IMPROVING EFFICIENCY OF NODES USING DEPLOYMENT FRAMEWORK IN ZIGBEE WIRELESS NETWORKS

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Abstract:
ZigBee is a wireless communication technology which operates on top of the IEEE 802.15.4 Medium Access Control (MAC) and physical layer wireless standards to provide network, security and application support services. ZigBee provides self-organized, multi-hop and reliable networking facility with long battery lifetime. ZigBee provides wireless networking between low power devices, aimed to reduce the energy consumption and delay. Data transfer failures occur in ZigBee wireless network due to mobility. So, to find the displaced mobile end devices; the Broadcasting method is used to lessen the effects of mobility. But it consumes large amount of resources in terms of bandwidth and power consumption. Recently Node Deployment and Tree Construction framework is proposed to avoid such resource consumption and provides efficient data transmission between coordinator and mobile end devices. Data delivery ratio is increased efficiently during downlink communication i.e. between coordinator and mobile end device by using deployment framework, rather than using conventional route reconstruction method. Further reliability and energy efficiency of nodes is improved using bandwidth utilization technique in the deployed framework.

Keywords*:* - ZigBee wireless network, IEEE 802.15.4,Mobility

I. INTRODUCTION

ZigBee is a specification established for wireless personal area network (WPAN). ZigBee network has the capability of self-forming and self-healing and can accommodate more than 65000 address spaces. Thus the network can be easily extended in terms of size and coverage area. Based on PHY and MAC layers specified by the IEEE 802.15.4 standard [2], the ZigBee specification establishes a framework for the network and application layers. Network and Application layer can handle huge number of nodes. Physical layer accommodates high levels of integration to ensure simplicity and enable cheaper implementations. The MAC layer controls access to the radio channel by using the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) mechanism.

Other wireless standards like Bluetooth and Wi-Fi address high data rate applications. The low cost and low power consumption allows the ZigBee technology to be widely distributed in wireless control and monitoring applications. By using a ZigBee technology it is possible for controlling and monitoring a whole factory unit sitting in one cabin.It can be used in medical applications like patient monitoring, house security, toys and in almost every walk of life.

Mobility is a part of the ZigBee vision and is important for proper functioning of many ZigBee applications. It is crucial to provide ubiquitous connections to/from mobile device for various ZigBee applications. Device mobility is unavoidable in certain ZigBee applications. In the wireless environment, the signal strength sent by coordinator can be weakened as distance of nodes from it increases. Therefore it is difficult to perform stable and reliable wireless communication with wide range nodes.

II. OVERVIEW

ZigBee is designed under the IEEE 802.15.4 specification for low cost and low power network.ZigBee operates on top of IEEE 802.15.4 medium access and physical layers as shown in figure 1. Figure 1 shows the comparison and overview between ISO-OSI and ZigBee model. MAC layer interfaces between physical and other upper layers in the ZigBee stack. IEEE 802.15.4 standard provides a framework for application programming in the application layer.

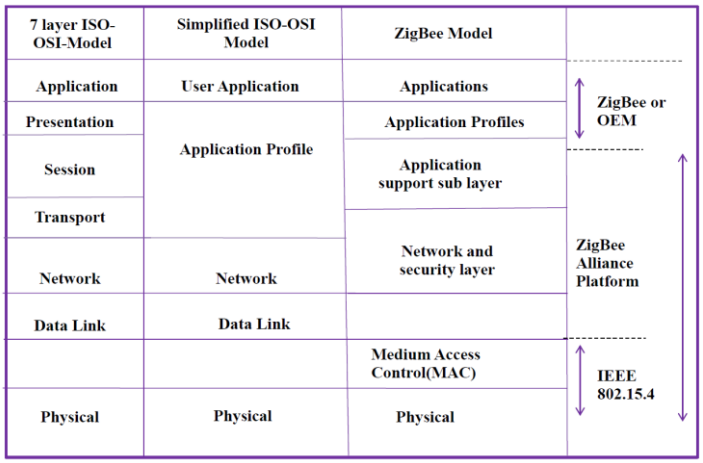

Figure 1: Overview of ZigBee Model

The IEEE 802.15.4 MAC layer defines four frame structures: Data frame, ACK frame, MAC frame, Beacon frame.

- The data frameused for all transfers of data.
- Acknowledgment (ACK) frame is another important structure for IEEE 802.15.4 used for confirming successful frame reception.
- MAC command frameprovides the mechanism for remote control and configuration of client nodes.
- Beacon frame used by a coordinator to transmit beacons.

Above PHY and MAC layer ZigBee defines the application and security layer specifications enabling interoperability between products from different manufacturers.ZigBee network layer defines how the network is formed and how the network address is assigned to each ZigBee node. Table 1 describes the analysis between different IEEE 802 wireless protocol standards. ZigBee is the simplest protocol compared to other wireless standards and it is used in sensor network applications because of its memory and computational capacity.ZigBee has the ability to accommodate more than 6000 nodes in a network. Even though the transmission speed of ZigBee is less than other

wireless standards it can be utilized for short range communications for about 30-50m based on environment. Transmission rate can also be increased based on traffic in the network.

Table 1: Analysis between different wireless standards

Category	ZigBee 802.15.4	Bluetooth 802.15.1	Wi-Fi 802.11
Battery Life	Years	Days	Hours
Complicity	Simple	complicated	Very complicated
Transmission speed	250Kbps	1Mbps	1.54Mbps
Network nodes	65535	8	50
Key Attributes	Reliable, low power, cost effective	Cost, Convenience	Speed, Flexibility
Application	Monitoring and Control	Cable replacement	Web,Video,Email

ZigBee network comprises of three types of communication devices. They are 1. ZigBee Coordinator (ZC) 2. ZigBee Router (ZR) 3. ZigBee End Device (ZED) The Coordinator forms the network and manages information about nodes in the network. Router act as an intermediate router, it passes data packet to other communication devices in the network. Router look's after mobile end device under its coverage area. ZigBee end device has enough functionality to talk to the coordinator or a router. It is less expensive to manufacture than ZC or ZR.These devices are used in proposed approach of node deployment and tree construction framework to improve packet delivery ratio during downlink communication.

III. MOBILITY IN ZIGBEE

Mobility is a critical component of various ZigBee applications. Major network topology changes occur, due to mobility data delivery ceases completely. A network with highly mobile users raises challenging mobility issues. Device mobility is unavoidable in certain applications, such as the health monitoring application described in [3, 4] where a ZigBee enabled health monitoring sensor alerts the hospital through a home ZigBee wireless network, if health related emergency occurs. The effect could be disastrous if the ZigBee home network failed to send the alert message as planned. Therefore it is important to know how nodal mobility affects the ZigBee routing protocols and various applications. Adequate mobility support is necessary to avoid topology changes that occur in the network.

Two types of communication such as uplink and downlink communication are possible in ZigBee network. During uplink communication mobile end device send data packet to coordinator. In Downlink communication coordinator send data packet to mobile end device. Mobility affects downlink communication, based on the ZigBee specification, a device discovery procedure is triggered if the central server cannot find a certain mobile end device.ZigBee provides mobility support in mesh and tree topology [5]. ZigBee provides mesh routing and tree routing scheme, which deploy different routing mechanisms to respond nodal mobility. ZigBee tree topology performs well when nodes are used as mobile and is suitable for low power consumption. ZigBee routers are routing capable, whereas ZigBee mobile end device are not. If ZigBee mobile end device moves out of range from Coordinator, router has the ability to route the path to that mobile end device.

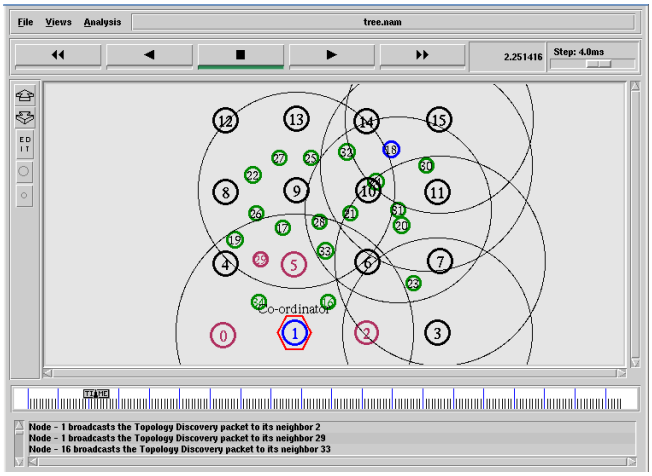

Figure 2: Coordinator floods data packet

During the process, the central server simply floods the whole network with messages to find the displaced end device. Figure 2 shows the routing process through flooding. Though this routing process through flooding the network is costly in terms of resources, node deployment and tree construction framework is proposed to improve efficient transmission between communication devices which is described in next section.

IV. ZIGBEE NODE DEPLOYMENT TREE CONSTRUCTION FRAMEWORK(ZNDTC)

In ZigBee network if the mobile end devices are within the range of Coordinator data delivery is completed easily. Due to mobility, mobile end device moves out of range from Coordinator. Mobility responsive node deployment tree construction framework is proposed to avoid data delivery failures in ZigBee wireless network. To improve the downlink data delivery ratio, node deployment tree construction framework approaches exploits the aforementioned information by the locations of routers and construct a mobility robust tree topology in a ZigBee wireless network. This approach consists of three phases.

ZigBee Node Deployment (ZND) is the first phase of this approach. In this phase routers nodes are deployed as static in appropriate locations of the network. This phase ensures that the map is fully covered by the router's communication range.Here, every router's communication range is at least partially overlapped with another deployed router's communication range. ZigBee Coordinator Decision (ZCD) is the second phase of this approach.Based on the deployment completed in the first phase, the ZCD phase selects one router in the region as the root (coordinator).

ZigBee Tree Construction (ZTC) is the third phase of this approach. In this phase mobility robust tree is constructed based on the following parameters. 1) R_m denotes the maximum number of child routers of a router or the Coordinator2) L_m the depth of the network. Results of these two phases are used along with network constraints R_m and L_m as the input to construct a single rooted tree T as the ZigBee routing tree.ZigBee communication devices are deployed in the network. Figure 3 shows that ZigBee router nodes are deployed in the network. From the deployed

router nodes one node is selected as Coordinator (node 1 as shown in fig 3) which is represented using red hexagon. Then Coordinator send data packet to mobile devices by choosing nearby mobile device as intermediate node. In deployment and tree construction framework mobile devices move toward the coordinator thus communication is established easily between nodes. Further to improve efficiency between nodes bandwidth utilization technique is introduced to increase the reliability between nodes.

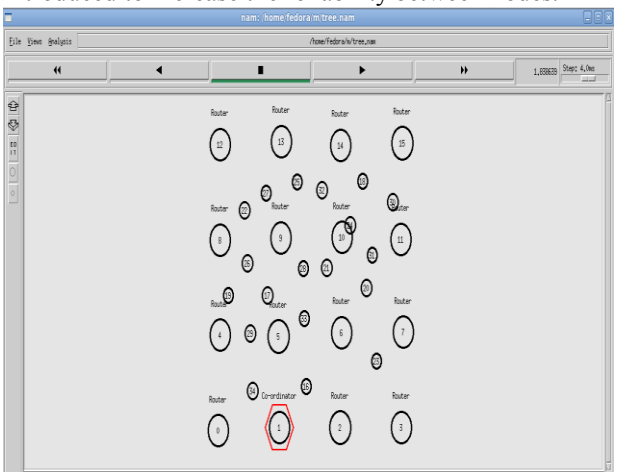

Figure 3:ZigBee devices deployed in the network

Comparison between these two approaches is done using NS2 simulator. ZNDTC is compared with routing protocol AODV.

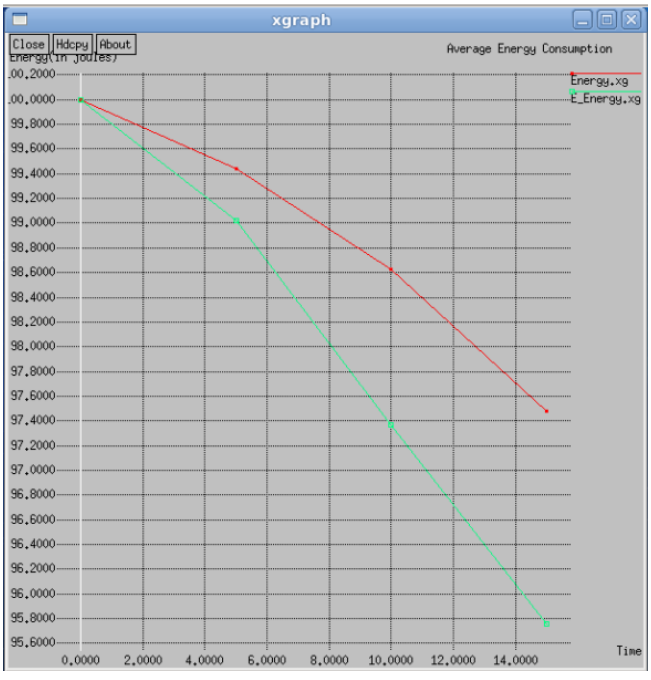

Figure 4: Comparison between two approaches

Figure 4 shows the comparison between ZNDTC and conventional route reconstruction method. E_Energy.xg denotes broadcasting approach, which shows that it consumes maximum available energy from nodes. But ZNDTC approach shows that it consumes less energy from nodes.

VI. CONCLUSION

Thus to improve the downlink data delivery ratio, mobility responsive node deployment tree construction framework approach is proposed to optimize the locations of routers and construct a tree topology in a ZigBee wireless network. Further bandwidth utilization technique is also introduced to improve reliability and energy efficiency among nodes.

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