

# Precision Agriculture Using Wireless Sensor Network System: Opportunities and Challenges

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## ABSTRACT

Wireless Sensor Networks (WSNs) have concerned much attention in recent years. The prospective applications of WSNs are enormous. They are used for collecting, storing and sharing sensed data. WSNs have been used for various applications including habitat monitoring, agriculture, nuclear reactor control, security and tactical surveillance. The WSN system developed in this project is for use in precision agriculture applications, where real time data of climatological and other environmental properties are sensed and control decisions are taken based on it to modify them. The architecture of a WSN system comprises of a set of sensor nodes and a base station that communicate with each other and gather local information to make global decisions about the physical environment. Farmers depend heavily on the rains because they lack the access to irrigation facilities. Their crop yields are highly unreliable due to the variability in both rainfall amount and its distribution. Also these farmers depend heavily on the prediction values of various factors such as weather, water, soil, etc. Agriculture faces many challenges, such as climate change, water shortages, labour shortages due to an aging urbanized population, and increased societal concern about issues such as animal welfare, food safety, and environmental impact. Sensor network and other agricultural techniques might help them to store and utilize the rain water, increase their crop productivity, reduce the cost for cultivation and make use of real time values instead of depending just on prediction.

**Keywords:** Wireless sensor networks; Precision Farming; Environmental monitoring; agriculture; water management; Smart agriculture; Sensor;

## 1. INTRODUCTION

The wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor [2] physical or environmental conditions, such as temperature, sound, vibration,

pressure [11], motion or pollutants and to cooperatively pass their data through the network to a main location. The availability of smarter, smaller and inexpensive sensors measuring a wider range of environmental parameters has

enabled continuous timed monitoring of the environment and real-time applications.

This was not possible earlier when monitoring was based on water sample collection and laboratory analyses or on automatic sensors wired to field loggers requiring manual data downloading. During the previous decade, environmental monitoring has developed from off-line sensors to real-time, operational sensor networks and to open Sensor Webs.

Sensor networks are used for collecting, storing and sharing the sensed data. They can also be defined as a system comprised of a set of sensor nodes and a communication system that allows automatic data collection and sharing. They allow monitoring remote, hazardous, dangerous or unwired areas, for example in the monitoring and warning systems for tsunamis, volcanoes, or seismologic phenomena.

Precision agriculture is a technique of management of large fields in order to consider the spatial and temporal variability. To use more sophisticated sensor devices with capabilities of chemical and biological sensing not only aids the personnel in the field maintenance procedure but also significantly increases the quality [2] of the agricultural product.

Precision farming is the ability to handle variations in productivity within a field and maximize financial return, reduce waste and minimize impact of the environment using automated data collection, documentation and utilization of such information for strategic farm

management decisions through sensing and communication technology.

Several technologies were used in the PF such as Remote Sensing (RS), Global Positioning System (GPS), and Geographic Information System (GIS). The most important step in PF is the generation of maps of the soil with its characteristics. These included grid soil sampling, yield monitoring, and crop scouting. RS coupled with GPS coordinates produced accurate maps and models of the agricultural fields.

The Wireless sensor network is composed of a large number of sensor nodes consist of sensing, processing, transmission, mobilizer, position finding system, and power units (some of these components are optional like the mobilizer and position finding system). These nodes are densely deployed either inside the phenomenon [6] or very close to it.

The position of sensor nodes does not need to be engineered or predetermined. Sensor nodes coordinate among themselves to produce high-quality information about the physical environment. Each of these scattered sensor nodes has the capability to collect and route data either to other sensors or back to an external base station(s).

Base station may be capable of connecting the sensor network to an existing communications infrastructure or to the Internet where a user can have access to the reported data.

## 2. METHODOLOGY

The WSN node is consisting of Intelligent Humidity sensors, microcontroller and low power radio transceivers to collect data in the field and transmit it to a remote receiver outside the field. To prevent node from the humidity in the field a corrosion proof casing is used. After setting up the network [8] topology, node runs its application software. The application software begins its active period by turning on its sensors and sensing the environment of the field. The application software reads humidity of the field from sensors and reports the result to the base via its other WSN nodes. If it receives any packets from its supporting nodes during this active time, it relays the packets to its other nodes. After the transmission of its sensing data, node waits for its working schedule such as sensing period. As it receives its sensing period, the application software turns off its attached sensors and puts the transceiver to power down mode. Finally, it sets up the internal sleep timer, goes to its sleep period

and waits for the expiration of the timer. After the expiration of the timer, the application restarts its next active periods by turning on the transceiver and the sensors and continues to sense the environment of the field.

The WSN nodes with the intelligent humidity sensor and the low power wireless transceiver will be deployed to collect data [5] and record SWT (**Soil Water Tension**) for facilitating irrigation management. The system consists of a number of WSN nodes for data acquisition and control systems on Agricultural farms. The data collection by WSN nodes will be transmitted to a base receiver outside the field stored processed and analysed. The data can be viewed with the push of a button and can be downloaded to a laptop computer or PDA. The processed SWT data make it possible to determine soil moisture trends and to predict or modify irrigation schedules for better crop yield and increase the application efficiency of irrigation system.

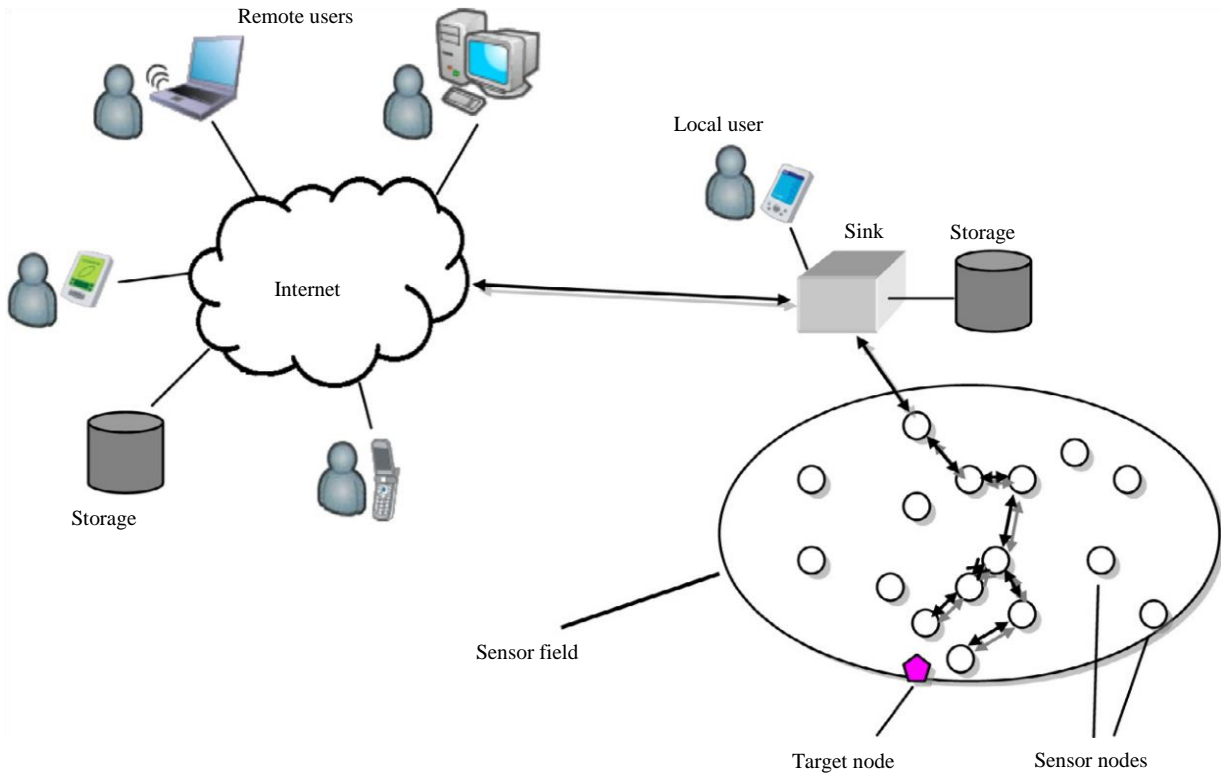


Fig. Sensor node scattered in the sensor field

### 3. CHALLENGES

Adoption, utility and applications [1] of WSNs in agriculture is not without multitude of challenges and the requirement of addressing difficult research problems. Some of those generic challenges are mentioned below.

#### 3.1 Cost per unit

A major obstacle to wider embracing of wireless sensor networks is the cost of nodes. At \$99 to \$300 apiece, nodes are currently too costly for many of the applications its inventors envisioned, such as extensive use in agriculture. The radio frequency identification (RFID) tag industry possibly has reached a cost as low as about \$0.20 per tag and seeks to reach in a decade,

the price of \$0.05 per tag for inventory tracking purposes.

#### 3.2 Battery Life

Wireless sensors run on batteries--which can create maintenance botheration if users are expected to replace them regularly and that too for hundreds and thousands of sensors. Without energy, a sensor is basically useless and cannot contribute to the usefulness of the network as a whole. However, there are upcoming WSN applications where sensors are required to operate for much longer periods (like years or even decades) after being deployed.

#### 3.3 Data Fusion and Quality

Location (the sensor node or base station) of data processing is another critical issue, because data processing at the sensor node consumes

energy and is limited by the device capacity, however, this saves transmission energy and network congestion. The correct trade-offs on processing location seem to be system dependent. At the same time data gathering has its own data quality issues, some of which are i) missing data ii) missing observations and iii) variations in observations.

### **3.4 Signal attenuation**

Radio waves are attenuated while transmitted from the sender [1] [11] to the receiver. The degree of attenuation is dependent on the medium between the receiver and the transmitter. Consider the case of using wireless sensors for monitoring cattle health, since the cattle are generally fed in herd, this results in massive increase in the surface area, which seriously affects the radio signals. The sensor communication system is required to minimizing the impact of radio attenuation through food and animal body.

### **3.5 Authenticity and Security**

Severe environmental operating conditions, hazards [1] of physical compromise and unpredictable data transfer rates are some of the challenges for WSN. WSN are usually deployed in an unattended environment. There are many small sensor nodes in a sensor network and these are prone to various attacks. But it is difficult to monitor each type of incoming attacks. Physical, link, network, transportation and application layers are basically the different types of layers which gets affected during attacks [3] [6] DOS attacks (Denial Of Service Attacks) are the ones which affect the above mentioned layers.

In addition to DOS Attacks, there are several other attacks on WSN such as Signal/radio jamming, Device tampering Attack, Node Capturing attack, Path Based DOS, Node Outage, and Eavesdropping. The existing protocols [3] cannot be used for WSN. There are other constraints and obstacles too that need be resolved while designing a security protocol for WSNs. Another technique is Encryption which is by far the best method to secure the Wireless Sensor Networks. Encrypting the signal increases the signal security by a large amount.

### **3.6 Operating Systems**

TinyOS is event-driven operating [1] system which is assumed to perform better under constrained environments. Yet such OS lack some system utilities resulting in imposition of their own constraints. Nevertheless, thread-driven systems such as MOS provide high concurrency with pre-emption, allowing their use in real-time applications. Research has shown the ability of thread-driven systems to outperform event-driven systems. Yet, in some cases such as high system load, the thread driven approach usually consumes more energy. Designers therefore have to prioritize or establish a trade-off between energy consumption and high concurrency.

## **4. FUTURE WORK**

### **7.1 Increasing Battery Life to Decades**

The biggest problem faced by WSN is energy. When [1] a sensor is drained of energy, it can no longer accomplish its role unless the source of energy is replenished. Therefore, it is normally

accepted that a wireless sensor dies when its battery runs out. Even when not in use, portable energy sources like batteries will experience current leakages that ultimately drain the resource; furthermore, any defects in the packaging due to long term wear and tear can result in environmental issues. Therefore, it is urgently needed to increase the battery life or decrease its discharge rate. One possible solution being pursued is energy harvesting. "Energy harvesters" are small devices which take ambient energy and convert that into electrical energy to power the wireless sensor. The aim is 20 year lifetime or more. Photo-voltaics are most commonly used, but there is work underway on other types of energy harvesters too, such as piezoelectrics (harvesting energy from vibrations), electro-dynamics (similar to bicycle dynamo), thermo-electrics (harvesting energy from a heat gradient) and However, these are not the major sources for harvesting energy in a typical agriculture environment.

#### **4.2 Reducing Amount of Data Transmitted**

With hundreds and thousands [1] of sensors deployed, collecting and transmitting data several times a day could quickly overwhelm a system. Therefore, ways and means need to be developed in order to avoid getting drowned in data while starving for information. One way of managing the flood of data is to work on the most relevant data. For example, the traditional humidity sensors utilized in agriculture have a downside that they acquire a large amount of data which is to be processed or transmitted. Subsequently only relevant information is extracted and then presented in a format

minimizing post-processing latency. Thus the intelligent humidity sensor reduces the amount of data processed by 50% (depending upon humidity changes) and thereby reduces the power consumption. Similar work is needed for other sensors too.

#### **4.3 Developing Distributed Algorithms**

A WSN is a form of distributed system, where individual [1] sensor nodes cooperate to ensure the network as a whole meets specific application requirements. The a-priori knowledge of a node is only about its own state. In order to know about other nodes in the network, a node has to talk to its neighbours. According to Laube and Duckham (2009), by collaboration of the nodes, global operations such as (multi-hop) routing or global knowledge discovery can be achieved. Since these activities are distributed among the nodes, we need distributed.

#### **CONCLUSION**

Deployment of sensor networks still is a problem and subject of wide range researches and developments. Prototype of WSN built in framework of current research shows that small networks are more or less functional while large scale WSNs with long range nodes are issue. Despite of problems our WSN prototypes gave possibility to gather valuable data for field weather monitoring. The sensor network technology will help the farmers to know the exact values of the requirements that they need to improve the crop productivity. It will help them in taking better decisions at the right time. This will save their time and labour also. The basic aim here

is to transport the Indian farmer from prediction to the exact values which are beneficial for their farms.

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