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Architecture Based on Environmental Monitoring System using ZigBee Wireless Sensor Networks

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Abstract

Wireless Ad hoc sensor nodes are playing an important role in wireless data transmission infrastructure in various environmental monitoring systems. Due to its compact size and energy efficient structure these nodes can be successfully deployed in wireless Ad hoc infrastructure. Recent developments wireless sensor technologies have provided the environmental management systems with capabilities of real time remote environmental monitoring system. We propose system architecture for wireless sensor networks and a database model for handling and storing sensor data stream in real time. The ZigBee wireless sensor networks is useful especially in monitoring or detecting possible natural disasters and reporting on it almost at real-time. A web based application developed to enable remote online access to wireless sensor network data with interactive data retrieval and visualization functionalities. The advantage of modular architecture is minimizing the software upgrade down time and enables hardware reusability.

Keywords:- ZigBee Network, Wireless Sensor Network, Disaster, Modular Architecture, Database Model.

1. Introduction

A Wireless sensor network (WSN) is a self configured and infrastructure less wireless networks. It consists of a number of sensors nodes (few tens to thousands) working together to monitor a region to obtain data about the environment. There are two types of WSNs: structured and unstructured. Unstructured WSN contains dense collection of sensor nodes and often deployed in ad-hoc manner in the field. In an ad-hoc deployment, sensor nodes can be dropped from a plane and randomly into the target area. In structured WSN on the other hand, all or some of the sensor nodes are deployed in a pre-determined locations. Structured network has fewer nodes and can be deployed with lower network maintenance and management costs.

A wireless sensor network (WSN) to monitor physical or environmental conditions such as temperature, sound, pressure, vibration, pollutants and to cooperatively pass their data through the network to a main location, where the data can be observed and analyzed . Wireless sensor networks have application of fields such as climate control, environmental monitoring, military surveillance, structural health monitoring, medical diagnostics, disaster management and emergency response [4]. The sensor nodes can communicate among themselves using radio signals and they have limited processing speed, storage capacity and communication bandwidth. The ZigBee Wireless Networks based on the IEEE Standard 802.15.4 as specifications, this wireless sensor networks (WSN) consists of light-weight, low power and small size sensor nodes (SNs). They have ability to monitor, calculate and communicate wirelessly. A set of applications require simple wireless connectivity, relaxed throughput, very low power, short distance and inexpensive hardware e.g. Industrial, Agricultural, Vehicular, Residential, Medical etc. Global climate change and atmospheric warming is increasing the occurrence of extreme climate phenomenon with increasing severity, both in context of human living as well as economic losses.

Authorities need to be better equipped system to control the natural disaster phenomena to face these global truths [4]. Now, wireless sensor networks have become one of enabling technologies for disaster early warning systems, event detection functionality of WSNs can be great help in the context of meteorological natural hazards, wild and residential fires. Wireless sensor network can be useful to disaster management in two ways.

Firstly, WSN has powerful early warning system and secondly provides a system able to learn about the phenomena of natural disasters. Wireless sensor network has the ability of quick capturing the image and processing then transmission of basic information continuously in real time with high resolution [3]. Efficient disaster detection and alerting system could reduce the loss of life and properties. When the event of disaster we use good search and rescue system with high level of precision, timeliness and safety for both the victims and rescuers [1]. Environmental monitoring comprises the processes, actions and data collection methods used to observe the condition of the environment. Examples of environmental data are an important input to many agricultural models, since crop yields depend on environmental conditions. To achieve a reliable and wide foundation for managing agricultural environment, there is a desperate need for data with high spatial resolution, wide thematic range and high thematic resolution [14].

2. Related work

2.1 Environmental Monitoring

WSNs have become an important tool in environmental monitoring. The relatively low cost of the devices allows the installation of a dense population of nodes that can adequately represent the variability present in the environment. They can provide risk assessment information, like for example alerting farmers at the onset of frost damage and providing better microclimate awareness. Another example of climate supervision is flood prediction by means of wireless sensors which can detect rainfall, water levels and weather conditions. The sensors supply information to a centralized database system [16]. The wireless nodes with moisture sensors were located at predetermined locations; geographic coordinates of these points were obtained with GPS and then, all the information was evaluated using the GIS. developed a wireless data transmission system using wireless ZigBee motes, developed to remotely monitor in real time sediment runoff at a low-water crossings. The gateway transmitted the sensor signals to an Internet server using the GPRS [15].

2.2 Precision Agriculture

The development of WSN applications in precision agriculture makes it possible to increase efficiencies, productivity and profitability in many agricultural production systems, while minimizing unintended impacts on wildlife and the environment. The real time information obtained from the fields can provide a solid base for farmers to adjust strategies at any time. Instead of making decisions based in some hypothetical average condition, which may not exist anywhere in reality, a precision farming approach recognizes differences and adjusts management actions accordingly [15].

2.3 Greenhouses

The Automation and efficiency is crucial in greenhouse environment monitoring and control. In order to control and monitor the environmental factors, sensors and actuators are essential. Greenhouse crops can benefit a lot from the use of WSNs, because inside the greenhouse the crop conditions such as climate and soil do not depend on exterior factors and the implementations are thus easier than in outdoor applications. The first application of WSN in a greenhouse was reported in the year 2003. It was a monitoring and control system developed by means of Bluetooth [15]. Since then, several applications have been developed, most of them making use of IEEE 802.15.4/ZigBee to monitor and control the environment in greenhouses.

3. Different Wireless Sensor Network Architectures for environment

3.1 Water Monitoring System

A water environmental monitoring system based on a wireless sensor network is proposed. It consists of three parts: data monitoring nodes, data base station and remote monitoring center. This system is suitable for the complex and large-scale water environment monitoring, such as for reservoirs, lakes, rivers, swamps, and shallow or deep ground waters. The data from the monitoring nodes is transferred to a remote monitoring center by the base station via a GPRS network; the monitoring center analyzes and processes the water quality parameters, gives an alarm for emergencies like water contamination, in addition any sudden changes in water quality, and provides support for decision making in prevention and remediation of water contamination; the end-user can also realize an all weather detection on the target water area via the Internet. The whole water environment monitoring system presents useful characteristics as large network capacity, flexible disposition, low power consumption, low cost, and minor influence on the natural environment [16].

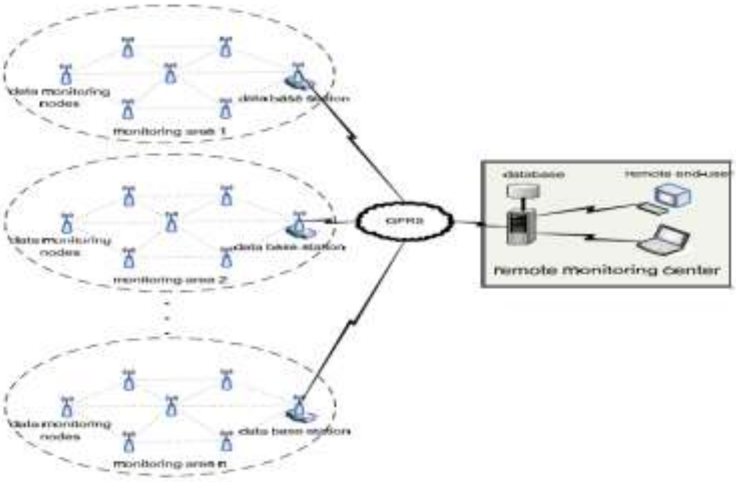

Figure 1: Water environment monitoring system based on WSNs [16].

3.2 Flood and Water Level Monitoring System

Figure 2 shows a pictorial view of the deployment of sensor nodes and data aggregation. This can be made possible with the help of communication technology employed on top of wireless sensor networks. The system development involves the various phases and all phases are equally important. Starting with the first phase of data collection, first level is to deal with the physical deployment of sensing devices in the riverbanks and implementation of an effective localization scheme depending on the situation and environment. The flow path of the river, past records of water flow and future prediction of the route of the river, influence the placements of the wireless sensors. These sensors form clusters to communicate with the local base stations. The local base stations are powerful enough to communicate with one another directly using wireless communications [11]. Figure 3 shows various phases used for monitoring system.

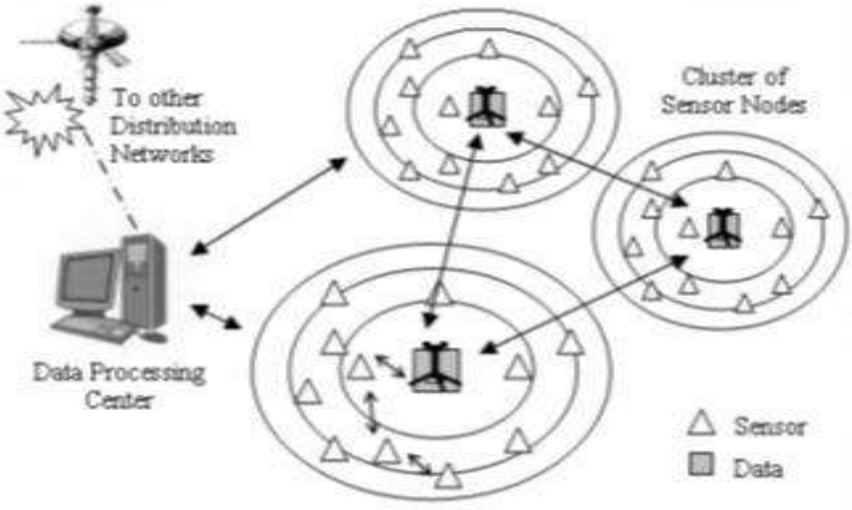

Figure 2: Data collection and aggregation in wireless sensor network [6].

The data sent from the sensors are aggregated in the local base stations to provide inputs to the data processing centers. Second level to deals with the setup of local base stations as well as with data communication at district level. Third level could be involved with the central monitoring system at the headquarters to process acquired data. Data analysis then takes place either at headquarter or at outside research centers that particularly do high-risk flood analysis.

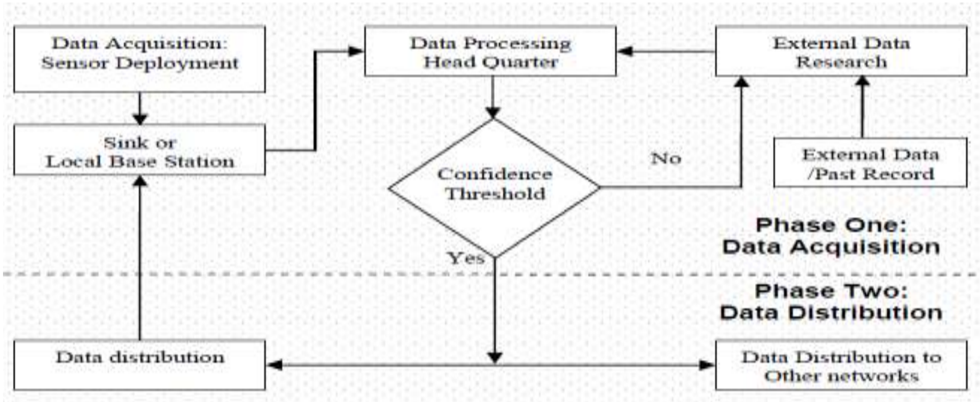

Figure 3: Smart System aided with Wireless Sensor Network [3].

3.3 Earthquake Detection Monitoring System

In figure 4 we show the System Architecture for the detection of earthquake. Each sensor detects earthquake event every sampling period based on seismic frequency spectrum using the system architecture in figure 5. Different studies show that the recurrence based finder has better location execution, when the sensor gets higher sign vitality [13]. The base station first chooses a negligible subset of instructive sensors in light of the sign energies got by sensors while fulfilling framework detecting quality prerequisites. The selected sensors then compute seismic frequency spectrum using Fast Fourier Transform (FFT) and make local detection decisions which are then transmitted to the base station for fusion. In addition to the detection of earthquake occurrences, node level earthquake onset time is critical for localizing earthquake source. In this approach, the base station first distinguishes an individual seismic tremor and gauges a coarse onset time [3].

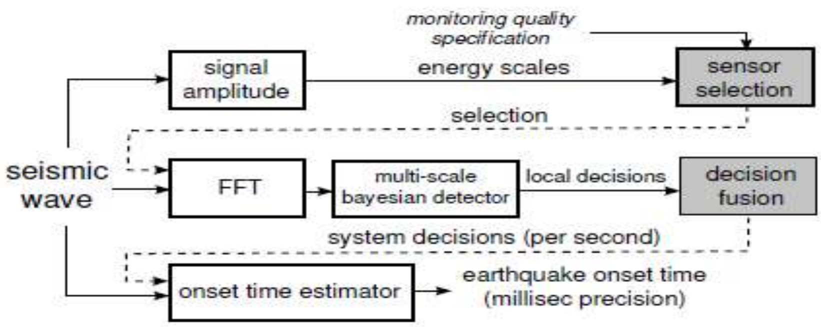

Figure 4: System Architecture for the detection of earthquake [6].

3.4 Forest Fire Detection Monitoring System

In figure 5 large numbers of sensor nodes are densely deployed in the forest. These sensor nodes are organized into clusters, so that each node has a corresponding cluster header. Sensor nodes can measure environment temperature, relative humidity and smoke. In that case we use wireless equipment's such as Global Positioning System (GPS), through GPS to know the exact location information where forest fire. Every sensor node sends measurement data, as well as the location information to the corresponding cluster head. The cluster header calculates the weather index using a neural network method and sends the weather index to the manager node via sink. The sink is connected to a manager node via a wired network. A few wind sensor nodes are manually deployed over the forest and connected to the sink via wired networks to detect wind speed. The manager node provides two types of information to users: (1) Emergency report for abnormal event (e.g. smoke or extremely high temperature is detected); (2) real-time forest fire danger rate for each cluster based on the weather indexes from the cluster header and other forest fire factors [6].

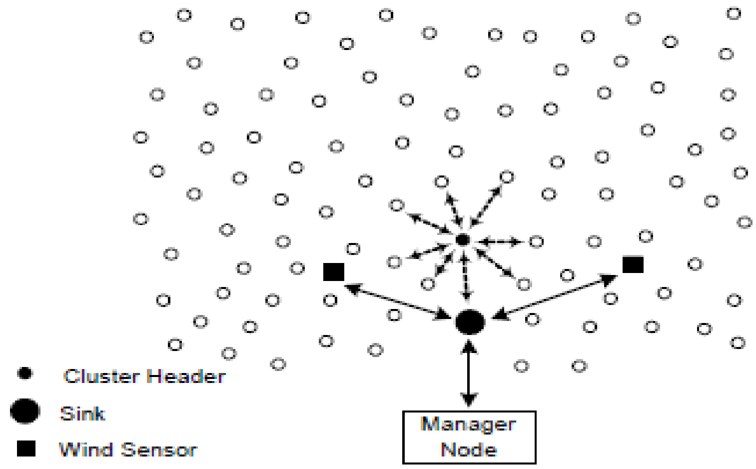

Figure 5: Wireless sensor network for real-time forest fire detection [6].

4 Problem Statements

Power consumption remains to be the central design consideration for WSNs, whether they are battery powered or energy harvesters. The sensor node lifetime typically exhibits a strong dependency on battery life. In many cases, the wireless sensor node has a limited power source, and replenishment of power may be limited or impossible altogether. The power management and power conservation are critical functions for sensor networks. Other problems are Localization, Security and Privacy etc.

5. Methodology

5.1 WSN System Architecture

The proposed system architecture consists of sensor nodes located in critical locations within crop field (vineyard in this case) for collecting weather, atmospheric and environmental data as well as plant related data such as leaf wetness and sap flow. Figure 6 shows the system architecture consists of three layers namely, mote layer, server layer and application layer.

Mote layer: This layer consists of all the wireless sensor nodes and a Base Station (BS). Each node has one or more sensors plugged into the hardware device with a transmitter, power supply and microcontroller. The nodes are distributed over an area of interest uniquely arranged in a manner that the distance between the nodes does not exceed the maximum RF communication range. Therefore, energy optimized routing becomes essential. Data transmission from sensor nodes to the BS depends on application maybe continuous, event driven, query-driven or hybrid. In continuous approach, data is transmitted to the BS periodically according to predetermined intervals. In query and event driven models, data is transmitted when an event takes place or a query is generated from the BS. The Hybrid model uses combinations of these approaches to transmit data from sensor nodes to the BS. Various types of routing protocols such as data-centric, hierarchical and location-based protocols are available.

Server layer: Data are sent to the data server from the BS through the internet. Two main tasks performed by data server are one way to obtain and process data from the BS and other way using populate database with WSN data enabling the application layer to access WSN data. The server layer also deals with on-time data delivery from the BS and generates alarm when an undesirable event takes place.

Application layer: This layer allows users of the system to have remote access to WSN data using web browsers. This provides a powerful tool to visualize real-time WSN data and compare data from various nodes. In addition, the BS can be accessed remotely to modify sensor nodes' configurations.

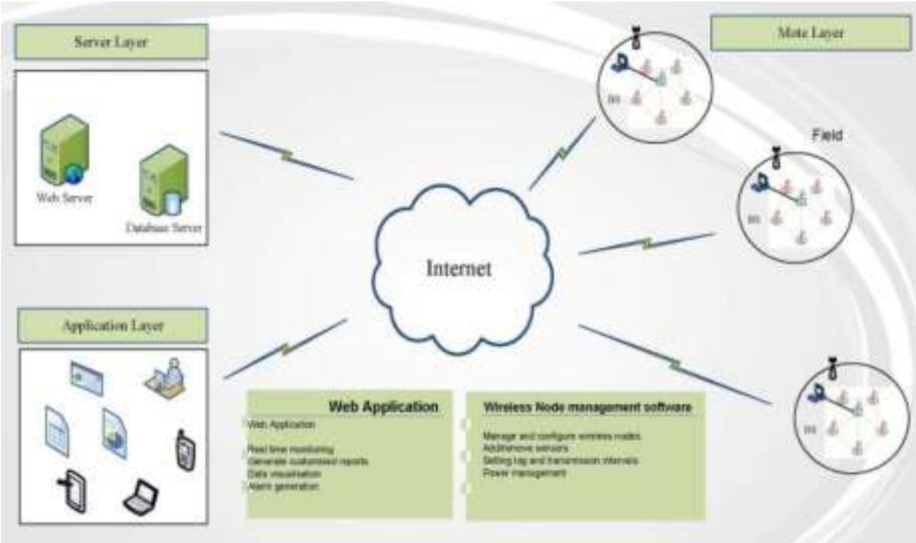

Figure 6: A schematic view of WSN architecture [14].

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5.2 Modular Sensor Architecture

During the past few years modular sensor node architecture shown to be popular due to increasing demand on more energy efficient micro processors, accurate and sensitive sensor developments, improved wireless radios and improvement of wireless software architecture for efficient data management. Modularity design imposes greater flexibility for the end product. Same node can be utilized for specific application equipped with required sensor modules. This is highly desirable when each sensor node collecting microclimate, atmospheric and plant data within different vineyards requires different sets of sensors. Figure 7 illustrates the building blocks of the proposed modular sensor design. The wireless microcontroller module controls the whole data communication aspect, while sensor data coordinating microcontroller module, collects and calibrates the data. It is possible to introduce various types of sensor modules required by application.

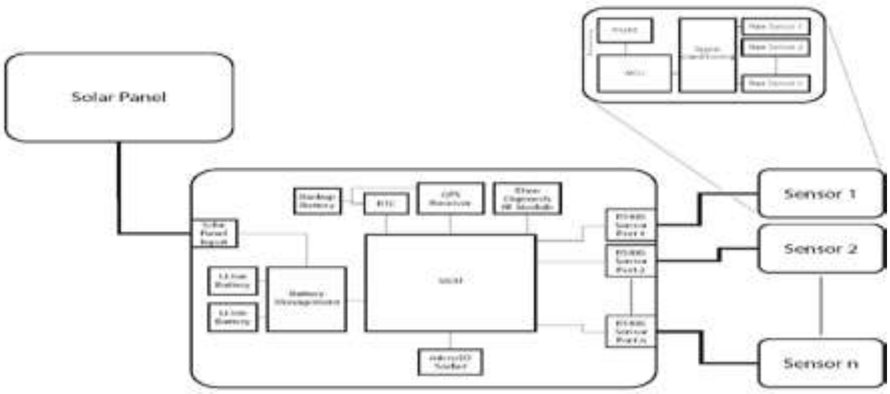

Figure 7: Building blocks of sensor node [14].

Table 1: List of sensors group and sensor [14].

Sensor Group	**Sensor Type**
CLIMATE	Air Temperature , Air Pressure , Humidity , Wind Speed ,Wind Direction and Rainfall
SOIL	Soil Temperature and Soil Moisture
PLANT	Leaf Wetness and Sap Rise
GASES	Carbon Monoxide (CO) ,Carbon Dioxide (CO_2) Ozone (O_3) and Methane (CH_4)
Radiation	UV Radiation and Solar Radiation

Table 2: Summary of disaster management [4]

Parameters	**Different Types of Disasters**			
	Earth Quake	**Volcanic Eruption**	**Storm**	**Tsunami**
Nature of Waves generated	Seismic waves have been generated	"A" waves or "B" waves have been generated	Cone shape waves have been generated	Harbor waves have been generated
Types of Parameters to be measured	Movement of Tectonic plates, Pressure below the earth's Surface	Movement of Tectonic plates, Temperature below the earth's Surface , Pressure	Speed of the wind, direction of the wind, humidity of the wind, Temperature of the	Movement of Tectonic plates, under sea pressure, height of the tides, water level height

		below the earth's Surface	wind	
Instruments to be used for measuring the disaster	Seismometer	Thermal monitoring, Hydrology monitoring, Cloud sensing, Gas sensing	Weather radar	Deep ocean Tsunami Buoys

Wireless Sensors (WS) measured based on the physical parameters of different types of disasters occur in mention of the above table 2, we detect a disaster region by nature of waves generated and prevents the disaster that is going to happen. If disaster occur minimum losses. The rescue teams properly to save victim in disaster affected area and health services provided at limited time span. We use different sensor type for different sensor groups in environment monitoring their design and implementation require.

CONCLUSION

The different types of disasters detection and alerting the system to reduce losses due to the occurrence of natural and man made disasters in worldwide. Wireless Sensor Networks (WSN) helps in disaster management to reduce the mass destruction and huge loss due to climate change by determining the amount of disaster occurred in a particular location. The Wireless Sensors (WS) measured based on the physical parameters of different types of disasters occur, appropriate remedial actions can be taken. Telecommunication infrastructure very much useful to save the life of thousands of people in critical emergency circumstances. The ZigBee wireless sensor networks is useful especially in monitoring or detecting possible natural disasters and reporting on it almost at real-time. However, this use also requires the networks to be as energy efficient as possible, to be accurate in reporting its location, and to endure the environment where it has been deployed and have a long lifetime.

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