INCREASING WORK EFFICIENCY OF WIRELESS SENSOR NETWORKS

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ABSTRACT

A wireless sensor network is a distributed, self-organizing network of many sensors (sensors) and actuators, interconnected via a radio channel. The coverage area of such a network can range from several meters to several kilometers due to the ability to relay messages from one element to another. The following article is devoted to exploring ways to increase the efficiency of wireless sensor networks.

Key words: wireless sensor network, radio channel, device, automation, signal, power supply, processing unit.

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INRTODUCTION

Advances in the field of semiconductor electronics, which allow integrating a large number of various devices on a single chip (including the ability to integrate analog and digital circuits), advances in integrated circuit manufacturing technology (reducing the cost of production), contribute to the penetration into everyday life of various electronic devices and systems. Often they become every day and invisible, but behind each of them is the work of many people and technology. Development is especially intensive in the field of embedded systems and portable devices using a radio channel - often these are the devices that surround us in everyday life, operating under various restrictions - legal, medical, weight and size. Such devices are classified as low-power radio devices.

Wireless systems have firmly entered our lives:

In everyday life these are various multimedia systems, control devices, wireless interfaces, various monitoring systems;

In industry - data collection systems, automated and automatic control systems (from lighting systems to automation of buildings and their complexes);

In transport - tracking cargo, monitoring traffic parameters, etc.

One of the promising market sectors is automation in the field of housing and communal services (HCS), especially in the field of accounting for resource consumption. Moreover, this problem is acute for all parties, sometimes pursuing completely different goals - these are resource or service providers, intermediary distributors, and, of course, consumers. Some require the most complete accounting of consumption, others are interested in the dynamics of resource consumption and the low cost of implementing and owning a metering system, and others are interested in the transparency of the process of setting tariffs and billing.

The main resources to be accounted for are electricity, water, gas, and heat. Systems that allow you to automatically take into account all these resources at a particular object or objects are called automated systems for monitoring and accounting for energy resources. Of course, the construction of those systems is not an easy task, and requires an individual approach for each case; moreover, it requires the solution of both engineering and organizational problems.

Usually in these systems there are several levels:

Level of information collection;

The level of information transfer (connecting);

Level of data collection, analysis and storage.

At the same time, we have an inverse relationship between the number of individual devices at each of the levels and the data flows with which they have to operate (the largest number of devices will be at the data collection level, and the largest data flow at the data collection and analysis level).

From the point of view of embedded systems, the first two levels are the most interesting. In organizational terms, we have interaction between end consumers (tenants, legal entities or individuals - objects of accounting (more precisely, the resources they consume)) and one or more intermediaries (partnerships of homeowners - HOAs, housing maintenance departments - housing departments, management companies - accounting entities). In engineering terms, these are the tasks of placing sensors and meters, organizing data transportation, and joint operation of all accounting systems. At the same time, both apartment-based and door-to-door accounting of resources is currently practiced.

Let us consider in more detail some features of the automated systems for monitoring and accounting for energy resources organization using wireless data transmission. Main problems:

Transition to autonomous power sources - high requirements for energy efficiency of transceivers and control devices - the operating time of devices without replacing the power source is taken into account;

mutual influence of radio devices - devices of the same type, alarm devices, communications, consumer electronics - possible signal interference, the possibility of several devices operating in the same frequency range, mutual influence of frequency channels, selective capabilities of receivers;

Ensuring reliable constant communication - the presence of obstacles, signal attenuation with distance, multipath propagation - receiver sensitivity, transmitter power, signals modulation methods;

Ensuring the information security of the system - traffic substitution, accessibility attacks, and signal suppression - signal modulation, traffic encryption, and exchange protocols.

At the moment, the low-frequency part of the ISM range, namely frequencies less than 1 GHz, seems to be more interesting for the implementation of wireless data exchange in AMR. The reasons for this are as follows:

in the 2.4 GHz band there are a large number of devices - computers and wireless network equipment, wireless headphones, headsets, smart home systems;

signals with frequencies less than 1 GHz are less affected by obstacles in the form of walls, houses, trees;

at equal powers, they can provide more confident data reception (reducing the transmission frequency by half increases the range by about the same amount (Freeze's formula)).

Currently, there is a steady trend towards the transition to automated resource accounting systems. Resource consumers and resource providers, as well as companies involved in the distribution of resources, are interested in this. The most common manifestation of this trend in everyday life is the installation of individual meters for the consumption of resources - cold and hot water, electricity, gas, heat. This allows the end consumer to optimize their own utility costs - it's no secret that paying "on average", as it was ten years ago, is no longer profitable, and more and more consumers, in addition to the usual electricity meters, install additional water, gas or heat meters. Moreover, during the construction of new apartment buildings, such meters are installed on individual entrances or houses as a whole.

In the future, this allows management companies to generate accounts specifically for the resources consumed by this house, getting the opportunity to report in detail to resource suppliers (and, accordingly, not pay for resource losses that occurred through no fault of the consumer - water or heat leaks, power losses). In general, resource consumption meters can be divided into two broad categories - electricity meters and flow meters.

One of the first prototypes of a sensor network can be considered the SOSUS system designed to detect and identify submarines. In the mid-1990s, wireless sensor network technologies began to actively develop; in the early 2000s, the development of microelectronics made it possible to produce a fairly cheap element base for such devices. Wireless networks of the early 2010s are mainly based on the ZigBee standard.

A Wireless Sensor Network (WSN) consists of sensor nodes that are tightly deployed, where each node has a sensor, processor, transmitter, and receiver. These nodes are low-cost, low-power and multifunctional devices for performing various sensing tasks. Sensor nodes are deployed throughout the area to monitor certain events (eg temperature) in real conditions. FSUs mainly operate in an open and unmanaged area. They are expected to play an important role in various areas such as military surveillance, forest fire monitoring, building safety monitoring and industrial process control. Most applications require a more precise localization process for nodes to get their coordinates within the network. This area of research opens up new horizons for algorithms and methods for optimizing the best position estimate for sensor nodes in various areas (eg, indoors, and outdoors).

In fact, the aspects of target tracking and localization have a very important bearing on all BSS scientific publications. Application of wireless sensor networks. The importance of using BSS is growing every year. This is directly related to the increase in the need for control, observation, measurement and solving many other problems of operation in such areas as industry, medicine, commerce, science, and everyday life. The most well-known applications of WSS are: Military: Military applications require a well-equipped and reliable wireless sensor that can withstand special operating conditions (e.g. high temperature, humidity, etc.) while having a compact size and design that does not attract the attention of the enemy. Particular attention in the military sphere should be paid to monitoring the occurrence of malfunctions for their timely elimination.

Each wireless node contains: A power supply, a sensor, a processing unit, and a transceiver part:

A. Power supply: The placement of the power supply mainly depends on the length of the acquisition area. Power is considered the main unit for the sensor, and also powers other units to perform their functions [1]. The life of the sensor node depends on its power source. To maximize power efficiency, methods are being developed to minimize the data flow rate between nodes. Improvement in the use of different materials used in power supplies balances costs with performance (eg nickel cadmium, lithium ion).

B. Sensor: In WSS, it is defined by the function that is measured by the sensor part of the sensor inside its nodes (eg temperature, smoke, humidity...). The sensory part inside the nodes converts the physical event needed for the measurement into meaningful data that needs to be processed and stored. Sensors are divided according to the type of output signal: analog and digital. Sensor units should have a minimum size and minimum power consumption.

Processing unit: The processing unit is responsible for processing the data received or transmitted by the transceiver, as well as managing the data received by the sensor part. This object contains three main components: analog-to-digital converter (ADC), central processing unit (CPU), and memory. In some systems, the ADC is considered part of the sensor block, but it actually performs the pre-processing task of converting the signal to digital format.

MATERIALS AND METHODS

The processor is responsible for managing the functionality within the sensor node with several forms of hardware and software: FPGA, ASICS. The processor can be replaced in some nodes with microcontrollers, which are lower in power consumption. Storage memory is the input/output part that controls the flow of data to be stored or processed. Memory can be: Random Access Memory (RAM), which stores data to be sent and does not retain it when the node is restarted, and Read Only Memory, Read Only Memory (ROM), which stores the operating system and the basic algorithm of operation.

Transceiver: It has a dual function of transmitting and sending signals between nodes, node and beacon or node and control base. This part mainly uses the Industrial-Scientific-Medical (ISM) frequency band, which is free for user applications and can be reused worldwide.

Regardless of the technology used and the mode of operation of the transceiver, transmitter operation must be optimized to reduce power consumption by improving hardware or reducing transmission time.

Improving the performance of wireless sensor networks

The ability to use wireless sensors in the military ranges from monitoring vehicles (friendly or opposing), monitoring possible threats, and many other dense topology targets to collect more reliable data. Medical technology: Currently, wireless sensors are in demand in medicine to simplify the relationship between the patient and the monitoring system. There are also functions that are performed by medical sensors, such as disease control and drug administration. To improve remote monitoring of vital indications of the patient, the sensitivity of the sensor is increased. Environmental Programs: WSS can be used to measure several environmental parameters such as temperature, humidity, pressure, light intensity, and soil characteristics. It is also used to track, control the movement and behavior of animals, birds and other creatures.

In most cases, sensor nodes are attached to moving creatures or densely placed within the target environment. Some functions require the controllability of the sensor in order to control it. Environmental applications require long-term autonomous operation with data transmission protocols for monitoring and control in hard-to-reach habitats of the object of study. Household appliances: The active use of BSS could not but affect a person in everyday life. Home / office equipment control with a remote control that allows you to change the parameters of devices within the target area by direct communication between the user and devices, using the Internet or satellite communications. Interactivity between home appliances and the user requires artificial intelligence, which, with the help of sensor nodes, develops its reactions to adapt to the needs of the user.

Hardware architecture Sensor nodes are the basis of WSN and along with control systems, like other electrical devices, it consists of two main areas: software platform and hardware architecture. The software platform consists primarily of an operating system that controls the sensor node. This is due to the procedures and algorithms of the measurement methods that will be loaded into each sensor node. On the other hand, the hardware architecture must support measurement proceduresFSU development trends. Wireless sensor networks in general, and the area of localization in particular, still cover a wide area of research and development, such as: – Development of new methods that rationalize the use of GPS, since it is not energy efficient and expensive for low performance indoor hardware (line-of-sight propagation problems). – Minimization of errors to improve the accuracy of sensor node location estimation, which includes the use of mathematical and geometric relationships and the development of new measurement methods (may be a hybrid technique between old techniques). The mobility of sensor nodes in some applications can change the network topology, leading to a new area of research that can track changes and store a location estimate.

– Network topology density improvements to reduce the number of anchors/beacons needed to evaluate good coverage for all other sensor nodes. – 3D localization is still of interest to some researchers, as most research focuses on surface planes, which may be inefficient for real world simulations. – New hardware implementation will result in lower cost with higher energy efficiency, especially for high precision methods in the range-based category, which also includes performance gains (longer battery life, faster processing speed, more memory, and minimization of sensor node hardware size) . – Security threats and attacks are subject to additional research to improve existing protection schemes and develop more secure protocols with powerful detection algorithms.

Wireless sensor networks (also called ad hoc or multipoint networks) are built from small nodes called motes. Motes are small, self-contained, battery-powered computers with radio links that allow them to organize themselves into specialized networks by communicating with each other and exchanging data. Data from individual nodes travels across the network from node to node (hence the name "multipoint networks") and usually ends up on a "supernode", or server, that has higher processing power.

Intel motes are currently running TinyOS, developed by the University of California at Berkeley. Each mote establishes a connection with its neighbors immediately after switching on. Despite the fact that a single sensor has limited power and computing capabilities, many motes, spontaneously organizing themselves into a network, are able to perform tasks that a conventional computing system is not able to handle.

Productivity increase

As the sensor network grows, it is possible that its performance will decline. The reason is this: in a typical wireless sensor network, the data collected by all nodes is stored on a single server acting as a gateway to the IP network. In order to reach the gateway, data travels through the network from node to node, and there is a possibility of losing some data, increasing with the size of the network. In addition, when a node transmits data to a neighboring node, which then transmits it further, energy is consumed. Large networks with many nodes consume much more electricity for data transmission. Therefore, as the sensor network grows, its performance decreases.

To address performance issues, Intel uses specific technologies and protocols to increase the level of heterogeneity in sensor networks. Intel's approach allows the sensor network to automatically pool resources in environments such as corporate network infrastructure with wall outlets or high-performance processor nodes to improve network uptime and data transmission accuracy.

For example, a sensor network may use a corporate (or dedicated) 802.11 network to operate. High performance nodes (such as nodes based on Intel XScale technology) connect to the WLAN and cover the sensor network as shown in the figure.

CONCLUSION

This structure is analogous to the situation where expressways complement the normal traffic structure. Sensors can be connected and disconnected from 802.11 "backbones" (Intel XScale nodes) in various combinations to bypass sensor network motes. Intel researchers have shown that eliminating data transfer bottlenecks speeds up data propagation across the network, resulting in improved reliability and reduced power consumption.

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