A Presentation
brought to you by PROXIMUS

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Agenda

- Introduction
- Market Analysis
- System and Features development
- Questions and Answer
- Project Demonstration

Introduction

Problem

- Hospital’s struggle to provide care in an efficient cost effective manner
- Poor management of physicians
- Overall poor patient flow
- Patients complain being ‘bed ridden’ or confined
- Capacity constraints affect service quality and physician and patient satisfaction

Introduction

Solution

- Address capacity and patient flow problems
- The technology change is WMS (Wireless Monitoring System)
- WMS integrates real-time patient monitoring through Bluetooth

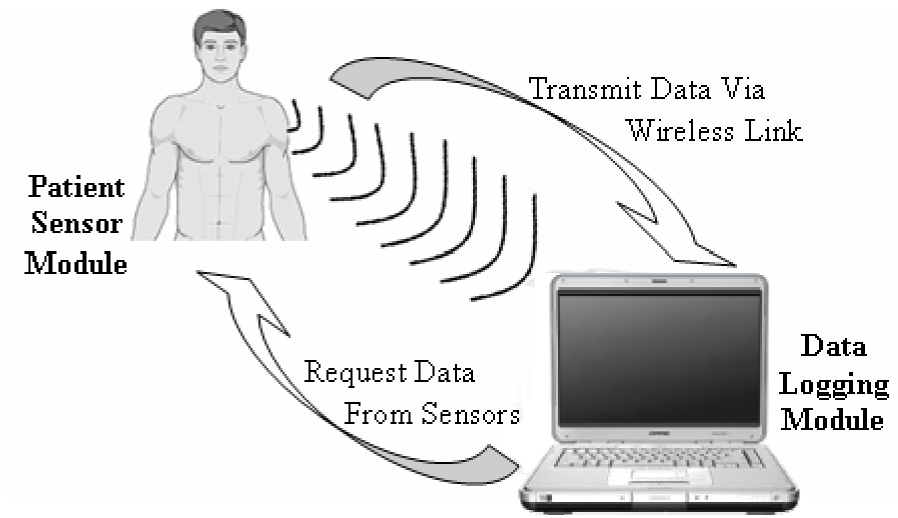
Introduction

Impacts of the WMS

- Allowing for greater access throughout hospitals for doctors and patients
- Doctors able to view patient information remotely from anywhere in the Hospital
- Patient can be as far as 100 meters away from station
- Potential for data mining to reduce paper work for Physicians
- Better management of medical staff time

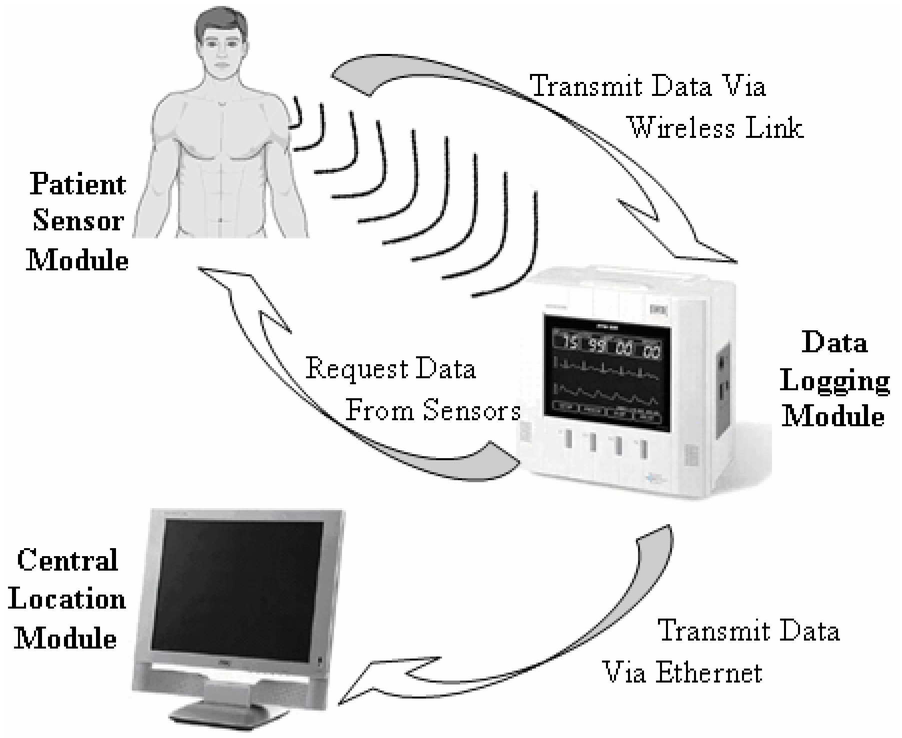
Introduction

Wireless Monitoring System (Phase 1)



Introduction

Wireless Monitoring System (Phase 2)



Market Analysis

Figures

- Current healthcare costs exceeds $3 billion/year CAD
- Hospitals misuse this money!

Existing solutions (ECG)

- Wired, and cost the user $800+ CAD
- Large and bulky
- Require new machine for each patient
- 7 patients require 7 machines:
  7x $800 = $5600 CAD

Market Analysis

Our solution

- Costs $250, wireless (Phase 1)
- Expandable amount of sensors
- Single Monitoring station can monitor up to 7 users.
- Single Monitoring station costs approximately 500$
- 7 patients: 7x $250 + $500 = $2250 CAD

Market Analysis

Potential Profit: $5600 – $2250 = $3350 CAD

- Higher Potential Profit:
- Decreasing costs of Bluetooth Technology
- Mass production = lower costs!
- Estimated savings of 200$ per module
- And creates a market for plug and play sensors.

Additional Benefits

- Better management of healthcare staff, saves healthcare money.
- Expandable to home healthcare ($$)
- Data mining, saves physicians time with paper work.
- Can plug into existing infrastructure for hospital or home care

Lemos International

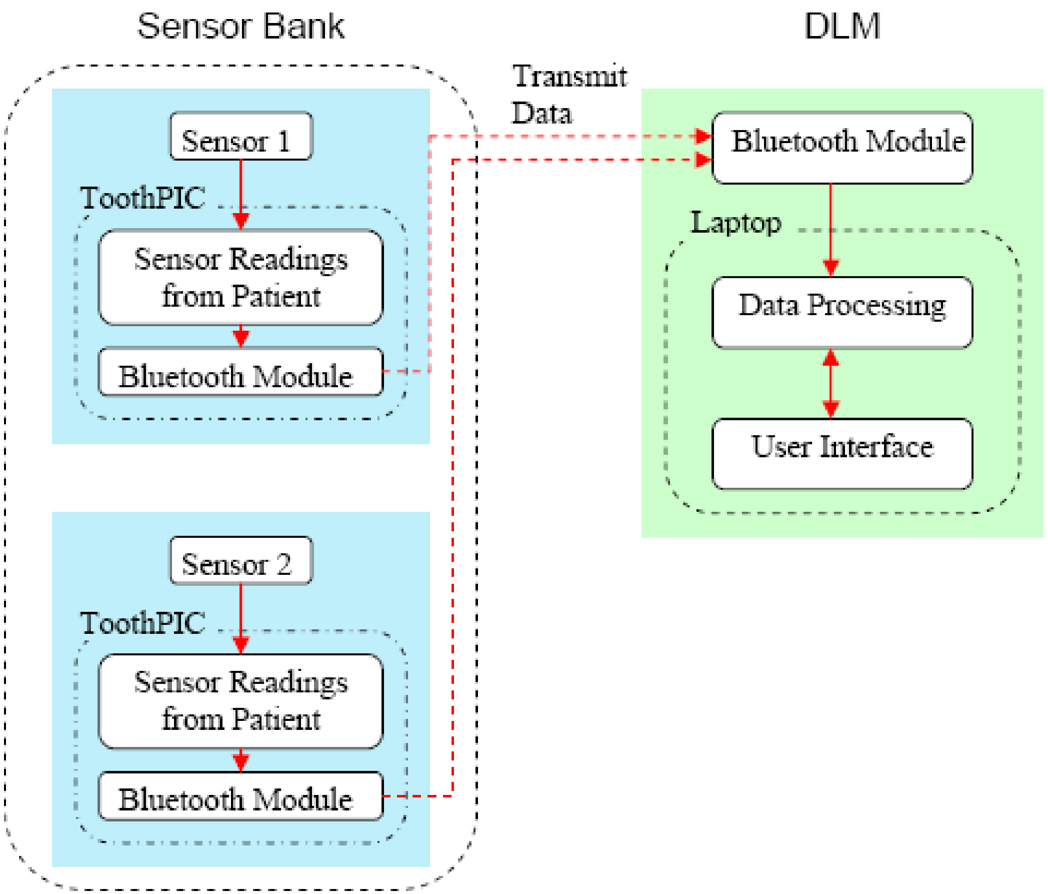
- Bluetooth modules cost ($56->$50)
- www.lemosint.com/scripts/bluetooth_promiesd.asp

Current Products out

Code Blue

- http://www.eecs.harvard.edu/~mdw/proj/codeblue/
  - Possible competitor, however, not streamlined to work with computers
  - Scaled towards working on PDAs
  - Not marketed yet

Wireless Monitoring System



Wireless Monitoring System

Developed by Proximus © 2006

- Two Main components
  - Software
  - Hardware
- Addresses all problems discussed earlier
- New to a growing market with great potential

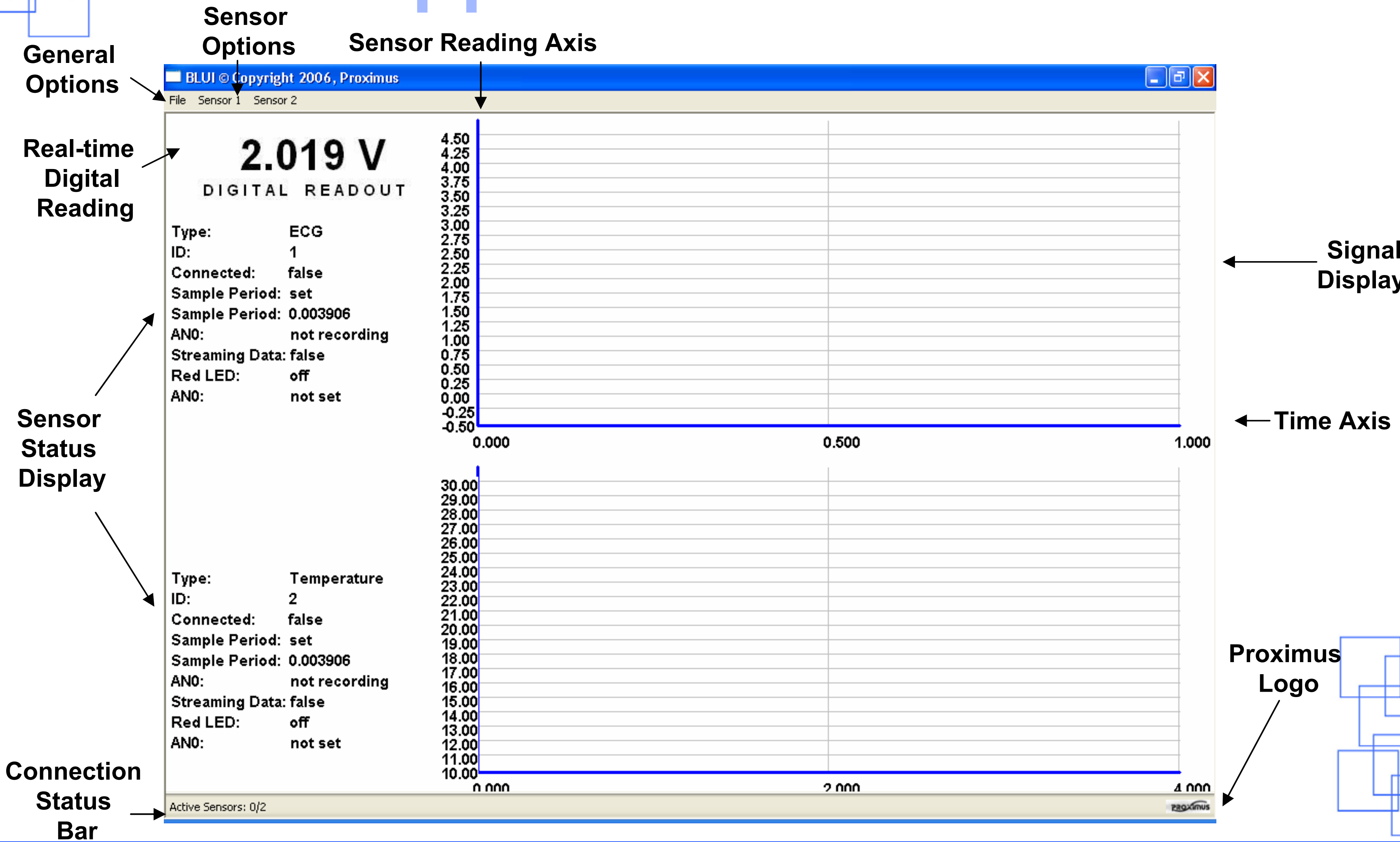
Software

BLUI
- Appearance
- Improvements

PC-side
- GUI Design
  - Programming APIs
  - Data Structures/Algorithms
  - Design Challenges
  - Remaining Issues
  - Improvements
- Firmware

Device-Side
- Firmware

BLUI: Appearance



BLUI: Appearance Cont…

BLUI: Improvements

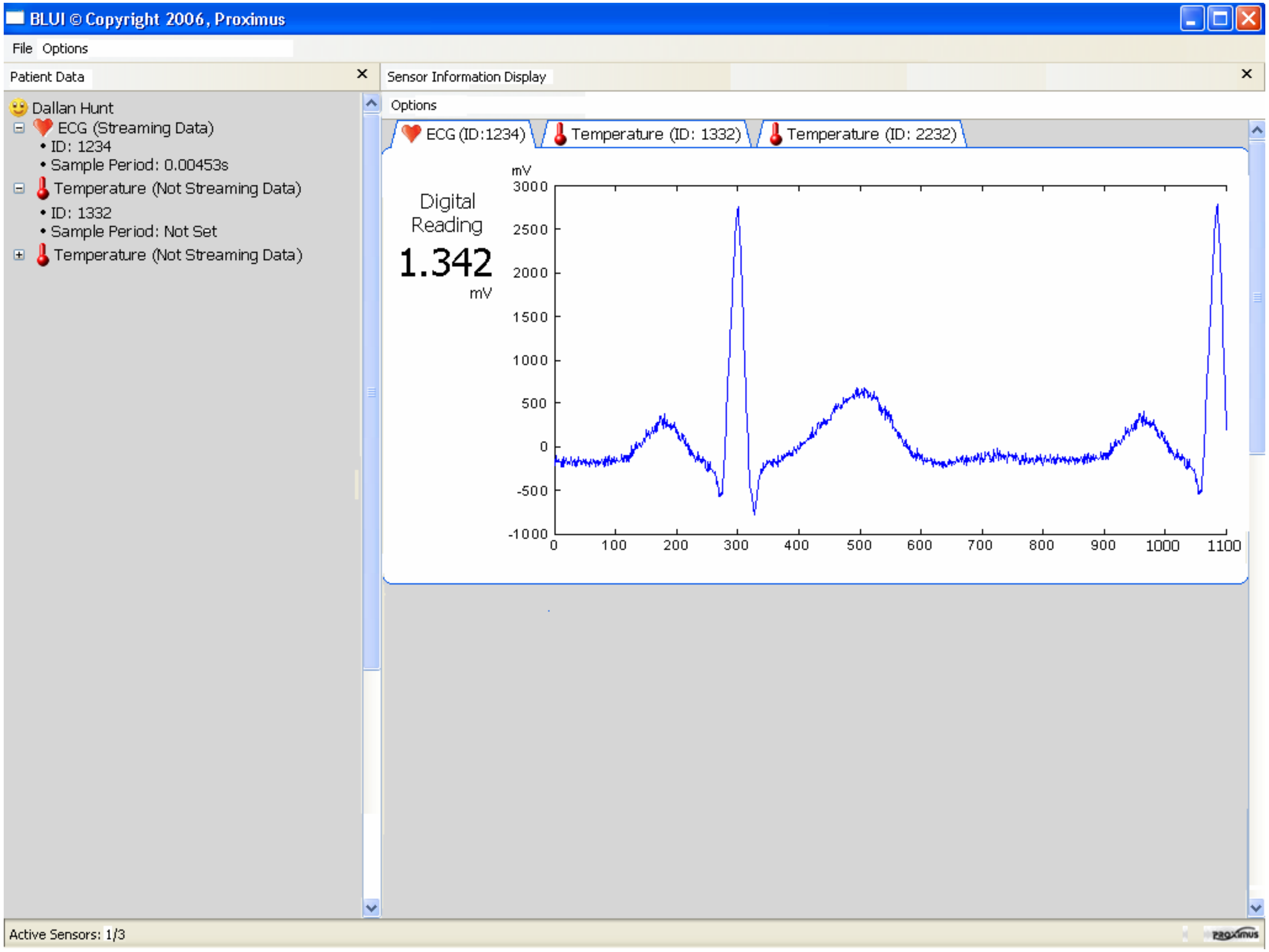
General Options

Patient Data

Sensor Status Display

Connection Status Bar

Sensor Information Display



PC-side: GUI Design

APIs

- C/C++
- Microsoft Foundations Classes (MFC)

PC-side: GUI Design

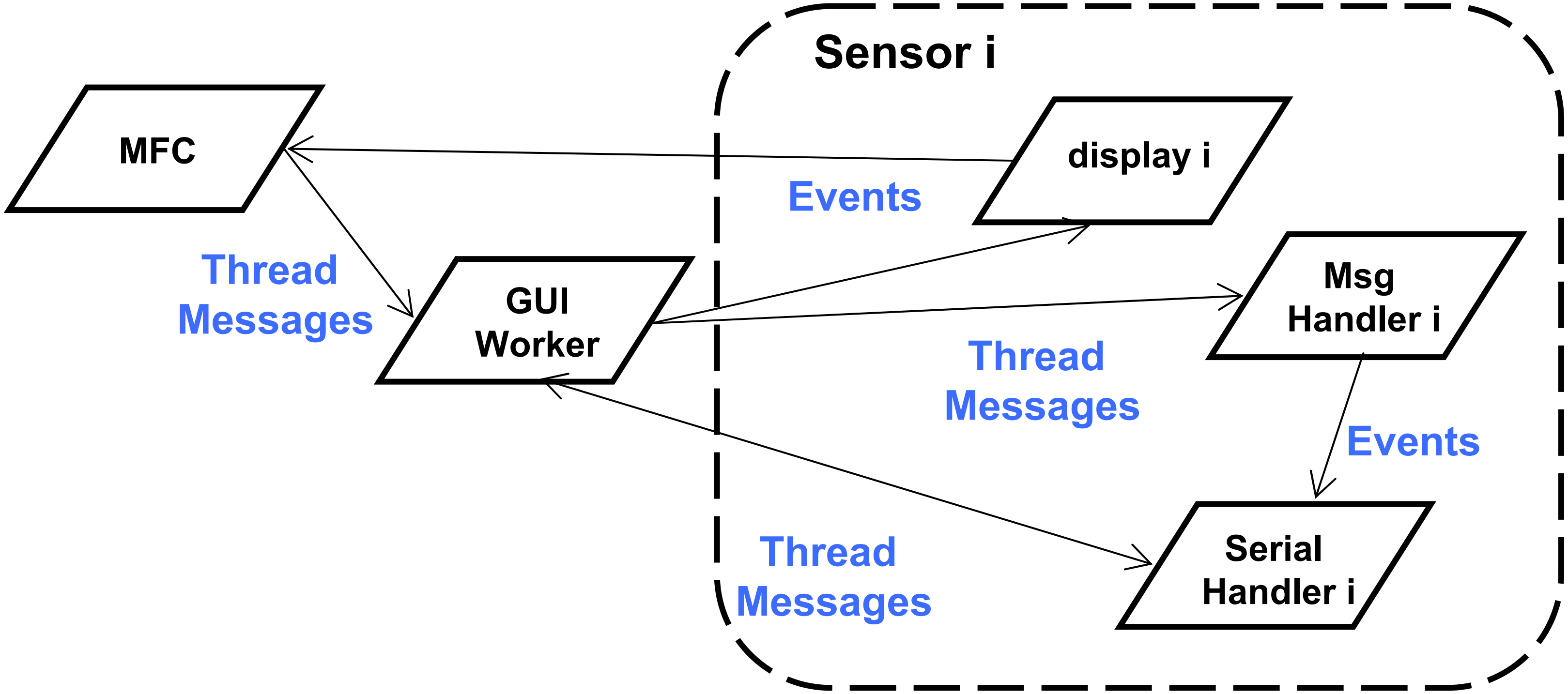
Data Structures/Algorithms

- C++ objects for sensor and sensor bank structures
  - sensorModule
    - stores/modifies sensor
    - information
  - sensorModuleList
    - specifically list of sensorModules
    - access sensor information
  - sensorModuleBank
    - similar API as sensorModuleList but designed for control of sensorModules
    - Includes data for entire bank (eg. # connected sensors)

PC-side: GUI Design

Data Structures/Algorithms cont'd…

- Threads, messages, and events



PC-side: GUI Design

Design Challenges

- Sensor data management
- Effective Real-time display
- Efficient GUI updating

Remaining Issues

- Pulse Display

Improvements

- Switch to Java
- Comment code extensively
- Invalidation
- Buffered Display
- Dialog Box

PC-side: Firmware

Protocol

- Bluetooth
  - Why?
- Serial Communication

Architecture

- Multithreaded Driver
- Scalable

Bluetooth Protocol

Packet Structure

Access Code	Packet Header	Payload
72 Bits	54 Bits	0-2746 Bits

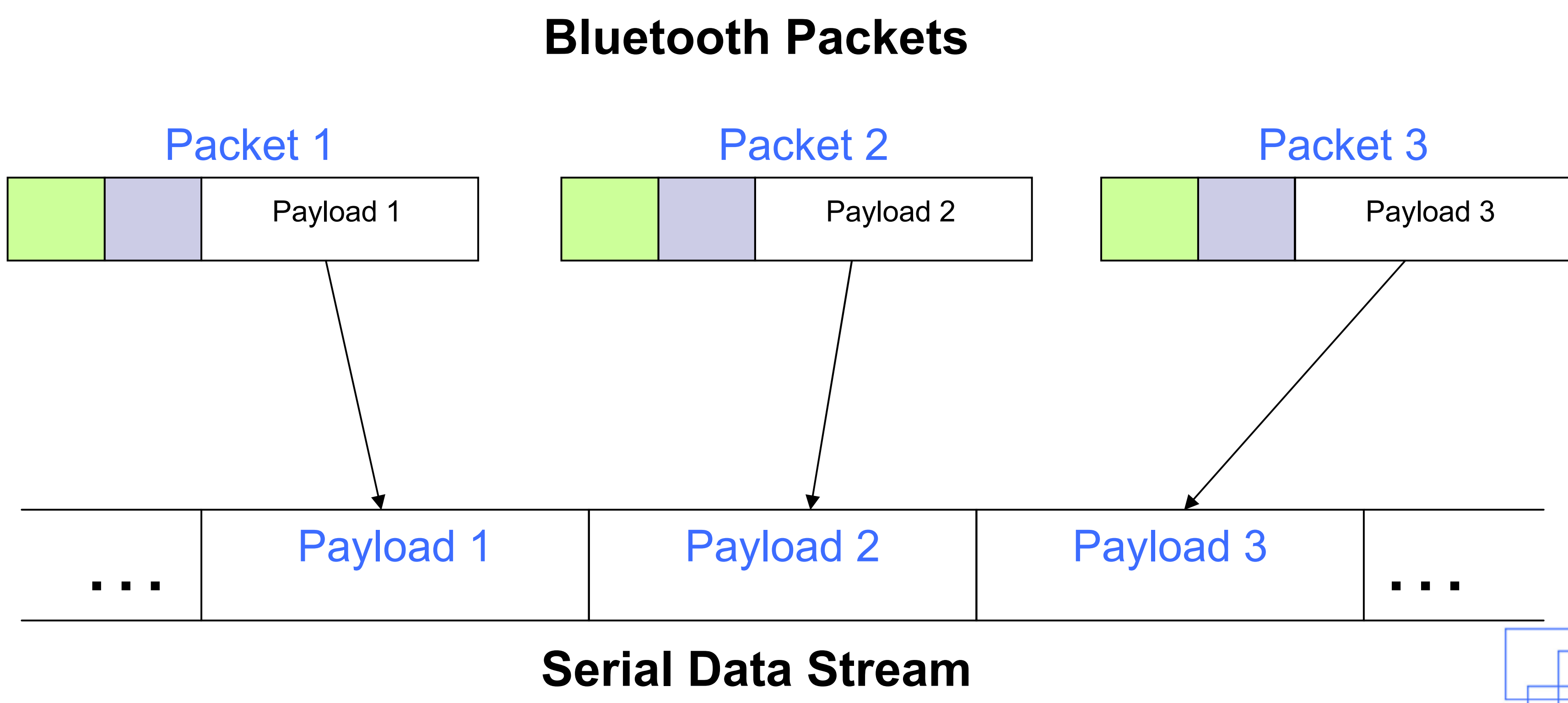
- Transmits at 2.4GHz

Bluetooth Protocol

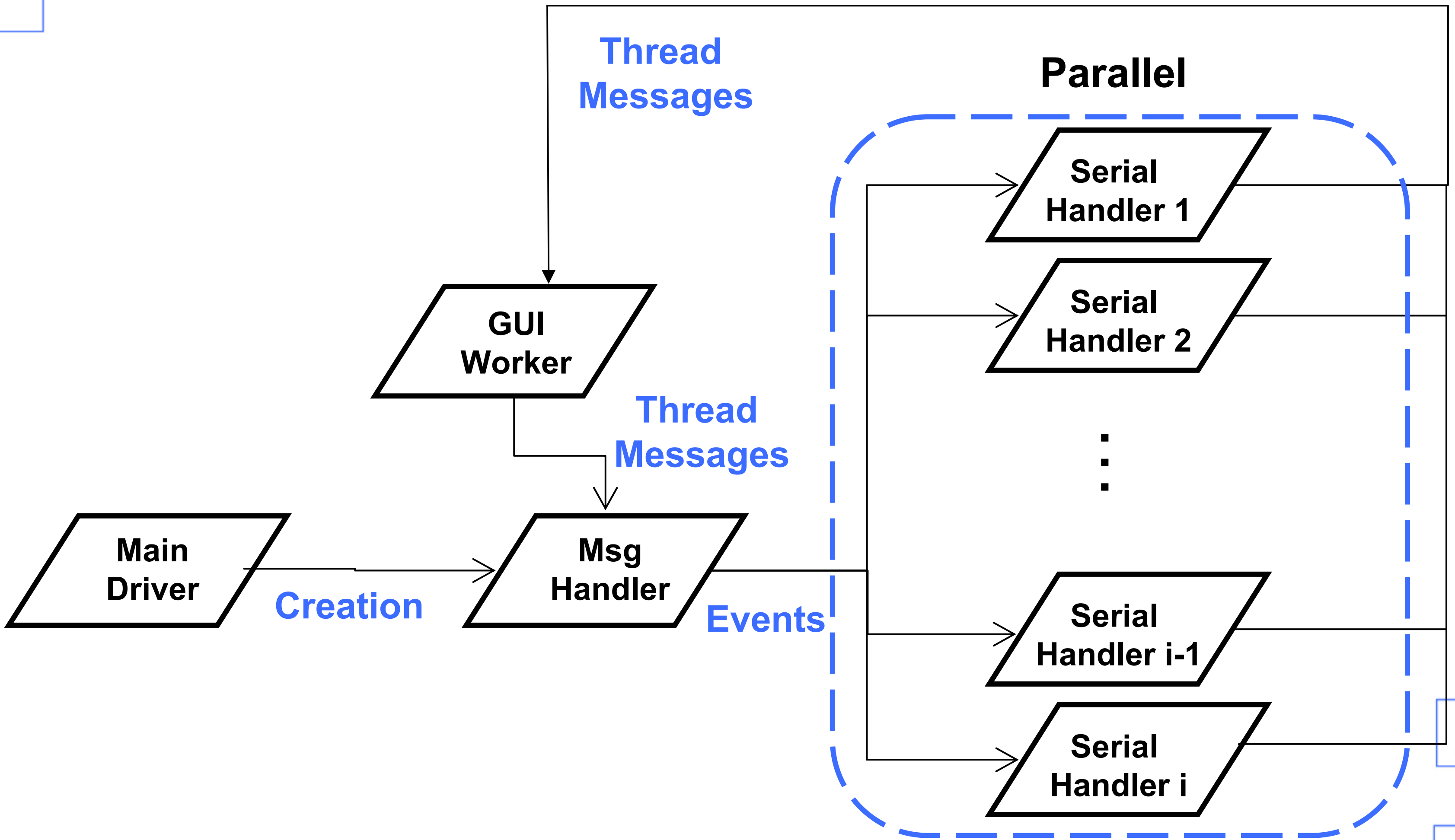
Why Bluetooth?

- Permitted by the FCC
- Secure
- Reliable
- Scalable

Serial Communication



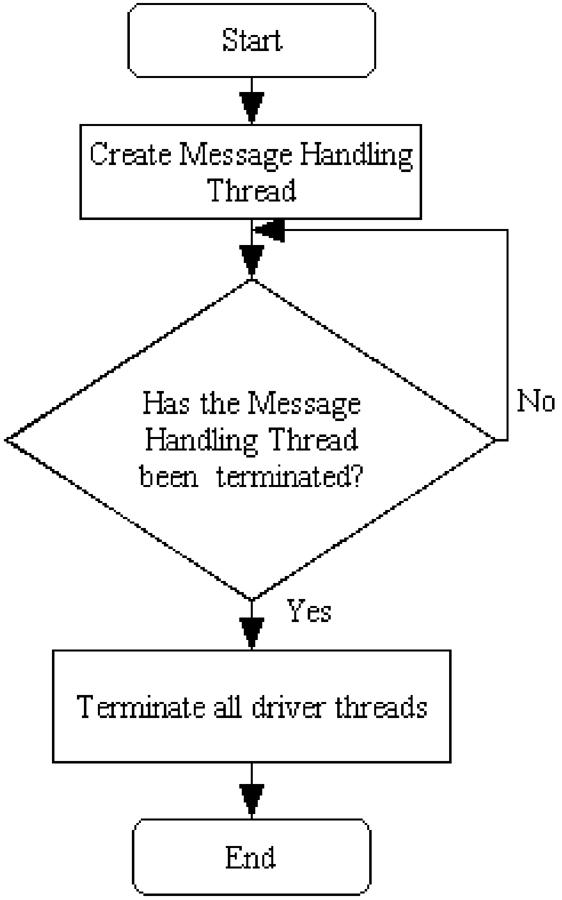
Multithreaded Architecture



Main Driver Thread

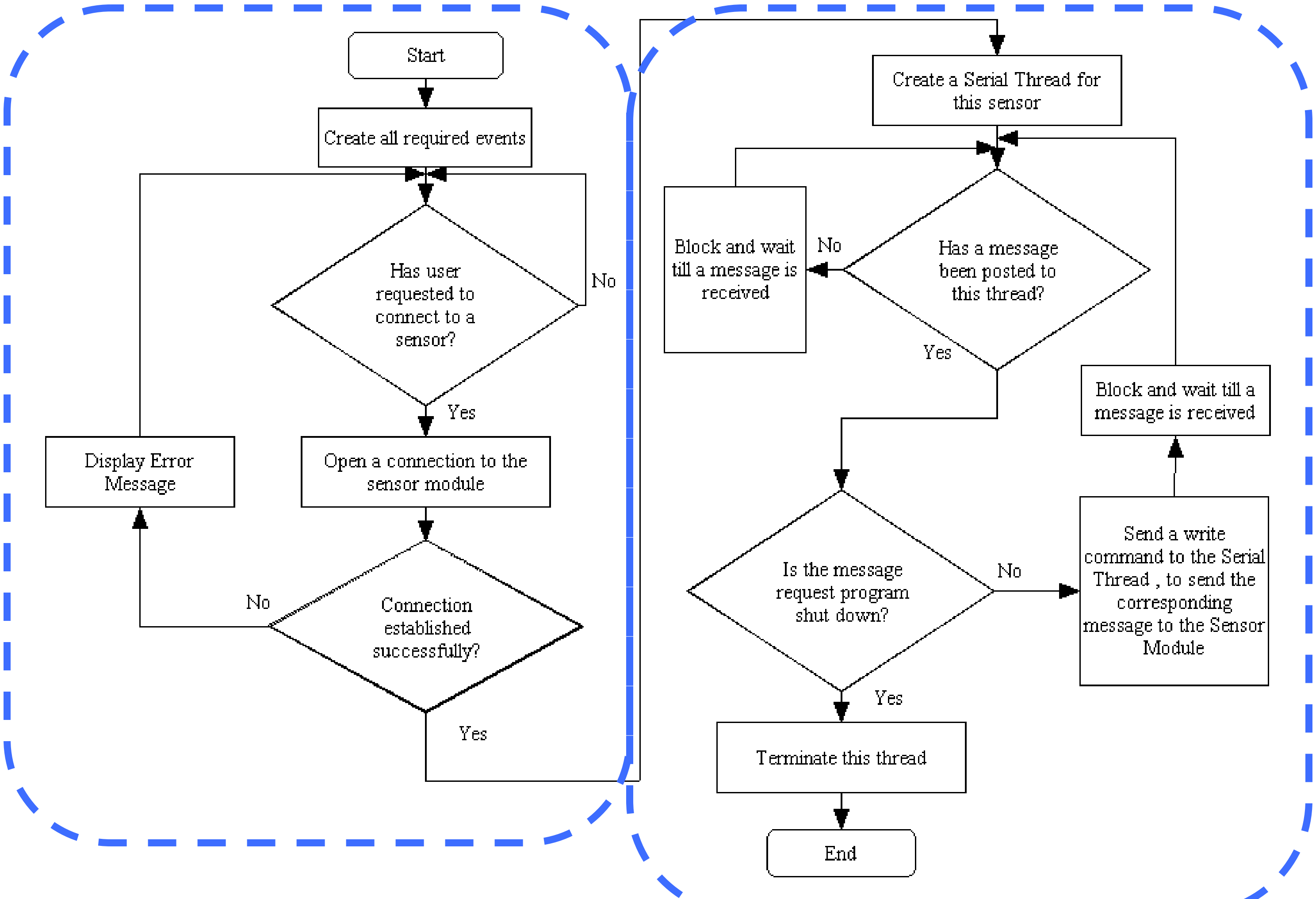
Tasks

- Spawns Message Handler Thread
- In charge of cleanup

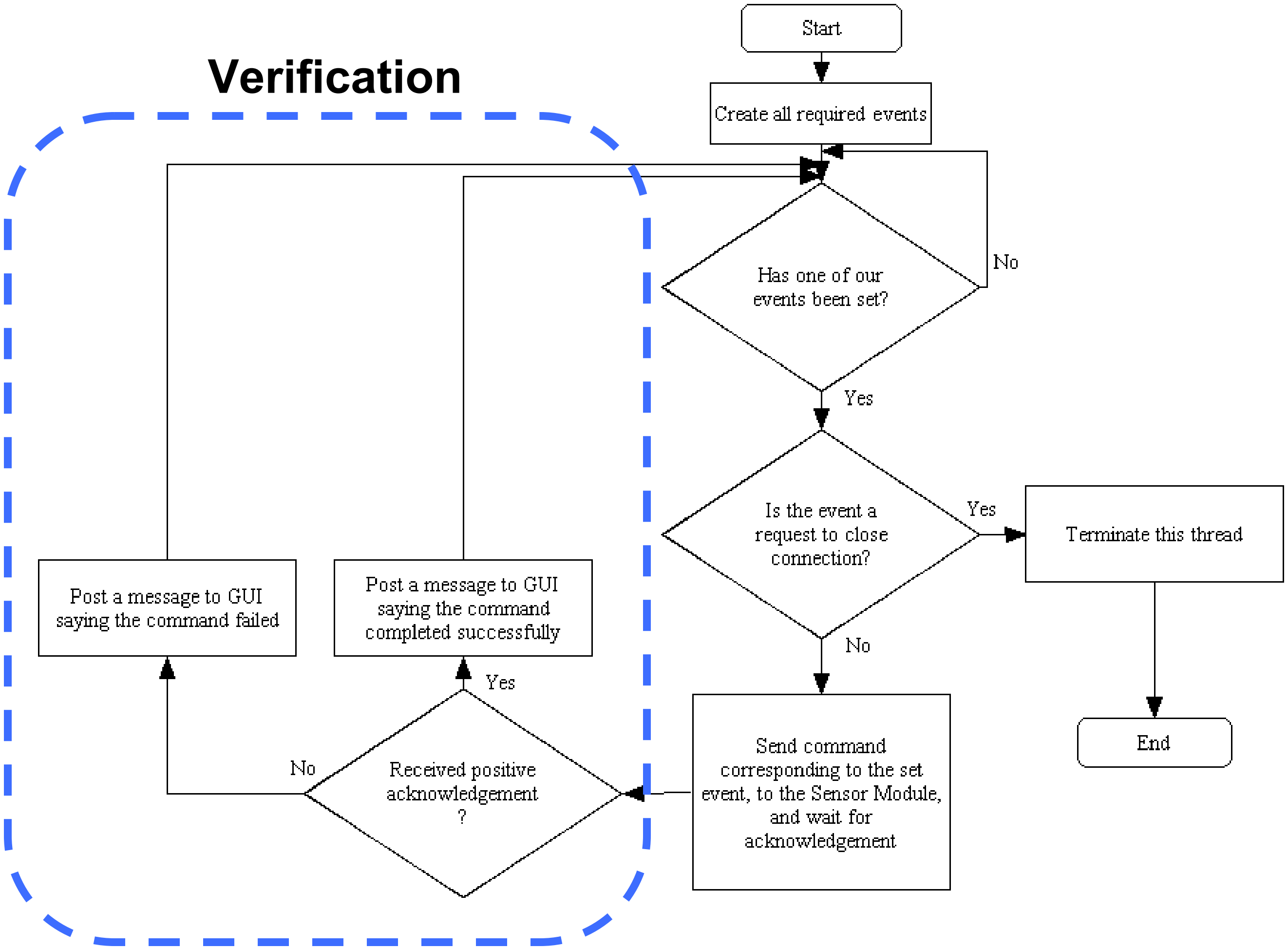


Message Handler Thread

Initialize Communication **For each sensor module**



Serial Thread



PC-side: Firmware

Benefits of this design

- Scalable
- Parallel data Transmission
- Easily expandable
- Easily ported for Phase 2

Device-side: Firmware

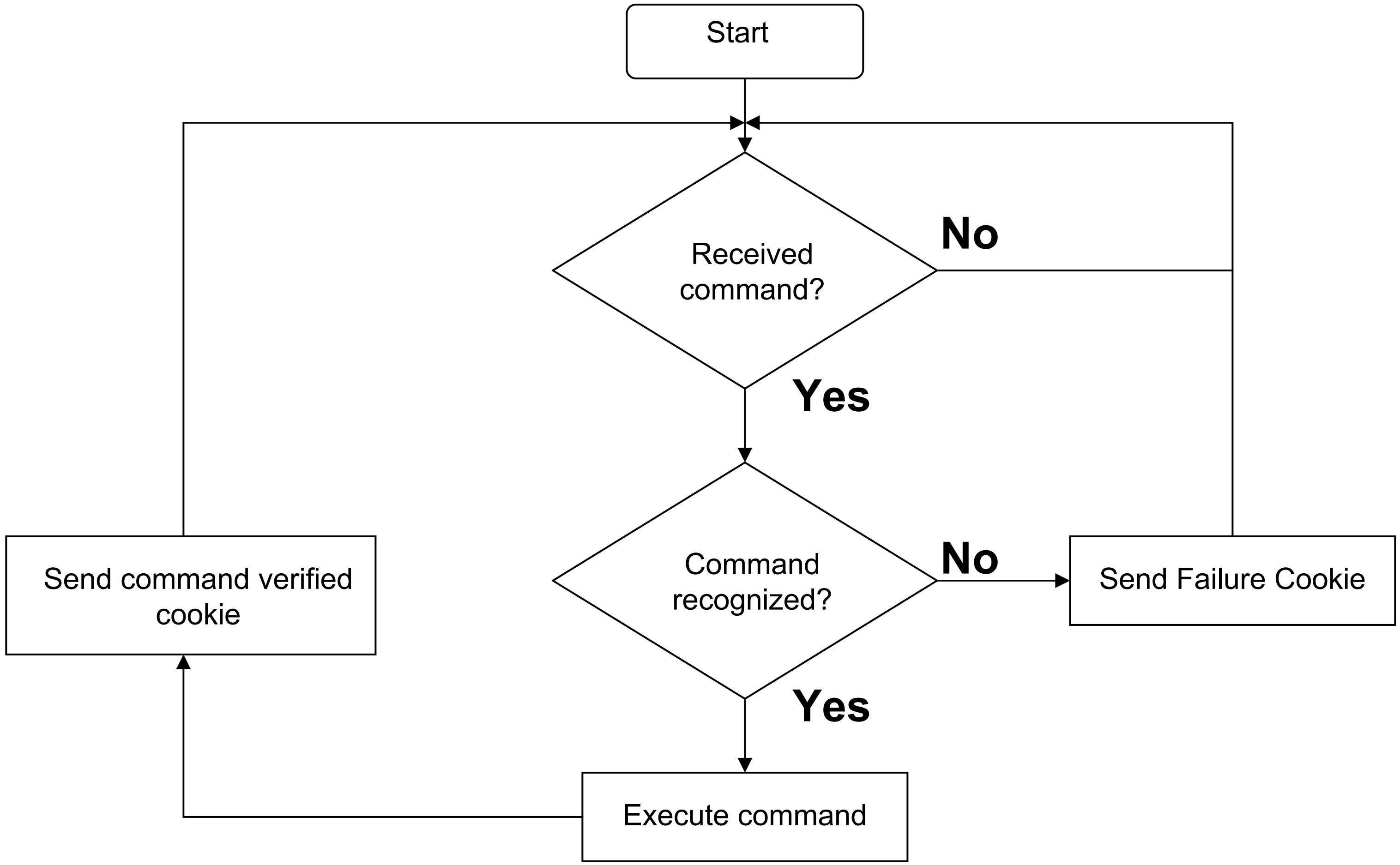
Operating System

- Device acts like a slave to the PC
- Developed with basic Embedded Commands
- Handshaking

Command structure

Size	Command	Payload
1 byte	1 byte	0-253 bytes

Device-side: Firmware



Device-side: Firmware

Commands

- Turn the LED On/Off
- Set voltage reference
- Set the input pin
- Record data from specified pin
- Set sample rate
- Start/stop streaming

Device-side: Firmware

Improvements

- Re-initialize state of device
- Further handshaking
- Better use of the LED
- Power management notification
- Back-up data incase power loss occurs

HardwareHardware

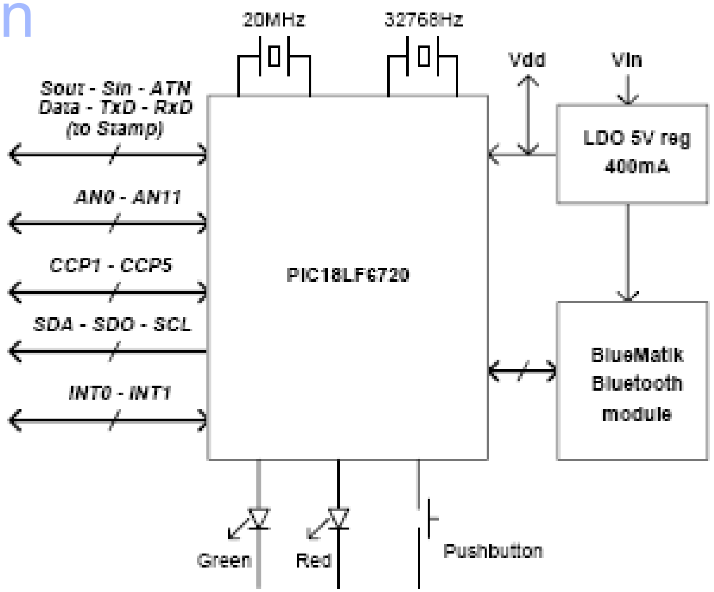
Components

- ToothPIC Module (www.flexipanel.com)
- ECG Circuit
- Temperature Circuit
- Probes

ToothPIC Module

Integrated Components

- PIC Processor (PIC18LF6720)
- 12 x 10-bit A/D converters
- Serial UART Connection to PIC



ToothPIC Module

Design

- Small dimensions and lightweight
- Bluetooth radio (Class 1, 100 m, antenna)
- On/Off LED indicator
- 5-10V(unregulated) or 4.5V-5.5V (Regulated) voltage input

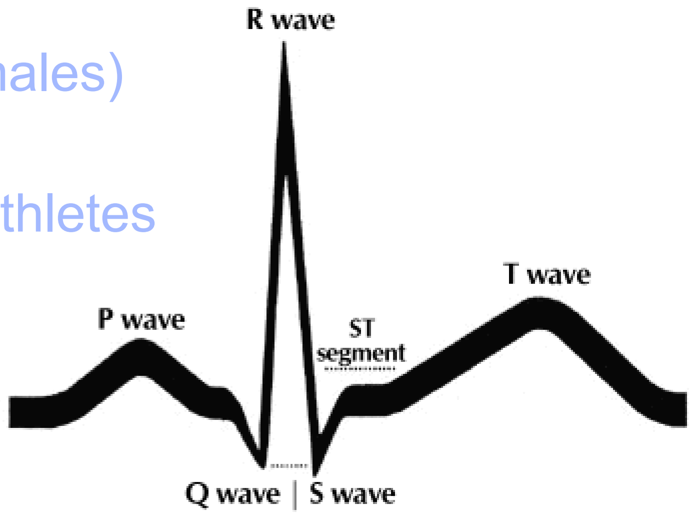
ECG Circuit

- What is the ECG signal?
- What important information can be gathered?
- How is it obtained?
- Current Schematic of circuit
- Current PCB Layout
- Cost of the ECG

ECG Circuit

What is the ECG Signal?

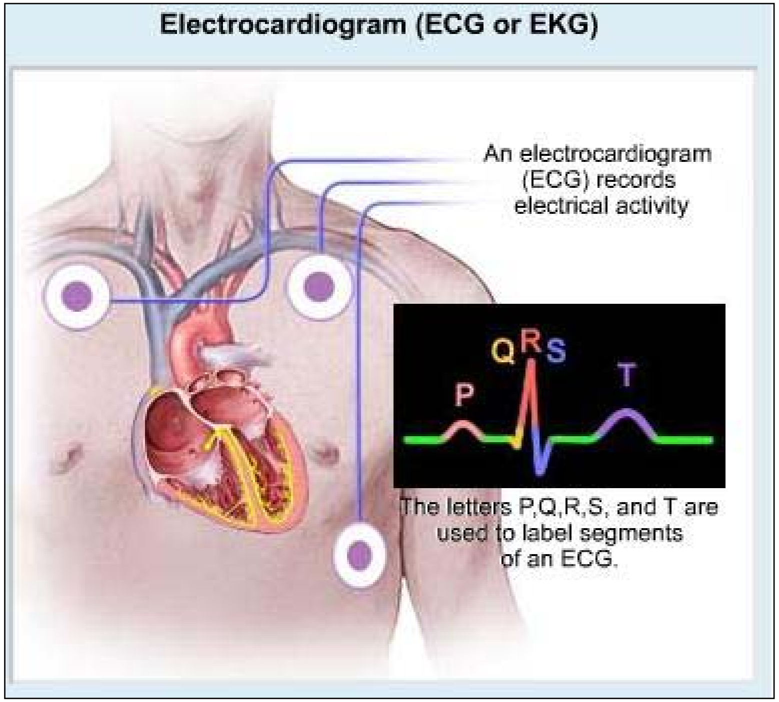
- ECG (Electrocardiograph)
- A graphical recording of the cardiac cycle
- Resting heart beat is 70bpm(males) and 75bpm(females)
- Resting heart rate is lower in athletes compare to obese people.



ECG Circuit

How is it obtained?

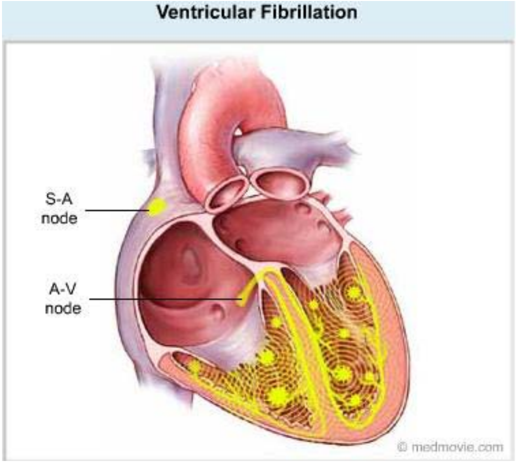
- Electrodes are attached to near rib cage and collarbone.
- Required at least 3 electrodes to get the ECG graph
- Person is asked to take deep breath or hold breath

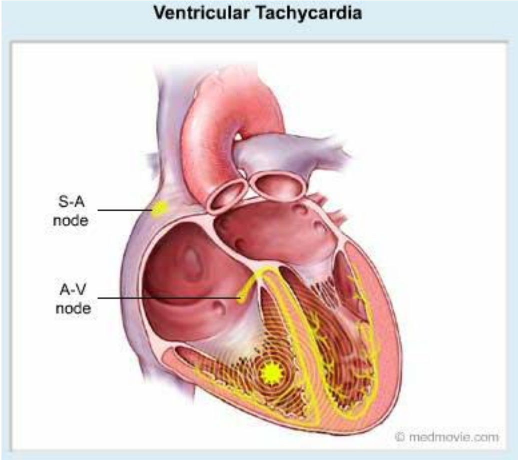


ECG Circuit

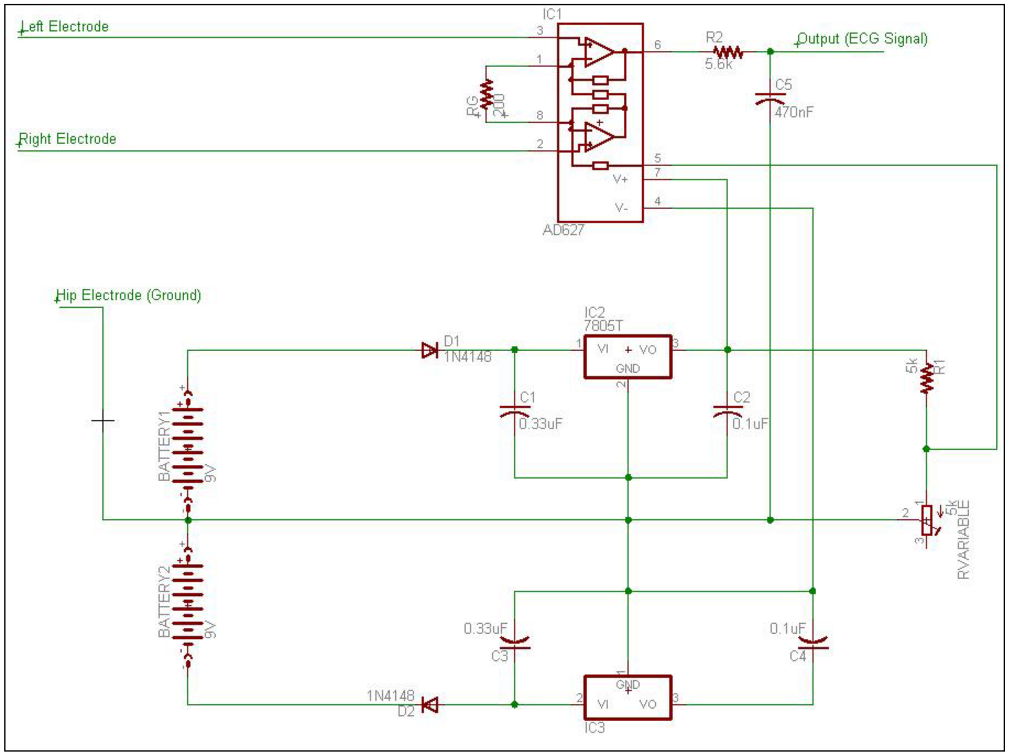
What important information can we gather?

- To detect heart disease such as Ventricular fibrillation and Ventricular Tachycardia
- To detect immediate effects of changes in activity or medication levels
- Standard procedure in a critical condition or heart surgery
- Common clinical tool for diagnosing arrhythmias
- Stress test: athletes are monitored during exercise





ECG Circuit



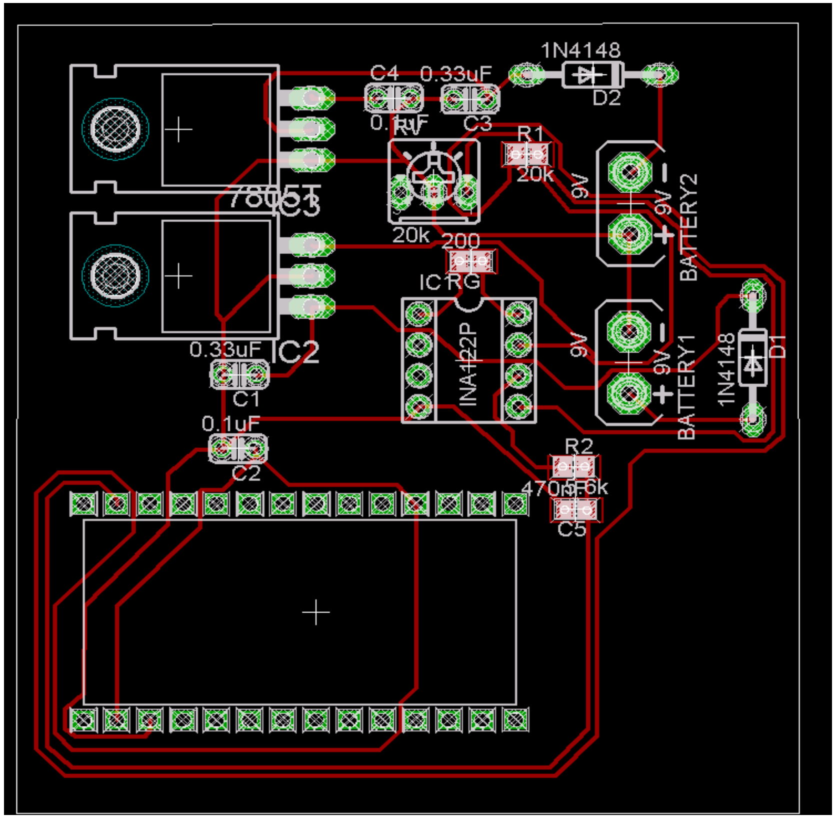
Current Schematic

- Output: 1-5V
- Heart Signal as low as 3-5mV
- Programmable gain set to approximately 1000.
- Cut-off frequency, 60Hz
- Two 9V Battery Input
- Regulated to 5V
- Adjustable resistor to regulate DC offset.

ECG Circuit

Current PCB Layout

- Small board size
    - 64.75mm x 59.90mm
- Single-Sided Wafer
- Light-weight
- DIP Socket components placed on layout



ECG Circuit

Cost of the ECG Circuit

- According to imagesco.com, factory assembled and tested ECG is $89.95
- Our Cost for ECG circuit came down to $23.13
- Includes small-mobile casing
- DIP Socket components for easy replacement

Items	**Cost**
LM7805 – 5V Regulator	$0.48
LM7905 – 5V Regulator	$0.48
AD627 – Instrumentation Amplifier	$5.44
5K Trimpot Resistor	$0.10
Resistors, Diodes and Caps	$2.50
OPA703 – Operation Amplifier	$2.93
PCB Board	$3.60
Casing	$7.60
Total	$23.13

Temperature Circuit

- What important information can be gathered?
- How is it obtained?
- Current Schematic of Circuit
- Current PCB layout
- Cost of temperature Circuit

Temperature Circuit

What important information can be gathered?

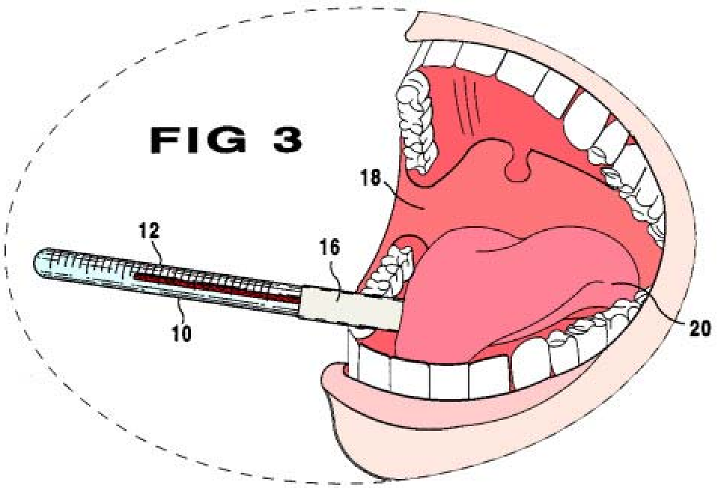
- Detection of Hyperthermia or hypothermia
- Gather if patient has fever (above 38 C)
- Oral, general way of gathering temperature

Temperature Circuit

How is it obtained?

- Traditionally, thermometers are placed in mouth
- Current arrangement situates under patient's armpit.

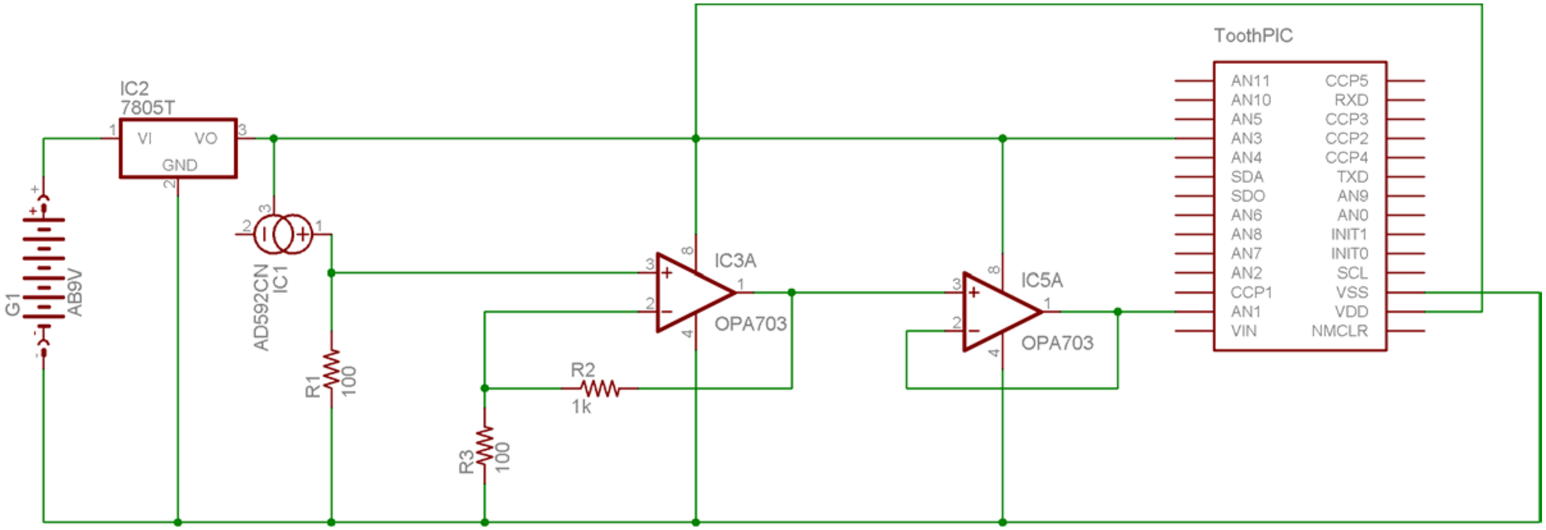
FIG 3



Temperature Circuit

Current Schematic

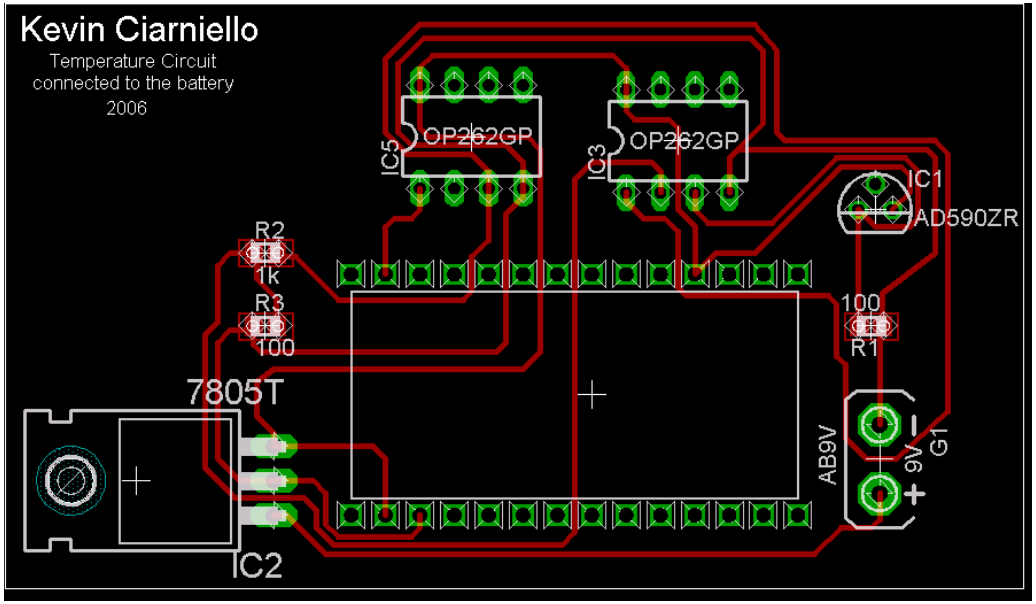
- Output: 2.07V-3.60V (1mV/Kelvin)
- AD592CN output: 1uA/K (Linear characteristics)
- Gain of 1000
- Powered by single 9V battery, regulated to 5V.



Temperature Circuit

Current PCB Layout

- Small board size
  - 74.93mm x 43.18mm
- Single-Sided Wafer
- Light-weight
- DIP Socket components placed on layout



Temperature Circuit

Cost of the Temperature Circuit

- Currently, no wireless temperature monitoring system exists for patient-hospital monitoring
- Our Cost for temperature circuit came down to $22.32
- Includes small-mobile casing
- DIP Socket components for easy replacement

Items	**Cost**
LM7805 – 5V Regulator	$0.48
2 OPA703 – Operation Amplifier	$5.86
AD592CN – Temperature Transducer	$4.28
Resistors, Diodes and Caps	$0.50
PCB Board	$3.60
Casing	$7.60
Total	$22.32

Probes

Made from 3M Corp.

- Red Dot Electrodes
- Disposable
- Micropore adhesive gel
- Lightweight
- Adhesive isn't too discomforting
- Must be placed in shaved or hairless area
- Connected through standard shielded wiring by clips
- Inexpensive: $6.24/25 (25c each)

Hardware

Future Developments

- Implement on a DSP Chip
  - Allows for greater flexibility
- Better temperature probe
  - Oral sensor for temperature
- Cheaper Bluetooth module
  - ToothPIC too costly and too many features not needed
- Custom designed A/D circuitry
- Oximeter sensor to detect pulse rate
  - Put on finger and exam pulse much like doctors do
- Blood-Glucose detector
- Better Wiring, and shielding

BlueTooth SIG Group

Bluetooth Special Interest Group (SIG) is a privately held, not-for-profit trade association

- 4000 members
- Founded in 1998
- headquarters are in Bellevue, Washington, USA
- includes Promoter member companies Agere, Ericsson, IBM, Intel, Microsoft, Motorola, Nokia, and Toshiba, and thousands of Associate and Adopter member companies.

BlueTooth SIG Group

BlueTooth SIG aims to improve healthcare experience through interoperability

- Formation of a Medical Devices Working Group
- Made up of 19 member companies including IBM, Intel, Motorola, Nonin Medical, Philips Electronics and Welch Allyn
- create and ratify a *Bluetooth* Medical Device Profile
- Looking to expand the profile into medical, health and fitness markets

Future Development Plans

Hardware

- PCB is being manufactured currently
- Reduce costs for modules
- Develop lower cost Data Logging Module

Software

- Port BLUI over to the Central Location Module and new Data Logging Module

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- Professor, School of Engineering Science, SFU

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Research In Motion

- PCB Fabrications

Flexipanel.com

- Technical Support with Bluetooth Modules

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Mr. Brad Oldham

- Teaching Assistant for ENSC 440, School of Engineering Science, SFU

Conclusion

- Cost effective solution
- Great Potential since there is a market
- No products currently on the market
- Costs can be lowered
- Efficient use of hospital staff hours
- Allows for patient mobility

Questions?

The
End.