Applications of Wireless Sensor Networks In various Areas

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Abstract : Wireless sensor networks (WSNs) are one of the most rapidly developing information technologies and promise to have a variety of applications in Next Generation Networks (NGNs). This technical paper presents design techniques and guidelines, overview of existing and emerging standards for the subject area, modeling principles for WSNs. In addition, this technical paper covers important particular issues: efficiency estimation and application of WSNs for critical tasks such as emergency management and healthcare. The following technical paper is concerned with such rapidly developing information and communication technologies (ICT) directions as Next Generation Networks (NGNs), Wireless Sensor Networks (WSNs), as well as their convergence.

Keywords: Wireless sensor networks (WSNs), Next Generation Networks (NGNs) and information and communication technologies (ICT)

1. INTRODUCTION

It is possible to say that history of sensor network technology originates in the first distributed sensing idea implementations. The continuous work of researchers and engineers over sensor networks which lately became wireless sensor networks (WSNs) has started exactly with this idea. WSNs technologies started to actively develop in mid 1990s, and in the beginning of 2000s the microelectronics development made it possible to product rather inexpensive elementary base for sensor nodes. It also became possible due to the rapid development of wireless technologies and microelectromechanical systems.

A network comprised of interconnected sensor nodes exchanging sensed data by wired or wireless communication. Sensor node consists of a great number of nodes of the same type (sensor nodes), which are spatially distributed and cooperate with each other. Each such node has a sensing element (sensor), a microprocessor (microcontroller), which process sensor signals, a transceiver and an energy source. Distributed over the object, sensor nodes with the necessary sensors make it possible to gather information about the object and control processes which take place on this object. While choosing or developing a WSN platform for particular application, developers make a rather wide range of demands to the sensor nodes. Generally, high demands for autonomy, cost and size are made. These and others technical requirements often can be contradictory. For example, increasing in power of sensor node's transmitter leads to increasing of energy consumption and decreasing of autonomy, causing a bad influence on WSN lifetime. At the same time, WSNs (unlike other kinds of networks) have some rigid restrictions, such as a limited amount of energy, short communication range, low bandwidth, and limited processing and storage in each sensor node. Also, WSN has to be sustainable to elements failures, support self-organization; moreover, sensor nodes have not to require service and special installation. So, finding a balance between demands which are made and sensor nodes' cost is a very special task for each specific application.

A lot of WSN applications in agriculture, environment monitoring and emergency management are deployed in the places without any specially prepared infrastructure, and require easier and more rapid ways of sensor node installation. In the most cases under these circumstances dissemination (e. g., scattering, dropping) of sensor nodes with the help of some moving vehicle, such as car, airplane etc. is used. In such cases sensor nodes get in rather difficult conditions, and establishing connection with other sensor nodes is not easy. Thus, successful WSN deployment depends on both the hardware characteristic and the network self-organization protocols which are used.

2. Overview

WSNs are spatially distributed systems which consist of dozens, hundreds or even thousands of sensor nodes, interconnected through wireless connection channel and forming the single network.

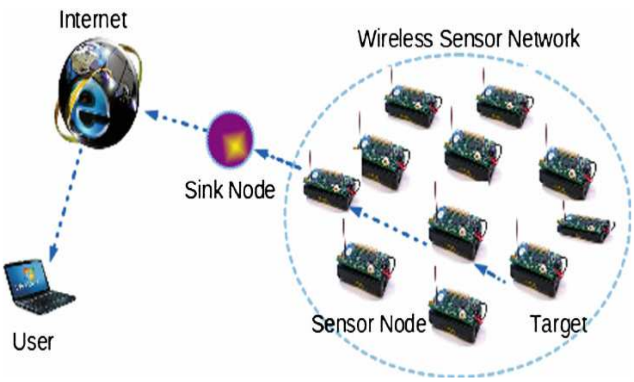

Figure 2.1: An example of a WSN

Figure 2.1 represents an example of a WSN. Here we can see a WSN which consists of twelve sensor nodes and a network sink, which also functions as a gate.

In WSNs communication is implemented through wireless transmission channel using low power transceivers of sensor nodes. Communication range of such transceivers is set up in the first place for reasons of energy efficiency and density of nodes spatial disposition, and, as a rule of thumb, this quantity is about a few dozens meters. Sensor node's transceiver has limited energy content, and this fact makes it impossible for the most spatially remote sensor nodes to transmit their data directly to the sink. So, in WSN every sensor node transmits its data only to a few nearest sensor nodes which, in turn, retransmit those data to theirs nearest sensor nodes and so on. As a result, after a lot of retransmissions data from all the sensor nodes reach the network sink.

3. Use Cases of WSNs

In this chapter we are going to consider the main WSN use cases which are available on the market or are discussed in scientific and technical literature as potentially possible. From the great variety of WSN applications we have chosen those ones which, in our opinion, will be in the greatest demand in the next decade: home automation, building control, agriculture, civil and environmental engineering, emergency management.

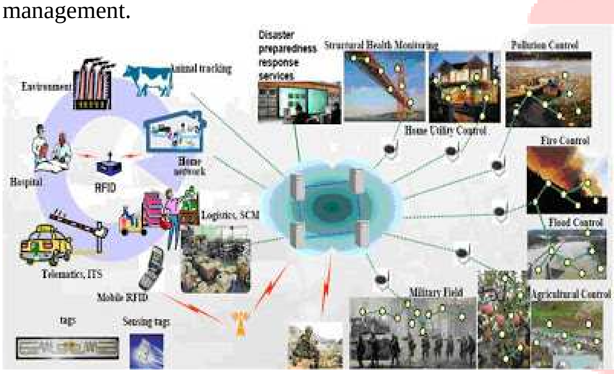

Figure 3.1 Uses of WSNs

3.1 Agriculture

Agriculture is one of the most interesting fields where WSNs can be used. That is due to the agriculture specific tasks which make it possible to use in practice almost all modern developments in WSN:

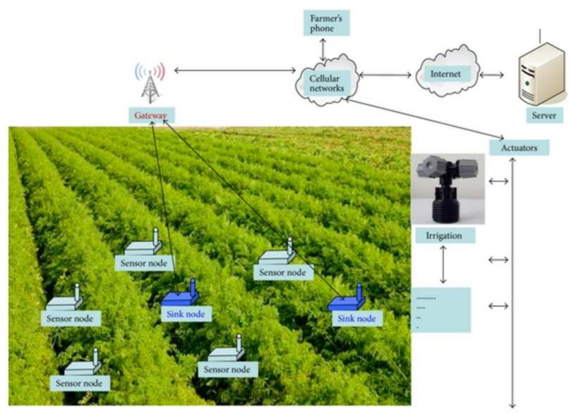

Figure 3.1.1 Uses of WSNs in Agriculture

- To monitor vast areas it is necessary to create networks which consists of dozens thousands of sensors;
- The existence of several kinds of measured values (temperature, humidity, chemical composition of the soil) makes it necessary to operate with heterogeneous networks;
- The necessity to work with mobile objects for animal husbandry tasks;
- The difficulty of battery changing in the field makes it necessary to create energy effective sensors and radio transceivers;
- Good opportunities for data mining application.

3.2 Home Automation

Home automation is a general name for technologies for automation of maintenance of residential buildings. As a synonym of home automation a more 'marketing' term smart home is often used. The first ideas of smart home appeared in the science fiction, but the most part of these ideas came true recently. Largely it was facilitate by WSNs development.

- Monitoring of different parameters, such as temperature, turning on the light, opening of locks in rooms;
- Automatic management of systems in the house according to the monitoring data;
- Efficient resources consumption (water, electricity, heat);
- Monitoring condition of aged and ill people presenting in the house;
- Taking care of pets

3.3 Civil & Environmental Engineering

WSN applications for civil and environmental engineering first of all deals with monitoring condition of the objects created by human, as well as the environmental objects. For a researcher these applications are interesting first of all because of a great number of various types of sensors used, and also because of variety of places where it is necessary to implement a network.

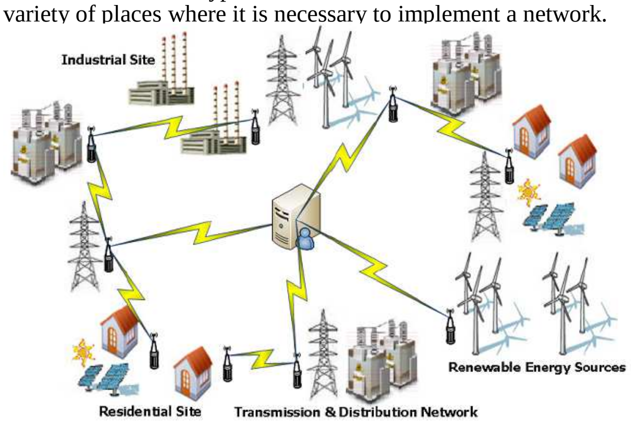

Figure 3.3.1 Uses of WSNs in CE

3.4 Emergency Management

The previous use case shows that WSN can solve the problems on which can depend lives and security of a large number of people. It is possible to say that one of the most critically important WSN applications is *emergency management*. This term means not only emergency detecting, as in the previous example, but also people and equipment management meant for minimizing damage caused by a disaster. Emergency management applications are the ones where WSN peculiarities such as decentralization, possibility of autonomous power supply, self-healing and self-organizing become critically important. In addition, mass mobile devices, such as smart phones, tablet computers and laptops, can be used by WSN applications in the case of the disaster to control people individually, what is impossible when the traditional resources of emergency warning are used.

4. Usages of WSNs for Critical Tasks

Consistency of decisions, discussed in the previous chapter, is a desired design goal for every use case of WSNs. However, there are a number of tasks where every decision is required to be well-founded and validated, because they have a direct impact to human life, health and security. These tasks are considered separately, because they have problems and issues as well as design approaches that are not relevant for common tasks.

4.1 Security and privacy

Wireless media is much more vulnerable than wired media for attackers. In critical tasks information security problems are particularly important since a security breach can result in a variety of negative effects. WSN applications for critical tasks are required to support integrity and confidentiality of the data exchanged during the application operations. These applications are required to provide security of exchanged data against malicious attacks. It is recommended to provide a secure channel to protect the data flows.

4.2 Fault tolerance

Errors in a WSN can occur for the following reasons: malfunction of one or more of sensor nodes, the change of environmental conditions, the actions of the attacker. According to most common practices, sensor node can be considered as failed if it sends measurements which significantly deviate from the results of the neighbor sensor nodes. A faulty sensor node can be identified by the WSN as workable but provide bad measurement results.

4.3 Quality of Service

The strict reliability requirements are often a key challenge for WSN utilization for critical tasks. Some applications require low latency in updating sensor readings, others may require high accuracy of measurements. Time response and accuracy characteristics of a WSN affect the accuracy and timeliness of the decision-making. Critical tasks ordinary need high levels of both of these parameters. Appropriate QoS mechanism must be implemented to make sure that QoS requirements are satisfied.

4.4 Context Awareness

Context involves the information which can be used to describe the state of some physical object. This information has to be considered when making responsible decisions based on WSN measurements. For example, many of the processes are affected by temperature and time of day (especially in e-health applications). Without consideration of such dependencies, the data obtained from the WSN can be interpreted incorrectly.

Data processing and decision-making systems of the WSN should also take into account the natural noise in sensor nodes, possible node failures and other sources of context information. For this purpose, context information is required to be collected, stored and used for decision making.

5. Conclusion

In the conclusion part of the work, we'd like to concern the problems, strongly connected with organization, provision management and administration of public services, or technological structure of the global information society, which will already include NGN and IoT objects. The number of interacting subjects and objects, that can access the global networks, has increased tremendously. This will lead to noticeable and probably even full destructuring of the existent world-perception. Besides, this will demand working out new ideas on the world imagery. This process will naturally influence on services contents while organizing these services and providing with them, as well as on their administration's effectiveness. The systems of IoT sensors, implied in the environment (e. g., multisensor systems), will provide us with new opportunities, but also will bring new troubles.

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