WISENET

Wireless Sensor Network

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Senior Project Proposal

Project Summary

WISENET is a system that acquires environmental data such as light, temperature, and humidity from a low-power wireless sensor network consisting of "sensor motes." This data is transmitted to a server where it is then stored in a database. A web program then retrieves the data for analysis and display using a web browser.

Each mote consists of low-power components including a microcontroller with integrated RF transceiver, environment sensors, and power circuitry. A real-time operating system known as TinyOS (see http://webs.cs.berkeley.edu/tos/index.html) is being used to minimize power consumption while providing efficient modularity and allowing concurrency-intensive operations.

The intended application of this project is to monitor conditions in the labs and offices of Jobst Hall at Bradley University.

Background

The technological drive for smaller devices using low power with greater functionality has created potential in the sensors and data acquisition sectors. Low-power micro-controllers integrated with RF transceivers and various digital and analog sensors allow a wireless, battery-operated network of sensor modules ("motes") to acquire a wide range of environmental data. This data can be downloaded onto a computer and stored in a database for later retrieval and analysis via a web-based application. These results can then be accessed by a standard browser from anywhere on the Internet.

The TinyOS project at UC-Berkeley (http://today.cs.berkeley.edu/tos/) has created an operating environment to address the priorities of such a sensor network (low power, robust communications). However, it is currently only developed for two or three hardware platforms. The first stage of our project involves creating a new hardware platform based on the Intel 8051 architecture. Once the platform is completed and TinyOS has been ported to it, the next stage is to use this platform to create a small-scale system of wireless networked sensors. The purpose of this system would be to monitor environmental conditions in the labs and offices in the ECE department at Bradley University.

System Description

The overall system block diagram is shown in figure 1. The primary subsystems are Data Analysis and Data Acquisition; the three primary components are Client, Server, Sensor Motes. Each is described below.

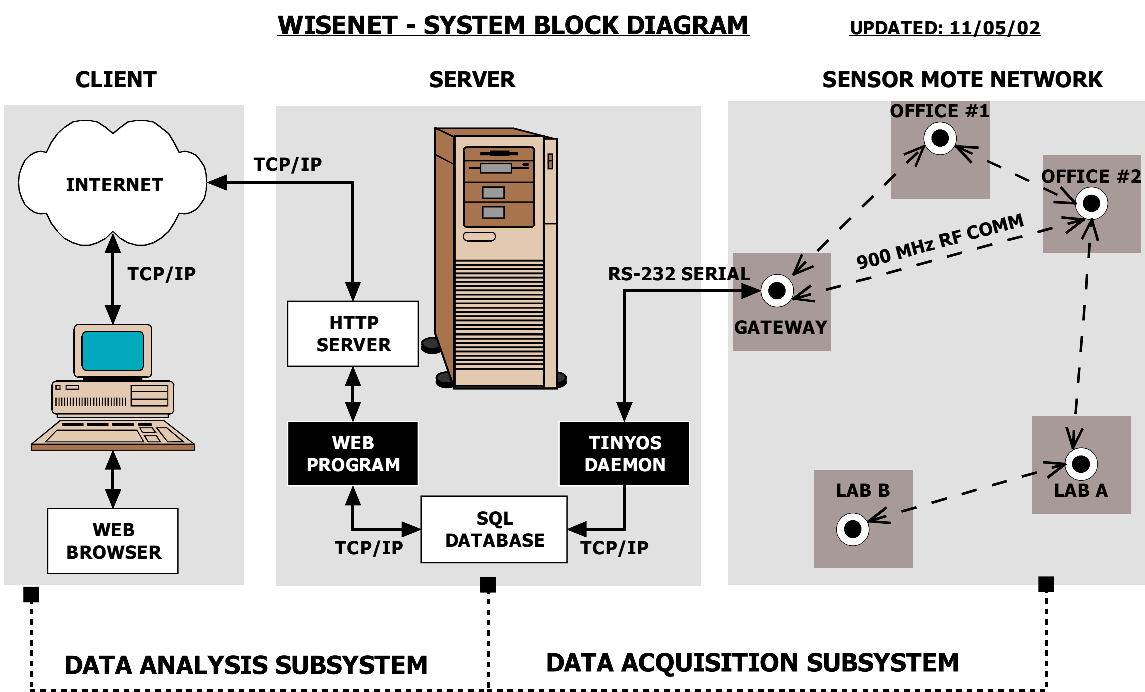


Figure 1: System Block Diagram

Primary Subsystems

There are two top-level subsystems – Data Analysis and Data Acquisition.

Data Analysis: This subsystem is software-only (from our project's perspective). It relies on existing Internet and web infrastructure (HTTP) to provide communications between the Client and Server components. The focus of this subsystem is to selectively present the raw environmental data collected by the Data Acquisition system in a meaningful manner to the end user. This might include historical graphs, averages, highs/lows, etc.

Data Acquisition: The purpose of this subsystem is to collect and store raw environmental data in a database for later processing by the data analysis system. This is a mix of both PC & embedded system software, as well as embedded system hardware. It is composed of both the Server and Sensor Mote components.

System Components

There are three primary system components: Client, Server, and Sensor Mote. Each is described in detail below.

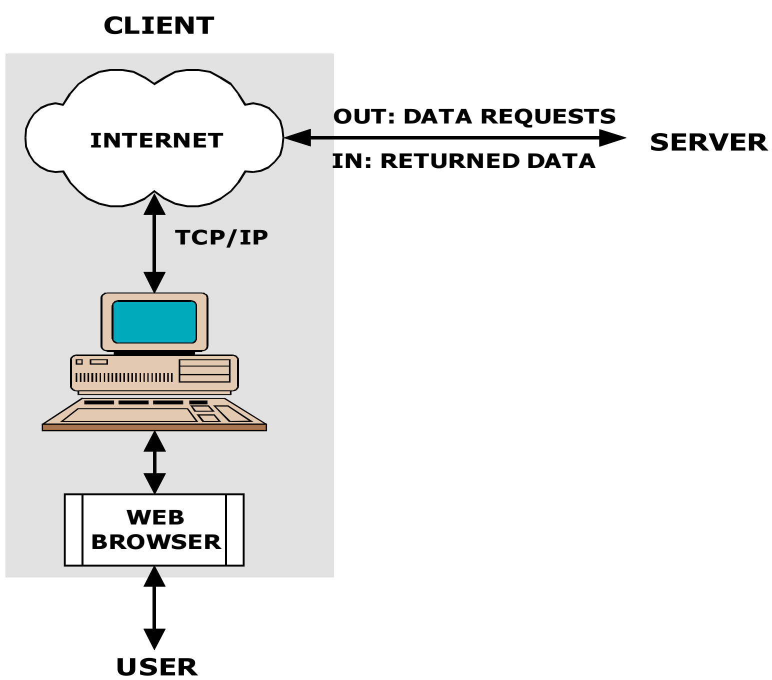


Figure 2: Client Component

Client (figure 2): From our project's perspective, the Client component is necessary but external. That is, so long as a Client (any computer with a web browser and Internet access) is available, no more work needs to be done for this component. It serves only as a user interface to the data analysis subsystem.

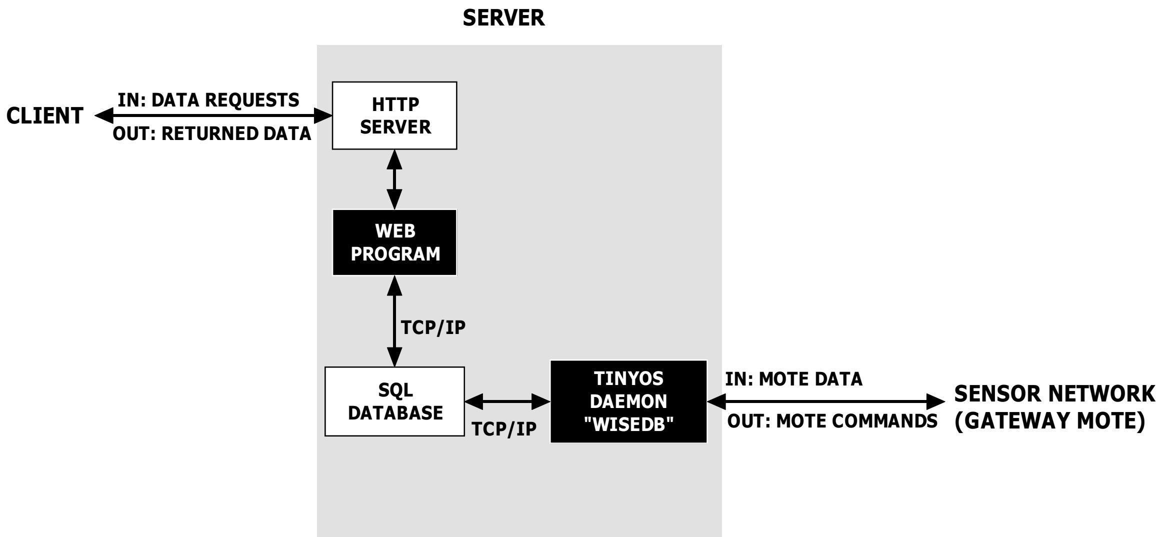


Figure 3: Server Component

Server (figure 3): This is a critical component, as it serves as the link between the Data Acquisition and Data Analysis subsystems. On the Data Analysis side is an HTTP server hosting a web application. When a page request comes in, the HTTP server calls the web application, which retrieves data from the SQL database, processes it, and returns a web-page which the HTTP server serves to the Client. See figure 4 for this flowchart. For the Data Acquisition system there is a daemon named WiseDB running to facilitate communication with the sensor network. WiseDB is responsible for sending commands over a RS-232 serial link to the gateway mote for transmission to the sensor network. It is also responsible for collecting data from the sensor network (again via the gateway mote.) The data collected is then deposited into the SQL database with minimal processing. Thus, the SQL database provides the link between the Data Acquisition and Data Analysis subsystems. It should be noted that since the SQL database communicates via TCP/IP, only the HTTP server and web-program blocks need to be located on the same physical machine. The HTTP server, the SQL database, and WiseDB can all be on different physical machines connected via the Internet. From a project perspective, this would make no difference.

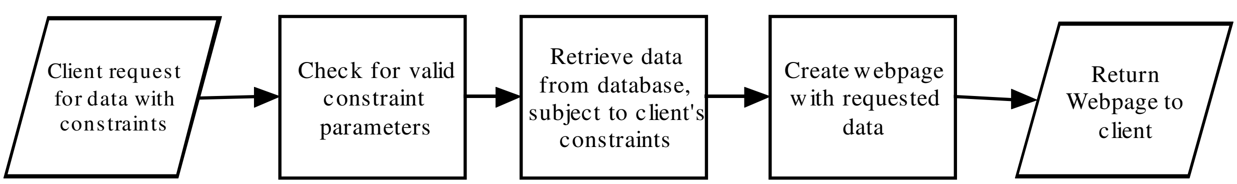


Figure 4: Web Program Flow

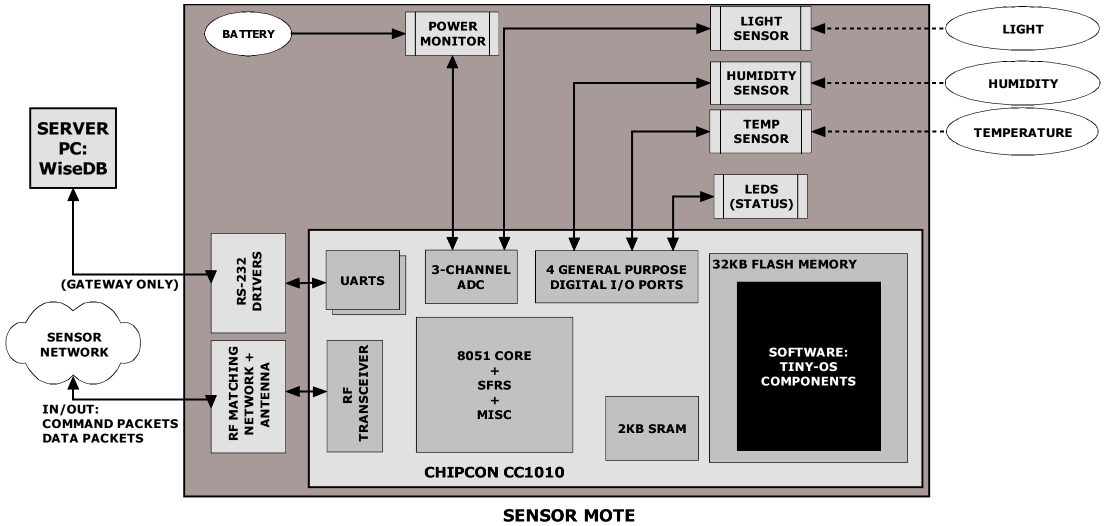


Figure 5: Sensor Mote Component

Sensor Motes (figure 5): The primary focus of our project will be developing the Sensor Mote component. It is the component responsible for collecting raw environmental data and transmitting that data to the Server. It also must receive commands from the Server (possibilities include request for data, reprogram, etc). There will be two physical implementations of this component – the first is the standard mote. The primary purpose of standard motes is to collect and transmit raw environmental data including light, humidity and temperature. They communicate over low-power RF links in the 900MHz ISM band and are also responsible for ensuring all data packets are received by the gateway mote. They also have hardware to regulate and monitor battery power. The gateway mote is the second implementation. Its purpose is to serve as the liaison between the Server and the Sensor Mote Network via an RS-232 link and deliver all data packets to WiseDB. Both implementations will have the same hardware and software; they will differ only in functionality.

Standards

Our project makes use of the following standards:

- Hypertext Transfer Protocol (HTTP)
- Structured Query Language (SQL)
- Serial Link (RS-232)
- Micro-Controller Serial Link (I2C)
- FCC regulations (ISM Bands)

Patents

There are a couple of patents that are relevant to this project involving wireless sensor networks. They are:

- Reprogrammable remote sensor monitoring system (5,959,529)
- Wireless integrated sensor network using multiple relayed communications (6,208,247)
- Early warning detection and notification network for environmental condition (6,023,223)
- Modular architecture sensing and computing platform (6,402,031)
- Distributed topology learning method and apparatus for wireless networks (6,414,955)

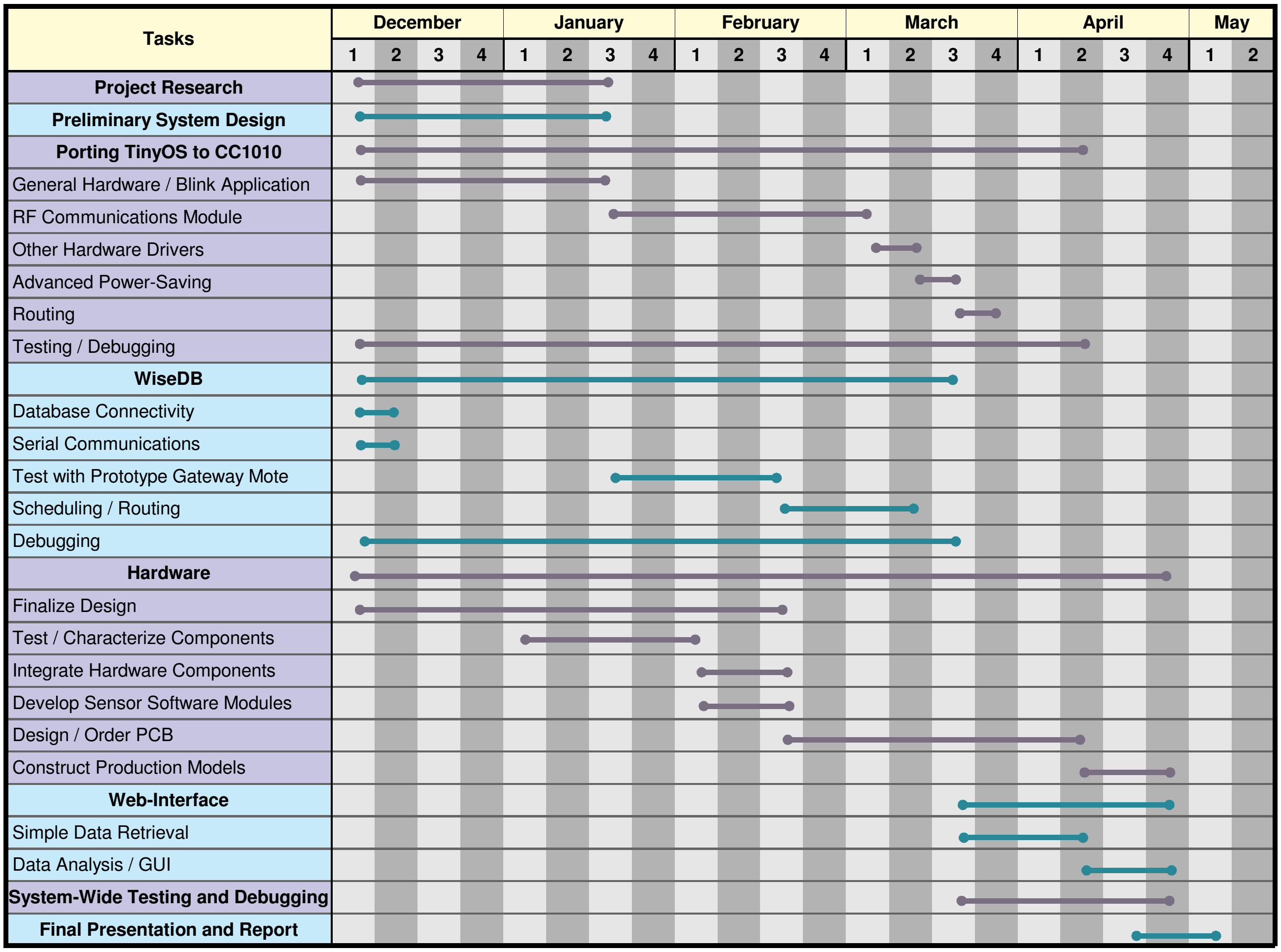
There are also other patents that pertain to potential applications of the project (such as wireless security systems, and system-monitoring), but are not directly applicable to the scope of this particular project as it has been defined.

Project Specifications / Datasheet

After careful consideration, the following specifications were chosen:

- Environmental Conditions
  - -20 – 80º C
  - 0 – 100% Relative Humidity (RH)
- Sensor Accuracy
  - Light Sensor: ±10% Lumens
  - Humidity: ±4% RH
  - Temperature: ±3º C
- Power Usage
  - 3.3V Operating Voltage
  - Goal: 6 Month Battery Life

Project Timeline



Bibliography

The following sources have been used in the research and preliminary design of this project.

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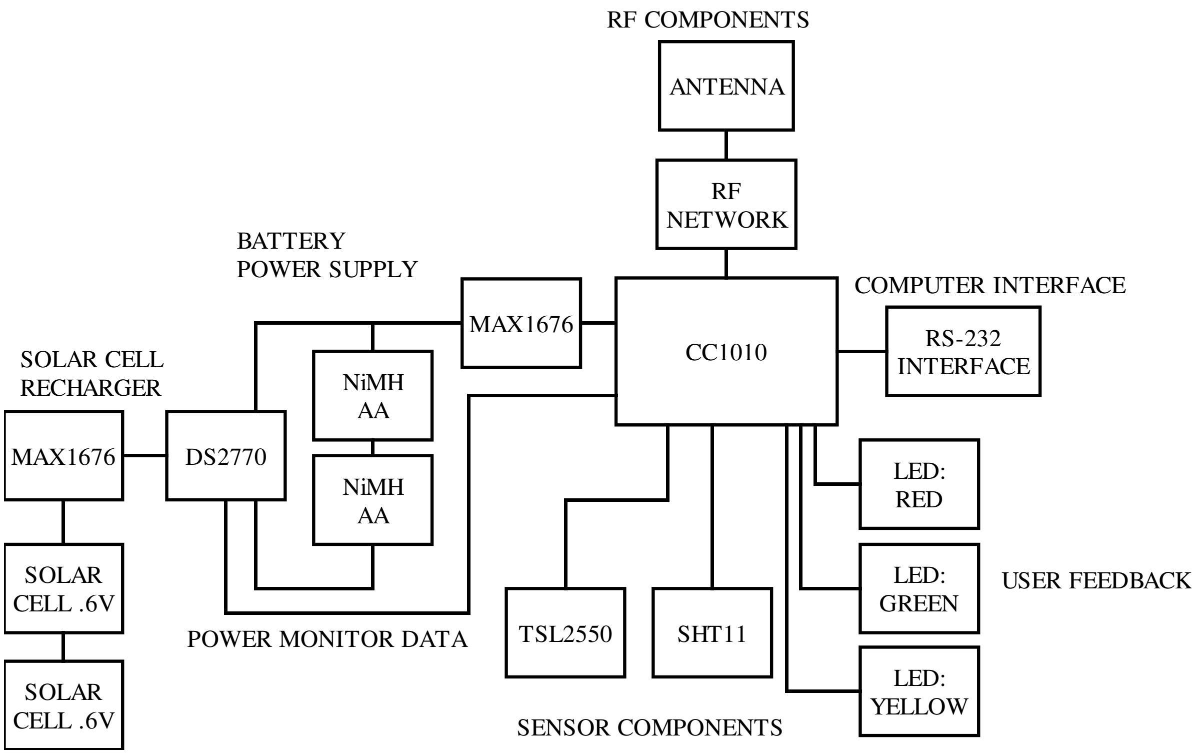
Equipment List

WISENET will require the extensive use of the following lab equipment:

- Server
  - Pentium-class PC or better
  - NT-based OS
  - Internet Connectivity
  - Serial Port
  - MySQL Database
  - Apache / PHP Webserver

The block circuit diagram for a mote is show below:



The attached bill of materials lists uncommon parts, along with their vendors and other information. During the PCB design / production phase additional parts will be needed, but these should all be easily obtainable (ie surface mount resistors / capacitors, etc) and will be defined at that time.

WISENET Bill of Materials

Item	Part Number	Description	Qty / Mote	Qty / 5 Motes	Price / Unit	Price / Mote	Price / 5 Motes	Mfgr	Vendor	Lead Time	Notes
1	MAX1676	DC-DC Step Up Converter	2.00	10.00	$3.61	$7.22	$36.10	Maxim-IC http://www.maxim-ic.com	Maxim-IC https://shop.maxim-ic.com	8 weeks	
2	DS2770 (DS2770AE)	Charge Controller / Battery Monitor	1.00	5.00	$4.15	$4.15	$20.75	Maxim-IC http://www.maxim-ic.com	Maxim-IC https://shop.maxim-ic.com	1 week	
3	SS-PSC-300	Solar Cell	2.00	10.00	$1.50	$3.00	$15.00	Silicon Solar http://www.siliconsolar.com	Silicon Solar http://www.siliconsolar.com/solar_cells.htm	none	
4	P060-ND	NiMH Rechargeable batteries	2.00	10.00	$2.95	$5.90	$29.50	n/a	Digikey http://www.digikey.com	none	1550 mAH, 1.2v
5	BH2AA-W	2xAA Battery Holder	1.00	5.00	$1.42	$1.42	$7.10		Digikey http://www.digikey.com		
6	TSL2550	Digital Light Sensor	1.00	5.00	n/a	n/a	n/a	TAOS http://www.taosinc.com	Seltec Sales Corp christy.meyer@seltec-sales.com	?	2 samples on order, ETA Dec 15, 02
7	SHT11	Digital Humidity / Temp Sensor	1.00	5.00	$17.03	$17.03	$85.15	Sensirion http://www.sensirion.com	Onset Computers 800-564-7377	none	
8	L62501CT	Red surface mount LED	1.00	5.00	$0.32	$0.32	$1.60	Chicago Miniature Lamp	Digikey http://www.digikey.com	none	Mfgr Part: CMD17-21VRD
9	L62505CT	Yellow surface mount LED	1.00	5.00	$0.39	$0.39	$1.95	Chicago Miniature Lamp	Digikey http://www.digikey.com	none	Mfgr Part: CMD17-21VYD
10	L62507CT	Green surface mount LED	1.00	5.00	$0.32	$0.32	$1.60	Chicago Miniature Lamp	Digikey http://www.digikey.com	none	Mfgr Part: CMD17-21VGD
11	n/a	Antenna	1.00	5.00	n/a	n/a	n/a				Part not chosen yet
12	n/a	RS-232 interface (electronic & physical)		0.00	n/a	n/a	n/a				Parts not chosen yet – will require at least male DB9 connector
13	CC1010	Chipcon Micro-controller + supporting hardware	1.00	5.00	n/a	n/a	n/a	Chipcon http://www.chipcon.com	Chipcon http://www.chipcon.com	?	5 uC samples on order, to be mailed from Oslo; other components should be readily available