Smart Garden Project

Manu

This document can also be downloaded from http://smartgarden.sensorapp.net

29/09/2010 12:19:54 AM

Introduction

This project will demonstrate the potential benefits of integrating social networks with environmental sensor networks via broadband-enabled neighbourhoods, and explore the role of social networking within interconnected neighbourhoods for the overall benefit of community and neighbourhood members.

This documentation explains how to build the internet enabled garden monitoring platform and how it works behind the scenes.

Project home page: http://www.broadband.unimelb.edu.au/members/community/044.html

Project portal: smartgarden.sensorapp.net www.smartgardenwatering.org.au

Contacts

Dr. Jon Pearce	Senior Lecturer@UniMelb	http://disweb.dis.unimelb.edu.au/staff/jonmp/
Dr. Adrian Pearce	Senior Lecturer@UniMelb	http://ww2.cs.mu.oz.au/~adrian/
Paul Peng Deng	Research Assistant@UniMelb	http://resume.sensorapp.net/

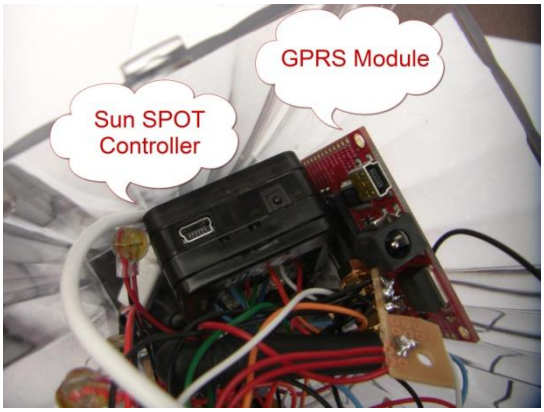
Architecture

The system consists of two major components:

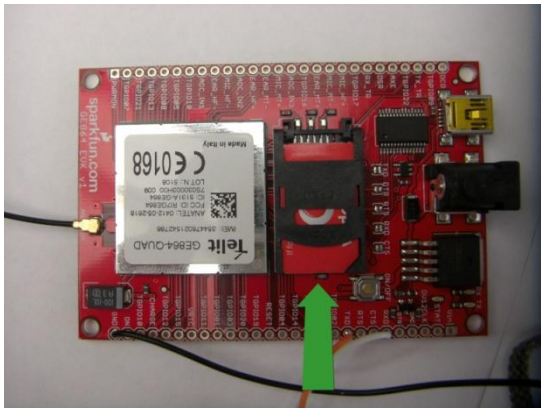
1. Sensor platform which collects environment data and transmit it through mobile phone network.
2. Server application which collects data from geographically distributed sensors.

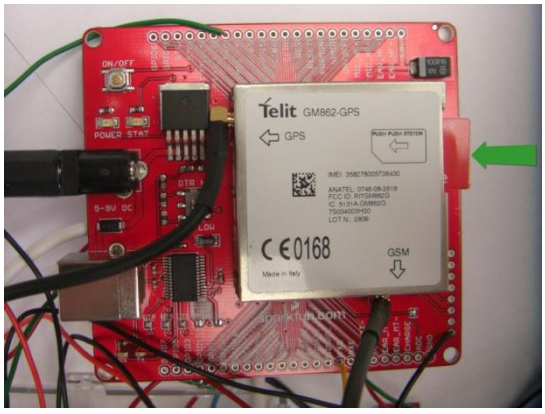
How to use

Insert SIM card



Open the lid of garden light enclosure; take out the GPRS module (Red colour) carefully.



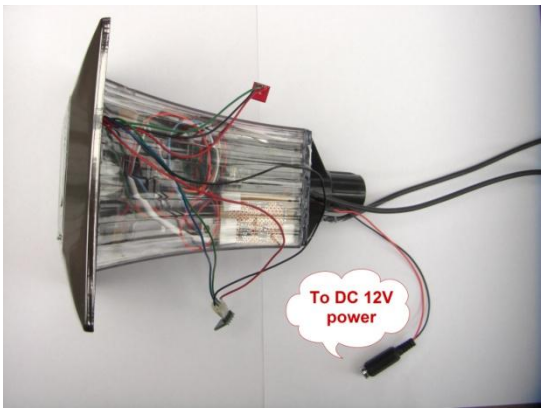


Bury sensors

Put the sensors to the place you want to monitor.

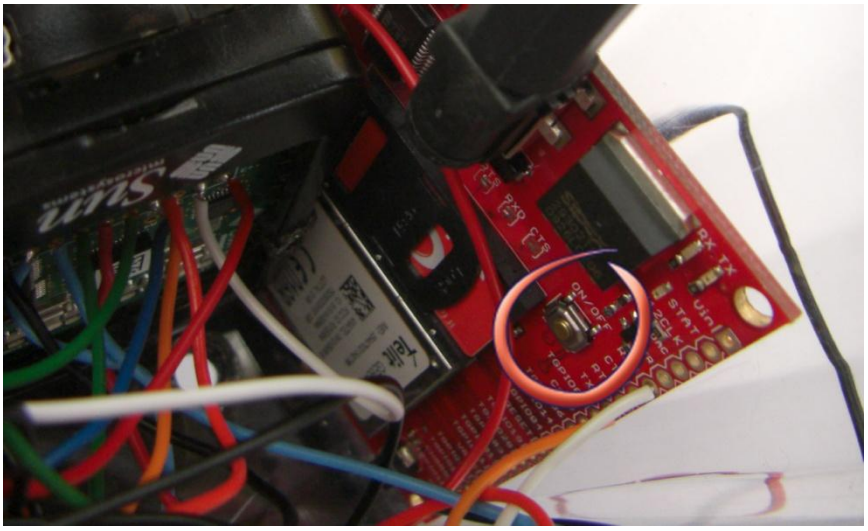
Connect power

Connect the power socket to **DC 12V** mains power.



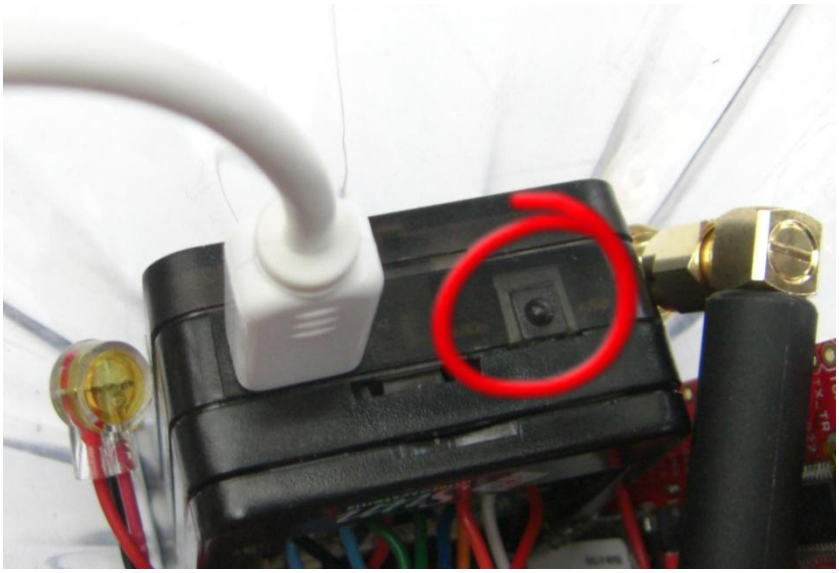
Switch on

Switch on GPRS module by press and hold button for 5 seconds, just like how you switch on your mobile phone.



Once the red led changes its quick flash to slow flash, it means it's connected to mobile phone network successfully.

Connect the USB power cable to Sun SPOT and press the Sun SPOT button twice.



Check the web

Wait for 1 minute; you should see a new record have been added to database.

Sensor platform design

Sun SPOT

Sun SPOT (Sun Small Programmable Object Technology) is a wireless sensor network (WSN) mote developed by Sun Microsystems. The device is built upon the IEEE 802.15.4 standard. Unlike other available mote systems, the Sun SPOT is built on the Squawk Java Virtual machine.

Data Sheet: http://www.sunspotworld.com/docs/Red/SunSPOT-TheoryOfOperation.pdf
Can be purchased from: http://www.sunspotworld.com/products/index.html

Processing

- 180 MHz 32 bit ARM920T core - 512K RAM - 4M Flash
- 2.4 GHz IEEE 802.15.4 radio with integrated antenna
- AT91 timer chip
- USB interface

Sensor Board

- 2G/6G three-axis accelerometer
- Temperature sensor
- Light sensor
- 8 tri-color LEDs
- 6 analog inputs
- 2 momentary switches
- 5 general purpose I/O pins and 4 high current output pins

Battery

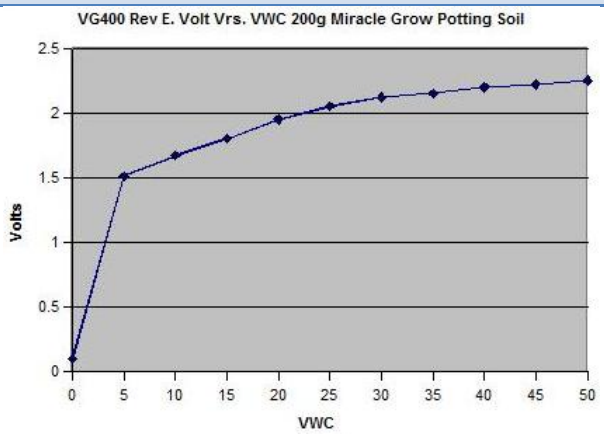
- 3.7V rechargeable 750 mAh lithium-ion battery
- 30 µ A deep sleep mode
- Automatic battery management provided by the software

Soil moisture sensor

The VG400 has an output range of 0 to 3V related proportionally to water content. Probes come standard with a 2 meter cable.

VG400 Probe (Standard Voltage Probe)	
Power consumption	< 800uA
Supply Voltage	3.3V to 20 VDC.
Power on to Output stable	400 ms
Output Impedance	100K ohms
Operational Temperature	-40°C to 85°C
Output	0 to 3V related to moisture content

Shell Color	Black

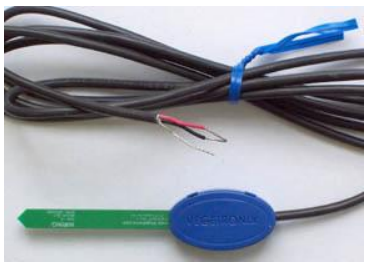


Data sheet: http://www.vegetronix.com/Products/VG400/
Can be purchased from: http://www.vegetronix.com/Products/VG400/

Soil temperature sensor

The THERM200 is a soil temperature probe, which has a temperature span from -40°C to 85°C. It outputs a voltage linearly proportional to the temperature, so no complex equations are required, to calculate the temperature from voltage. It is highly accurate with 0.125°C of resolution.

The sensor has a simple 3 wire interface: ground, power, and output, and is powered from 3.3V to 20VDC, and outputs a voltage 0 to 3V. Where 0 represents -40°C and 3V represents 85°. The probes can be buried, or inserted into pots.



THERM200 Temperature Sensor Probe	
Power consumption	< 3mA
Supply Voltage	3.3V to 20 VDC.
Power on to Output stable	2 seconds
Output Impedance	100K ohms
Operational Temperature	-40°C to 85°C
Accuracy	±0.5°C
Resolution	0.125°C
Output Voltage Range	0 to 2.44 linear to temperature
Voltage Output Equation	Temperature (°C) = Vout*41.67 -40
Cable Length	2 meters

Data sheet: http://vegetronix.com/Products/THERM200/
Can be purchased from: http://vegetronix.com/Products/THERM200/

Humidity and temperature sensor

The Sensiron SHT21 is the smallest relative humidity sensor with I^2C digital interface. It will be placed out side of plastic box.

Data sheet: http://www.sensirion.ch/en/pdf/product_information/Datasheet-humidity-sensor-SHT21.pdf
Can be purchased from: http://misenso.com/?page_id=15&shopp_pid=1

Light sensor

TEMT6000 is a silicon NPN epitaxial planar phototransistor in a miniature transparent mould or surface mounting onto a printed circuit board. The device is sensitive to the visible spectrum.

Data sheet: http://www.sparkfun.com/datasheets/Sensors/Imaging/TEMT6000.pdf
Can be purchased from:
http://www.sparkfun.com/commerce/product_info.php?products_id=8688

GPS and GPRS

The first prototype uses Telit GM862-GPS. The GPS is not critical in this system, maybe removed in volume production.

Data sheet: http://www.telit.com/en/products.php?p_id=3&p_ac=show&p=7
Can be purchased from:
http://www.sparkfun.com/commerce/product_info.php?products_id=280

GPRS

The first prototype uses Telit GM862-GPS. The future product may switch to smaller and cheaper Telit GE865 module. Note GE865 does not have a GPS module.

Data sheet: http://www.telit.com/en/products.php?p_id=3&p_ac=show&p=47
Can be purchased from: http://www.littlebirdelectronics.com/products/GE865-Evaluation-Board.html
Antenna need to be purchased: http://www.littlebirdelectronics.com/products/Quad%252dband-Wired-Cellular-Antenna-SMA.html

Mobile network provider

Vodafone Australia provides a long expiry pre-paid plan 365 Day Recharge. Since our project uses very few data and need long availability, this is the best plan I can find. 20 dollars credit gives us 20MB data.

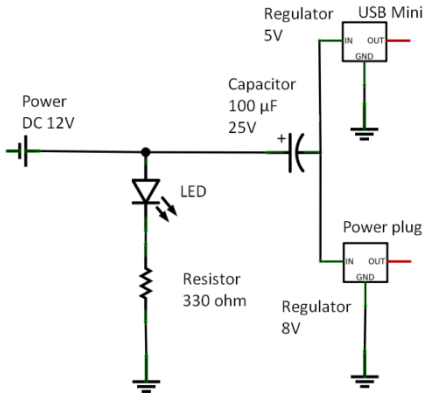
Vodafone 365 Day Recharge: http://www.vodafone.com.au/personal/prepaid-mobile/365day/index.htm

Housing and power supply circuit

Solar garden light is the best housing solution I can find. It is purchased from Bunnings Warehouse.

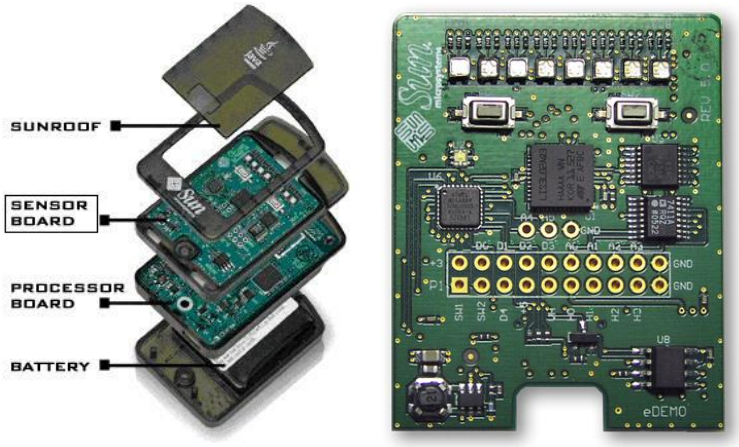
Since Sun SPOT requires 5V input via USB mini cable, GPRS module needs 5-9V power supply via power plug, so an integrated power converter circuit is needed.

Parts can be found in local Dick Smith and JayCar stores.



Connection

Sun SPOT consists of three staked layers: battery, main board and sensor board. I connect external sensors to sensor board.



There are 20 I/O pins on sensor board which allows you to connect.

V_{CC} +3VDC Output 100ma Maximum	SW1	1	2	V_{CC}
V_{+5V} +5VDC Output 100ma	SW2	3	4	D0
V_H +4.5V to 18VDC Input	D4	5	6	D1
A0-3 Analog Input 10 bit 0V to 3.0VDC	V_{+5V}	7	8	D2
D0-4 GPIO	V_H	9	10	D3
H0-3 High Current Output 125ma 0V to V_H	H0	11	12	A0
	H1	13	14	A1
	H2	15	16	A2
	H3	17	18	A3
	GND	19	20	GND

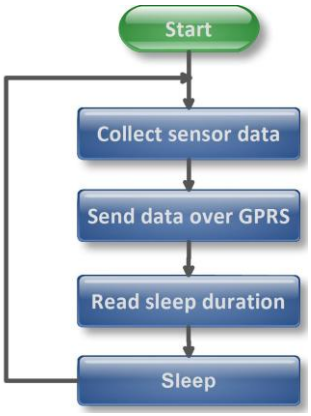
Here is how I connect sensors:

Sensor Board Pin	External Sensor	External Sensor Pin
D0	Sparkfun GM862-GPS USB Evaluation Board	RXD
D1	Sparkfun GM862-GPS USB Evaluation Board	TXD
D2	Digital Humidity Sensor SHT21 Breakout	SDA
D3	Digital Humidity Sensor SHT21 Breakout	SCL
A0	Light Sensor TEMT6000	SIG
A1	Soil Temperature Sensor	Black wire
A2	Soil Moisture Sensor	Black wire

A3	Reserved

Embedded application

The application logic is simple, first read values from temperature sensor, light sensor, soil moisture sensor; then send these data to server and read the duration of next sleep from the server.



Embedded application is written in Java. The Java source code is attached in the Source section.

Server side design

Database design

MySQL database is chosen since my web host on Dreamhost uses MySQL. There are two tables in this project. Database name is smartgarden. SQL script is attached in the Source section.

Records table

No.	Key	Field Name	Type	Length	Description
0	P	RecordId	Int		Auto incremental
1		SunSPOTId	String		Foreign key to Sensor table
2		Time	Timestamp		DB automatically inserted value
3		SoilMoisture	Int		Volumetric water content
4		SoilTemperature	Int		Celsius degree
5		AirTemperature	Int		Celsius degree
6		DeviceTemperature	Int		On SunSPOT, Celsius degree
7		Humidity	Int		Relative humidity in percentage
8		Light	Int		In Lux
9		GPSLatitude	String		In degree
10		GPSLongtitude	String		In degree
11		GPSAltitude	String		Meters above the sea level

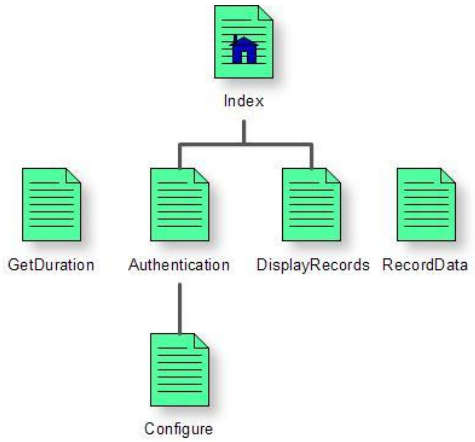
Sensor table

No.	Key	Field Name	Type	Length	Description
0	P	RecordId	Int		Auto incremental
1	U	SunSPOTId	String		Mac address of each Sun SPOT node

2	U	Name	String	Assign a name to SPOT
3		SleepingDuration	Int	The Sun SPOT sleep duration in minutes
4		Location	String	Where is the Sun SPOT located
5		Notes	String	User can take notes

Web front

PHP is chosen since my web host on Dreamhost supports it only. There are six pages need to be created. PHP source files are attached in the Source section.



Homepage

Project description and links

Authentication page

Only admin can login and set parameter

Configure and edit Sun SPOT

Assign a name to each sun spot and set parameters

Record data

Hidden page, retrieve values from HTTP Get command and store them to MySQL database. Two reason to have this page:

1. Embedded system can not access and manipulate data base directly
2. Dreamhost does not allow access database from remote PC

HTTP Get interface

Input Parameters	
Key	**Description**
spotid	Sun SPOT MAC address
sm	Soil moisture
st	Soil temperature
at	Air temperature
dt	Device temperature
hum	Humidity
lit	Light
lat	Latitude

lng	Longitude
alt	Altitude

Sample query:
http://smartgarden.sensorapp.net/RecordData.php?spotid=1234&sm=5&st=6&at=7&dt=8&hum=9&lit=9&lat=10&lng=11&alt=12

Output Parameters	
Data type	**Description**
String	Values insert status

Display records

Show all history records.

Get sleep duration

Read db and display a number of sleep duration in minutes which could be retrieved back to sensor.

HTTP Get interface

Input Parameters	
Key	**Description**
spotid	Sun SPOT Mac address

Sample query:
http://smartgarden.sensorapp.net/GetDuration.php?spotid=4ca4

Output Parameters	
Data type	**Description**
integer	Sleep duration in minutes

Pachube

Sending data to Pachube is currently disabled due to unknown issue that Sun SPOT can not correctly parse return HTTP response.

Pachube is a data brokerage platform for the internet of things, managing millions of datapoints per day from thousands of individuals, organisations & companies around the world. It enables you to store, share & discover realtime sensor, energy and environment data from objects, devices & buildings around the world.

Environment feeds fall into one of two categories. "Manual" feeds are those where the environment or device manually updates Pachube, usually via a PUT request - this is often done on a timed interval, on value-change or at some other significant moment (e.g. upon button press). These tend to be environments that sit behind a firewall or that are too low-powered to sustain a fully functioning server. "Automatic" feeds are those where the environment or device is able to serve data on request: Pachube automatically requests data from them either every 15 minutes or whenever another client requests it (whichever is the more frequent).

Due to the nature of mobile internet connection, we choose manually push data from sensor to Pachube.

Pachube REST API

Pachube provides most of its functionality via its REST style Application Programming Interface (API), rather than via the website itself.

We only use HTTP PUT function to store data to Pachube. The HTTP PUT request is like this one below:

```
curl --request PUT --header "X-PachubeApiKey: YOUR_PACHUBE_API_KEY" --
data 200,0 "http://www.pachube.com/api/8161.csv"
```

Update Pachube from AT commands of GPRS module. Note <CR><LF> is line terminator.

```
AT#SKTD=0,80,"www.pachube.com",0,0<CR><LF>


PUT /api/8161.csv HTTP/1.1<CR><LF>

Host: www.pachube.com<CR><LF>

X-PachubeApiKey: YOUR_PACHUBE_API_KEY<CR><LF>

Content-Type: text/csv<CR><LF>

Content-Length: 1<CR><LF>

Connection: close<CR><LF>

<CR><LF>

5<CR><LF>
```

If you can see response message like this, it means update was successful.

HTTP/1.1 200 OK
Server: nginx/0.6.35
Date: Fri, 13 Aug 2010 07:32:34 GMT
Content-Type: text/plain; charset=utf-8
Connection: close
X-Runtime: 215
Cache-Control: no-cache
Set-Cookie: _pachube_app_session=0cc29a6d3ec17f94c923d6e7de3950ba; path=/; expires=Fri, 13 Aug 2010 07:52:34 GMT; HttpOnly
Content-Length: 1
Vary: Accept-Encoding

Photos

Sensor Platform 2.0 Development

1. Change the platform: from Sun SPOT to low cost Arduino
2. Add long range radio communication capability
3. Solar powered system
4. Geiger counter
5. Gas sensor
6. Air quality sensor
7. Improve reliability
8. Servo motor control over the web

Contact

Paul Peng Deng
Sensor Network Developer

Phone: +61 402 837 152
Skype: dengpengcd
Web: SenSorApp.net
E-mail: pdeng@sensorapp.net

Source

Please visit http://smartgarden.sensorapp.net to download source code or contact pdeng@sensorapp.net.