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Data and Management Traffic of IEEE 802.15.4 ZigBee-Based WSN

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Abstract— **Wireless sensor networks (WSNs) are an amalgam of wireless technologies. They are extensively utilized in numerous industries, including agriculture, medical, and military fields. In the vast majority of cases, these technologies are deployed in monitoring environmental or physical parameters including sound, pressure, and temperature. WSNs employ various technologies, including radio frequency (RF), Wi-Fi, Bluetooth, ZigBee, and Z-Wave. Zigbee in particular has greater potential for energy-savings in long-distance transmissions, and consequently has emerged as the preferred standard for use in WSNs. In Zigbee-assisted networks, the three primary data-communication devices are ZigBee coordinators, routers, and nodes. The coordinator device gathers, stores, and processes the data before forwarding it to the next appropriate node or the base-station. The system model comprises several zones with each zone containing several sensors. Each sensor node transfers data to the master node, which serves as the ZigBee coordinator. The software used for this simulated investigation is the Riverbed Modeler V17.5. This paper examines the data traffic, management traffic, and load performance of the four modelled systems. The findings demonstrate that whereas the number of coordinators has no effect on data traffic, an increase in the number of routers correspondingly increases both the amount of data sent and received. The MAC follows the same pattern.**

I. INTRODUCTION

Wireless Sensor Networks (WSNs) have various modern applications in data processing, analysis, mining, and storage. WSN applications include the Internet of Things (IoT), environmental control, threat identification, ambient noise level, security monitoring and surveillance, and patient monitoring in medical applications. Small, inexpensive nodes known as wireless sensors can be used to construct WSNs. These sensors send and receive data packets to communicate with one another inside a network [1].

The nodes act as environmental sensors by transmitting their findings to a central unit known as a sink. With the main disadvantage of wireless sensors being their short battery life, energy performance and network lifetime are the two main areas of WSNs that need to be improved. ZigBee was developed to address this problem at a reasonable cost. The lifetime of the network's wireless nodes may be extended in this way.

In order to meet the primary WSN requirements of cost, complexity, flexibility, scalability, and power, ZigBee was developed as the IEEE 802.15.4 standard [2].

The IEEE 802.15.4 ZigBee standard was used in order to analyze the data traffic for various WSN situations using the Riverbed Modeler V17.5. The study demonstrates how bidirectional data traffic behaves in WSNs when the number of routers and/or coordinators is increased.

A. ZigBee Based WSNs

Sensor networks have been the subject of extensive research in recent years. WSNs are dispersed network architectures where a large number of wirelessly connected sensors interact with one another. The IEEE 802.15.4 ZigBee standard is used in this research due to its low power consumption, data transfer rate, and cost, and two-way WSN communication abilities. In this work, IEEE 802.15.4 performance is examined using the Riverbed Modeler, which enables accurate result generation and analysis to pinpoint the real system's behavior. This simulator application presents the impact of four system scenarios' data traffic situations, such as data traffic sent and received[3].

Initially ZigBee and IEEE 802.15.4 were independent upcoming industry standards with potentially widespread applications. The ZigBee Alliance had created a very low-cost,

low-power wireless standard for WANs and the application layer to satisfy the demands of automation and remote controls applications. Elsewhere, the IEEE 802.15.4 committee had begun developing a low data rate standard for the physical and MAC sub-layers. Subsequently, the IEEE and the ZigBee Alliance decided to collaborate, and ZigBee became the technology's chosen brand name [4].

B. Data Traffic in a ZigBee WSN

Wi-Fi, Bluetooth, ZigBee, and radio frequency (RF) are some of the communication technologies that WSNs employ to convey data between devices like routers, sensors, and coordinators. One of the biggest challenges facing these WSNs is energy consumption. To address this, researchers have been examining methods of harnessing energy from the environment utilizing technologies such as piezoelectric, solar, or wind power. It is critical to apply such environmental power technologies to reduce the increasing demand in energy consumption in WSNs [5].

C. 802.15.4 Data traffic received:

Represented in bits/sec. The total amount of traffic that the MAC has successfully received from the physical layer. Also applicable to retransmissions [6].

D. 802.15.4 Data traffic sent:

Bits/sec of traffic sent by the 802.15.4 MAC layer of the network. The physical layer and the packet's MAC headers are taken into account when calculating the size of the sent packets during measurement. This excludes anything that has to do with management and control traffic [6].

E. Literature Review

The data traffic received and sent were tested for different numbers of sensors for different types of ZigBee WSNs in [2,6]. Depending on the type of topology (mesh, star, or cluster tree) and the number of coordinators needed to construct the WSN, the effects on data traffic will be different depending on which nodes fail [7]. The data traffic received and sent were discussed in [2] for different numbers of sensors in single- and multiple-coordinator networks. The data sent from point to point using a ZigBee based WSN was discussed in terms of distance in [8].

The MAC load stays high when the mobile node moves to PAN 2 from its original route. After the first four minutes, when the trajectory was from the end device, the load starts to diminish [9]. In [10], it is stated that a higher number of routers in a WSN produces a higher traffic load upon the PAN. Sercan VANN and Ebubekir ERDEM evaluate and discuss the ZigBee network's performance in various network topologies in a subsequent publication [11]. A MAC load evaluation is offered. The author used mesh, tree, and star topologies in this paper.

II. MATERIAL AND METHOD

This paper investigates the following four scenarios, each containing 24 nodes (sensors), but with differing numbers of coordinators (master nodes) and routers: -

A. First Scenario

A ZigBee coordinator represents the master node in this case, while a ZigBee end device represents each of the 24 sensors that are grouped together. As seen in Fig. 1, the traffic should cross over from the end devices (sensors) to the coordinator (master node).

Fig. 1 Scenario Number 1

B. Second Scenario

Four coordinators, or master nodes, are involved in this situation. As seen in Fig. 2, in this design, each coordinator is in charge of receiving traffic from just six sensors.
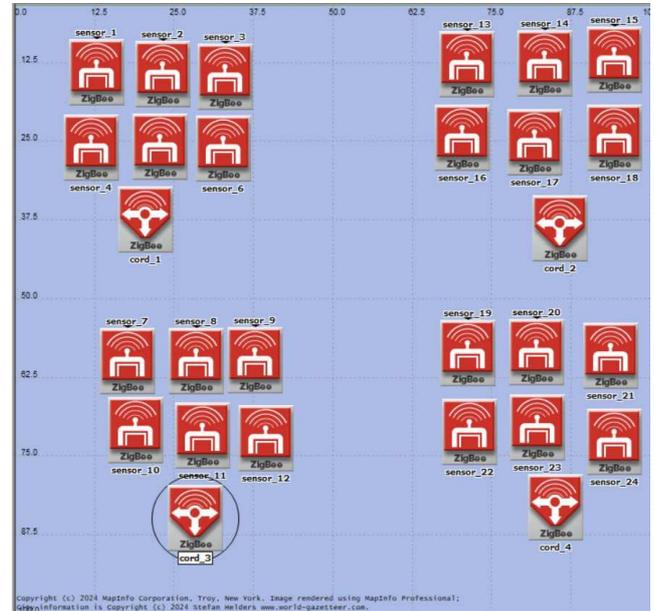

Fig. 2 Scenario Number 2

C. Third Scenario

We have expanded scenario 1 by adding a single router to this scenario. As "Fig.3" below illustrates, we now have 24 sensors together with one coordinator and one router.
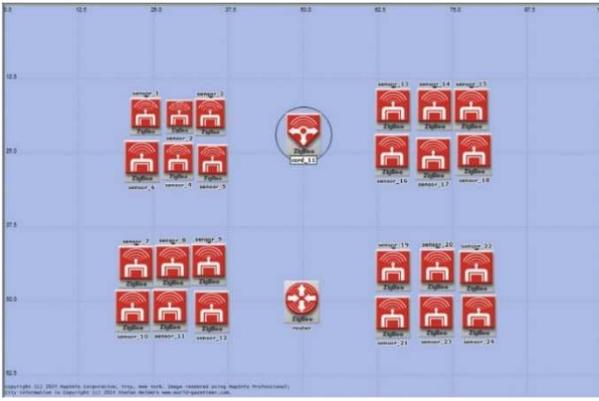
Fig. 3 Scenario Number 3

D. Fourth Scenario

In this circumstance, the number of routers has been increased. As seen in Fig. 4 below, we currently have 24 sensors, 4 routers, and 1 coordinator.
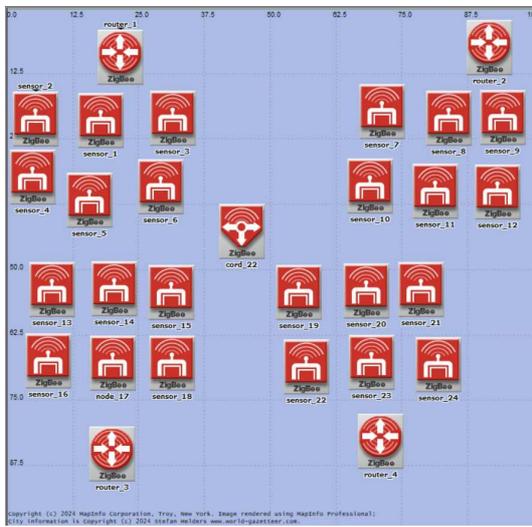

Fig. 4 Scenario Number 4

III. RESULTS AND DISCUSSIONS

The performance of WSNs can be studied in terms of numerous criteria by presenting a multitude of statistics. In this paper, data traffic, management traffic and load were taken into consideration to compare various WSNs when the number of coordinators and/or routers was altered in accordance with the previously specified scenarios. The entire hour was spent running the simulation. The following are the outcomes:-

A. Data Traffic

The entire traffic that the MAC successfully receives from the physical layer, including retransmissions, is measured in bits per second as "Data Traffic Received". The data traffic received for the four scenarios is displayed in Fig. 5. The chart shows that as the number of routers rises, so does the amount of data received. Furthermore, comparing scenarios 1 and 2 allows us to draw the conclusion that adding coordinators has no impact on the amount of data received.
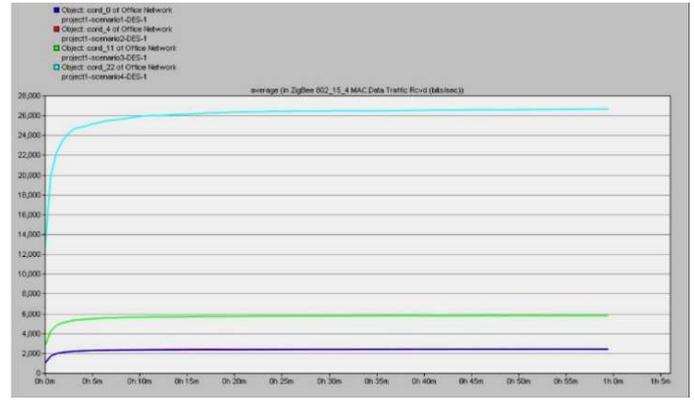

Fig. 5 Data Traffic Received for the Four Scenarios

The entire amount of data that the MAC is able to send from the physical layer, including retransmissions, is measured in bits per second. The data traffic sent for the four scenarios covered in the preceding section is displayed in Fig. 6. The chart shows that the amount of data sent is correlated with the number of routers. The amount of data sent grows with the number of routers. The number of coordinators had no effect on the sent data, whether it was in transient state or steady state.
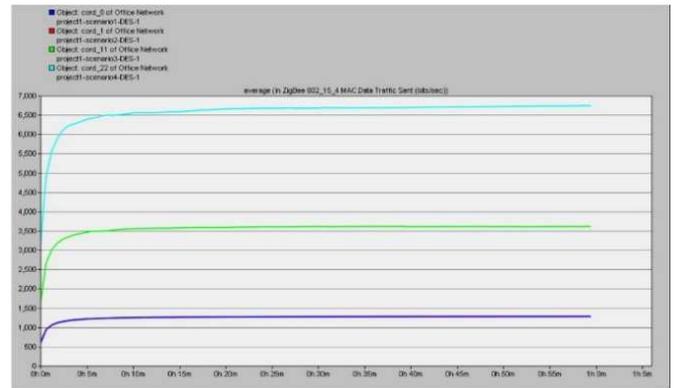

Fig. 6 Data Traffic Sent for the Four Scenarios

B. Management Traffic

Network management: the gateway can receive routing data from the router and sensor nodes and will host the computer that receives commands delivered to them. The router node acts as a middleman to facilitate communication between the gateway and sensor nodes as the gateway and sensor nodes cannot connect directly[12].

The management traffic sent by the four scenario networks is displayed in Fig. 7. This chart makes it clear that using a single router lowers the quantity of management traffic sent, as demonstrated by the comparisons between scenarios 1 and 2 and between scenarios 2 and 4.

Fig. 8 shows the management traffic received by the four scenario networks that discussed in the previous section. It can be seen from this figure that the received management decreases when we decrease the number of routers and the number of coordinators. If we compare scenario 4 with 3, the management traffic received reduces due to the reduction of the routers from 4 to 1. Also, the received management decreases when we cancel the single router when we compare scenario 3 with 1.
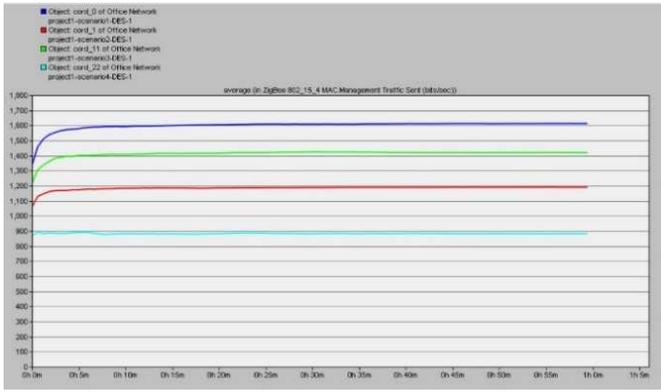
82

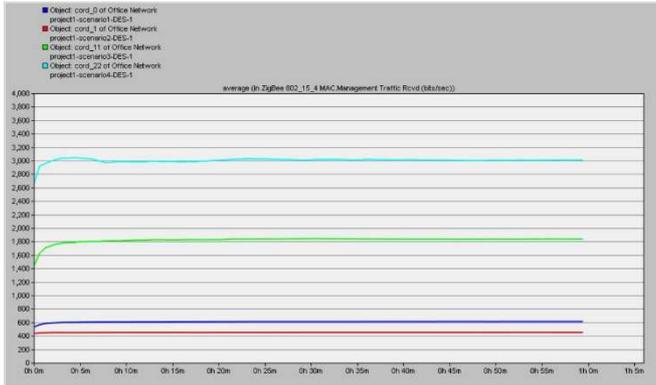Fig. 7 The management traffic sent by the four scenarios

Fig. 8 The management traffic received by the four scenarios

C. Load

Fig. 9 illustrates the load in bits/sec that this node's higher layers deliver to the 802.15.4 MAC[9]. The graph shows that when the number of routers is at its highest, the load is at its highest, and when we reduce the number of routers, the load is reduced. There is no difference in the loads of scenarios 1 and 2, meaning that the quantity of coordinators has no bearing on the burden.
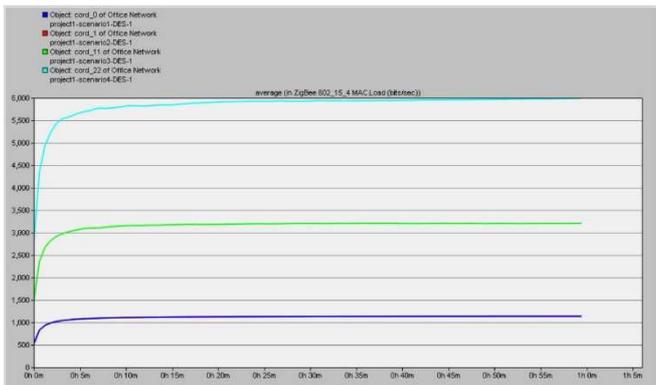

Fig. 9 Load of the four scenario networks

IV. CONCLUSIONS

The amount of data traffic that is received grows in direct proportion to the number of routers. While the data remains unaffected by the number of coordinators. The sent data traffic is subject to the same rules. When the number of coordinators (and/or) routers is raised, the amount of MAC management traffic sent is reduced. It is evident by comparing

the management traffic graphs for scenarios 1, 3, and 4 that as the number of routers drops, so does the amount of management. When there are fewer routers, the MAC load lowers and the load is unaffected by the number of coordinators.

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