Wireless Sensor Networks for Environmental Modelling

November 2002

Dr Rachel Cardell-Oliver
Department of Computer Science & Software Engineering
The University of Western Australia

Project Goal:

To design, implement and test a prototype wireless sensor network for outdoor environmental monitoring of local soil conditions. The network will consist of a weather station with state of the art sensors and several micro-controllers, each provided with soil moisture sensors and wireless transmission. Sensor data will be transmitted to a central PC which will store and display the gathered data.

Since the design of efficient wireless sensor networks is highly dependent on the specific monitoring application and hardware used, this project will focus on two specific applications. Initially, tests will be made using an indoor application monitoring light (and possibly temperature) levels in an office, together with data on the weather conditions outside the office. This stage will allow us to establish a network with known hardware and favourable operation conditions. The second application will use water pressure sensors connected to robust wireless micro-controllers to measure water penetration in soil. A micro-controller will be placed near soil surface level in a waterproof tube, with its water pressure sensor about 30cm below the soil surface, at the base of the tube. This type of monitor could be used, for example, to more accurately control the amount of water applied in parks and ovals. Experiments by Agrilink show that water savings from penetration monitoring can be substantial.

The outcomes of this project will be used to identify important areas of further work in data sampling and presentation, ad hoc wireless communications protocols, efficient management of micro-controller nodes, network monitoring and re-tasking of micro-controllers in the field.

Project Milestones:

1. *Motorla weather station* installed, wireless link operational, sensors calibrated, PC server and SW installed, continuous data monitoring operational. (Dec 02)

2. *Light Monitoring Application:* Apx. 5 RCX micro-controllers and light sensors programmed to measuring and transmit their local light level directly to infrared tower attached to a PC server. New sensors (e.g. temperature) will be added as they become available. Local and weather station data integrated. (Jan 03)

3. *Light Monitoring Application:* Extend the monitoring programs on the RCX to provide ad hoc routing of data so that distant monitors can relay their data through other monitors on the way to the central system. (June 03)

4. *Watering Application*: Select, source and assemble micro controller, power supply (battery), wireless transmitter/receiver, basic sensors. The micro-controller must be enclosed

in a robust casing. We hope to be able to use the Habitat monitoring *motes* available from EECS at University of California at Berkley. (Apr03)

5. *Watering Application* Install a version of the milestone 2 monitoring program on each mote and repeat the experiment transmitting sensor readings to a central computer. (Apr03)

6. *Watering Application:* Install and test water pressure sensors on the motes. (Jun03)

7. *Watering Application* Test the full system in an outdoor setting. (Dec03)

8. *Watering Application* Install a version of the milestone 3 ad hoc routing program on the motes and retest the system in its outdoor setting. (Oct03)

Context:

Environmental Modelling State of the Art
Weather stations with wireless connections to a central base have been successfully used in Australia, particularly for viticulture (a high price, low acreage crop). Stations are manufactured by AgriLink and Environdata and the former have published numerous case studies championing the benefits of this technology. Current models for deploying weather stations support a small number of stations communicating with a central computer which hosts one or more decision support systems.

Our approach differs, in that our monitoring systems will have a large number of simple monitoring stations and will utilise techniques for distributed decision making. In sensor networks "each sensor … is placed close to the phenomenon of interest, [and so] the sensors can often be built using small and inexpensive individual sensors. High spatial resolution can be achieved through dense deployment of sensor nodes. Compared with traditional approaches, which use a few high quality sensors with sophisticated signal processing, this architecture provides higher robustness against occlusions and component failures." [MPS+02]

Mainwaring, Polastre, Szewczyk et al.
Wireless Sensor Networks for Habitat Monitoring
In ACM Workshop on Wireless Sensor Networks and Applications 2002, Atlanta USA, September 2002

Complex Systems Research at UWA
The context of this project is ongoing research on Complex Systems in the Department of Computer Science & Software Engineering at UWA addressing:

- Study and increased understanding of naturally occurring complex systems, particularly spatial systems such as traffic networks, bushfire dynamics, infection spread, precision agriculture.

  Outcomes will be models and simulation technology allowing us to predict future behaviour of such systems. In real-time, allows better management of evolving systems such as traffic and fire; non real-time allows better design of road systems and urban spaces, and development of back burning and infection control strategies.

- Describe, design and analyse “engineered” or constructed complex systems such as electronic, software or mechanical systems.

  Outcomes will be better design methods, and description and validation techniques to allow 1) more rapid design, and 2) correct design, i.e. design with assurance of

design correctness. System scale and complexity increases design time and probability of design errors. New techniques needed to attack these issues.

Project Resources:

Source	*Equipment*
Motorola Software Centre, Perth	Motorola weather station
Motorola Software Centre, Perth	PC and SW for collating and displaying gathered data
Complex Systems Group, CSSE, UWA	RCX micro-controllers
Complex Systems Group, CSSE, UWA	Light sensors for the RCX
To be purchased (optional)	Temperature sensors
Centre for Water Research, UWA	Water Pressure sensors
To be purchased. Approach UCBerkley habitat motes for research usage or Motorola wireless modems	Outdoor environmental monitoring motes

Researcher	*Affiliation*	*Leads Project Activities (see Milestones)*
Rachel Cardell-Oliver	CSSE UWA	2,4,5,8
Honours students (2)	CSSE UWA	3,8
Keith Smettem	Centre for Water Research, UWA	4,6,7
Ian Fillery	CSIRO Plant Industry	7
Mick Poole	CSIRO Plant Industry	7
Andre Stefan	Motorola SW Centre, Perth	1