



WIRELESS SENSOR NETWORKS FOR GREENHOUSE ENVIRONMENTAL CONTROL USING FUZZY LOGIC

Ramesh A P
Research Scholar
Department of Electronics
Erode Arts and Science College
Erode, TamilNadu
ramesh.palanivel@gmail.com

Dr Pasupathy N
Associate Professor
Department of Electronics
Erode Arts and Science College
Erode, TamilNadu
npathy@gmail.com

Abstract

Sensor networks offer a powerful combination of distributed sensing, computing and communication. They lend themselves to countless applications and, at the same time, offer numerous challenges due to their peculiarities, primarily the stringent energy constraints to which sensing nodes are typically subjected. The distinguishing traits of sensor networks have a direct impact on the hardware design of the nodes at least four levels: power source, processor, communication hardware, and sensors. Various hardware platforms have already been designed to test the many ideas spawned by the research community and to implement applications to virtually all fields of science and technology. We are convinced that CAS will be able to provide a substantial contribution to the development of this exciting field.

Keywords: WAN, MEMS, VLSI, and Sensor.

I. INTRODUCTION

The increasing interest in wireless sensor networks can be promptly understood simply by thinking about what they essentially are: a large number of small sensing self-powered nodes which gather information or detect special events and communicate in a wireless fashion, with the end goal of handing their processed data to a base station. Sensing, processing and communication are three key elements whose combination in one tiny device gives rise to a vast number of applications [1], [2]. Sensor networks provide endless opportunities, but at the same time pose formidable challenges, such as the fact that energy is a scarce and usually non-renewable resource. However, recent advances in low power VLSI, embedded computing, communication hardware, and in general, the

convergence of computing and communications, are making this emerging technology a reality [3]. Likewise, advances in nanotechnology and Micro Electro-Mechanical Systems (MEMS) are pushing toward networks of tiny distributed sensors and actuators.

II. MOTIVATION FOR THE WORK

Wireless Sensor Network (WSN) technology has broad applications in many areas because of its advantages such as low-cost equipment, safe and reliable data transfer, simple and flexible network and easy deployment. The implementation of precise control irrigation for crop water demand information is one of the important ways to improve the utilization of water. WSN has proved to be useful in applications that involve monitoring of real-time data. In order to optimize the yield and the use of the available resources, wireless sensor networks can play a relevant role because of their ability of providing real-time data collected by spatially distributed sensors.

II. WIRELESS SENSOR NETWORK ARCHITECTURE

A typical wireless sensor node consists of five main hardware modules as shown in Figure 1.1: (i) Microcontroller (ii) Radio transceiver (iii) One or more sensors (iv) Memory chip (v) Battery. The WSN nodes usually wake up on the timer interrupt. They may also have application dependent additional components such as location finding system and a power generator [1].

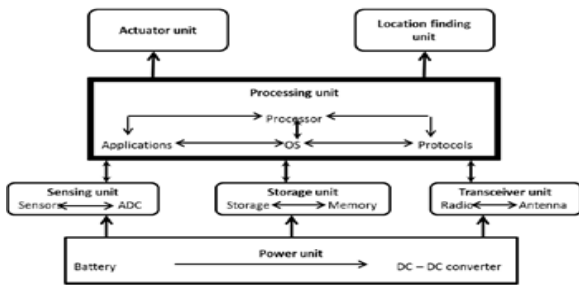


Figure 1: Architecture of WAN

A. Sensing unit

A sensor is a hardware device that produces a measurable response in signal to a change in physical condition such as temperature, pressure, humidity, etc. Sensors send detected values to the processor which runs the sensor operating system and manages the procedures required to carry out the given sensing task.

B. Storage unit

Memory in a sensor node includes in-chip flash memory and RAM of a microcontroller and external flash memory. Flash is used for persistent storage of application code and text segments and static random access memory (SRAM) is used for runtime data storage.

C. Transceiver unit

A transceiver is responsible for wireless communication of sensor node. The operational states of transceiver are: transmit, receive, idle and sleep. The transceiver unit consists of a radio and antenna. The radio contains different operating modes like transmit, receive, idle and sleep for power management purposes. The sleep mode provides the lowest power consumption.

D. Power unit

The power entity is generally composed of a couple of standard AA batteries. Many research are being conducted to minimize energy consumption and increase the lifetime of sensors. Power can be stored mainly in batteries or also in capacitors. A TelosB consumes the least power, but very limited in terms of storage and processing. On the other hand, IMote2 is

the most powerful in terms of processing, but it consumes a lot of power.

E. Processing unit

The processing unit consists of mainly of processor; the responsibilities include controlling sensors, gathering and processing sensed data, executing WSN applications, managing communication protocols with the help of operating system.

IV. IMPLEMENTATION OF SYSTEM HARDWARE

This section presents proposed Fuzzy based Irrigation Control System architecture using WSN for monitoring and controlling the irrigation in an agriculture which is as shown in Figure 2. It consists of four basic components namely [A] Wireless Sensor Network [B] Gateway Node / Sink Node [C] Fuzzy based Irrigation Controller [D] Irrigation Pipe Network.

The first component consists of Wireless Sensor Network which sense physical and environmental parameters and send data to the gateway node. Second component is application server which receives data from gateway and processes it. The last component is irrigation pipe network which is laid over the irrigated areas and the electric control valves are installed on pipelines.

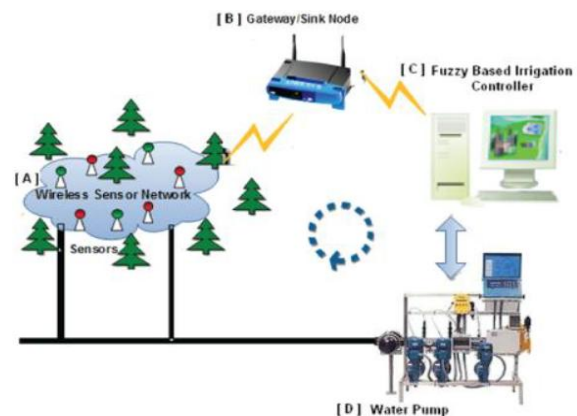


Figure 2: Wireless Sensor Network

A. Wireless Sensor Network:

The proposed system implemented using the MEMSIC eKo Pro Series which is a wireless agricultural and environmental sensing system for crop monitoring. The system also provides an easy deployment of wireless monitoring system in an



agricultural layout for efficient collection of data about its needs from multiple locations.

The eKo Node is a fully integrated, rugged outdoor sensor package that uses an energy-efficient radio and sensors for extended battery-life and performance. The eKo Node integrates MEMSIC's IRIS processor/radio board and antennathat are powered by rechargeable batteries and a solar cell. An eKo Node is capable of an outdoor radio range up to 2 miles depending on the deployment and the hardware configuration chosen. The nodes themselves form a wireless mesh network that can be used to extend the range of coverage. By simply adding an additional eKo Node, it is easy to expand the coverage area. The nodes come pre-programmed and configured with MEMSIC's XMesh low-power networking protocol. This provides plug-and-play network scalability for wireless sensor networks. The system can be easily enhanced with various sensors such as soil moisture, ambient temperature and humidity, leaf wetness, soil water content, solar radiation, etc.

B. Sensors for Precision Agriculture

Soil Moisture and Temperature: The ES1100 Watermark Sensor (granular matrix sensor) is a soil moisture and soil temperature sensor. Up to four ES1100 sensors can be connected to measure soil moisture at different soil depths. By monitoring the sensor measurements between irrigations, it is possible to measure the rate at which the soil is drying out [7].

C. Soil Water Content

The ES1110 uses the Decagon EC-5 which obtains volumetric water content by measuring the dielectric constant of the media through the utilization of capacitance/ frequency domain technology. It incorporates a high frequency oscillation which allows the sensor to accurately measure soil moisture in any soil with minimal salinity and textural effects.

D. Ambient Temperature and Humidity

The ES1201 is a temperature/humidity sensor that measures the ambient relative humidity and air temperature. These readings are also used to calculate dew point. The sensor enclosure protects the sensor from mechanical damage, and a membrane filter protects the sensor elements from dust, dirt, and water spray [7].

Leaf Wetness Sensor(LWS): Leaf wetness sensor from Decagon. Many fungal and bacterial diseases affect plants only when moisture is present on a leaf surface.

The leaf wetness determines the presence and duration of canopy wetness allowing users to forecast disease and protect the plant canopy. The LWS outputs 445 raw counts when dry. When the sensor is totally wet, as in a heavy rain, the signal can range up to around 1400 counts. Varying amounts of water on the surface of the sensor cause a sensor output proportional to the amount of water on the sensor's surface. The figure 2 shows the sample raw output from LWS sensor [7].

V. TYPES OF SENSORS AND CONTROLLING PARAMETERS IN GREEN HOUSE

In this case study and analysis, we have considered three types of sensors. Sensor Node 'A' which is, outside climate sensor will help to get time to time information about wind flow, wind direction, ambient light, temperature, ambient pressure, humidity and percentage of CO₂. Sensor node 'B' is inside climate sensor and will monitor ambient light, temperature, ambient pressure, and humidity and CO₂ percentage from the inside of the green house. Soil sensor node type 'C' would be specially design for to monitor the soil conditions like humidity of soil, temperature, pH value, and electric conductivity of a soil. As shown in fig.4. The minimum size of the each parameter value shall be one byte, hence the size of data for each type will be required as: 07 byte for 'A', 05 byte for 'B', 4 byte for 'C' will be sufficient.

A. Air Temperature Control

Growth of Plants depends on the photosynthesis process which is a measure of photo syntheticallyactive radiation. It is observed that proper temperature level influences the speed of sugar production by photosynthesis radiation. Temperature has to be control properly since higher radiation level may give a higher temperature. Hence, in the diurnal state, it is necessary to adjust the temperature at an optimal level for the photosynthesis process. In nocturnal conditions, plants are not active therefore; it is not necessary to maintain such a high temperature. For this reason, two temperature set-points are usually considered are diurnal and nocturnal. Infavorable weather conditions of temperature during the daytime the energy required to reach the optimal temperature is provided by the sun. In fact, the usual diurnal temperature control problem is the refrigeration of the greenhouse using natural ventilation to achieve theoptimal diurnal temperature. On the other hand, heating of the greenhouse up to requiredtemperature is the case of nocturnal temperature control. Some cases



forced-air heaters are commonly used as heating systems.

B. Humidity Control

Water vapour inside the greenhouse is one of the most significant variables affecting the crop growth. High humidity may increase the probability of diseases and decrease transpiration. Low humidity may cause hydric stress, closing the stomata and thus it may lower down the process of photosynthesis which depends on the CO₂ assimilation. The humidity control is complex because if temperature changes then relative humidity changes inversely. Temperature and humidity are controlled by the same actuators. The main priority is for temperature control because it is the primary factor in the crop growth. Based on the inside relative humidity value the temperature set-point can be adjusted to control the humidity within a determined range. Hence to control the required humidity is very complex task. For proper control of humidity internal air can be exchanged with outside air by properly controlling ventilations of the green house.

C. Soil Condition Control

Soil water also affects the crop growth. Therefore, the monitor & control of soil condition has a specific interest, because good condition of a soil may produce the proper yield. The proper irrigations and fertilizations of the crops vary as per the type, age, phase and climate. The pH value, moisture content, electric conductivity and the temp of soil are some key parameters. The pH values and other parameters will help to monitor the soil condition. The temperature and the moisture can be controlled by the irrigation techniques like drip and sprinkler system in a greenhouse. The temperature of the soil and the inside temperature of the green house are interrelated parameters, which can be controlled by proper setting of ventilation. Since the temperature control depends on direct sun radiation and the screen material used, the proper set point can be adjusted to control soil temperature. The temperature set-point value depends on actual temperature of the inside and outside of the greenhouse.

VI. FUZZY LOGIC THEORY

Fuzzy Logic Control (FLC) system is based on fuzzy set theory. This set theory is an advanced version of classical set theory called crisp theory. In crisp set theory, an element either belongs to or does not belong

to a set. But fuzzy set supports a flexible sense of membership of elements to a set. Many degrees of membership, between 0 and 1, are allowed. The membership function is associated with a fuzzy set in such a way that the function maps every element of the universe of discourse or the reference set to the interval [0, 1]. In crisp logic, the truth values acquired by propositions or predicates are two-valued, namely TRUE or FALSE which may be treated numerically equivalent to (0, 1). However, in fuzzy logic, truth values are multi-valued such as absolutely true, partly true, absolutely false, very true, and so on and are numerically equivalent to any value in the range 0 to 1 [6]. In general, a Fuzzy Logic System (FLS) is a nonlinear mapping of an input data vector into a scalar output. It depicts a FLS that is widely used in fuzzy logic controllers. A FLS maps crisp inputs into crisp outputs, and this mapping can be expressed quantitatively as $y = f(x)$. It contains four components: fuzzifier, fuzzy rules, inference engine, and defuzzifier.

VII. CONCLUSIONS

In green house technology, more number of parameters is to be controlled because the varieties of the crop are large. They are increasing day by day because of the development in agriculture technology. In this situation, the wireless sensor network with additional hardware and software is an efficient solution for green house control. Experimentally it is proved that the hardware developed by Cypress Inc. is the best solution which works on low power with less complexity and high reliability for greenhouse control. In the future, if parameters still increase, then for WSN technology with currently available bandwidth, may not be sufficient. Then WSN with cognitive radio technology may be the solution. This advancement in precision agriculture through Wireless Sensor Network in green house control is extremely useful. This has scope in developing countries in globe, where agriculture is the main business.

References

- [1] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks," in *IEEE Communications Magazine*,
- [2] L.B. Ruiz, L.H.A. Correia, L.F.M. Vieira, D.F. Macedo, E.F. Nakamura, C.M.S. Figueiredo, M.A.M. Vieira, E.H.B. Maia, D. Câmara, A.A.F. Loureiro, J.M.S. Nogueira, D.C. da Silva Jr., and A.O. Fernandes, "Architectures for wireless sensor networks (In Portuguese)," in *Proceedings of the 22nd*



Brazilian Symposium on Computer Networks (SBRC'04),
Gramado, Brazil,

[3]C.Y. Chong and S.P. Kumar, “Sensor networks: Evolution, opportunities, and challenges,” in *IEEE Proceedings*,

[4]P. Udayakumar, Ranjana Vyas, O.P. Vyas, the research paper titled “Energy Efficient Election Protocol for Wireless Sensor Networks”, was published in the *IEEE DigitalExplore*, pp. 1028-1033, ISBN 978-1-4673-4921-5, July 2013.

[5]<http://www.memsic.com/products/wireless-sensor-networks.html> (eKo Pro Environmental Monitoring System manual)

[6]http://manuals.decagon.com/Manuals/10386_Leaf%20Wetness%20Sensor_Web.pdf

[7]Domingo Gómez-Melendez, Fuzzy irrigation greenhouse control system based on a field programmable gate array, *African Journal of Agricultural Research* Vol. 6(11), pp. 2544-2557, 4 June, 2011