REAL TIME WIRELESS SENSOR NETWORK SYSTEM FOR ENVIRONMENTAL MONITORING: THE GREENHOUSE CASE STUDY

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Abstract Precision Agriculture refers to the user of information system for the with-in field management of crops, the monitoring of environmental conditions and livestock management. In fact with precision agriculture techniques every part of the field is treated differently. The use of PA techniques gives agronomists the potential to apply new and continuously developing technologies which help them to manage production in an optimal way.

1. A Typical Wireless Sensor Network – Sensor Boards

A WSN comprises a group of nodes each measuring a variable, for example soil moisture, which wirelessly interact with their neighbors creating an ad-hoc network which passes information to a central database. By covering a farm with these nodes the farmer can always have an accurate picture of soil moisture levels to determine the most effective irrigation needs for a field. By combining this important information with additional information gained from sensor networks, a wealth of knowledge can be gained as to the effect of environmental and herd factors on animals. These sensors can be programmed to record measures like temperature and humidity. All the data which are collected from the sensors end up in the gateway, which either transfer them to the end used through wireless network, internet or LAN.

In this application we mainly used the Motives Tmote Sky Platforms for the measurement of main environmental elements such as humidity, temperature, light density etc. In order to meet all the measurement requirements of the demo application we also used a variety of other sensors, which are the following:

- Soil Moisture Sensors: In addition with the above motes, we used the EC-5 Decagon Sensors for the measurement of soil moisture. The EC-5 Soil Moisture Sensor meets the needs of those who are looking for an all-around ideal soil moisture sensors. Moreover, the EC-5 sensors incorporate a high frequency oscillation, which allows the sensor to accurately measure soil moisture in any soil or soilless media with minimal salinity and textural effects. These sensors are appropriate for Watershed characterization, vadose zone monitoring and Plant-soil-water interaction studies.

- Leaf Wetness Sensor: One more Decagon sensor that we used is about sensing the leaf wetness. Many fungal and bacterial diseases affect plants only when moisture is present on a leaf surface. So measuring leaf wetness is an important factor that gives feedback to the agronomists about diseases of that kind. The Leaf Wetness Sensor determines the presence and duration of canopy wetness, allowing you to forecast disease and protect the plant canopy. Because the Leaf Wetness Sensor measures the dielectric constant, droplets do not need to bridge electrical traces for the sensor to detect moisture. The presence of water or ice anywhere on the surface of the sensor will be detected. Some benefits of leaf wetness sensors include:

  0 High resolution detects trace amounts of water or ice on the leaf surface.

  1 No painting or calibration necessary; factory calibration set at standard wetness threshold.

  2 Ammonia Measurement Sensors

For the measurement of the concentration of ammonia in air, the wireless sensor systems laboratory team has developed its own sensor board which uses a sensory element sensitive in ammonia and allocates the essential electronic circuits for this operation. As outlet it gives a value which is read by the node of wireless network. The sensory element that we used is: TGS-2444 of Figaro Ltd. This particular sensor has very small consumption factor and presents high sensitivity even in low concentrations of ammonia. Moreover it has very small size that allows the restriction of enlargements of final sensing board. The sensor board is depicted as follows:

- Air Wind Measurement Sensor: In order to measure and display wind – related conditions such as wind speed, wind direction, wind run, wind chill and the temperature – humidity – sun - wind index we used the Davis anemometer (model 7911). The Anemometer includes both wind speed and wind direction sensors. Rugged components stand up to hurricane-force winds, yet are sensitive to a light breeze. It includes sealed stainless-steel bearings for long life. The range and accuracy specifications of this unit have been verified in wind-tunnel tests.

2. Software and Application Application

The architecture of the monitoring system is based on java open source software and comprises of three parts:

1 The sensors software which deals with the instructions to the hardware that control sensing behaviour, such as sampling and reporting frequency and is implemented in NesC programming language and services offered by TinyOS.

2 The Collection and Storage software which is responsible for receiving the node measurements and to forward them, through the Serial Forwarder interface, to a database RDBMS built in MySQL. The application responsible for this is also written in Java programming language.

3 The measurement representation visualization tool which is the main interaction point between the user and the sensor network and allows for the examination of the selected measurements, the representation of these via graphic interfaces, the notification services (emails, sms, alerts) for the data.

3. Wireless Sensor Network Web Monitoring Interface

All the measurements taken from the sensors and stored to the database can also be represented graphically through a web monitoring interface which is located at `http://wssl.inf.uth.gr/greenhouse`. This interface consists of five tabs, each of which refers to a different way of data representation. Specifically:

- One node with one attribute (1 to 1)
- One node with many attributes (1 to N)

- Many nodes referring to one attribute (N to 1)
- Real time data monitoring.
- Data mining through database queries.

The importance of this tool is that the interface can be "connected" to any underlying database system, giving the users a way of real time monitoring of the measurements through internet connection. This possibility decouples the user from the observation field.