The IEEE 802.15.4 for Wireless Sensor Network

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Abstract

Wireless sensor networks (WSN), sometimes called wireless sensor and actuator network (WSAN), are spatially distributed autonomous sensor to monitor physical or environmental condition, such as temperature, sound, pressure, etc. One class of applications envisaged for the IEEE.802.15.4 LR-WPAN (Low Data Rate Wireless Personal Area Network) standard is wireless sensor networks for monitoring and control applications. Wireless sensor networks provide a new paradigm for sensing and sending information. Current WSNs typically communicate directly with a centralized controller or a satellite, thus communication between the sensor and controllers is based on a single hop. An on-going area of research is, where WSN nodes or terminals that communicates with each other forming a multi hop network. Such WSNs could change their topology dynamically when connectivity among the nodes varies with the time due to node mobility.

Keywords: Wireless sensor network, IEEE 802.15.4, Physical layer, Media access control

I. INTRODUCTION

A WSN is a collection of sensors which communicate over the wireless channel. These sensor devices have computational processing ability, wireless receiver and transmitter technology and a power supply. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. A WSN is composed of a number of sensor nodes (SN) transmitting wirelessly the information they capture. An SN is generally composed of a power unit, processing unit, sensing unit, and communication unit. Power consumption is the main limiting factor of an SN. In cellular and wireless local area networks, wireless communication only occurs on the last link between a base station and the wireless end system. In multi-hop wireless networks there are one or more intermediate nodes along the path that receive and forward packets via wireless links.

II. THE IEEE 802.15.4 FOR WIRELESS SENSOR NETWORKS

The IEEE 802.15.4 protocols specify the Medium Access Control (MAC) sub-layer and physical layer for Low-Rate Wireless Private Area Networks (LR-WPAN). Even though this standard was not specifically developed for wireless sensor networks, it is intended to be suitable for then since sensor networks can be built up from LR-WPANs. In fact, the IEEE 802.15.4 protocol targets low-data rate, low power consumption, low cost wireless networking, with typically fits the requirements of sensor networks. The IEEE 802.15.4 protocol is very much associated with the zigbee protocol. The standard IEEE 802.15.4 does not define how to build a cluster tree network. It only indicates that this is possible and may be initiated by higher layers. The IEEE 802.15.4 standard was originally designed for personal area networks. Its application fields expand and diversify to touch wireless sensor networks thanks to several features. In fact, the IEEE 802.15.4 defines characteristics of the physical and data link layers for LR-WPN (Low-Rate Wireless Sensor Network). The standards aim to allow the interconnection of wireless devices with low autonomy (battery powered) and does not require high bit rate. In today's world we are faced with increasingly many types of emergencies in our environments. One example which stands out is the gun violence which has plagued our universities and communities alike. In addition, institutions with poor infrastructure may not be able to minimize loss of resources and human life in times of natural catastrophes. Low-power consumption low-cost communications are the key points that lead to the specification of IEEE 802.15.4 standard.

III. WIRELESS SENSOR NETWORK

Wireless sensor network is a wireless network consisting of spatially distributed autonomous devices using sensors to monitor physical or environmental conditions. A WSN system incorporates a gateway that provides wireless connectivity back to the wired world and distributed nodes. The wireless protocol you select depends on your applications requirements. Some of the available standards include 2.4GHz radios based on either IEEE 802.15.4 or IEEE 802.11(Wi-Fi) standards or proprietary radios, which are usually 900 MHz. A WSN is a collection of sensors which communicate over the wireless channel. Wireless sensor network is an

emerging field for research in today's world. Wireless sensor network have vast potential for usage of sensor networks in different areas like military are, disaster management, sensing environment conditions such as temperature, humidity etc. Wireless sensor network is a collection of huge number of micro sensor nodes, which are generally deployed in such an environment where unattended operation is required by the applications. The service provided by WSNs is based on collaboration among small energy-constrained sensor nodes. The large deployment of WSNs and the need for energy efficient strategy necessitate efficient organization of the network topology for the purpose of balancing the load and prolonging the network lifetime.

IV. THE IEEE 802.15.4 PHYSICAL LAYER

Physical layer provides the data transmission service as well as the interface to the physical layer management entity. It manages the physical RF transceiver and performs channel selection and energy and signal management function. The physical layer of IEEE 802.15.4 is responsible for the data transmission and reception. The IEEE 802.15.4 standard offers an implementation for the lower layers, physical layer and media access layer, for a typical wireless sensor network. The IEEE 802.15.4 focuses mainly on low-cost, low-speed communication between devices. The basic IEEE 802.15.4 framework defines a 10-meter communications area with a maximum transfer rate of 250k/bits. It is the basis for the zigbee specification, which further attempts to offer a complete networking solution by developing the upper layers which interface with the IEEE 802.15.4 MAC[2].
The physical layer is responsible for the following tasks:

- Data transmission and detection.
- Channel frequency selection.
- Activation and deactivation of the radio transceiver.
- Energy detection within the current channel.
- Link quality indicator for received packets.
- Clear channel assessment for carrier sense multiple access with collision avoidance.

V. THE IEEE 802.15.4 MEDIA ACCESS LAYER

The MAC layer is responsible for point-to-point delivery between nodes. Besides the data services, it offers a management interface and itself manages access to the physical channel and network beaconing. It also controls frame validation, guaranteed time slots and handles node associations. The MAC sub-layer of the IEEE 802.15.4 protocol provides an interface between physical layer and the higher layer protocols of LR-WPANs. The most important characteristic of IEEE 802.15.4 MAC layer is that it has the same common features with the IEEE 802.15.4 protocol such as the use of CSMA/CA as a channel access protocol.
The MAC sub-layer handles all access to the physical radio channel and is responsible for the following tasks:

- Generating network beacons if the device is a coordinator.
- Synchronizing to network beacons
- Supporting PAN association and disassociation.
- Supporting device security.
- Employing the CSMA-CA mechanism for channel access.
- Handling and maintaining the GTS mechanism.
- Providing a reliable link between two peer MAC entities.

The MAC sub layer provides an interface between the service specific convergence sub layer and the physical layer. The MAC sub layer conceptually includes a management entity called the MLME. This entity provides the services interface through which layer management functions may be involved. The MLME is also responsible for maintaining a database of managed objects pertaining to the MAC sub layer. This database is referred to as the MAC sub layer PIB[3].

VI. NETWORK STRUCTURE FOR WSN

Wireless networks can have two distinct mode of operation: Ad-hoc and infrastructure. Infrastructure wireless networks usually have a base station which acts as a central coordinating node. The base station is usually AC provided in order to enable access to the Internet, an intranet or other wireless networks. Base stations are normally fixed in location. The disadvantage over ad hoc networks is that the base station is a central point of failure. If it stops working none of the wireless terminals can communicate with each other. Suggests a protocol for providing a WSN with a hierarchical organization. Differently from previously proposed solutions, the protocol, termed clique clustering (CC), includes in its operation a fail-safe mechanism for dealing with node failure or removal, which are typical of WSN. More specifically, the network is partitioned into clusters that are cliques i.e., nodes in each cluster are directly connected to each other. An efficient mechanism for building a connected backbone among the clique clusters is provided. Clustering, backbone formation and backbone maintenance are completely localized, in the precise sense that only nodes physically close to a failing node are involved in the reconfiguration process.

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