EMBEDDING THE ROLE OF SENSOR NETWORK TECHNOLOGY FOR SECURE AND PRECISE DATA AGGREGATION AND COMMUNICATION FOR GLOBAL AGRICULTURAL DEVELOPMENT

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ABSTRACT

The sensor network environmental sensing was done by a small or large quantity of labor force. They retrieved data directly from the agri-fields or its related environment and submitted upward for processing by consuming the whole days and nights. In this paper we have given a best solution to the outdoor environmental sensing especially with a good focus on agriculture production. In various countries agriculture is one of the main and strongest sources of economy and employment. We have presented the utilization of wireless sensor nodes for sensing the outdoor environment. This system will keep an eye on the every minute change in the given field including sudden rains, evaporation, humidity, sun light, water levels and various other Gas reactions along with the crop development under the given area. We have used the end to end sensor node technology deployed in the outdoor environment having capabilities of the thermal, solar and Gas sensations. This paper reduces the labor force, enhances precise monitoring and thus enhances the economy of the said sector in a smart way.

***Keywords**: Sensor Networks, Environmental Sensing, Agri-Fields, Gas Reactions, Tree Topology, Environment, Crop.*

I. INTRODUCTION

Recent advances in wireless sensor network technology have made the technical conditions to make multi-functional tiny sensor devices, which can be used to observe and to react according to physical phenomena of their surrounding environment [1]. Wireless sensor nodes are low-power devices equipped with processor, storage, a power supply, a transceiver, one or more sensors and, in some cases, with an actuator. Several types of sensors can be attached to wireless sensor nodes, such as Gas, optical, thermal and biological. These wireless sensor devices are small and they are cheaper than the regular sensor devices. They can automatically organize themselves to form an ad-hoc multi hop network. Wireless sensor networks (WSNs), may be comprised by hundreds or maybe thousands of ad-hoc sensor node devices, working together to accomplish a common task. Self-organizing, self-optimizing and fault-tolerant are the main characteristics of this type of network [2]. A Sensor Node detects things like temperature, sound, vibrations, pressure, motion, or pollutants through spatially distributed autonomous sensors. They are currently being used for industries and civilian use such as industrial process monitoring and control, machine health monitoring, monitoring of the environment, healthcare applications, home automation, and traffic control. Each node can have more than one sensor and generally also has a radio transceiver or some other type of device used for wireless communication, a small microcontroller, and an energy source (such as a battery). The prices, complexity, and sizes of sensor nodes vary, a complex node the size of a shoe box could be a few hundred dollars and a very small one that isn't very complex could be pretty cheap. The price and size of these nodes depend on energy, memory, computational speed, and bandwidth. Each sensor supports a multi-hop routing algorithm where nodes function as forwarders, relaying data packets to a base station; this is known as a wireless as-hoc network. Widespread networks of inexpensive wireless sensor devices offer a substantial opportunity to monitor more accurately the surrounding physical phenomena's when compared to traditional sensing methods [3]. Wireless sensor network has it own design and resource constrains [4]. Design constrains are related with the purpose and the characteristics of the installation environment. The environment determines the size of the network, the deployment method and the network topology. Resources constrains are imposed by the limited amount of energy, small communication range, low throughput and reduced storage and computing resources. Research efforts have been done to address the above constrains by introducing new design methodologies and creating or improve existing protocols and applications [1,2]. Sensor nodes are the elementary components of any WSN and they provide the following basic functionalities [1-2,7]:

1. Multi Variant Data Sensing.
2. Storage of the sensed data.
3. Data Processing & Analysis.
4. Sensing for Self.
5. Scheduling and execution of the programmed sensing tasks.
6. Node configuration in the network.
7. Environment Sensing.
8. Self Organization and Coordination.
9. Sleep & Awake Mode Processing.
10. Node Recognition and data exchange within own network.

Sensor node is composed of one or more sensors having signal conditioning unit, an analog-to-digital conversion module (ADC), a central processing unit (CPU), memory, a radio transceiver and an energy power supply unit as shown in Fig. 1. Depending on the deployment environment, it can be necessary to protect the sensor hardware against mechanical and Gas aggressions with an appropriate package.

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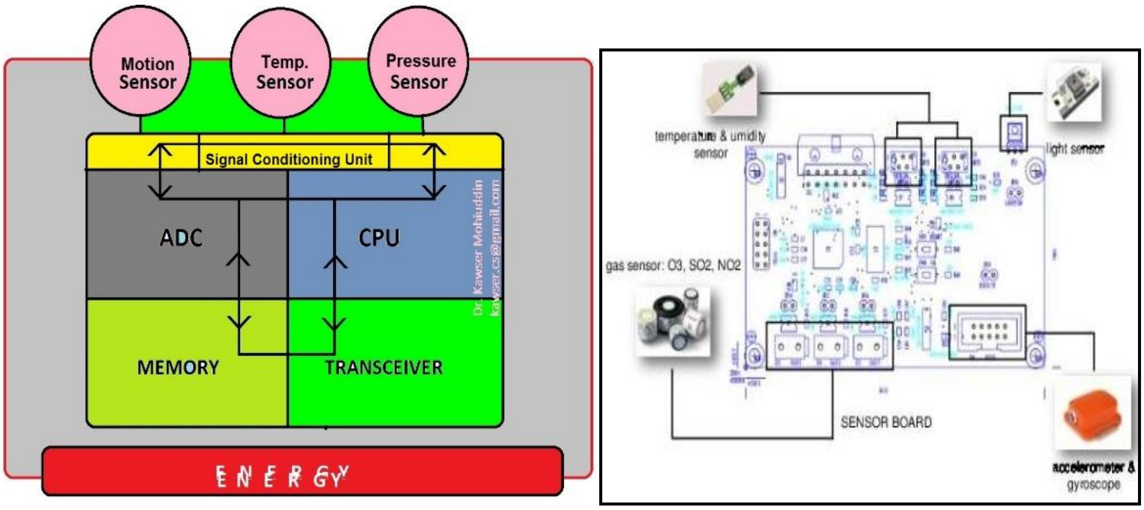

Figure 1: Hardware Layout and Motherboard Layout.

Applications of WSNs generally are used for some type of monitoring, tracking or controlling. More specific applications would be things like habitat monitoring, tracking objects, detecting fires or landslides, and monitoring traffic. Generally a WSN would be scattered in an area where its sensor nodes collect data. Area monitoring would involve a WSN being put in an area where some occurrence is being monitored. An example of this could be a country at war with another could place many nodes over a battlefield which would then detect enemy intrusion. These sensors would detect heat, pressure, sound, light, electro-magnetic fields, vibration, etc.), if a sensor were to go off it would be reported to a base station (a message could be sent through things like the internet or satellite). Another form of area monitoring could be detecting vehicles (motorcycles to train cars). Environmental monitoring is similar to area monitoring but is a little different because generally the application of these sensors aren’t long lasting projects because of what is being monitored. Usually environmental monitoring would be monitoring the state of permafrost in the Swiss Alps, monitoring coastal erosion, or glacier monitoring. Greenhouse monitoring would involve monitoring the temperature and humidity levels inside a green house. If the temperature and/or humidity drops the sensor could notify the manager of the green house (through an email or text) or trigger misting systems, open vents, turn on fans, or control a wide variety of system responses.

II. SYSTEM REQUIREMENTS AND ARCHITECTURE

The architecture of the proposed system has been made simple to create and implement in any environment whether friendly or hostile. This system in addition to its purpose has ability to get deployed in various other environments, but it has been especially designed and developed for the outdoor environment sensing with respect to agricultural productions in any location or country. The requirements that adopting a WSN are expected to satisfy in effective agricultural monitoring concern both system level issues (i.e., unattended operation, maximum network lifetime, adaptability or even functionality and protocol self-configuration) and final user needs (i.e., communication reliability and robustness, user friendliness, versatile and powerful graphical user interfaces). The most relevant mainly concerns the supply of stand-alone operations. To this end, the system must be able to run unattended for a long period, as nodes are expected to be deployed in zones that are difficult to maintain. This calls for optimal energy management ensuring that the energy spent is directly related to the amount of traffic handled and not to the overall working time. In fact, energy is nevertheless a limited resource and the failure of a node may compromise WSN connectivity as the network gets partitioned. Other issues to be addressed are the capabilities of quickly setting-up an end-to-end communication infrastructure, supporting both synchronous and asynchronous queries, and of dynamically reconfiguring it. An additional requirement is robust operative conditions, which need fault management since a node may fail for several reasons. Other important properties are scalability and adaptability of the network's topology, in terms of the number of nodes and their density in unexpected events with a higher degree of responsiveness and reconfiguration abilities. This also has the development of a plug and play sensor interface and the provisioning of remote connectivity. Figure 2 shows the design architecture of the proposed model.

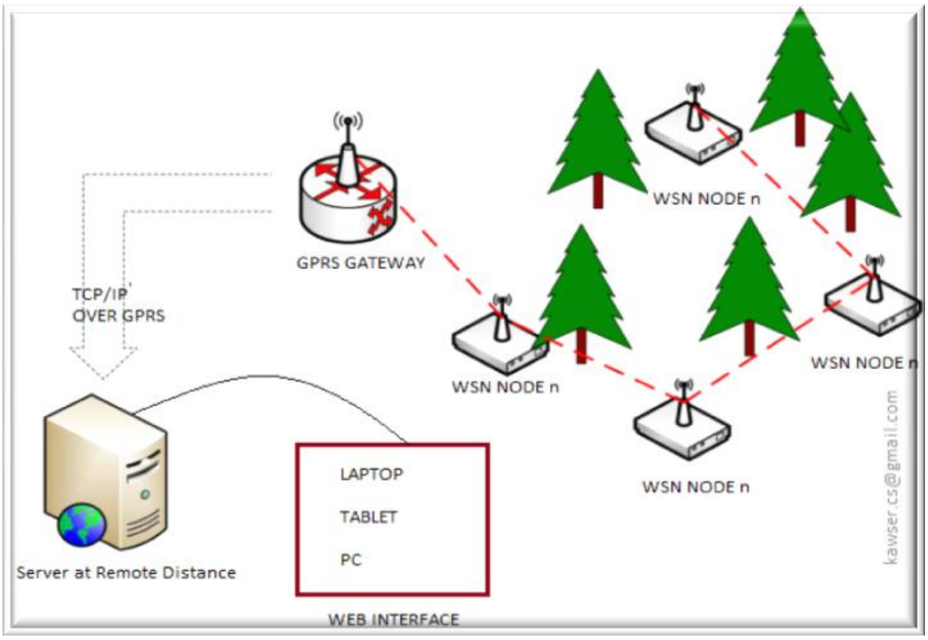

Figure 2: Architecture and Field Deployment

2.1. Sensor Requirements

In this paper we are providing a single solution to multiple issues. Typically a sensor node contains single sensor for a particular purpose. We argue the use of multiple sensors integrated into a single unit so that we can harness all the required results from a single node. We look into these separate nodes for their makeup and working mechanism. The various kinds of sensor nodes for special use in our work include the sensor nodes having capability to sense the light, heat, motion and various other gas reactions in the environment.

2.1.1. Motion Sensing Nodes

These are the wireless motes responsible for detection of every kind of motion in the monitoring field. This will provide the live movements in the agri fields caused by human being, animals, birds or the winds. They are helpful in relaying the physical movements across the agri fields covering the entire area. However there are other various things that have no physical look and can't be seen by human eye like Temperature, Pressure, Gases in the fields etc. We have deployed separate kind of sensors in the field embedded and integrated on a single board having a common battery backup and transmission exchange interfaces. The wireless motion sensor works in a special manner by monitoring the given area, capturing the data and transmitting the same to the server for further processing. These nodes have been designed and placed in a best manner to tackle every situation. Let's have a look upon the layout deployment in the agri field also shown in Figure 3.

[1]. Keep sensors 10 -15 feet away from heating vents, where the sunlight shines in, and radiators. If a motion sensor detects a swift change in heat, even that of a cloud passing quickly over direct sunlight shining into your living room, it could be tripped.

[2]. Place motion sensors at "choke-points"—areas where men have to walk through, like the stairwell or main hallway. That way, an intruder will trip the sensor regardless of where they are headed. Intruders usually go right for the master area, so put a sensor in a possible stealthy manner.

[3]. Motion sensors work best when the intruder walks parallel to the sensor, not toward it. For example, in a hallway you tend to walk parallel to the walls, not directly toward them. Find places that an intruder would walk alongside, like a hallway or narrow pathway that leads to a room.

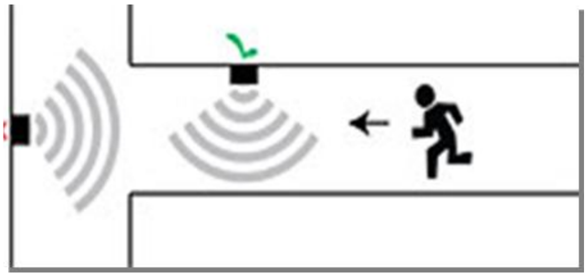

Figure 4: Placing of the sensor nodes in agri-field.

Features:

- Automatic body IR sensor light switch
- Time delay automatically switch off
- Light Control Induction: 6LUX (IR induction)

- Operating Voltage: AC 220V
- Detection Angle: 115 degrees
- Delay Time: 40s
- Sensor Probe Size: 23mm
- Sensor Type: Light control.
- Power: <200W (energy saving lamp), <500W (incandescent lamp)
- Size (L x W x H): Approx. 6.4 x 3.8 x 2.8cm
- All stainless steel construction
- Zero & span adjustment
- Wide operating Motion detection range
- Outstanding performance & stability
- Reverse polarity protection
- Short circuit protection.

2.1.2 Temperature Sensing Nodes

These are the nodes having facility to sense and relay the prevailing temperature in the monitoring field around the distance of 2 km for a particular node. We are introducing the use of ADAM-2000Z series. It utilizes the IEEE 802.15.4 standard I/O and latest sensor technology whilst supporting 2.4GHz mesh networking to provide the flexibility and build a cost-effective distributed monitoring system. The wireless ADAM-2000Z series includes six modules, including a Modbus/RTU gateway, router node, and I/O and the sensor devices listed below. The network topology can be Star / Tree / Mesh. The ADAM 2031Z is a wireless Temperature Sensor with operating range -20 to 70degC and Humidity Sensor with operating range of 0-100%. To learn more about the ADAM-2000 series Video on ADAM-2000 series. It has a variety of features for the proposed project:

- Easy maintenance and field installation
- Low duty wireless communication
- Smart and simple indicator design
- 1 Temperature Sensor, 1 Humidity Sensor
- Outdoor range up to 200 m
- Supports battery input with 2 x AA Alkaline batteries

Node Specifications:

LED Indicators	Ext PWR, Error, Status, Level Index
Connectors	1 x plug-in terminal block (#14~22 AWG)

Channels	1 Temperature Sensor 1 Humidity Sensor
Resolution	Temp. Sensor: 0.02°C (0.04°F), Humidity Sensor: 0.15%RH
Operating Temp	-20~70 °C (-4~158 °F)
Operating Humidity	20~95 %RH

Wireless IEEE Standard: 802.15.4

Frequency Bands	ISM 2.4 GHz (2.4 GHz ~ 2.4835 GHz)
Transmit Power	3±1 dBm
Outdoor Range	100 m
Receiver Sensitivity	-97 dBm
RF Data Rate	250 kbps
Power Input	Unregulated 10~30 VDC Battery Input: 2xAA Alkaline 3 VDC

2.1.2. Pressure Sensing Nodes

These nodes have a wide range of ability and applications. Pressure is caused by any of the factors depending upon the saturation of any such substance in the monitoring fields. The excessive rains may increase the water levels and pressure exerted by presence of the excess water will be relayed to the server for immediate action. Sometimes the excessive presence of certain gases including smoke etc. may occur and will be also reported to the base station server. The node used in the project must have contain the below features and specifications to meet achieve the desired and quality results.

Features:

- All stainless steel construction
- ±0.3% Combined error
- Industrial standard 4 to 20 mA output
- Zero & span adjustment
- Wide operating temperature range
- Integral O-ring seal
- Outstanding performance & stability
- Reverse polarity protection
- Short circuit protection

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Specifications:

Pressure Range:	0 to 1500 Bar
Burst Pressure:	2400 Bar
Output Span:	4 to 20 mA
Output Type:	2 wire
Zero Offset:	±1.0 % of full scale
Span Tolerance:	±1.0 % of full scale
Combined Error:	±0.3 % of full scale
Repeatability:	±0.1 % of full scale
Long Term Stability:	±0.2 % of full scale / 6 months
Supply Voltage:	13 to 36 VDC
Intrinsic Load:	3 µA/V
Load Driving Capacity:	1150 Ω @ 36 VDC
Load Resistance:	≤(Vs-13.0)/(0.02)
Insulation (Conn. to Case):	100 MΩ @ 100 VDC
Load Resistance:	≤(Vs-13.0)/(0.02)
Zero Adjustment:	±10.0 % of full scale
Span Adjustment:	±10.0 % of full scale
Pressure Media Material:	SS316
Media Temperature:	-20 to 85 °C
Ambient Temperature:	-40 to 90 °C
Thermal Effect on Zero:	±0.04 % of full scale
Thermal Sensitivity:	±0.04 % of full scale
Mechanical Shock Tolerance:	15 g @ s (11 mS)
Vibration Tolerance:	10 g to 50 Hz
Ambient Humidity:	≤95 %

Pressure Connection:	½" BSP Male
Electrical Connection:	DIN Plug
Environmental Rating:	IP65
Sensor Weight:	90 g

III. IMPLEMENTATION

A number of n Sensor Nodes are deployed in the agricultural field or forest etc. linked with each other through a wireless connection. The inter-node distance has been fixed as 2 km. Every node is equipped with sufficient hardware programming instructions to integrate the three sensing capabilities for onward transmission to the gateway. The gateway is being operated on GPRS can establish a live session with the remote server using TCP/ IP. The actual data acquisition is done with the help of sensor nodes and transmitted via wireless links within its own network to the server. The remote server on the other side can be accessed using any of the web interfaces i.e. laptop or any cellular devices etc. Each node in our sensor network is configured first and mapped with the base station node and thus can only be accessible to its base node to avoid any possible compromising of the nodes or its data exchange in the network. All the nodes have been arranged in a tree topology fashion as per the agri field requirements. The agricultural area under our project is a rectangular area having length of 20 km long and16 km wide. Figure 5 shows the node layout in the said agri land with any array of 8 x 10 nodes. The total end node strength in the said project is 80. Besides the 80 end nodes there are 2 cluster heads nodes and various other passive nodes on standby. The nodes are having the best battery backup that can last for the minimum period of 10 days. The Figure 3 shows the node deployment as per the area requirement. The given area is put under the tree topology of the sensor nodes. There are 80 nodes divided into a matrix of 8 x 10 pattern ranging from A1 to H10. The horizontal lines are denominated by 8 alphabets from A through H. The node number ranges from A1 to A10 for the first row up to 8^{th} row i.e. H1 to H10. In every row there are 10 nodes at the distance of 2 km each. The horizontal distance of the area is 20 km and is thus divided into 10 sections having 10 sensor nodes deployed at the distance of 2 km each. While as the vertical distance of the agri land is 16 km and contains 8 nodes at the length of 2 km each. Every node will be responsible for its own area only from 0 km to 2 km. The TCP/ IP layers in accordance with the system will work in a systematic fashion. The end nodes (n nodes) serve for data acquisition purpose and provide physical interface for the system and the surrounding environment. On the other server side there are other interfaces like laptop or PC that will produce output to the user.

Data captured by any of the sensors mounted on a single board is continuously transmitted to the base station/ server for user information and analysis. Motion sensors detect every movement caused by any agent including human being, birds, animals or the blowing winds. The motion sensor gets immediately activated on occurrence of every little movement and this information is transmitted upwards for processing at server side. However at no motion from anywhere these sensors will relax and thus helping in the the extension of battery life too.

Figure 5: n Node Layout and Deployment

Sensor = 1, Mode = 1, Acquisition = 1, Transmit = 1 /Data being transmitted/

Sensor = 0, Mode = 0, Acquisition = 0, Transmit = 0 /No data available/

Sensor = 1, Mode = 1, Acquisition = 0, Transmit = 1 /Empty packets transmitted/

Data to be acquired by sensor nodes is of various types and varying in nature. It can be motion detections, temperature detections or pressure detection. All these detections can be positive or negative and are accordingly transmitted to the server via GPRS gateway. The data received at the server side by users is continuously being monitored and analyzed for every possible requirement. This model works smoothly when executed properly as per the specifications and under the expert management.

IV. CHALLENGES FOR ENVIRONMENTAL SENSING

Environmental sensing with reference to the large area agricultural monitoring is slightly a difficult process. A large number of issues need to be considered and taken well care of everything to achieve the desire and satisfactory results. Following are various common challenges needed to be timely addressed and looked into properly.

4.1 Power Management

This is essential for long-termoperation, especially when it is needed to sensing remote and hostile environments. Harvesting schemes, cross-layer protocols and new power storage devices are presented as possible solutions to increase the sensors lifetime.

4.2 Scalability

A wireless sensor network canaccommodate thousands nodes. Current real WSN for environment proposes the use of tens to hundreds nodes. So it is necessary to prove that the available theoretical solutions are suited to large real WSN.

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2.3 Remote Management

Systems installed on isolatedlocations cannot be visited regularly, so a remote access standard protocol is necessary to operate, to manage, to reprogramming and to configure the WSN, regardless of manufacturer.

2.4 Usability

The WSNs are to be deployed by users whobuy them off the shelf. So, the WSN need to become easier to install, maintain and understand. It is necessary to propose new plug and play mechanisms and to develop more software modules with more user-friendly interface.

2.5 Standardization

The IEEE 802.15.4 represents amilestone in standardization efforts. Although, compatibility between of-the-shelf modules is in practice very low. It is important to specify standard interfaces to allow interoperability between different modules vendors in order to reduce the costs and to increase the available options.

2.6 Size

Reducing the size is essential for manyapplications. Battery size and radio power requirements play an important role in size reduction. The production of platforms compatible with the smart dust can be determinant in WSN environmental sensing.

2.7 IP end-to-end connectivity

Originally it was notthought appropriate the use of IP protocol in WSN networks, because of the perception that is was to heavy weight to the WSN nodes resources. Recently, the industry and the scientific community start to rethink many misconceptions about the use of IP in all WSN nodes. Supporting IPv6 on sensor nodes simplifies the task of connecting WSN devices to the Internet and creates the conditions to realize the paradigm of Internet of Things community. Additionally, by using IPv6 based protocols, users can deploy tools already developed for commissioning, configuring, managing and debugging these networks. The application developing process is also simplified and open.

2.8 Support other transducers verities

Environmentalsensing usually uses limited type of transducers, such as temperature, light, humidity and atmospheric pressure. New environmental sensing applications will be developed and new transducers will be necessary to measure new physical phenomena, for example image and video. Transmit images and video on resources and power constrained networks are a challenge.

V. CONCLUSION AND FUTURE WORK

In this paper we have developed a model for Sensor based Environment Sensing with respect to the Agricultural Monitoring and Production. We used a variety of sensor nodes for different purposes embedded on a single board apparently looking as a single sensor node. The Motion sensors detected the motions and

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other movements caused by human being, birds, animals or the winds. On the other hand temperature sensors continuously monitored the temperature and relayed to the server. The pressure sensors acquired the data related to pressure caused by excessive or lesser presence of the water, pressure caused by excess or lack of certain gases etc. This Model yielded best results thus helps in decreasing the manual labor force and increasing the precision and quality agriculture. We argues that WSN technology must be much developed and utilized in a much better way for the agricultural development in India or in any other countries.

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