Application Domain of Wireless Sensor Network: - A Paradigm in Developed and Developing Countries

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Abstract

Wireless sensor networks are network of small sensing devices, which collaborate with each other to gather process and communicate over wireless channel information about some physical phenomena. These self-organizing, highly robust and energy efficient networks can be excellent sentinels for monitoring underground mining, wildlife and various physical infrastructures such as bridges, pipelines, and buildings. The smart sentinels go by the name wireless sensor networks and interface the physical world with computers, thereby creating a profound flexibility for awareness and remote controlling. They are characterized by their little demand for attention from human operators, their capability of self-management; operation in adverse places and near the occurrence of the actual phenomena; great accommodation of node mobility or failure; and effective node cooperation in order to carry out a distributed sensing task. But the fact that most previous research revolved around military applications. Sensors integrated into structures, machinery, and the environment, coupled with the efficient delivery of sensed information, could provide tremendous benefits to society. Potential benefits include: fewer catastrophic failures, conservation of natural resources, improved manufacturing productivity, improved emergency response, and enhanced homeland security. This paper introduces wireless sensor networks, identifies specific application domains and investigates their scope and usefulness in real world. We also present survey of current scenario of wireless sensor networks in developed and developing countries. Application domains in developed countries are Industrial Automation and Civil Structure monitoring, in contrast application domain in developing countries are Environmental Observation and Forecasting, Disaster Prevention, Agricultural Management.

Keywords : *WSN, self-organizing, Remote controlling, Energy efficient.*

1. Introduction

Recent advances in computing and communication have caused a significant shift in sensor network research and brought it closer to achieve the original vision. Small and inexpensive sensors based upon micro-electro-mechanical system (MEMS) technology, wireless networking, and inexpensive low-power processors allow the deployment of wireless ad hoc networks for various applications. Though Wireless applications were originally developed for the military applications but small smart micro-electronic nodes can deal with those problems, which require duly reporting of properties of a cer tain physical phenomena. The relative simplicity, smallness in size and affordable cost of wireless sensor nodes permit heavy deployment in places or objects in which a sensing task is carried out. Sensors integrated into structures, machinery, and the environment, coupled with the efficient delivery of

sensed information, could provide tremendous benefits to society. Potential benefits include: fewer catastrophic failures, conservation of natural resources, improved manufacturing productivity, improved emergency response, and enhanced homeland security. Today, sensor networks hold the promise of improving conditions in many areas as well as leading to entirely unforeseen opportunities.

This paper introduces wireless sensor networks, identifies specific application domains and investigates their scope and usefulness in real world. We also present survey of current scenario of wireless sensor networks in developed and developing countries and new application domain in developing countries. Application domain in developed countries are Industrial Automation, Structural Heath Monitoring and Civil Structure Monitoring, in contrast application domain in developing countries are Environmental Observation and Forecasting, Disaster Prevention, Agricultural Management.

The paper is organized as follows section 2 Wireless sensor Networks section 2 Application domains of Wireless Sensor Networks, Section 3 Developed and developing countries, section 4 WSN in developed countries, section 5 WSN in developing countries, section 6 Comparison, section 7 conclusion.

2. Wireless Sensor Networks

Sensor network development was initiated by the United States during the Cold War [1].The system called Sound Surveillance System (SOSUS)[2], network of acoustic sensors was placed at strategic locations on the bottom of the ocean to detect and track Soviet submarines. Human operators played an important role in these systems. The popularity of small handheld devices likes laptops, cell phones, PDAs, GPS devices, RFID, and intelligent computing devices are increasing day-by-day. This made the things cheaper, more mobile, more distributed, and more pervasive in daily life of human being. In this scenario, the emergence of wireless sensor networks (WSNs) is essentially toward the miniaturization and ubiquity of computing devices.

Wireless sensor networks are network of small sensing devices, which collaborate with each other to gather process and communicate over wireless channel information about some physical phenomena[3]. These self-organizing, highly robust and energy efficient networks can be excellent sentinels for monitoring underground mining, wildlife and various physical infrastructures such as bridges, pipelines, and buildings. They are characterized by their little demand for attention from human operators, their capability of self-management; operation in adverse places and near the occurrence of the actual phenomena; great accommodation of node mobility or failure; and effective node cooperation in order to carry out a distributed sensing task.

But the fact that most previous research revolved around military applications and that the basic assumptions for these applications may not hold for non-military commercial applications. In many practical applications, a good portion of the sensed data is accumulated at a control center, usually called a base station. The sensor nodes pre-process raw data and collaborate with each other on a meta-data basis to reduce the amount of data effectively transmitted to the base station which acts mainly as a gateway to the Internet, to a local area network (LAN), or to a stand-alone computing device. The destination computer eventually analyses the data and extracts meaningful information as a result of which an action can be carried out. This action can be carried out automatically by an actuator or manually by a human agent.

2.1 Wireless Network Model

Wireless Sensor Networks are resource limited, they are deployed densely, they are prone to failures, and number of nodes in WSNs is high orders. The major components of a typical sensor network are:

Sensor Field*:* A sensor field can be considered as the area in which the nodes are placed.

Sensor Nodes*:* Sensors nodes are the heart of the network. They are in charge of collecting data and routing this information back to a sink.

Base Station*:* The base station is a centralized point of control within the network, which extracts information from the network and disseminates control information back into the network. It also serves as a gateway to other networks, a powerful data processing and storage center and an access point for a human interface. The base station is either a laptop or a workstation. Data is streamed to these workstations either via the Internet, wireless channels, satellite etc.

User: User is the user of the information of wireless sensor network who uses the information to do desired task or take decision.

So, hundreds to several thousand nodes are deployed throughout a sensor field to create a wireless multi-hop network. Nodes can use wireless communication media such as infrared, radio, optical media or Bluetooth for their communications. The transmission range of the nodes varies according to the application.

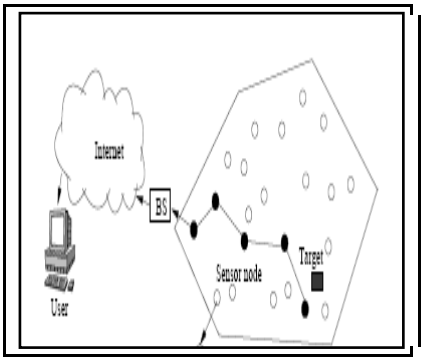

Figure1. Architecture of Wireless Sensor Network

3. Application Domain of WSN

The applications for WSNs are varied, typically involving some kind of monitoring, tracking, or controlling. In a typical application, a WSN is deployed in a region where it is meant to collect data through its sensor nodes.

- Environmental Observation and Forecasting
- Disaster Prevention
- Structure Health Monitoring
- Habitat Monitoring
- Area monitoring
- Environmental monitoring
- Greenhouse monitoring
- Landslide detection
- Industrial monitoring
- Machine health monitoring
- Water/Wastewater monitoring
- Landfill ground well level monitoring and pump counter
- Agriculture
- Fleet monitoring
- Smart aeration
- Lighting control
- Extensive traffic monitoring in large urban areas,
- Supply-chain monitoring in state-of -art production plants

4. Developed and developing countries

Developed country the word is used to describe countries that have a high level of development according to some criteria. There are no fixed criteria for categorizing the countries in category of developed and developing country. Some of them are Economic criteria like gross domestic product per capita, Industrialization [4]. More recently another measure, the Human Developemnet Index (HDI), which combines an economic measure, national income, with other measures, indices for life expectancy and education has become prominent. This criterion would define developed countries as those with a very high (HDI) rating [5]. Following are the countries which are cosidered as developed countries such as Australia, Austria, Canada, and France, Germany, Italy, Japan, Russia, UK, and US. Developing countries are which countries which are in transition of non-developing to developed. The countries which are more developed then some other countries but not developed like developed countries.[6] some of the developing countries are India , some middle-east countries like Iraq ,Iran, Brazil [7]

5. WSN in Developing Countries

Developing countries have a multifaceted challenge in utilizing and maintaining resources most dear to them. While the causes of inefficient utilization of resources are complex and their remedies may not be straightforward, we motivate the use of smart micro-electronic sentinels to deal with those problems, which require duly reporting of properties of a certain physical phenomena. In general, the most severe difficulties when applying Information and Communications technology (ICT) in developing countries are low capital, less device, less electricity supply and human force. In view of these challenges, wireless sensor devices can be well-suited for some application areas in less developed countries because they are relatively cheap; a sensor module is usually energized through a battery, solar or geothermal power; At the same time, both sensor hardware and protocols are constantly improving thereby further reducing total power consumption.

By this means, a sensor network can be operated independent of any external communication infrastructure or electricity network. From the large set of applications only subsets of the proposed applications are of interest to developing countries. Costs and effort required for deploying and maintaining a sensor network, probably substituting other technology in place that people are familiar with, have to be justified. We believe that sensor networks are relevant to developing countries in the following application areas, which are listed in descending order with regard to their importance:

5.1 Environmental Observation and Forecasting

Concrete applications that can be assigned to the first three application areas more or less directly affect the people's living conditions. Environmental Observation and Forecasting have many of the application like Volcanic Studies and Eruption Warning System, Meteorological Observation, Fire Detection, Earthquake Studies and Warning System, Water Quality Monitoring, Flood, Cyclone and Tsunami Warning System can be used to save the lives. An earthquake or volcano eruption warning system and monitoring of hazardous zones on a production plant can increase safety and prevent devastating incidents. A good warning system can effectively help to mitigate the damages caused by natural disasters [8].

- Example of this is a wireless sensor network consisting of three nodes was deployed on Volc´an Tungurahua in central Ecuador in 2004 [9]. The sensors were equipped with microphones and collected continuous data from the erupting volcano.
- In 2005, a larger and more capable network was deployed on Volc´an Reventador in northern Ecuador. An array of 16 nodes equipped with seism acoustic sensors was deployed over 3 km. The system routed the collected data through a multihop network and over a long-distance radio link to an observatory, where a laptop logged the collected data.
- In [8], the authors outline a system aided with sensor networks for flood controlling and warning in Bangladesh.
- In [10] the author describes two systems the first one is a system to understand the prevalence of arsenic in Bangladesh groundwater; the second one is a system to monitor nitrate propagation through soils and groundwater in California. First field experiments raise the hopes for future undertakings to come.

5.2 Disaster Prevention

In addition to the warning systems sensor networks can be used for hazardous workspaces like underground mining, steelworks, and refineries. Most of these places entail a high risk by nature which is amplified by poorly engineered constructions in developing countries. Wireless sensor networks can be deployed in underground mining for surveillance of deteriorating grounds, toxic gases, and unstable grounds. In refineries sensors can be used to track workers which can facilitate to alert an operator if someone accidentally enters a temporary hazard zone or to guide firefighters to the people in danger.

5.3 Agricultural Management

Similarly, the ability to retrieve soil moisture in real time enables efficient irrigation and agricultural planning which is especially important in semi-arid regions of developing countries. [11]. In order to map out a farming strategy that uses the available resources most effectively, information on the temporal and spatial variability of environmental parameters, their impact on soil, crop, pests, diseases, and other components of farming is needed [12][13].

- In [14], the authors present their experiences with the ongoing design of a decision support system for farmers, which use the wireless sensor network technology for the improvement of farming strategies in the face of highly variable conditions. The field study is carried out in rural Karnataka (India) and focuses on water conservation measures and the prediction of crop water requirements for deficit irrigation.

5.4 Habitat Monitoring

The same holds for habitat monitoring, where wildlife can be studied without unnecessary human intrusion in remote areas. of special concern are the disturbance effects of even well-intended researchers frequently trampling into the animal's habitat this can lead to distorted results by changing behavioral patterns or distributions or even reduce sensitive populations by increasing stress factors. In [15], the authors present their experiences with a deployed network of 32 nodes on Great Duck Island, Main. The goal was to monitor the behavior of storm petrel.

5.5 Structure Health Monitoring

As for structure health monitoring, safety, environmental, and commercial aspects come into play. Fast detection of a leaking oil pipeline can certainly reduce environmental damages and thus reduce negative impacts on the health of people and animals. At the same time, remote controlling of railroads and pipelines enhance effectiveness and help to reduce expenses. Structure health monitoring system includes detecting damage, localizing damage, estimating the extent of the damage and predicting the residual life of the structure [16].

- A flood monitoring system is deployed in Bangladesh. In many developing countries we find old and derelict infrastructure.

Bridges and railroads, perhaps built by a former colonial power, are still in use and are at the same time extremely vital points of the transportation infrastructure. Historical buildings such as churches, castles, and monasteries are in bad repair but these objects of cultural value are obliged to be preserved for future generations. Here, seismic and pressure sensors can be deployed to detect and localize stress fractures. A precise knowledge of stress fractures can be applied for predictive maintenance and for issuing timely warnings to users.

6. WSN in Developed countries

Developed countries have the sufficient technology and resources. Apart from applications described in above section application domain in developed countries are different and more specific. With the advance technology and resources developed countries use Wireless sensor networks in different domains.

6.1 Smart aeration

Aerating[17] is the process of punching holes into land to allow water, oxygen, fertilizers, and other nutrients to penetrate the soil and better reach the roots of your grass. Wireless underground sensor networks (WUSN) can be used for it. They measure the physical phenomena and inform to the node about the lack of water, oxygen and other values.

6.2 Intelligent lighting control

Intelligent light control system, which find and manages the best light actuation, profiles using incident light measurements by light sensors and user requirements. For Example Illuminator[18] helps media production crews characterizing, control and setup lights in performance and filmmaking using sensor network technology.

6.3 Public security

Wireless magnetic sensor networks offer a very attractive, low-cost technology for traffic measurement in freeways, urban street intersections and presence detection in parking lots. DIT-ASTEC[19] is an extensive traffic monitoring in large urban areas. The system has the wireless sensor network, the localized traffic flow model policy, and the higher level coordination of the traffic lights agents. The wireless sensors are deployed on the lanes going in and out the intersection. These sensors detect vehicles' number, speed, etc. and send their data to the nearest Intersection Control Agent (ICA) which, determines the flow model of the intersection depending on sensors' data .Coping with dynamic changes in the traffic volume is one of the biggest challenges in intelligent transportation system (ITS).

6.4 Supply-chain monitoring in state-of-art production plants

RESCUEIT [20] project by SAP Labs France is integration of Wireless Sensor Networks for secure Supply Chain Management Systems. The objective for deployment is secure solution within WSNs in order to mitigate identified risk in the supply chain. On the background of these application domains, we foreseen the deployment of security mechanisms in WSNs based on identified risk in the Supply Chain. Solutions for secure tracking, optimization of the supply chain with preserving privacy of all parties involved in the supply chain is one of our major concern.

6.5 WSN for healthcare

Code Blue[21] is the systems that automate patient monitoring have the potential to increase the quality of care both in disaster scenes and clinical environments. The systems automate patient monitoring have the potential to increase the quality of care both in disaster scenes and clinical environments. CodeBlue, improve the monitoring process of hospital patients and disaster victims as well as first responders. Another health care system with WSN is MEDiSN[22].

7. Comparisons

We show the different application domain for WSN. The application domain in the developing countries and developed countries has a distinct variation. In developing countries the domain is more or less directly affect the people's living conditions. In contrast to developing countries the application domain in developed countries is towards enhancing the life styles and HDI. WSNs in developing countries is for *Environmental Observation and Forecasting, Disaster Prevention, Agricultural Management, Structure Health Monitoring, Habitat Monitoring* whereas in developed countries with all these traditional application it is also used for some resource rich application like *smart aeration, light control, traffic management and in the supply chain management*. In [23] author give the report of 700 projects in word in current scenario and most of them are in developed countries.

8. Conclusion

In this paper, we presented wireless sensor networks as an emerging technology that has the potential of aiding developing countries to carefully utilize scarce resources, to protect and maintain infrastructures, and to prevent undesirable occurrences. Subsequent to an overview of anatomy and benefits of these networks, we present a series of application areas where sensor networks could be most helpful. Developed countries used them for traditional application as well as for some new applications, which require a good amount of resources. As the developing countries are less in resources they may use it but it takes some time.

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