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February 21st, 2005

Lakshman One
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RE: ENSC 440 Project Remote Health Monitor Functional Specification

Dear Lucky,

We have attached the Remote Health Monitor Functional Specification based on the project described in the proposal we submitted previously. Remote Health Monitor is to collect a patient's health data and manage them in a low cost, scaleable, and user-friendly fashion. Patients can be monitored anywhere there is internet access. The Remote Health Monitor measures health parameters such as body temperature and pulse, and then transmits the readings to the hospital's database through the internet. With the software that comes with the package installed, patients can also access their personal clinical information.

The functional specification describes in detail the goals we plan to achieve for this project. The overall system operational specifications, functions of each component of our system, and safety specifications are provided.

Remote Medical Inc. consists of four experienced and enthusiastic 3rd and 4th year engineering students: Dong Zhang, Calvin Che, Marian Chang, and Lotus Yi. If you have any questions or concerns, please feel free to contact us through the email at ensc440-rabbit@sfu.ca.

Sincerely,

Lotus Yi

Lotus Yi
Chief Executive Officer
Remote Medical Inc.

Enclosure: Functional Specification for Remote Health Monitor

REMOTE MEDICAL INC.

Functional Specification for
Remote Health Monitor

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ABSTRACT

Management of patients with chronic conditions is a long-standing challenge for health care organizations. These conditions include diabetes, chronic heart failure, Asthma, HIV / AIDS, and cancer. Patients are required to adopt lifelong diet and drug control to maintain optimal health and avoid the complications of the disease. These complications can arise suddenly and can be life threatening. Therefore, the health condition of patients with chronic diseases should be reported frequently.

We propose to implement the data reporting into a single stationary device that collects health information for physicians via internet connections. Our solution, Remote Health Monitor (RHM), measures a patient's medical conditions and sends the measurements to the hospital database through internet. The design of a stationary device ensures consistency of the environment under which measurements are taken. The database can be accessed either by the physicians or patients with specific login identifications to keep information confidential.

Attached is the Remote Health Monitor Functional Specification. The functional specification describes in detail the goals we plan to achieve for this product. The functions of each component of our system, as well as overall system operational specifications, are discussed. In addition, safety specifications are provided.

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GLOSSARY

AC	Alternating current, the current that reverses in direction at a fixed interval.
bpm	Beats per minute, a measurement of pulse.
bytes	A collection of 8 bits, which is the fundamental of digital information with a possible values of 0 and 1.
CND	Canadian Dollars
CPU	Central processing unit, the main processing chip of a computer.
DC	Direct current, the electric current that flows in one direction.
Ethernet	A common method of networking computer in a LAN (local area network), which is a network for communication between computers
input capture	A method for measuring pulse width. When the first pulse is received, the value of the timer is latched into a register, which will then be used to compare with the timer value when the second pulse is received so the time between the pulses can be determined.
interrupt	The suspension of normal program execution to perform a higher priority task as requested by a peripheral device. After completion of the task, the execution of the interrupted program is resumes from the point where it was left off.
IO ports	Input and output ports, which is used along with connection cable to link one device to the other and allow communication.
IP	Internet protocol, the basic network transmission protocol of the Internet.
IP address	An address with 4 numbers separate by periods that uniquely identifies a certain computer on the internet.
ISR	Interrupt service routine, a piece of code that the processor executes when an external event, such as a timer, occurs.
KB	Kilobyte, a measurement of disk capacity, equivalent to 1024 bytes.
LED	Light-emitting diode, a semiconductor device that produces light when conducting currents.
MB	Megabyte, a measurement of disk capacity, equivalent to 1024 kilobytes.
Mbps	Mega bits per second, a measurement of data transmission rate.

OS	Operating system. software interface between application and hardware.
PC	Personal computer, a computer that is designed to be used by one individual at a time.
protocol	Standard procedure for regulating data transmission.
RAM	Random access memory, the most common computer memory which program can read and write to in order to perform their task.
registry	A database used by Microsoft Windows to store configuration information.
RHM	Remote Health Monitor, the name of our product.
ROM	Read only memory, the computer program can only read the contain within the memory but cannot write new information to it.
Rabbit 2000	An 8-bit microprocessor that is made by Rabbit Semiconductor Inc. and is commonly used in embedded systems.
SPI	Serial peripheral interface, a method of communication between host processor and peripheral device with data sending one bit at a time through a single channel.
TCP / IP	Transmission control protocol / internet protocol, a protocol that computer used to communication and exchange information over the internet.
zip	A data compression method that speeds up the data transmission of large and / or multiple files through internet.

1. INTRODUCTION

The goal of the Remote Health Monitor (RHM) is to collect a patient's health data and manage them. Patients can be monitored from anywhere there is internet access. The RHM measures parameters such as temperature and pulse, and transmits the information to the database located in the hospital. The database can be accessed through a software application that we will provide along with the purchase of RHM. The application can be logged in either as a doctor or as a patient, thus allowing the care providers to monitor a patient's health condition and the patients to review their own medical history.

Our goal in implementing RHM is to provide chronic disease patients with an easy to use device that will help them track health information without going to the hospital, and to allow doctors to review the patient data with a software application that organizes and updates information automatically.

This document lists the necessary functional specifications of the Remote Health Monitor. The requirements are tailored by incorporating the consumer's needs and the limitations of our device. A system overview block diagram will be provided along with an overall device requirement section. Then, each functional block will be discussed in detail in the subsequent sections where we list the requirements and briefly explain how the functional decisions were made. We will use this document as a guideline to implement our device to ensure consumer satisfaction and safety.

2. SYSTEM OVERVIEW

Figure 1 shows the high level structure of the system. The database server is located in the hospital; the Microcontroller and measuring devices are installed in the patient's house; the user access can be done from any PC that have the client software installed, and can be logged in as doctor or patient mode.

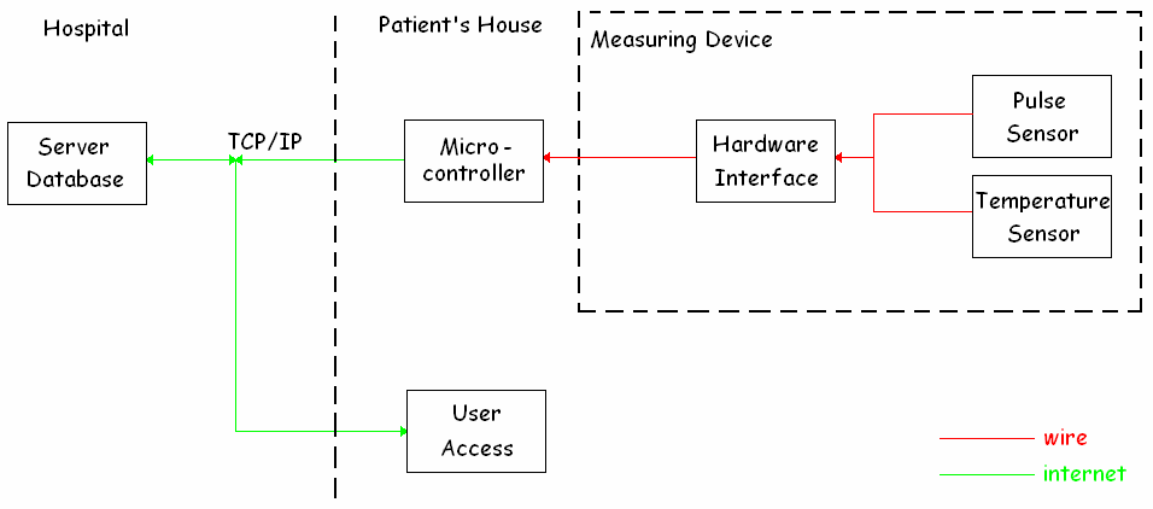

Figure 1: System Block Diagram

Figure 2 presents the basic functionality of RHM in a graphical manner.

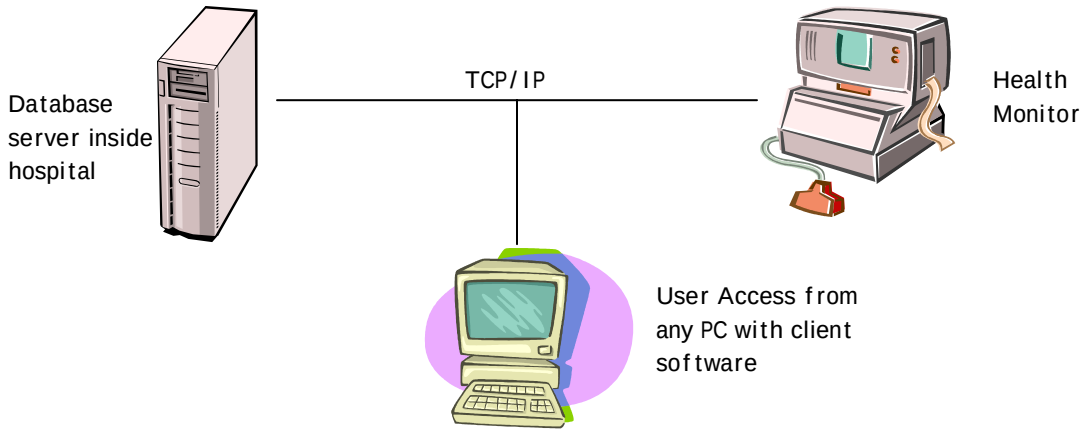

Figure 2: Graphical Diagram of the System

3. OVERALL SYSTEM REQUIREMENT

3.1 General Requirements

This section outlines the overall packaging users will receive upon purchase. The physical specifications are decided so that one person can carry the device easily. And the adapter type is chosen to be compatible with North America standard.

(Req. 1) This overall packaging dimension should be less than 40cm × 40cm ×25cm.

(Req. 2) The weight of overall package should be less than 600g.

(Req. 3) The power adapter should work with 110V, 60Hz AC.

(Req. 4) The price of the product should be less than $500 CND.

3.2 Safety Requirements

The remote health monitor should follow the following specifications in order to protect the welfare of the user.

(Req. 5) The outer packaging of the device should have smooth edge and corners for easier and safer handling.

(Req. 6) All electrical connections should be enclosed and should not be accessible by the users.

(Req. 7) This device should not produce “shocks” at all times, especially during power-up and shutdown.

(Req. 8) This device should be able to power-off safely anytime during measurement in case of emergency such as power outage.

(Req. 9) This device should not cause interference to other devices.

3.3 Environmental Requirements

The environmental requirements are meant for the device to maintain and operate properly in Vancouver.

(Req. 10) The device should operate in temperature ranging from -20° C to +60°C [1].

(Req. 11) The device should operate with a humidity level ranging from 5% to 95% [1].

(Req. 12) The part that attaches to the patient’s skin must be water proof (to avoid degradation due to sweat).

3.4 Physical Requirements

The lengths of the various cables are chosen based on the power line design in households and also the body size of the patient.

(Req. 13) The power cord should be longer than 1.5m.

(Req. 14) The Ethernet connection cable should be more than 50cm in length.

(Req. 15) The length of connection cables for the temperature sensor should be more than 1m so the patients will not need to tilt their head while obtaining measurements.

(Req. 16) The length of pulse sensor connection cables should be more than 1m.

3.5 Functional Requirements

The following items are required for measuring patient's health condition with ease and minimal accuracy.

(Req. 17) The device must have at least two buttons for input, one for each sensor.

(Req. 18) The device must have at least two LED lights for user feedback, one for each measurement.

(Req. 19) The pulse sensor must acquire an accuracy of 5 bpm.

(Req. 20) The temperature sensor must have an accuracy of ≤ 0.5°C, which is the minimal difference to identify fever.

4. REQUIREMENT FOR MICROCONTROLLER BOARD

The functions, requirements, and interfaces of the microcontroller are specified in this section.

4.1 General Requirements

(Req. 21) The microcontroller circuit board must be powered by 12V DC power supply with 1A of current maximum rating.

4.2 Physical Requirements

In order to fit the board into the device case, our board should be smaller and lighter than the value specified in overall system requirement.

(Req. 22) The dimension of the microcontroller board should be no more than 30cm by 30cm.

(Req. 23) The weight of the microcontroller board should be less than 500g.

4.3 Functional Requirements

(Req. 24) The circuit board must have at least 8 digital IO ports, 2 for LED, 2 for switches, 2 for sensors, and 2 extra IO ports for implementing other features if time allows.

(Req. 25) The board must be able to accept data from the temperature sensor.

(Req. 26) The board must be able to capture the pulse signal generated by the pulse sensor.

(Req. 27) The board must have some network connection to send data to a remote database server.

(Req. 28) The network connection speed should be no less than 10Mbps to be compatible with most of the routers and switches.

(Req. 29) Pulse and temperature information must be processed in no more than 0.5 seconds to capture the data as in real time as possible.

(Req. 30) The microcontroller must be able to handle interrupt to accept user input.

(Req. 31) The microcontroller must have at least 512KB ROM and 512KB RAM in order to store our firmware program.

4.4 Environmental Requirements

The board must satisfy the environmental requirements listed for the overall system, namely (Req. 10) ~ (Req. 12).

4.5 Cost Requirements

(Req. 32) The microcontroller board with the microcontroller should be less than $300 CND so the cost and price of our device can be keep within $500 CND as specified in the overall system requirement.

4.6 Test Requirements

This section lists all the testing requirements needed to ensure the functionality of the microcontroller.

(Req. 33) Test the device under various temperatures between -20° C to +60°C.

(Req. 34) Use the microcontroller input to measure the duration of a known frequency pulse to test if the capturing is successful.

(Req. 35) Write a simple ISR to print a message on the monitoring computer to test the interrupt handling capability.

(Req. 36) Use a timer to measure the timing requirements of the measurements.

(Req. 37) Send dummy data to see if the network connection is successfully established.

5. REQUIREMENT FOR PULSE SENSOR

This section will describe the functions and requirements for the pulse sensor and its interface to the microcontroller.

5.1 General Requirements

(Req. 38) The pulse sensor must be powered by a 5V DC power supply.

(Req. 39) The pulse sensor interface must be compatible with the microcontroller input.

5.2 Physical Requirements

(Req. 40) The pulse sensor must be attached to a band to wrap around the patient's wrist.

(Req. 41) The length of the band should be able to vary from 10cm to 40cm, so upon installation of the device at the patient's house, the band can be customized to appropriate length.

(Req. 42) The pulse sensor must be smaller than 2.5cm × 1.5cm × 1.5cm.

(Req. 43) The total weight of the pulse sensor should be less than 200g (the weight of a watch), for the comfort during measurement.

5.3 Performance Requirements

(Req. 44) The pulse sensor output must be compatible with microcontroller input.

(Req. 45) The pulse sensor output should provide an accuracy of at least 5bpm.

5.4 Environment Requirements

The pulse sensor must satisfy the environmental requirements listed for the overall system, namely (Req. 10) ~ (Req. 12).

5.5 Cost Requirements

(Req. 46) The pulse sensor along with its interface must cost less than $80 CND.

5.6 Test Requirements

This section outlines the tests we will perform to ensure the functionality and reliability of our pressure sensor.

(Req. 47) Measure the required physical dimensions.

(Req.48) Observe the output from the pulse sensor to interpret its accuracy.

(Req.49) Verify that the pulse sensor output is readable by the microcontroller.

6. REQUIREMENT FOR TEMPERATURE SENSOR

This section will describe the functions and requirements of the temperature sensor.

6.1 Physical Requirements

(Req. 50) The detection part of temperature sensor must have a surface area smaller than 1cm × 1cm to be inserted into the ear.

(Req. 51) The detection part of temperature sensor must be flexible enough to be inserted into the ear.

6.2 Performance Requirements

(Req. 52) The output of the temperature sensor must be compatible with the microcontroller input.

(Req. 53) The output accuracy must be ≤ 5°C.

6.3 Environmental Requirements

The temperature sensor must satisfy the environmental requirements listed for the overall system, namely (Req. 10) ~ (Req. 12).

6.4 Cost Requirements

(Req. 54) The temperature sensor must cost less than $120 CND.

6.5 Test Requirements

This section outlines the tests we will perform to ensure the functionality and reliability of the temperature sensor.

(Req. 55) Measure the required physical dimensions.

(Req. 56) Verify that the temperature sensor output is compatible with the microcontroller, and via microcontroller outputs, ensure the specified accuracy is achieved.

7. SOFTWARE REQUIREMENT

This section will describe the functions and requirements of the client software MediNet which as specified in the system overview will have two modes – doctor mode and patient mode.

7.1 Operating Requirements

This section outlines the basic requirements a user computer must possess to use our software.

(Req. 57) Minimum Pentium or compatible CPU with operation system: Microsoft Windows 95 or higher.

(Req. 58) 1 to 2 MB of hard disk space.

(Req. 59) Minimum 8 MB of RAM.

(Req. 60) TCP / IP network protocol support.

7.2 Performance Requirements

(Req. 61) The program must be able to connect to database and save / retrieve information from the database.

(Req. 62) The program must display a login screen upon startup, and can identify user type (patient or doctor) by their ID during login and open up the appropriate dialog.

(Req. 63) The program must not expose user password as plain text during any operation.

(Req. 64) The destination database server address can be changed before logging in, so replacing the server or changing to a different hospital can be compensated without re-installation of the software.

(Req. 65) Help must be accessible throughout the program for user friendliness.

7.3 Requirements for Doctor Mode

If the login ID is detected to be a doctor's ID, the program will be in the doctor mode, which will display a list of his or her patients. To manage his / her patient, the doctor should be able to:

(Req. 66) View the basic information of all patients and their status.

(Req. 67) Add and remove patient from his / her patient list, or transfer the patient to another doctor.

(Req. 68) Add a new patient or search for an existing patient then add to the list.

The doctor should not be able to remove a patient from database in case the hospital needs a record of all its patients. Removal of patient from database should be done only by system administrator.

For the data stored in the database, the doctor should be able to:

(Req. 69) View and change their personal information, and view all patients' information.

(Req. 70) Change the machine IP associated with the patient.

(Req. 71) List patient's measurement data by date or by entry number.

7.4 Requirements for Patient Mode

If the login ID is detected to be a patient's ID, the program will be in the patient mode, which will display their information and allow them to:

(Req. 72) View and change their personal information, and view the information of their doctor.

(Req. 73) List their measurement data by date or by entry number.

7.5 Ideal Features

The following features are ideal and may be added to our program for completeness and user-friendliness if time is permitted.

(Req. 74) Search for a specific measurement data by date.

(Req. 75) Provide a graphical display and summary statistics of the data.

(Req. 76) Export patient's and doctor's detail and / or measurement data.

(Req. 77) Send message to the doctor / patient through the software.

7.6 Additional Components

(Req. 78) The software should be released in two formats: an executable installer and a zip distribution that do not require installation.

(Req. 79) The software should include a help document.

7.7 Test Requirement

This section outlines the tests we will perform to ensure the functionality and reliability of the client software.

(Req. 80) Split the program into modules and dialogs, and test each of them separately during implementation.

(Req. 81) Merge each module into the main program after it is being tested, and test run the entire program to ensure it runs properly.

(Req. 82) Build the program first without the database module and use simulated "dummy data entries" to perform program test.

(Req. 83) Performance test: test the program by entering boundary data values and perform all available operations in order to make it bug-free.

(Req. 84) Usability test: give the program to several potential users after completion and receive feedback in order for the software to be user-friendly.

8. DATABASE REQUIREMENT

This section will describe the function and requirements of the database server that holds the doctor's and patient's data.

8.1 Operating Requirements

The system requirement for the database server is similar to the requirement of the software, but instead, a minimum of 200MB of hard disk space is required to store the patients' and doctors' data.

8.2 Performance Requirements

(Req. 85) The database must be able to store and read data at anytime during operation.

(Req. 86) The database must be able to identify the user by using its ID.

(Req. 87) The database must operate 24 hours a day, 7 days a week to ensure all read and write requests can be processed.

(Req. 88) There must be designated data fields that store the doctor's and patient's data such as name, address, phone number, etc.

(Req. 89) The table for measurement data should contain both timestamp field that store measurement time and an integral field that store measurement value.

(Req. 90) The database and data tables should be searchable, by entry and by date.

(Req. 91) There should be at least 1 system administrator per hospital that is trained for maintaining the database.

8.3 Test Requirements

The database can be tested with a program that reads and write data to it as if it is the actual client. All fields should be tested before the database is made accessible to the actual software and firmware.

(Req. 92) Using the test program to write a value to the database then read it immediately to see if the two values match.

9. CONCLUSION

This document outlines the requirements for our product in several aspects; these requirements should be met during the production to ensure this device to be stable, safe to the user as well as environmentally friendly. The overall system requirement specifies all the general requirements that should be satisfied so that the device will operate in most households. The more detailed requirements for each part of the design are clearly presented so that during the design and implementation stage of the project, the proper operation between different components is ensured. Using this documentation as a design guideline, we are confident that we can design this device to meet the user's expectations.

10. SOURCES AND REFERENCES

[1] BBC World Weather, "Average conditions - Vancouver," 2005, http://www.bbc.co.uk/weather/world/city_guides/city.shtml?tt=TT000950.