A Review: Wireless Sensor Networks Application and Technology

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ABSTRACT

This paper describes the concept of wireless sensor networks which is used for sensing the tasks and the potential sensor networks applications are explored. The communication architecture for wireless sensor networks is explained. There are many technologies used for the wireless sensor networks. Some technologies like Bluetooth, ultra-wideband, and ZigBee are used for short- range wireless communications with low power consumption. From an application point of view, bluetooth is intended for a cordless mouse, keyboard, and hands-free headset, UWB is oriented to high-bandwidth multimedia links, ZigBee is designed for reliable wirelessly networked monitoring and control networks.
Keywords: wireless sensor networks; applications; technologies; IEEE 802.15.4; IEEE 802.15.1; IEEE 802.15

1. INTRODUCTION

A Wireless sensor networks are networks of nodes that sense and potentially also control their environment. They communicate the information through wireless links "enabling interaction between people or computers and the surrounding environment". There are four basic components in a sensor network: (1) an assembly of distributed or localized sensors, (2) an interconnecting network, (3) a central point of information clustering; and (4) a set of computing resources at the central point to handle data correlation, event trending, status querying, and data mining. The sensing and computation nodes are considered part of the sensor network; in fact, some of the computing may be done in the network itself. Because of the potentially large quantity of data collected, algorithmic methods for data management play an important role in sensor networks. The computation and communication infrastructure associated with sensor networks is often specific to this environment and rooted in the device and application-based nature of these networks. The information collected is typically parametric in nature, but with the emergence of low-bit-rate video and imaging algorithms, some systems also support these types of media.

2.Wireless Sensor Network Architecture

The sensor nodes are usually scattered in a sensor field as shown in Fig. 1. Each of these scattered sensor nodes has the capabilities to collect data and route data back to the sink and the end users. Data are routed back to the end user by a multihop infrastructure less architecture through the sink as shown in Fig. 1. The sink may communicate with the task manager node via Internet or Satellite.

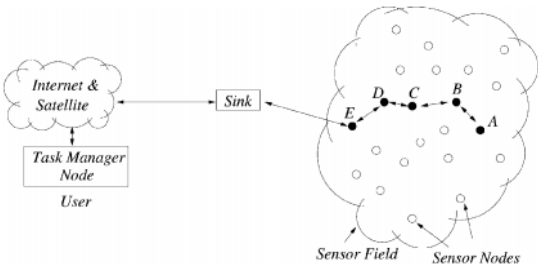

Fig.1. Sensor nodes scattered in a sensor field.

The protocol stack used by the sink and all sensor nodes is given in Fig. 2. This protocol stack combines power and routing awareness, integrates data with networking protocols, communicates power efficiently through the wireless medium, and promotes cooperative efforts of sensor nodes. The protocol stack consists of the application layer, transport layer, network layer, data link layer, physical layer, power management plane, mobility management plane, and task management plane. Depending on the sensing tasks, different types of application software can built and used on the application layer. The transport layer helps to maintain the flow of data if the sensor networks application requires it. The network layer takes care of routing the data supplied by the transport layer. Since the environment is noisy and sensor nodes can be mobile, the MAC protocol must be power aware and able to minimize collision with neighbors' broadcast. The physical layer addresses the needs of a simple but robust modulation, transmission and receiving techniques. In addition, the power, mobility, and task management planes monitor the power, movement, and task distribution among the sensor nodes. These planes help the sensor nodes coordinate the sensing task and lower the overall power consumption.

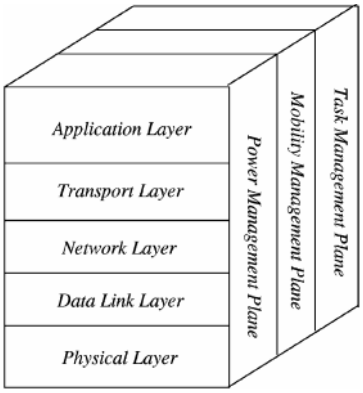

Fig.2. The sensor network's protocol stack.

The power management plane manages how a sensor node uses its power. For example, the sensor node may turn off its receiver after receiving a message from one of its neighbors. This is to avoid getting duplicated messages. Also, when the power level of the sensor node is low, the sensor node broadcasts to its neighbors that it is low in power and cannot participate in routing messages. The remaining power is reserved for sensing. The mobility management plane detects and registers the movement of sensor nodes, so a route back to the user is always maintained, and the sensor nodes can keep track of who are their neighbor sensor nodes. By knowing who are the neighbor sensor nodes, the sensor nodes can balance their power and task usage. The task management plane balances and schedules the sensing tasks given to a specific region. Not all sensor nodes in that region are required to perform the sensing task at the same time. As a result, some sensor nodes perform the task more than the others depending on their power level. These management planes are needed, so that sensor nodes can work together in a power efficient way, route data in a mobile sensor network, and share resources between sensor nodes.

Without them, each sensor node will just work individually. From the whole sensor network standpoint, it is more efficient if sensor nodes can collaborate with each other, so the lifetime of the sensor networks can be prolonged.

3.Working of Wireless Sensor Networks

Working of wireless sensor networking is based on its construction. Sensor network initially consists of small or large nodes called as sensor nodes. These nodes are varying in size and totally depend on the size because different sizes of sensor nodes work efficiently in different

fields. Wireless sensor networking have such sensor nodes which are specially designed in such a typical way that they have a microcontroller which controls the monitoring, a radio transceiver for generating radio waves, different type of wireless communicating devices and also equipped with an energy source such as battery. The entire network worked simultaneously by using different dimensions of sensors and worked on the phenomenon of multi routing algorithm which is also termed as wireless ad hoc networking.

4.Features of Wireless Sensor Networks

Wireless sensor networks do share some commonalities with general ad hoc networks. Thus, protocol design for sensor networks must account for the properties of ad hoc networks, including the following:-

- Lifetime constraints imposed by the limited energy supplies of the nodes in the network.
- Unreliable communication due to the wireless medium.
- Need for self-configuration, requiring little or no human intervention.
- However, several unique features exist in wireless sensor networks that do not exist in general ad hoc networks. These features present new challenges and require modification of designs for traditional ad hoc networks.
- While traditional ad hoc networks consist of network sizes on the order of 10s, sensor networks are expected to scale to sizes of 1000s.
- Sensor nodes are typically immobile, meaning that the mechanisms used in traditional ad hoc network protocols to deal with mobility may be unnecessary and overweight.
- Since nodes may be deployed in harsh environmental conditions, unexpected node failure may be common.
- Sensor nodes may be much smaller than nodes in traditional ad hoc networks (e.g., PDAs, laptop computers), with smaller batteries leading to shorter lifetimes, less computational power, and less memory.
- Additional services, such as location information, may be required in wireless sensor networks.
- While nodes in traditional ad hoc networks compete for resources such as bandwidth, nodes in a sensor network can be expected to behave more cooperatively, since they are trying to accomplish a similar universal goal, typically related to maintaining an application-level quality of service (QoS), or fidelity.

- Communication is typically data-centric rather than address-centric, meaning that routed data may be aggregated/compressed/prioritized/dropped depending on the description of the data.
- Communication in sensor networks typically takes place in the form of very short packets, meaning that the
- Relative overhead imposed at the different network layers becomes much more important.
- Sensor networks often have a many-to-one traffic pattern, which leads to a "hot spot" problem.

5.Applications of Wireless Sensor Networks

Sensor networks have been used in the context of high-end applications such as radiation and nuclear-threat detection systems, ''over-the-horizon'' weapon sensors for ships, biomedical applications, habitat sensing, and seismic monitoring. More recently, interest has focusing on networked biological and chemical sensors for national security applications; furthermore, evolving interest extends to direct consumer applications. Existing and potential applications of sensor networks include, among others, military sensing, physical security, air traffic control, traffic surveillance, video surveillance, industrial and manufacturing automation, process control, inventory management, distributed robotics, weather sensing, environment monitoring, national border monitoring, and building and structures monitoring. A short list of applications follows:-

1. Military applications
- ✓ Monitoring inimical forces
- ✓ Monitoring friendly forces and equipment
- ✓ Military-theater or battlefield surveillance
- ✓ Targeting
- ✓ Battle damage assessment
- ✓ Nuclear, biological, and chemical attack detection

2. Environmental applications
- ✓ Microclimates
- ✓ Forest fire detection
- ✓ Flood detection
- ✓ Precision agriculture

3. Health applications

✓ Remote monitoring of physiological data

✓ Tracking and monitoring doctors and patients inside a hospital

✓ Drug administration

✓ Elderly assistance

4. Home applications

✓ Home automation

✓ Instrumented environment

✓ Automated meter reading

5.Commercial applications

✓ Environmental control in industrial and office buildings

✓ Inventory control

✓ Vehicle tracking and detection

✓ Traffic flow surveillance

6.Technologies Used in Wireless Sensor Networks

IEEE 802.15.4 wireless technology is a short-range communication system intended to provide applications with relaxed throughput and latency requirements in WPAN. The key features of 802.15.4

wireless technology are low complexity, low cost, low power consumption, low data rate transmissions, to be supported by cheap either fixed or moving devices. The IEEE 802.15.4 Working Group focuses on the standardization of the bottom two layers of ISO/OSI protocol stack. There are some options for the upper layers definition: ZigBee protocols, specified by the industrial consortia ZigBee Alliance, Bluetooth and Ultra Bandwidth Technology.

Some technical details related to the physical and MAC layers as defined in the standard are reported. Finally some characteristics related to higher layers will be presented, considering Zigbee, Bluetooth and Ultra Bandwidth Technology, with particular attention to the former.

6.1.1 IEEE 802.15.4 Physical Layer

The 802.15.4 core system consists of an radio frequency (RF) transceiver and the protocol stack, depicted in Figure 3.

The 802.15.4 physical layer operates in three different unlicensed bands (and with different modalities) according to the geographical area where the system is deployed. However,

spread spectrum techniques are wherever mandatory to reduce the interference level in shared unlicensed bands.

IEEE 802.15.4 specifies a total of 27 half-duplex channels across the three frequency bands and is organized as follows:

•the 868 [MHz] band: only a single channel with data rate 20 [kbps] is available; −92 [dBm] RF sensitivity required and ideal transmission range approximatively equal to 1 [km];

•the 915 [MHz] band: ten channels with rate 40 [kbps] are available; the receiver sensitivity and the ideal transmission range are the same of the previous case;

•the 2.4 [GHz] ISM band: sixteen channels with data rate 250 [kbps] available; minimum −85 [dBm] RF sensitivity required and ideal transmission range equal to 220 [m].

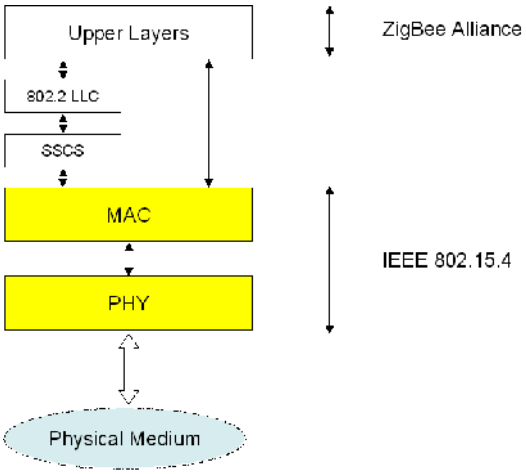

Fig.3. .ZigBee protocol stacks.

IEEE 802.15.4-compliant devices should be capable of transmitting at −3 [dBm].

According to the energy efficiency issue, low rate and low duty cycle are provided. IEEE 802.15.4-compliant devices are active only during a short time and the standard allows some devices to operate with both the transmitter and the receiver inactive for over 99% of time.

6.1.2 IEEE 802.15.4 MAC Layer

IEEE 802.15.4 uses a protocol based on the CSMA/CA algorithm, which requires listening to the channel before transmitting to reduce the probability of collisions with other ongoing transmissions.

IEEE 802.15.4 defines two different operational modes, namely the "beacon-enabled" and the "non beacon-enabled", which correspond to two different channel access mechanisms.

In the non beacon-enabled mode nodes use an unslotted CSMA/CA protocol to access the channel and transmit their packets. The algorithm is implemented using units of time called backoff periods. First, each node will delay any activities for a random number of backoff periods. After this delay, channel sensing is performed for one unit of time: if the channel is found free the node immediately starts the transmission; if, instead, the channel is busy the node enters again in the backoff state. There exists a maximum number of time the node can try to access the channel (i.e., to sense the channel). When this maximum is reached, the algorithm ends and the transmission cannot occur.

In the beacon-enabled mode, instead, the access to the channel is managed through a superframe, starting with a packet, called beacon, transmitted by WPAN coordinator. The superframe may contain an inactive part, allowing nodes to go in sleeping mode, whereas the active part is divided into two parts: the Contention Access Period (CAP) and the Contention Free Period (CFP), composed of Guaranteed Time Slots (GTSs), that can be allocated by the sink to specific nodes (see Figure 4). The use of GTSs is optional.

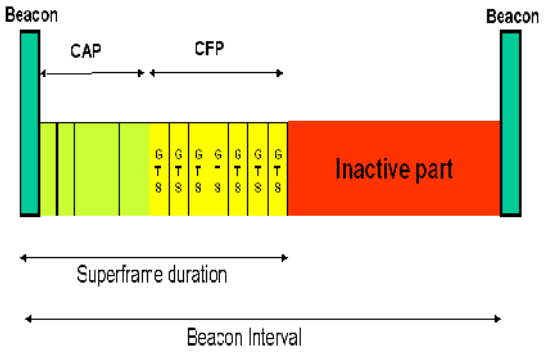

Fig.4. Superframe Structure

The duration of the active part and of the whole superframe, depend on the value of two integer parameters ranging from 0 to 14.

6.2Ultra Bandwidth Technology

Ultrawide bandwidth radio is a fast emerging technology with uniquely attractive features that has attracted a great deal of interest from academia, industry, and global standardization. bodies. The most widely accepted definition of a UWB signal is a signal with instantaneous spectral occupancy in excess of 500 MHz or a fractional bandwidth of more than 20%. One

of the most promising UWB techniques, especially for WSN applications, is named Impulse Radio-UWB (IR-UWB) [37, 38]. The IR-UWB technique relies on ultra-short (nanosecond scale) waveforms that can be free of sine-wave carriers and do not require IF processing because they can operate at baseband. The IR-UWB technique has been selected as the PHY layer of the IEEE 802.15.4a Task Group for WPAN Low Rate Alternative PHY layer [39]. The baseline of 802.15.4a is based on two optional PHYs consisting of a UWB impulse radio (operating in unlicensed UWB spectrum) and another option operating in unlicensed 2.4 GHz spectrum, where the former will be able to deliver communications and high precision ranging.

6.3 Bluetooth Technology

Personal area network (PAN) is a computer network designed for communication between computer devices (including telephones and personal digital assistants close to one person). The devices may or may not belong to the person in question. The reach of a PAN is typically a few meters. PANs can be used for communication among the personal devices themselves or for connecting to a higher level network and the Internet. Personal area networks may be wired with computer buses such as USB and FireWire. A wireless personal area network (WPAN) can also be made possible with network technologies such as IrDA and Bluetooth.

A Bluetooth PAN is also called a piconet, and is composed of up to 8 active devices in a master-slave relationship. The first Bluetooth device in the piconet is the master, and all other devices are slaves that communicate with the master. A piconet typically has a range of 10 meters, although ranges of up to 100 meters can be reached under ideal circumstances.

7.Pros and Cons of Wireless Sensor Networks

There are many advantages of wireless sensor networking some of important prose's are: they can store a limited source of energy, they have no hassle of cables and has mobility, one of its major advantage is that it can work efficiently under the harsh conditions, and it has deployment up to large scale etc. Where it has advantages at the same time it also has some disadvantages which really take the moral of this technology down such as they have very insufficient speed of communication, it is to disturb the propagation of waves and hack your networking and the major disadvantage of wireless sensor networking is it is too costly to use.

8.Open Issues

Wireless sensor networks provide many challenges not faced in conventional wireless networks. While the current body of work on sensor networks has enabled these networks to produce high quality results for longer periods of time, many open research issues still remain.

- Appropriate QoS Model. Due to the data-centric nature of sensor networks, describing QoS remains a challenge. In traditional networks, parameters like delay, packet delivery ratio and jitter can be used to specify application QoS requirements. In sensor networks, on the other hand, these parameters are replaced with ones like probability of missed detection of an event, signal-to-noise ratio and network sensing coverage. It is much more difficult to translate these data-specific QoS parameters into meaningful protocol parameters.
- Reliability. In sensor networks, links and sensors themselves may fail, either temporarily or permanently.
- Heterogeneous Applications. The sensor nodes may be shared by multiple applications with differing goals.
- Heterogeneous Sensors. Much existing work assumes the network is composed of homogeneous nodes. Making best use of the resources in heterogeneous sensor networks remains a challenging problem.
- Security. Some initial work has focused on different aspects of security such as ensuring privacy and preventing denial-of-service attacks, but many open questions remain. How much and what type of security is really needed? How can data be authenticated? How can mis behaving nodes be prevented from providing false data? Can energy and security be traded-off such that the level of network security can be easily adapted? These and many other security-related topics must be researched to find low energy approaches to securing sensor networks.
- Actuation. Eventually sensor networks will "close the loop" by providing not only sensing capabilities but also the ability to automatically control the environment based on sensing results. In this case, data do not need to reach any sort of base station or sink points, and thus current models for sensor networks may not be valid.
- Distributed and Collaborative Data Processing. While much work has been done on architectures to support distributed and collaborative data processing, this is by no means a solved problem. One open question is how to best process heterogeneous data? Furthermore, how much data and what type of data should be processed to meet application QoS goals while minimizing energy drain? These and other questions remain to be solved.

➢Integration with Other Networks. Sensor networks may indeed interface with other networks, such as a WiFi network, a cellular network, or the Internet. What is the best way to interface these networks? Or should the sensors have dual network interface capabilities? For some sensor network applications, these questions will be crucial and research is needed to find good solutions.

➢Sensor Deployment. Given that sensor networks suffer from the "hot spot" problem due to the many-to-one traffic patterns, if it is possible to place the sensors at particular locations (or at least certain areas), how should the sensors be deployed so that both sensing and communication goals can be satisfied?

CONCLUSIONS

Wireless sensor networking has a bright future in the field of computer networking because we can solve the monitoring problems at an advanced level in the future with the help of such technology of networking.

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