Electrocardiogram Application for Android Based Mobile Devices

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Background

- **Electrocardiogram (ECG)** – Records the electrical activity of the heart
  - 5 to 10 minutes in duration
  - Insights into the rhythm of the heartbeats

- **Goals**
  - Find causes of chest pain
  - Explain symptoms such as dizziness or irregular heartbeats
  - Check effects of medication and pacemaker
Terminology

- **P Wave** – electrical activity through the upper heart chambers
- **QRS Complex** – electrical impulses through the lower heart chambers.
- **ST Segment** – ventricle contracting, no electricity flowing
- **T Wave** – lower heart chambers resetting for the next muscle contraction
- **MLII and V5** – two favoured leads, electrodes on torso

![Diagram of heart and electrocardiogram](www.webmd.com)
Problem Statement

- An application is needed to monitor and record ECG data
- It must have a large data capacity
  - For diagnosing more conditions
- It must have a long monitoring period
  - For detecting transient symptoms
- It shall be convenient to use
- It shall be inexpensive for the user
Existing Solutions

**AliveCor** (FDA cleared)
- Sensor attachment + Mobile app
- Records, displays, stores, and transfers the ECG through the app
- Disadvantages: limited monitoring time, accuracy, price

**ECGCheck** (Competitor of AliveCor)
- New product only on iOS devices
- Sensor unit need not be attached
- Better priced than AliveCor

**Beat2Phone** (Not yet released)
- ECG recordings during physical activities
- Information is sent via email to health care provider
- Storage capacity not clearly specified
Proposed Solution

- An external device capable of recording ECG data
  - 3 lead cable (2 electrodes and 1 ground)
  - on-board storage designed as a ring buffer, minimum 12 MB (~30 minutes at 360 Hz sampling rate)

- An Android application that receives the ECG data
  - ECG Plotting
  - Cloud data storage

- Communication via TCP message passing

- Difference from the existing solutions: **On-board storage**
  - Option to record data without burdening the phone and transfer later.
  - Data recovery in case of errors during data transfer

*Due to the lead time associated with obtaining a development board for implementing the hardware/firmware component, as stated in the project proposal, we developed instead a soft emulator*
Users

- Patients with a diagnosed heart condition
- Individuals who suspect they suffer from arrhythmia
- Regular people interested in endurance sports
- Athletes when training
Approach Description

- Research Availability of Components
- Define Use Cases
- System Architecture
- System State Machine
- Implementation and Unit Test
- Emulator, App Integration
Components Availability

**Emulator**
- MIT-BIH Arrhythmia Database ([www.physionet.org](http://www.physionet.org)) – It offers several dozens of 30 minutes ECG recordings
- Wfdb.dll – open source C/C++ library for ECG Database access

**Mobile App**
- Androidplot – Android API for plotting data
- 2freehosting – online provider for cloud database storage
General Data Flow

- Emulator
  - Start Emulator
- ECG Database
  - Display and Store Data Flow
- Cloud Storage
  - Retrieve Data from Cloud Data Flow
- Android App
  - Display and Store/Retrieve from Cloud
- User Command
Use Cases

Live Mode
• The user may acquire his/her ECG data in real time
• ECG data plotted, and stored in the cloud

Playback Mode
• The user may acquire his/her ECG data from on-board storage
• ECG data plotted, and stored in the cloud

View History Mode
• The user may view a list of history records
• ECG data retrieved from cloud, plotted in display
System Architecture
Emulator State Machine

- Start
  - User Sends Start Cmd.
- Idle
  - 250 ms Elapsed && isPlayback
  - Buffered 250 ms of Data
- Buffering
  - Buffered 250 ms of Data && isLive
  - TCP Send ECG Data
- Stop
  - User Sends Stop Cmd.
  - isPlayback
  - isDoneSending
Mobile State Machine
Emulator

- Visual C++ 6.0, MFC 4.21
- WFDB C library
- Ring Buffer emulates the on-board storage of a real device
- TCP Server
- Simple UI for the front end
- Unit testing - implemented a TCP client that emulates the behaviour of the mobile app
Implementation, Unit Test (II)

**Mobile**

- Java
- Eclipse with Android Development Tool (ADT) plugin
- Androidplot Library
- TCP socket
- Cloud database library
- Unit testing
  - Retrieve data from the server
  - Store and retrieve data from cloud
  - Data plot
Demo
Future Work

**Software:**
- Data analysis
- Bluetooth

**Hardware:**
- Develop a prototype using Freescale’s TWR-MCF51MM-KIT Tower System with the Medical EKG Module (MED-EKG)
- Performance analysis — must support sampling rate of 360 Hz
- Assess the possibility (mostly cost) of creating an IP67 version (Ingress Protection rating 67)
Conclusions

- We produced a proof of concept for a potential future product
- Based on the existing alternative solutions, we believe our proposed product would be marketable
- We experimented with design for reuse and design with reuse
- Challenges:
  - Using open source components - documentation is not always up to date or complete
  - Android SDK learning curve
References

- MIT-BIH Supraventricular Arrhythmia Database,
  http://www.physionet.org/physiobank/database/svdb/


- Wfdb.dll a library for reading and writing annotated waveforms (time series data)
  Copyright (C) 1983-2012 George B. Moody

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Thank You