, *e*AR Inc is proud to announce the birth of a wireless solution, ***e*AR**, for hearing impaired people. In the beginning, five young, enthusiastic, motivated and intelligent engineers – Aaron Lee, Daniel Tang, George Tsai, Minhong Zhou and Rick Liu – proposed to help deaf people with this new device. Though the stages of analysis, design, implementation and testing, the team is able to overcome all problems encountered and complete the project of ***e*AR** to make a better future for hearing impaired people. This document re-examines the process of the ***e*AR** development and briefly describes the experience of each team member.

Current State of the Device

System Overview

***e*AR** is a wireless solution that provides convenience and safety to the hearing impaired when devices, such as telephones, doorbells or smoke detectors, need immediate attention. ***e*AR** consists of a transmitter module that sends the signal from an external device through a radio frequency of 418MHz, and a receiver module that receives and decodes the signal, and sends it to the micro-controller. The micro-controller displays the appropriate messages, i.e. “Phone”, “Doorbell”, or “Smoke Detector”, and activates the vibrator for 15 seconds. The user has an option of stopping the vibration by pressing the reset button. If more than one device is sending out the signal, the corresponding messages will alternate for 15 seconds.

User Interface

***e*AR** is a pocket-sized pager that will receive signals from devices that require immediate attention, and alert the user by means of vibration as shown in figure 1.

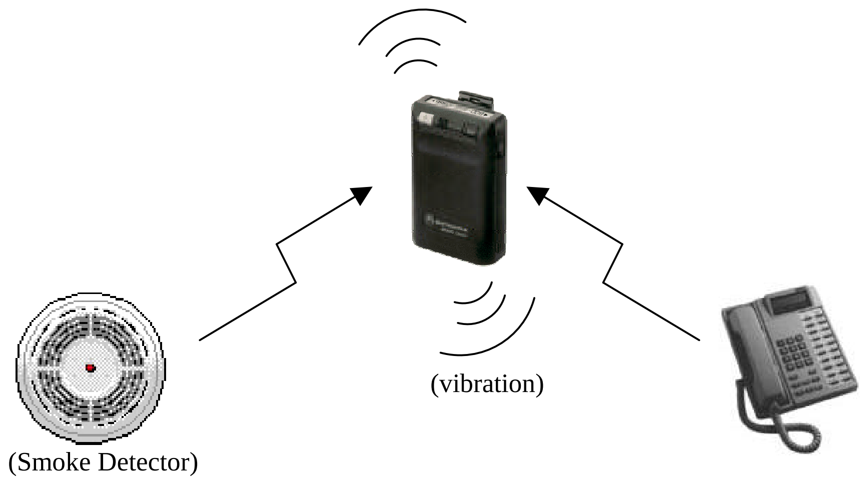

Figure 1: System Overview

The user interface of the ***e*AR** receiver module includes one Liquid Crystal Display (LCD), one power LED indicator, and one low battery LED indicator. The LCD displays the name of the devices, such as "Phone", "Door Bell", or "Smoke Detector".

Methodology Specification

The basic operation of ***e*AR** is illustrated in Figure 2.

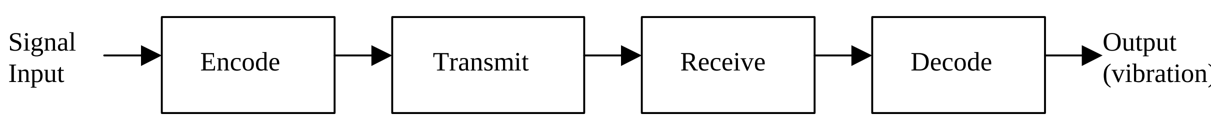

Figure 2: System Block Diagram

***e*AR** can be designed to work with a most common appliances at home. For now, three devices (i.e. a telephone ring detector, a doorbell, and a smoke detector have been successfully implemented). Each has a unique coding scheme. For example, the telephone ring detector is a simple circuit consisting of a photocoupler and a transistor. It sends out a RF signal to the receiver when it detects an incoming ring. For the doorbell, it simply enables the *transmit enable* pin of the encoder when someone presses the doorbell button. For the smoke detector, it detects the output voltage of the speaker. If it is high (smoke detected), a signal will be sent to the receiver module.

For signal transmission, Linx LC-418 transmitter and receiver modules are used for their compact size and affordable price. The modules send a series of data bits through radio frequency of 418 MHz. Two data bits are assigned to indicate which transmitter module sends the signal (e.g., “00” = telephone, “01” = doorbell, “10” = smoke detector). The data bits will be decoded and analyzed by the micro-controller unit (68HC11E2). Upon receiving the decoded data bits, the micro-controller drives the LCD module and activates the vibrator. Appropriate messages will be displayed for 15 seconds. If more than one signal is detected, the corresponding messages will alternate for 15 seconds.

For the low battery indicator, a red LED lights up when the battery is below 7V since the voltage regulator needs at least 7V to operate properly.

Deviation of the Device

Overall System

There was not much modification on our ***e*AR** system except for the antennas. Initially, we planned to purchase antennas from Linx Tecnology for a stable data transmission. Instead, in the early stage of development, we obtained the same efficiency at lower cost by simply using a piece of wire. However, we will need to consider special antennas such as those from Linx if the next generation of ***e*AR** requires longer distance and heavier volume in data transmission.

Transmitter

We removed the speakers that were supposed to be placed in the doorbell and the smoke detector for some user feedback. Since a long-time operation is expected for our transmitters, the fact that the speakers draw heavy current is not appropriate. A further research on the issue of power consumption becomes necessary for the next generation of ***e*AR**.

For the phone ring detector, we placed the antenna outside the case. The 220V AC signal of telephone would interfere the data transmission if the antenna were inside the case. As a result, we designed an external antenna to prevent this problem. Moreover, we constructed our own detector circuit instead of using Motorola ring detector chip directly. The reason is that the new ring detector is simple, and it is easy to be modified for our transmitter.

Reciever

The implementation of the receiver has not deviated at all from the functional and design specifications. The 68HC11 micro-controller still operates in the same algorithm, and each component is the way as expected.

Future Improvement Plan

For ***e*AR** to be a competitive commercial product, further improvement can be done in three areas – the overall system, the receiver and the transmitter.

Overall System

- *Increase the transmission range*

  One possible solution is to replace the existing radio frequency modules with high performance ones. Better antennas can be considered as well.

- *Reduce the manufacturing cost*

  The overall cost for each transmitter and receiver modules are $23[1] and $79 CDN respectively. These costs are not wholesale prices, which means the cost can be reduced significantly once mass-produced.

- *Ability to be modified*

  We plan to install an RS-232 port connecting to the micro-controller. The receiver then can be modified easily by a personal computer whenever an additional transmitter is introduced to the system.

Transmitter

- *Add to more applications*

  The next generation of ***e*AR** shall be applied to many more devices such as microwave, oven, alarm clock and so on. For further improvement, a multi-channel transmitter module is proposed to be placed in personal computers. It is responsible for any alarm or warning message generated by the computer.

- *Capability for AC power supply*

  Changing batteries periodically is inconvenient to the users. An AC power supply for the all devices can save some time. However, emergency devices, such as smoke detector, shall contain a battery just in case of blackout.

[1] the average cost of the three transmitters

Receiver

- *Reduce the size of the pager*

  The prototype of ***e*AR** is a pocket-sized device, but it is still bigger than a pager. The size is a bit inconvenient, so we propose to reduce the size as small as a lighter. The solution for this is to implement the circuit with smaller components (i.e., construct a micro-receiver chip).

- *Reduce the power consumption*

  We control certain parameters for less power consumption once when we start to develop the micro receiver chip. Other solution is to implement a sleep mode that draws very small current or even no current in some places when the device stands by.

- *Improve the LCD screen*

  A smaller and more adaptable LCD will be the new output screen, which is able to display in variety of color for personal preference. An indiglow is useful on the LCD at the dark. With further development, the new LCD can even show messages in different languages as well. This requires a more complex processing circuit to do the job.

- *Improve the functionality*

  We propose the receiver to be multi-functional so that it shall contain functions such as two-way pager, time/date, schedule and so on. This means, a more complex micro-controller is required to perform the tasks listed above. Also, a memory chip is needed for the storage of schedule data.

- *Ability to be recharged*

  A long-lasting rechargeable battery for the receiver is economic and environmental friendly. The future receiver shall come with a rechargeable battery and a power cord, which the user simply plugs into an AC power source.

- *Ability to identify the signal by sound*

  With this feature, it is no need to install transmitter modules anymore. The receiver is able to pick up the sound and identify the source device. A possible solution is to install a sensor to acquire the sound wave and a precise micro-controller to distinguish it. The receiver also needs a memory chip to store different kinds of sound in advance for signal comparison.

Each improvement above needs an well-organized testing plan. We will randomly pick several people with hearing disability to try the new feature, and then we obtain their feedback on the system to make further modification if necessary.

Budgetary and Time Constraints

Transmitter Budget

Table 1 lists the estimated cost and the actual cost of the three transmitters. The total estimated cost is the average cost to construct a transmitter. The actual cost of each transmitter varies in different applications. All prices listed below are in Canadian dollars.

Table 1: Cost of the Transmitters

Items	Estimated Cost	Actual Cost		
		Doorbell	Smoke Detector	Ring Detector
Transmitter Module (1)	8.40	10.00	10.00	10.00
Encoder (2)	2.00	3.00	3.00	3.00
Smoke Detector	15.00	N/A	6.50	N/A
Miscellaneous Electrical Components (3)	2.00	2.00	2.00	10.00
Antenna (4)	7.46	-	-	-
Enclosure	5.00	3.00	3.00	3.00
TOTAL	29.46	18.00	24.50	26.00

Note:

1. LC series from Linx Technologies
2. Holtek 6010
3. Accessory such as PCB boards, transistors, photocouplers, opamps, switches etc.
4. PW series from Link Technologies

The average cost to construct a transmitter is about $23 CDN. This is less expensive than our estimated cost because the purchase of the antennas from Linx Technologies was never made. Instead, we used a piece of wire as the antenna for each transmitter. It worked quite well, so we reduced the total cost by at least $25 CDN, including the shipping cost and custom tax. As one can notice, the actual cost of the transmitter modules and the encoders is more than what we estimated. The main reason is that an extra shipping cost and proper custom tax are applied on our purchases. This can be improved once when we start to produce the transmitter modules in large quantity.

Receiver Budget

Table 2 lists the estimated cost and the actual cost of the receiver. All prices listed below are in Canadian dollars.

Table 2: Cost of the Receiver Module

Item	Estimated Cost	Actual Cost
Receiver Module (5)	17.70	20.00
Decoder (6)	2.00	3.00
LCD (7)	20.00	30.00
Vibrator	5.00	5.00
Miscellaneous Electrical Components	10.00	10.00
Antenna	7.46	-
Enclosure	10.00	11.00
TOTAL	77.16	79.00

Note:

5. LC series from Linx Technologies
6. Holtek 6042
7. Veronix 153-1031

The overall cost to construct a receiver is $79 CDN, which is a bit higher than our estimated cost. Like transmitter modules, tax and shipping cost are added up to the total cost. One possible solution is to produce the receiver module in large quantity.

Time

Figure 3 below shows an actual Gantt chart of our ***e*AR** project.

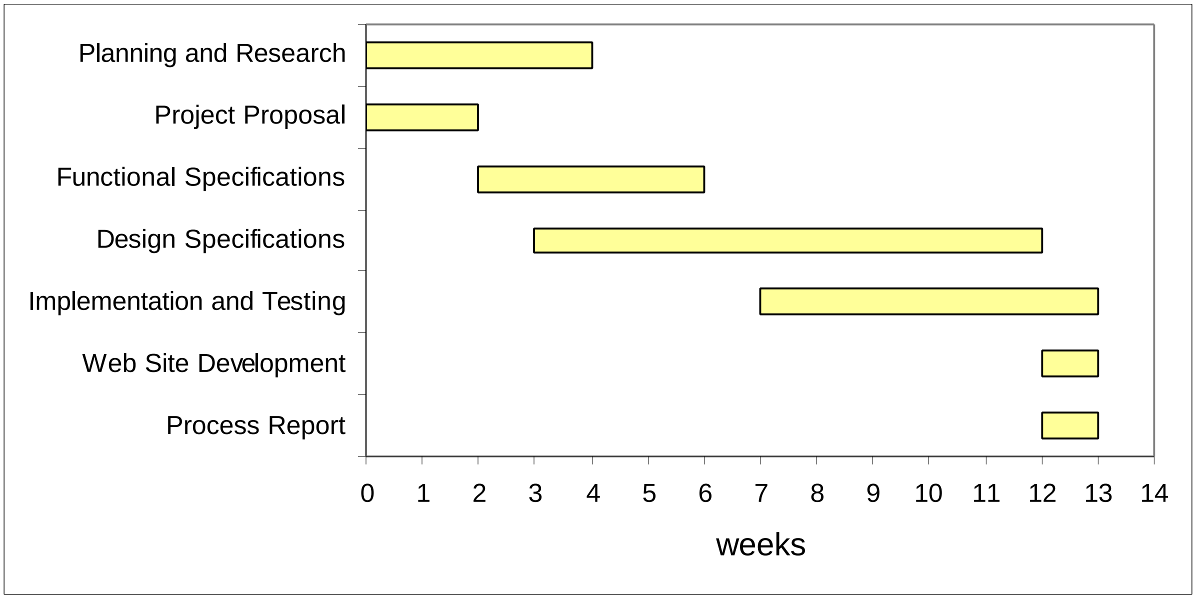

Figure 3: Gantt Chart of the *e*AR Project

The time that we spent on project preparation (i.e., planning, researching and project proposal) is obviously shorter than what we had expected. One reason is that we started our project early. First of all, the team was made up during the winter break. Each member tried to think of several interesting ideas for the project. In the first week's meetings, we made the final decision and soon started to research on the project, ***e*AR**. Another reason is that we talked to our teaching assistants, Victor and Jason, for advices. They shared their technical experience with us, so we were able to quickly choose the most suitable components for our design.

It is interesting to notice that we spent quite large amount of time in design, implementation and testing. The reason is probably that in late February, the project was slowed down because of our midterm examinations from other classes. Since we always did things early, we had plenty of time both to work on the project and to study other courses.

Generally, our progress was very satisfying because of our outstanding project management. We split up the tasks so that we can work in parallel. Besides, our leader even gave us early but reasonable deadlines for all the tasks so that we always intended to finish our jobs soon. This saved much time to give room for other unexpected problems, especially at the phase of testing.

Interpersonal and Technical Experience

Aaron Lee

Finished a large project in limited time really requires a lot of effort and support. Every detail about the project has to be well planned before proceed, also, compromise between group member should not be lacked. In this term, we have been having regular meetings, when we have to plan together as what is our next task and distribute the tasks fairly among every group member. The length of our meeting varies depends on the task we have to accomplish. In the meeting, our CEO George will chair the meeting and raise the issues about the project, and following will be the discussion and idea sharing period. Through the meetings, the group learned how to achieve team dynamics in a friendly, cooperative, contributive, and positive atmosphere. I find that group dynamics is the key factors to our success.

This project gives me a real technique experience in implementing a system, and provides me with a better understanding of the components. I also realized that there are some differences between theories I learned from courses and the actual implementation of circuits. In a technique prospective, I was introduced to the transmitter and receiver module. I found it very important to fully understand how each component works; most of the debugging time has been spent on understanding how the circuit works. For most of the time that we are implementing the hardware of the project, we usually worked in a small group of two. By working in this way, the two group member and help each other on designing and debugging and therefore the efficiency will increase. Last but not least, I have learned where to shop and how to choose useful components for our project.

I especially want to thanks George, Minhong, Rick, and Daniel, who has devoted their soul to the project. I really hope I can work with them again in another ENSC370 liked course!

Daniel Tang

From this project I have learn the importance of team dynamics and how the technical experience in implementing a system. Since our group has decided what to build for this project, all the group members attend regular meetings about 3 times a week. Most of the time in meeting is used to exchange the ideas of how to resolve technical problems our group had encountered, and to distribute the tasks fairly to each of the group member. At the end of each meeting, our group will discuss what to do for the next meeting. At the last two months of the semester, most of our meeting time spends on implementing the actual circuit design. Thanks to our leader George who always plans first and organizes the meeting carefully, our group is able to finish the project on time. Also, during the four months I have learned to not only work individually but also work as a team with one or two members on the tasks given. I then discover how efficient it is for a team to work in a cooperative and positive attitude.

This project also teaches me the difference between theories that I have learned from school and the actual circuits implementations. Several new electronic components are introduced to me during this project. I also learn how to detect the frequency signals from telephone, and how to build receiver and transmitter module. I spend most of my time working with Aaron as a partner for the designing of hardware circuits implementation. We find out that actual implementing is not as easy as we think. Most of our working time concentrates on debugging and understanding how the circuits really function. It is through this project I realize that how important the hand-on experience is.

George Tsai

After these intense four months, I have learned quit a few new electronic designs, such as how to provide large current from micro-controller output, and how to reverse-engineer. These topics never came through my mind until I faced it personally. The whole experience has been great.

As a team leader, I had learned the difficulties of organizing team works. I have to play two roles at the same time: friend and boss. This sometimes affects my decision as a leader. I also faced some personal conflicts among our group. Fortunately, conflicts were resolved. This has strengthened my ability as a team leader.

These 100+ hours that we spent in the lab will definitely be part of our memories as we struggled and overcame the obstacles together as a team. These technical and inter-personal experiences that we gained will definitely benefit us for the years to come. The engineering disciplines can not just be learned from the textbooks. They have to be learned through the hand-on experiences.

Minghong Zhou

This project introduced me to Assembly programming for Motorola 68HC11 micro-controller, LCD display and electronic design. In particular, I learned a lot about 68HC11 architecture and how to program the chip in assembly languages. Although the algorithm of my code is quite simple, there are a lot of I/O operations and timing functions, which require careful planning. For example, certain delays are required to properly drive the LCD display, various interrupt service routines to serve user input and timing controls. Overall, it gave me valuable experience on low level assembly programming that has a lot of interaction with the hardware. The project also helped me to learn how to work in a team environment, and most importantly, it gave me insight on how things work in the “real” world. For example, how to get “free” parts from manufactures such as Motorola, where to order the components used in the project, how to expect the unexpected and recover from the unforeseen stumbles. Fortunately, our project was completely relatively smoothly with only minor obstacles. Overall, doing this project was a very valuable and rewarding experience for me.

Rick Liu

In the beginning of Spring 99, I knew ***e*AR** would be a challenging and fun project. Our team came out with this wireless solution for hearing impaired people. It is such a good idea that it helps people with disabilities, involves the application of radio frequency, and it has a great market potential. Because of these motivations, each member of the ***e*AR** development team was concentrated and enthusiastic to participate whenever it is possible.

The success of the ***e*AR** project is mainly due to our outstanding project management. First of all, the project is divided into software and hardware development. In software programming, Minhong focused on coding the micro-controller and the LCD screen. In hardware assembly, Aaron, Daniel and I were assigned to complete the transmitter modules, the receiver module, the three applications (i.e., doorbell, phone ring detector, smoke detector) and other accessory components. As the team leader, George monitored the progress of the group and helped in both software and hardware, especially the areas which we had troubles with. Whenever we encountered problems, we always sought for solutions immediately and solved the problems as soon as possible. In our weekly meetings, future plans would be discussed among each other. George then made the final decisions for the group according to the conclusion. With this kind of project management, we never fell behind schedule and even completed our ***e*AR** project way before the semester ended.

I have learnt so many things from the *e*AR project especially the phone ring detector. With little supervision, I constructed a simple but useful detector. I modified it to meet specific requirements for the transmitter module. Besides, I also gained experience in the assembly and testing of radio frequency module as well. However, the thing that I really enjoyed the most is the intimate partnership with other team members. We worked cohesively as a team in a relaxing but motivating atmosphere. We were willing to help each other as much as we could. We even shared information with each other about our own subtasks. Therefore, we always knew how others were doing in their parts and were ready to help if needed. Sometimes stress and frustration caused conflicts among our group, but they can always be resolved within no time. This is the best team that I have ever worked with. For my future projects no matter at school or at work, it will definitely be my pleasure to work with a team just like this.