Evaluation of Bluetooth Low Power for Physiological Monitoring in a Home Based Cardiac Rehabilitation Program

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Background and Objectives

Background

• Care Assessment Platform (CAP), a home care model for the secondary prevention of cardiovascular diseases.
• Importance and issues in recording patient health data through mobile phone.

Objectives

• Review wireless technologies
• Evaluate the Bluetooth 4.0.
• Setup a platform for other projects in management of chronic diseases.
Traditional Centre-based Cardiac Rehabilitation

Low Uptake and Completion

QLD: 16% of all eligible patients complete CR [1].

NSW: 19%

USA: 18.7% of the eligible patients participate [2].


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Care Assessment Platform (CAP)

- **Care Assessment Platform (CAP)**
- **Wellness Diary Connected**
  - **Diary data**
  - **Measurement data**
  - **Health Reports**

- **Server Discussion, messaging**
- **Educational material**
  - **SMS Motivational/educational/relaxation - multimedia**

- **Community Care Team**
Existing Date Input Methods
## Short-range Wireless Technologies

<table>
<thead>
<tr>
<th>Wireless Technology</th>
<th>Estimated Life* (cell battery)</th>
<th>IEEE Standard</th>
<th>Data Rate (kB/s)</th>
<th>Supported OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BT 2.0/3.0</td>
<td>1 - 7 days</td>
<td>802.15.1</td>
<td>1000</td>
<td>Android, iOS**</td>
</tr>
<tr>
<td>BT 4.0</td>
<td>2 - 3 years</td>
<td>802.15.1</td>
<td>200</td>
<td>Android**, iOS5+</td>
</tr>
<tr>
<td>ANT+</td>
<td>3 years</td>
<td>Proprietary</td>
<td>1000</td>
<td>Sony Xperia</td>
</tr>
<tr>
<td>Zigbee</td>
<td>4 - 6 months</td>
<td>802.15.4</td>
<td>250</td>
<td>Special Design</td>
</tr>
</tbody>
</table>

* 8 Bytes data, 2 second interval, 24/7

- Medical devices specifically targeted
  - Special interest groups working on implementing health device standards
## Platform Support

<table>
<thead>
<tr>
<th>Capability</th>
<th>Android</th>
<th>iOS</th>
<th>WP7</th>
<th>Symbian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bluetooth 2.0 / 3.0</td>
<td>Yes</td>
<td>Limited [1]</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Zigbee</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>ANT+</td>
<td>Sony Xperia series only</td>
<td>Through dongle</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Bluetooth 4.0 (including Bluetooth Low Energy)</td>
<td>Limited [2]</td>
<td>iOS5 + iPhone 4S</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

[1] Requires “Made for iPhone” certification and special hardware

[2] Software support in Android 4.0. Currently, only Motorola Droid RAZR has hardware support.
What is Bluetooth 4.0?

- Includes **Bluetooth Low Energy**
  - Marketed as “Bluetooth Smart” / “Bluetooth Smart Ready”
  - Supported by the Continua Health Alliance.

- Designed for **wearable sensors**

- Official specifications for **medical devices** (IEEE10173)
  - Heart rate
  - Health thermometer
  - Blood Pressure
  - More in progress (glucometer, etc)
Architecture of BT4.0

- Specifies the structure of data to be exchanged.
  1. Heart rate
  2. Health thermometer
  3. Blood Pressure
  4. More in progress (glucometer, etc)

- Wireless application with ultra low power consumption

- 1) non-secure.
  2) service level enforced security.
  3) link level enforced security.
  4) link level enforced security with encrypted key exchange.

- Heart rate
- Health thermometer
- Blood Pressure
- More in progress (glucometer, etc)

- Bluetooth Low Energy Profile (BLEP)
- Generic Access Profile (GAP)
- Service Discovery Application Profile (SDAP)

- Generic Attribute Profile (GATT)
- Attribute Protocol
- Security Manager

- Logical link control and adaptation protocol (L2CAP)

- Host Controller Interface/Link Layer
Implementation

• Bluetooth Low Energy development board
  • Simulates medical devices

• iPhone application
  • Using new CoreBluetooth framework

• SQL client connection
  • Turns the measurements into database entries
Application Model

- Modular design approach
- Easily extendable for future medical device specifications
- Transferable to other platforms

CSIRO. Generic Mobile Application for Wireless Physiological Monitoring
Demonstration

Emulated Blood Pressure and Temperature
Summary

• What?
  • Reviewed wireless technologies and standards.
  • Implemented an application on iOS.
  • Setup a platform for the Mobile Health in research.

• Why?
  • Issues in manual data entry.
  • Explore automated solution in health data collection.
  • To streamline the process of medical data transmission.

• Where to from here?
  • Test with other sensors – make adjustments to app.
  • Apply the model to other mobile platforms.