RFID-Enabled Wireless Heart Monitoring

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Introduction

Wireless heart monitoring is a technology that can save lives and restore peace of mind to those with heart disease and those at-risk. Heart disease is the most prevalent health problem in the United States currently. Technology that can help manage the disease would reduce the financial burden placed on the national healthcare system and improve patient health. RFID has not had a major roll in cardiac healthcare systems, however it is an ideal technology for wireless heart monitoring devices [1].

Wireless Heart Monitoring use cases:

1) Automated emergency contact for at-risk people
People who have suffered a heart attack, suffer from one or more types of heart disease, or are generally at risk because of obesity or smoking, would benefit greatly by using an emergency contact enabled mobile cardiac monitor. Many of the at-risk people mentioned are elderly and do not have a person around 24 hours a day to call an emergency telephone number in case they go into cardiac arrest [2]. If a person went into cardiac arrest and could not reach a phone to call emergency services he/she would die. Using an emergency contact enabled mobile cardiac monitor would give the user peace of mind being alone and allow him/her to return to his/her normal lifestyle.

2) Disease management for heart disease patients
Heart disease patients must monitor many variables including medication, weight, and heart rate to accurately manage their condition. Many of these patients are elderly and have great difficulty keeping track of so many factors. A remote mobile cardiac monitor would automate the process and eliminate the need for the patient to remember to manually measure and record their heart rate. This data is analyzed by remote care managers and nurses who use it to detect early warning signs then provide patients medication and lifestyle adjustments [2]. Such a system would aid in preventing the need for the patient to be re-hospitalized.
3) Exercise in a specific heart rate zone

An optimal range of heart rates for exercising exists for each person. Athletes need to exercise in their optimal heart rate zones to effectively train. People with heart disease also need to stay in a safe heart rate zone. An emergency contact enabled mobile cardiac monitor would help these users exercise effectively and safely. It could also save their lives if, for example, they had a heart attack while exercising.

4) Detect heart disease in cases of unexplained fainting, palpitations, seizure-like events

Certain types of heart disease, such as cardiac arrhythmia, can be detected by analyzing heart rate data from a several days to a week. If a person complains of dizziness, lightheadedness, palpitations, or fainting, they may have a cardiac arrhythmia. Cardiac arrhythmia is characterized by a heart beat which is too fast, too slow, or irregular. It can vary from a normal condition not requiring medical attention to a life-threatening condition which requires emergency attention. The symptoms indicating cardiac arrhythmia may exhibit themselves randomly, making it difficult for a doctor to diagnose what kind of arrhythmia that patient has and what treatment to administer. A remote mobile cardiac monitor could collect heart rate data for a week interval and capture the irregular heart activity [3].

**Existing Products for each Use Case**

1) Automated emergency contact for at-risk people

Life Alert sells a wireless manually operated emergency contact device for the home. The user carries a device, which is a two inch square button with a 150 foot wireless range, and presses it if he or she is in trouble. The device transmits a signal to a base unit which then notifies a monitoring center which then notifies emergency services. Life Alert’s system lacks automated emergency contact – a useful feature in cases where the user is incapacitated or goes unconscious. CardioNet sells a device which combines a chest sensor with three electrodes, and a PDA-sized transceiver worn on the hip. The transceiver processes the data and can contact emergency services if the wearer’s heart rate is abnormal [4].
2) Disease management for heart disease patients
Carematix, and CardioNet sell disease management systems for heart disease patients. The systems each consist of a sensor connected to a wireless transmitter, a receiver connected to a PC, and a remote server where data is stored [5]. CardioNet has a staffed monitoring center that prepares reports based on the patients data and sends it to their physician. Based on the data and reports, physicians or nurses can recommend lifestyle and medication modifications that will help the patient avoid hospitalization [6].

3) Exercise in a specific heart rate zone
Heart rate monitors for exercise are available from Polar and NuMetrex in several different configurations. Polar heart rate monitors are comprised of a chest strap that senses the user’s heart rate and a watch-like transceiver that receives data from the chest strap and can transmit stored data to a PC via infrared [7]. These monitors can sample from every 5 seconds to every 60 seconds and store up 1 MB of data. NuMetrex eliminates the chest strap and integrates the heart rate sensor into a shirt [8].

4) Detect heart disease in cases of unexplained fainting, palpitations, seizure-like events
The most common device used to diagnose unexplained fainting, palpitations, and seizure-like events is called a Holter Monitor. Spacelabs Healthcare sells a system called the LifeCard 12 which consists of a 12 lead ECG sensor and a device that logs the data to a Compact-Flash card. The patient wears the monitor for a week and periodically transfers data from the memory card to a PC. The data collected from this interval will enable a physician to make a more precise diagnosis of the problem than a one hour checkup [9].

Proposed RFID-Enabled Wireless Heart Monitoring System

Overview
The system will consist of 1) a wristwatch-like device that contains a heart rate sensor, an active RFID chip and antenna, LCD display, vibration motor, and battery 2) cell phone with an integrated active RFID reader 3) (optional) home PC with active RFID reader and an internet connection. Heart rate data for the outlined use cases requires a bandwidth of 256 bps, assuming a data size of 32 bytes and data sent once per second. The HP Memory Spot, a state of the art RFID chip, has a bandwidth of 10 Mbps [13]. Active RFID is a perfect wireless technology for this application due to its range and bandwidth. The user will wear the wristwatch and the cell phone and his or her heart rate will be logged in the phone’s memory. Should his or her heart rate exceed or drop below a preprogrammed threshold the phone will automatically contact emergency services. Optionally, the user could leave the phone at home and heart rate would be logged to the RFID chip’s memory for later download to a PC. At home the user would wear just the wristwatch and data would be sent to the PC.

Figure 1: Proposed System Mockup

Hardware
The RFID technology to be used will be ISO 18000-7 active 433 MHz [14]. The requirements that affected this choice are as follows: 1) 100+ foot range when user is at home and heart rate data must be transferred to a PC. 2) cell phone RFID reader will have to be small and low power but also be able to read from up to 48 inches away. 3) 1 MB memory. 433 MHz was chosen because it is part of the ISO 18000-7 standard. Power and size constraints of the cell phone based reader dictated the need for active RFID. The use of a heart rate sensor in conjunction with the RFID chip also necessitated the use of active technology.

To measure heart rate a pulse oximetry sensor will be used, specifically a BCI Micro Power Oximeter. This sensor was chosen for its low power – 22 mW. Pulse oximetry works by sensing the light, from an LED source, reflected from the bloodstream. Heart rate is determined from the pattern and amount of light reflected [10]. Pulse oximetry is non-invasive and will provide accurate readings even when the user is in motion.

![Figure 2: How Pulse Oximetry Works](image)

The LCD display interface will display time and heart rate. Options to change sampling time (5s – 60s), set a target heart rate zone, and store data will be available. The vibration motor will serve as tactile feedback for those exercising who want or need to stay in a specific heart rate zone. Once the target heart rate zone is programmed, the motor will vibrate whenever the user falls below or rises above that zone. Lithium polymer battery technology was chosen because it is thin, light, and rechargeable.

The cell phone will be a Smartphone with 1 MB data storage capability. An example of a Smartphone is a Blackberry 8800. This specific phone has 64 MB of built-in memory.
and a 312 MHz processor – more than enough processing power and memory to handle heart rate data. A 433 MHz ISO 18000-7 reader will have to be integrated with a cell phone. The reader and battery will have to have similar dimensions to the phone. The range requirement of the reader is 72 inches.

**Current Related RFID Technology**

RF Code makes the M220, a mobile active 433 MHz RFID reader with a battery life of approximately 8 hours. This device can be worn on a person’s hip comfortably as it measures 4.37”x3”x1” and weighs only 5.2 ounces. A similar form factor and power consumption is desirable for the reader for the proposed system. This particular reader would not work for the proposed system since it uses a proprietary communication protocol and RF Code does not sell any tags with an integrated heart sensor.

![M220 Mobile Reader](image)

Figure 3: RF Code M220 Mobile Reader [12]

Third Eye Inc. sells a Security Alert Tracking System that includes a wrist-based heart sensor and active RFID chip, and a reader connected to a PC. The application of this system is security for casinos and banks. The active RFID chip operates at 915 MHz and has a range of 100+ feet, and the sensor is a pulse oximeter. The wristwatch portion of this system is similar to the proposed system’s, but the reader is not portable and the communication protocol is proprietary.
Software

The cell phone will need software to log the incoming heart rate data and to automatically contact emergency services if the user’s heart rate drops below or exceeds a programmed threshold for a programmed time. It will also need an interface so the user or a physician can set the heart rate thresholds for automatic emergency contact. A middleware that handles contacting emergency services over a cellular network or WiFi, if available and if featured on the phone, is necessary. Embedded software is necessary on the RFID chip to sample the heart rate data and store it. Software is also necessary on the user’s home PC, if he/she uses that optional part of the system. A middleware to handle automatic emergency contact, push heart rate data to a monitoring center, and facilitate secure patient data sharing between a hospital, the doctor’s office, and monitoring center, is needed.

Comparison of Proposed System to Current Technology for Use Cases

1) Automated emergency contact for at-risk people
The proposed system is an improvement over Life Alert’s system because it does not require the user to manually press a button to contact emergency services, and does not require the user to be at home. The user is given peace of mind knowing emergency services will automatically be contacted if anything happens to him or her. In addition to peace of mind, the user is allowed the freedom of a regular lifestyle.
2) Disease management for heart disease patients
The proposed system has similar functionality to existing systems for disease management, but the automatic emergency contact feature gives it an advantage. Those who require a disease management system are likely at risk of heart attack or stroke, so this feature is not only useful but indispensable.

3) Exercise in a specific heart rate zone
The advantages of the proposed system over existing heart rate monitors by Polar, Timex are having the heart rate sensor integrated into the wrist-watch, tactile feedback through a vibrating motor, and automated emergency contact. Eliminating the chest strap sensor and integrating it into the wrist-watch makes the product much more convenient. Tactile feedback makes exercising in a specific heart rate zone easier without having to periodically look at a watch.

4) Detect heart disease in cases of unexplained fainting, palpitations, seizure-like events
The proposed system is not as good as the current technology for detecting heart disease. To detect heart disease, 6-12 channels of full fidelity ECG data must be recorded and the RFID technology proposed for this system does not have the bandwidth to transmit that amount of data reliably.

**Conclusion**

RFID is an ideal technology for transmitting simple heart rate data. Research and development must be done on the reader as well as the sensortag side of this project in order to build such a system. A sensortag has to be developed that is active and operates according to ISO 18000-7, has 1 MB memory and a pulse oximetry sensor. A cell phone sized reader that is compatible with ISO 18000-7 must also be developed. The proposed system would integrate the sensortag into an LCD wristwatch, and incorporate the active reader with a cell phone. Embedded software on both devices would handle the reading and processing of heart rate data, and an intelligent middleware would route automated...
emergency contact through a cellular or WiFi network. This system could save lives and provide peace of mind to the elderly, people at risk for heart disease, and people who have heart disease and need help managing it.
References


