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of data is determined by a number of factors, including collisions, obstacles between nodes, and network topology.

- the productivity in the first scenario is greater than in the second and third scenarios, and the productivity in the fourth scenario is very low because there are not enough coordinators to receive all the packets, meaning that the productivity in the fifth scenario will be very high because there is a large number of coordinators, as shown in the figures.
- Traffic sent parameter is a large in the first scenario due to the short time in generating packets and is larger in the fourth scenario due to the large number of nodes and routers.
- traffic received number is low in the fourth scenario, which contains a large number of nodes and routers, and this number is almost the same for the second, third and fifth scenarios, and has the highest value in the first scenario, meaning that almost all the packets sent are received.

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Conclusion

By performing the simulation and displaying the results for a several network (OPNET, and to reach the best possible design of network According to the necessary network parameters. Time delay, loss of packets, throughput, traffic sent, traffic received and productivity, we clarify:

- The results obtained in this paper were used in practical applications in the field of monitoring and Controlling greenhouses.
- That in the first, second and third scenarios, the time delay between the final nodes is not affected by the number of nodes when it does not exceed 20 nodes the time delay is the same. That is affected by the density of data packet flow across the network, but it increases in both the fourth and fifth scenarios, that is, when the number of nodes in the network reaches 240 nodes, due to the large number of nodes that make up the network.
- We note in particular The time delay is greater in the fourth scenario due to the presence of one coordinator device, while in the fifth scenario there are (13) coordinators.
- The number of discarded packets decreased in the second and third scenarios compared to the first scenario when the time between packets generation changed, which led to a reduction in the density of packets in the network. This loss in the fourth and fifth scenarios was similar, meaning that the presence of routers did not affect the operation of the network. The following figure shows this:
- The increase in the number of users of the wireless medium is the reason behind the increase in interference, and thus the amount

of the decrease in data packets generated primarily within the network and thus the packets sent.

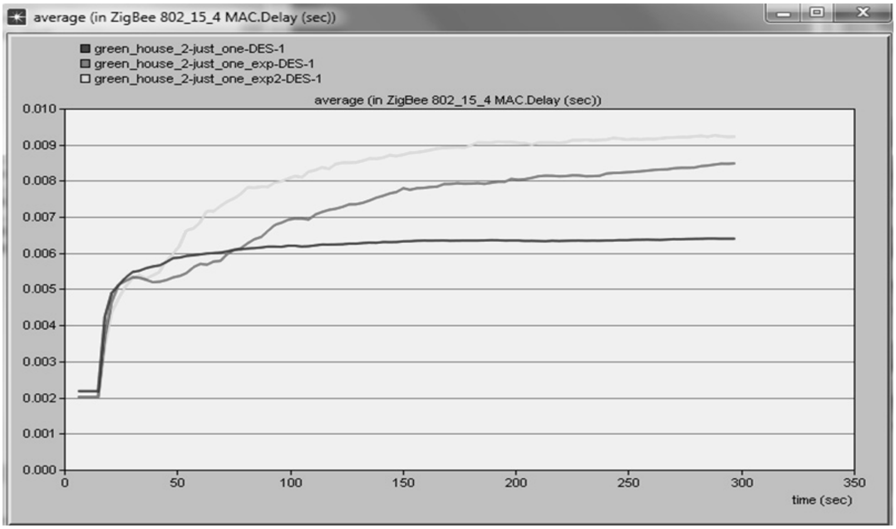

Figure (13) MAC DELAY

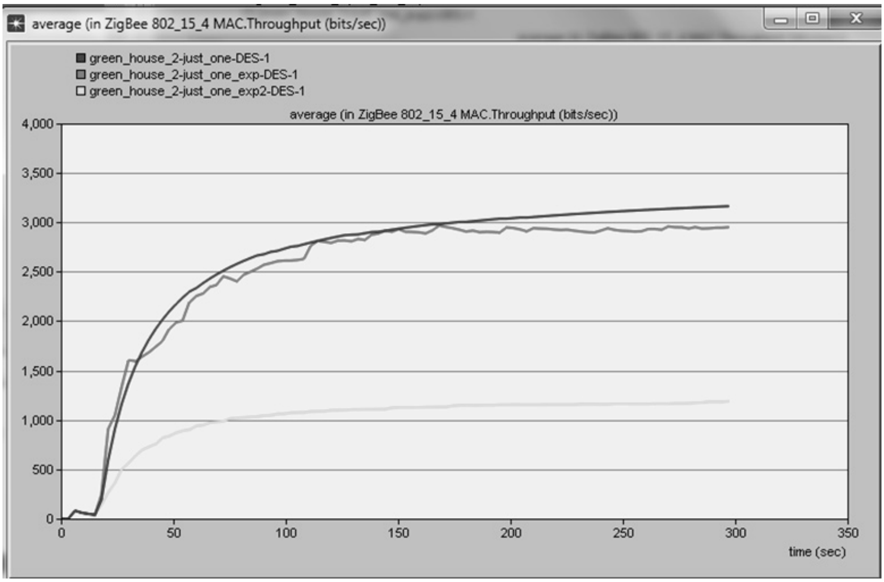

Figure (14) MAC-throughput

We notice that this number is low in the fourth scenario, which contains a large number of nodes and routers, and this number is almost the same for the second, third and fifth scenarios, and has the highest value in the first scenario, meaning that almost all the packets sent are received. As it illustrated in figure (12)

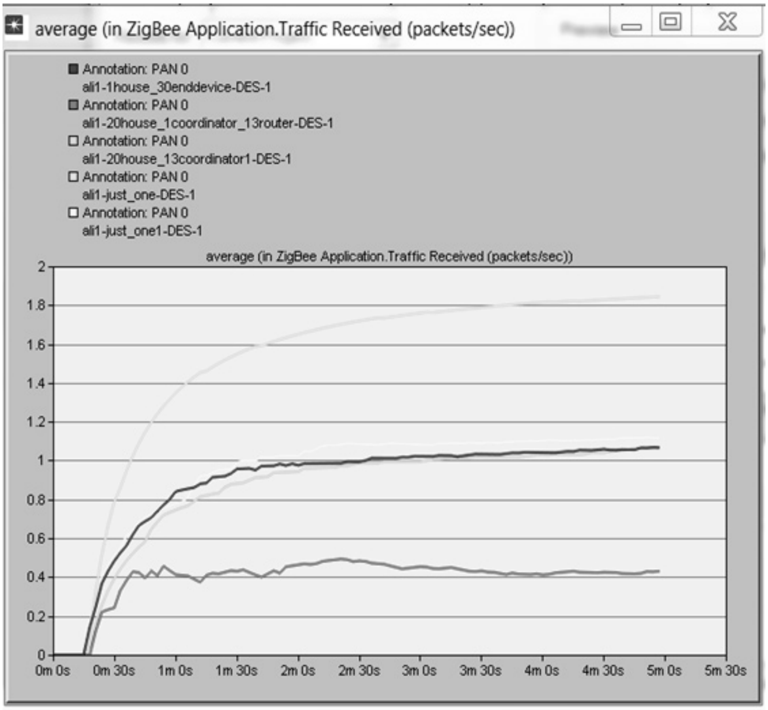

Figure (12) shows the graph of the transmitted and received data.

- **Delay:**

It is the time between waiting for the packet to be transmitted at the physical layer and receiving the last bit at the receiving node.

After conducting the simulation and displaying the graphs of productivity and delay, we notice an increase in delay and a decrease in productivity in the third scenario compared to the second scenario as a result

- **Data sent and received traffic sent & traffic received**):

- *traffic sent*: It represents the total number of data sent from the source to the destination in one unit of time regardless of whether it arrives or not.

We notice from the graph of this parameter after running the simulation as shown in figure (11), that it is large in the first scenario due to the short time in generating packets and is larger in the fourth scenario due to the large number of nodes and routers.

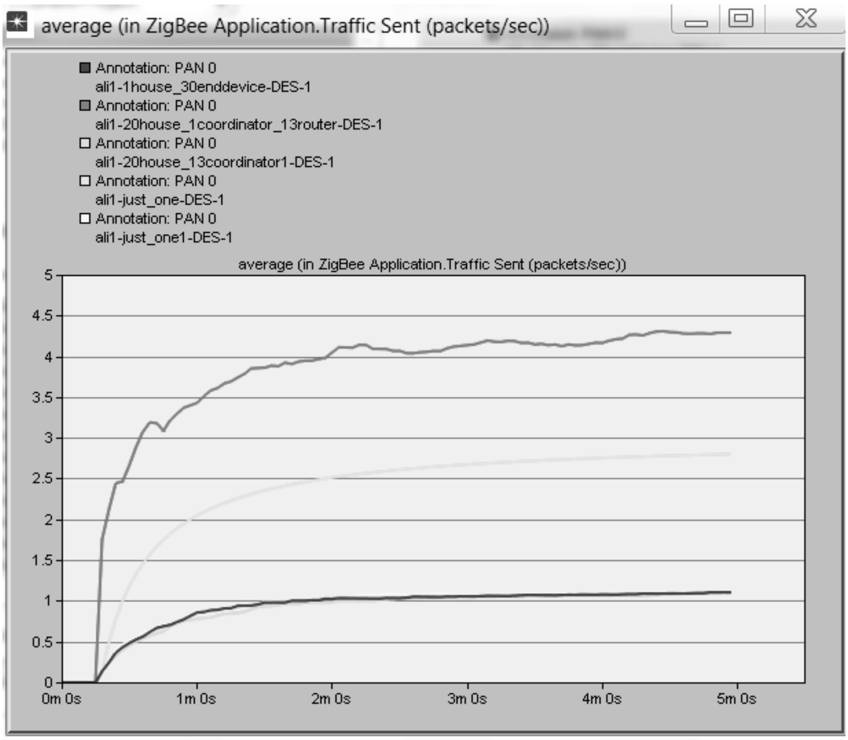

Figure (11) Chart of sent packets

- *traffic received*: Represents the number of packets received in one unit of time.

- **Throughput**:

The actual amount of data sent from the source to the target during a specified time (Second) The increase in the number of users of the wireless medium is the reason behind the increase in interference, and thus the amount of data is determined by a number of factors, including collisions, obstacles between nodes, and network topology.

After conducting the simulation and displaying the productivity charts for all scenarios, it became clear that the productivity in the first scenario is greater than in the second and third scenarios, and the productivity in the fourth scenario is very low because there are not enough coordinators to receive all the packets, meaning that the productivity in the fifth scenario will be very high because there is a large number of coordinators, as shown in the figure (10):

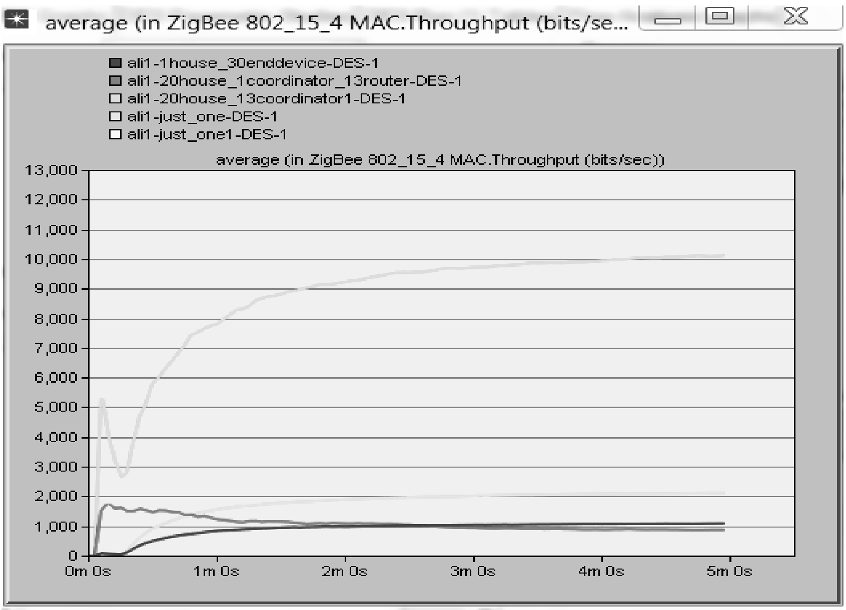

Figure (10) Productivity chart (throughput)

in the flow of data packets in it, so that the intermediate nodes' stores become full and unable to receive any new packets.

After running the simulation and displaying the graph of the discarded packets, it became clear that the number of discarded packets decreased in the second and third scenarios compared to the first scenario when the time between packet generation changed, which led to a reduction in the density of packets in the network. This loss in the fourth and fifth scenarios was similar, meaning that the presence of routers did not affect the operation of the network. The following figure shows this:

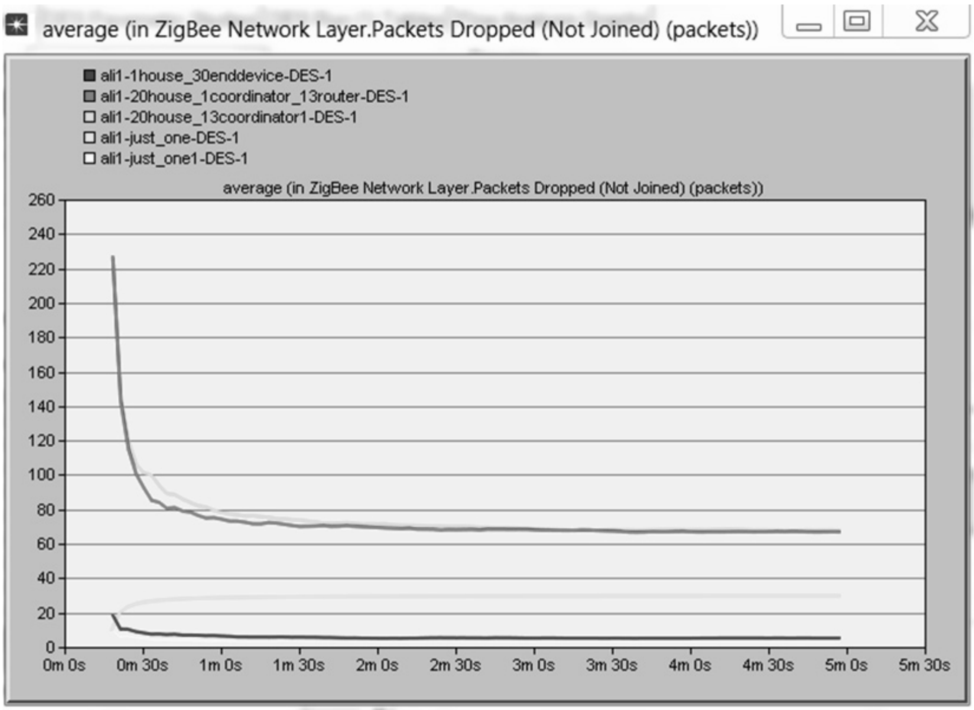

Figure (9) The graph of the neglected packets (loss of packets

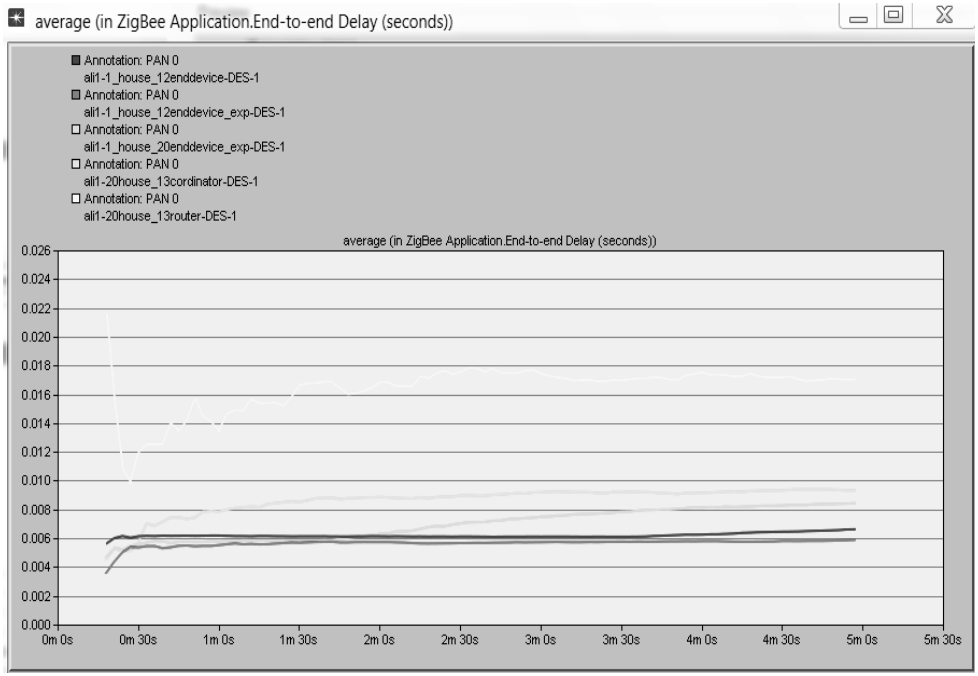

Figure (8) Time delay (end-to-end delay

- **Neglected packets (loss of packets)**:

This parameter is defined as the parameter that determines the data packets sent from the sending nodes that do not reach the receiving nodes as a result of their loss in the network or the packets that do not reach from the sender to the receiver as shown in Fig-(8). There are several factors that cause packets to be lost while they are traveling within the network, such as: the absence of any receiving node within the range through which the sending node broadcasts its signals, which may decrease in value.RSS is a result of various losses or the end of the battery life of neighboring nodes located within its radio range, and one of the other most important reasons is the occurrence of a congestion condition in the network due to the increase

- **Time delay (end-to-end delay)**:

It is defined as the total time delay between the sending node and the receiving node. By performing the simulation and displaying the results as shown in Fig-(8), it was observed that in the first, second and third scenarios, the time delay is the same.That is, the time delay between the final nodes is not affected by the number of nodes when it does not exceed 20 nodes, nor is it affected by the density of data packet flow across the network, but it increases in both the fourth and fifth scenarios, that is, when the number of nodes in the network reaches 240 nodes, due to the large number of nodes that make up the network. We note in particular: The time delay is greater in the fourth scenario due to the presence of one coordinator device, while in the fifth scenario there are (13) coordinators. The coordinator device represents the final node where all communications must end, and therefore the nodes located far from it will need a longer path and a greater number of hops, and thus a greater time delay to reach it, in addition to congestion and competition over the shared medium. As for the presence of more than one coordinator to enter the network, the nodes send data to the closest coordinator to the medium within the network, noting that the routing protocols are responsible for this task to form the parent-child tree or build the approved routing tables and a cage for the protocol and algorithm used, which is the same in all scenarios.

The following figure illustrates the characteristics of the proposed scenarios:

Inter arrival time	Size of data packets generated at the application layer	node spacing	Number of General Coordinator Contracts	Number of final nodes	Number and size of sites served	Scenario number
1second	1024	40	1	12	1 (200*160)	1
Exponentially increasing and step (10)	Exponentially increasing and step (100)	40	1	12	1 (200*160)	2
Exponentially increasing and step (10)	Exponentially increasing and step (100)	35	1	20	1 (200*160)	3
Exponentially increasing and step (10)	Exponentially increasing and step (100)	35	1	240	20 (200*160)	4
Exponentially increasing and step (10)	Exponentially increasing and step (100)	35	13	240	20 (200*160)	5
Exponentially increasing and step (10)	Exponentially increasing and step (100)	35	13	220	20 (200*160)	6

9. Simulation and results

After we have presented the design of this project with several network configurations and different parameters for the devices used, we will simulate these configurations using the chosen program (OPNET) and display the results in the form of graphs and analyze and discuss these results to reach the best possible design. As we mentioned in the introduction to this chapter, the comparison will be made on several parameters.

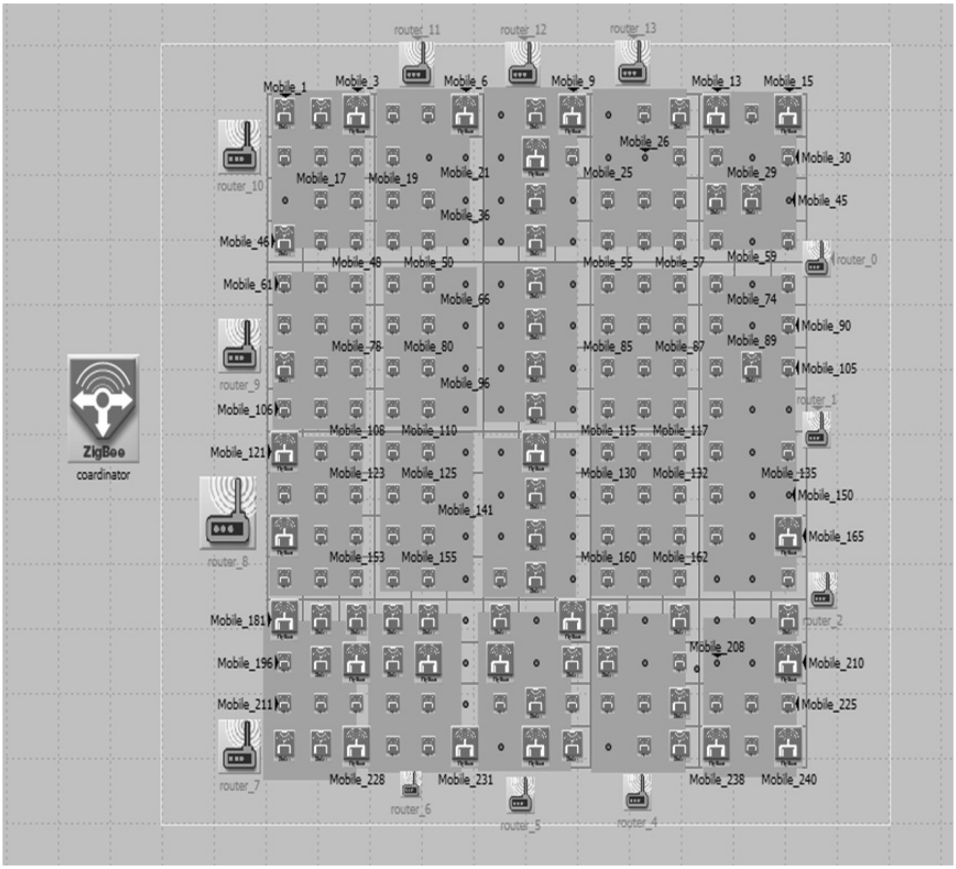

Figure (7) Network design illustrated for the fourth scenario

number of devices composing the network, as we will increase the number to 20 devices instead of 12 devices and we will make the distance between each two consecutive devices (30) meters..

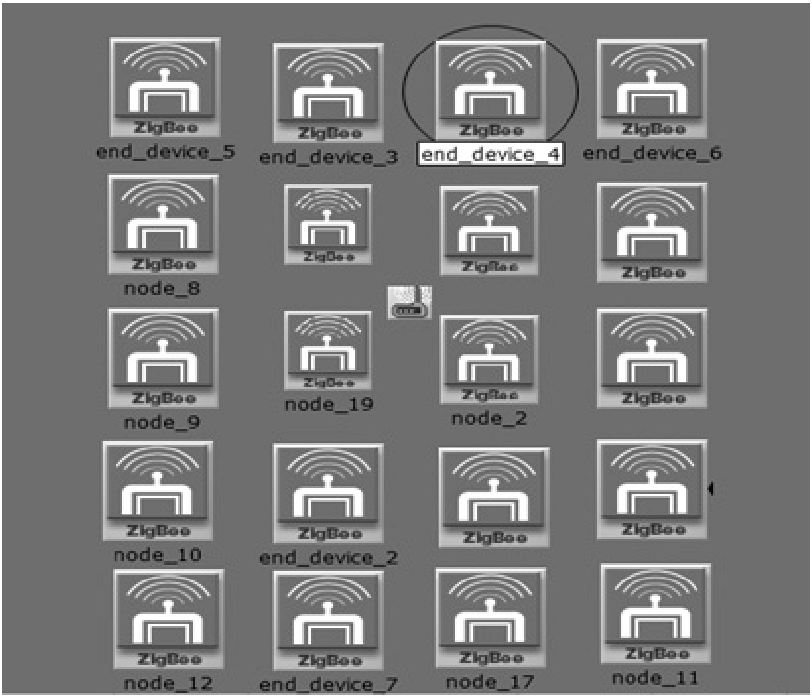

Figure (6) Network design in the third scenario

Scenario 4:

In this scenario, we will expand the network and increase the number of protected areas to become (20), each of which is identical to the design studied in the second scenario in terms of dimensions, area, number of nodes and their parameters. That is, this design will contain (240) end devices. However, we will use (13) routers here, and we will also use only one coordinating device for the design as a whole, as shown in the following figure (7):

Figure (5) first scenario, 12 Zigbee Nodes with one Coordinator

Scenario 2:

In this scenario, we will adopt the same design as in the first scenario in terms of dimensions, number of devices, and their distribution, but we will change the settings of the deployed devices. We will make the size of the transmitted data variable exponentially and with a step of (100). We will also change the time between generating two consecutive packets and make it variable exponentially as well and with a step of (10), as shown in figure-(6).

Scenario 3:

In this scenario, we will adopt the same previous design in terms of dimensions, the presence of one coordinating device and the same previous adjustment for device settings (the same size of the transmitted data and the same time between generating packets), but the change will be in the

- Productivity (throughput).
- Data sent and received (traffic sent & traffic received).

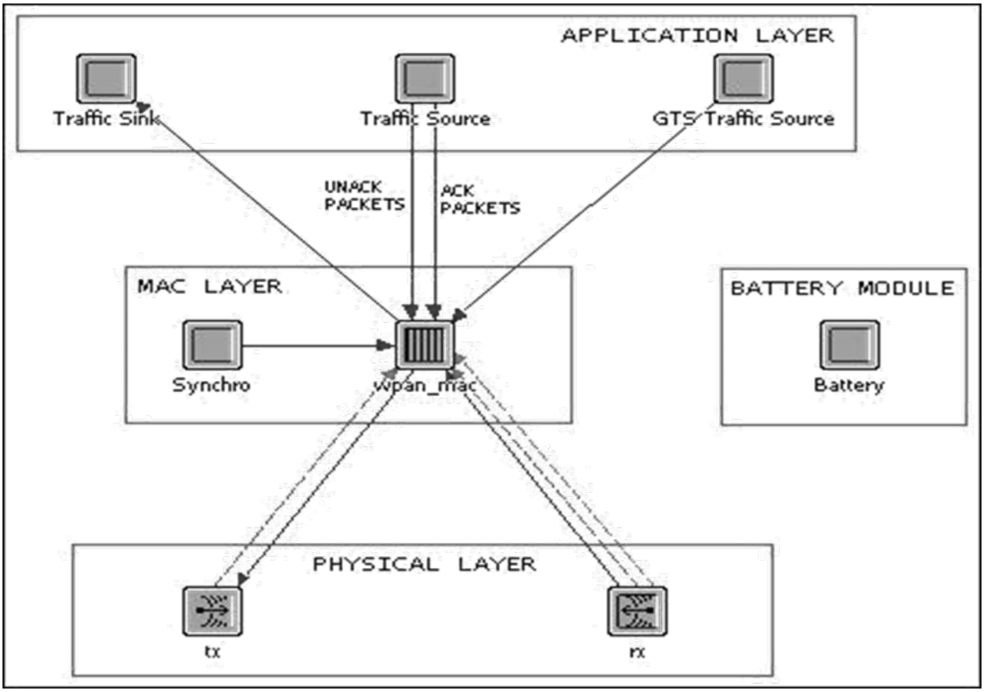

Figure (4) layers structure of Zigbee Protocol in OPENT

Scenario 1:

In this scenario as shown in Fig-(5) we have set up a protected area of dimensions (200*160) meters containing one coordinating device located in the center. The area has (12) final nodes representing the sensors, with a distance of (40) meters between each two nodes.

The default parameters of the devices used in the network were used in this scenario because they fit this design. The access method between nodes was set to random, meaning that each node sends to the closest node until the collected data reaches the primary node (coordinator).

The third model implements the media access protocol at the data layer.MAC.

The fourth model is responsible for routing data traffic, joining subnets to the overall network, and generating beacon requests.

7. Simulation using the program OPNET for IEEE802.15.4

The programOPNET contains version (1.0) of the accurate simulation model and this version is specific to and programmed for the IEEE802.15.4 standard. The PHY layer contains a transmitter and receiver operating at 2.4 GHz frequency, we use QPSK modulation. [12].

Contains a layer the MAC on Slotted CSMA-CA generates beacon frames and ensures synchronization of nodes with the network coordinator. We have the battery module which determines the power levels used. We also have the application layer which contains the data generator in the form of frames. The command frame generator in the MAC generates the ACK frames and the assembly module with statistics for the incoming frames. The radio model contains standard radio modules to simulate the radio channel along with other elements such as interference, noise, propagation delay.

8. Design and Simulation

In this research, we will study several scenarios with several differences, simulate them, compare the results, and analyze them to reach the best representation. There are many parameters that can be compared between different designs and in this research, we will rely on the study of

- Time delay (end-to-end delay).
- Neglected packets (loss of packets).

3. Transfer data between devices:

In style (beacon) cannot send between them.

In style ((non-beacon) Data is transmitted directly using un slotted CSMA/CA technology to access the channel.

The model is ZigBee in OPNET uses four operational models:

1. Model ZigBee MAC.
2. Model ZigBee Application.
3. Multi access carrier model ZigBee CSMA-CA.
4. Model ZigBee Network.

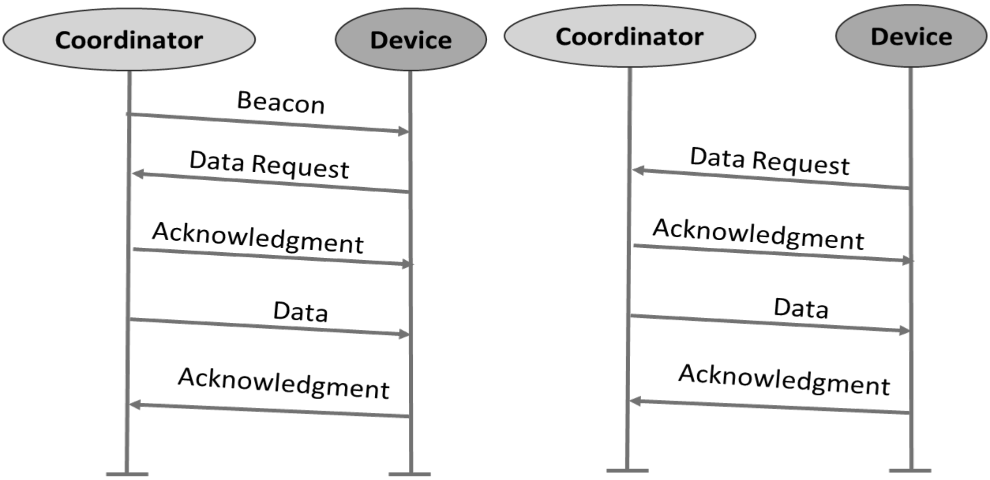

Figure (3) data transfer from the coordinator in Zigbee Protocol

The first model contains a model of (IEEE802.15.4 MAC Protocol) which is used for channel scanning, joining, failure and repair protocol in CSMA-CA unslotted system.

The second model represents a low-resolution version of the application layer in ZigBee contains network configurations, generates and receives traffic, and provides simulation reports.

The following figure-(2) shows the transfer of data to the coordinator:

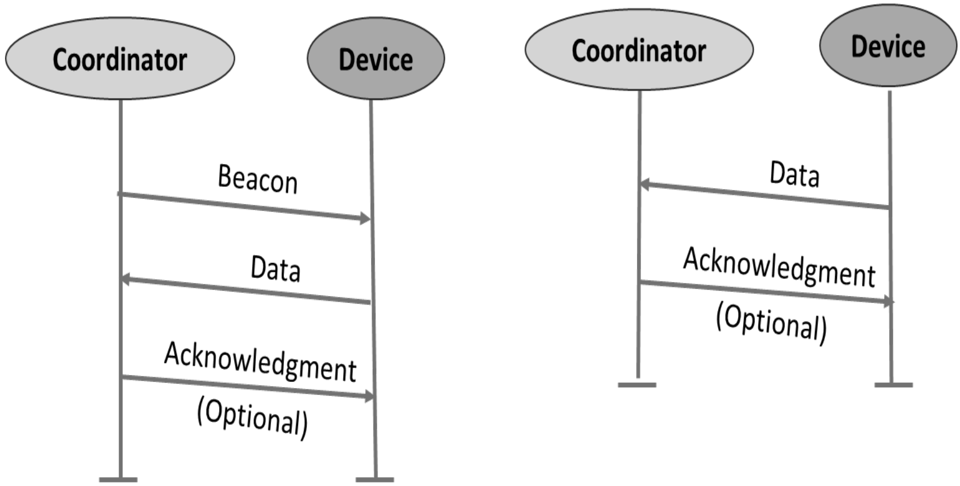

Figure (2) Data Transfer to the Coordinator in Zigbee Protocol Adapted [6]

2. Transfer data from the coordinator:

This is based on the coordinator's request, as it is in the indicative pattern (beacon) The coordinator tells devices that it has packets stored instead of directly sending frames to devices. The device that receives the beacon message first checks whether its identifier appears in the fields of the message. If it does, the device sends a request to send data to the coordinator. The coordinator responds with an ACK and passes the data to it.

As for the non-indicative pattern ((non beacon) The device must periodically send data request frames to inquire if there are packets stored for it, and if there are, the coordinator responds with an ACK and sends the frame to begin the data transfer procedures. The following figure-(3) shows the data transfer from the coordinator:

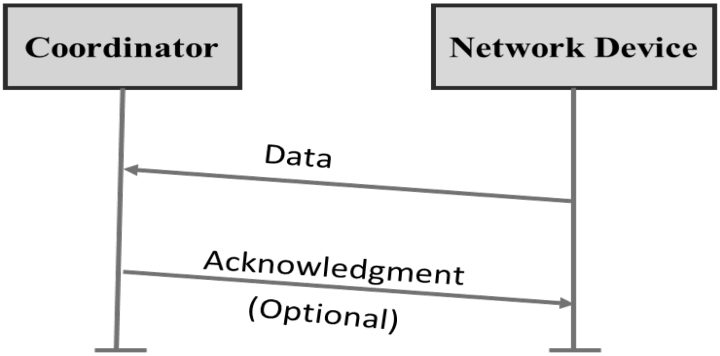

Figure (1) non-indicative pattern of Zigbee Protocol Adapted [6]

In general, the protocol ZIGBEE reduces the time that the sensor node is in the ON state and thus reduces the amount of energy consumed. Whereas in BEACON mode the sensor is only active during the data transmission period, while in NON-BEACON mode the energy consumption is absolutely not synchronous with the transmission since some sensor nodes are always in the ON state without working, so we notice that BEACON mode is the most important mode in WSN networks. So, we have three models for data transfer:

1. Transfer data to the coordinator:

Where in pilot mode when a particular device wants to transmit it uses time slots to compete for the channel using the technology of slotted CSMA/CA after receiving the beacon message.

In the non-guide mode, devices will compete for the channel using theunslotted CSMA/CA The data is sent directly to the coordinator and when the coordinator receives this data, it sends a report of it with an (ACK) message.

- **The guide pattern (beacon mode)**:

In which devices are used the super frame that starts with the beacon helps in synchronization between the devices participating in the network. Each super frame is divided into an active period and a variable inactive period. Communication between the devices takes place during the active period and stops during the inactive period, and the devices enter a sleep state and low power mode until the beginning of the new frame.

Here the devices are used. Slotted CSMA-CA. This mode is used when the CORDINATOR is powered by battery. In this mode, the END DEVICES wait for a BEACON message from the CORDINATOR, which is broadcasted periodically, to send the data. After completion, the CORDINATOT and END DEVICES enter the SLEEP mode.

- **Non-indicative pattern (non-beacon mode)**:

This pattern as shown in Fig (1) is employed when the feed is CORDINATOR via a power supply and in this mode the END is always in SLEEP mode and is activated when the required event occurs. For example, in wireless sensor networks inside the GREENHOUSE, the sensor nodes will wake up and become in an ACTIVE state when the temperature reaches the required value, then they send information to the CORDINATOR which remains in a continuous waiting state.

The disadvantage of this pattern is that the sensor node may find the channel busy and information will be lost.

This layer provides three important services:

Receiver Energy Detection (ED): It estimates the strength of the received signal within the channel bandwidth in order to determine the reception of this signal as a packet and is also used in the network layer to create a path.

The Link Quality Indication (LQI): is a process of characterizing the quality of the received packet and this characterization is done using an (ED) device in order to calculate the signal-to-noise ratio.

Channel Assessment (CCA): It is a logical function that exists to determine the current state of the wireless medium in order to be able to use it. In this standard, three types of CCA are used:

- **Energy over threshold**: Where it gives the CCA indicates that the channel is busy if the ED value is above the threshold.
- **Carrier Sense Only**: Gives the CCA states that the medium is busy only when a modulated signal is detected and has the propagation characteristics of the IEEE802.15.4 standard.
- **Carrier sensing with energy above threshold**: Gives the CCA indicates that the medium is occupied when a signal is detected with the IEEE802.15.4 standard modulation and propagation characteristics with power above the ED threshold.

6. The standard IEEE802.15.4 MAC ZigBee

It is located above the physical layer and works to secure access to the wireless channel by avoiding potential collisions in the channel. It provides services to the network layer and contains address data. frame to know the source and destination of this data, this standard allows two modes of operation in the network [9-16]:

- Equipment layer ZigBee is responsible for establishing local links between the source node and the target node, routing messages between devices, and defining device rules within the network such as: ZigBee Coordinator, Router or End Device.[14]

5-2 Network layer:

This layer is responsible for: - Initiating and defining the network topology (joining or leaving the existing network).

- Directing the Frame to target.
- Path discovery between peripheral devices (Sensors).

5-3 The standard IEEE 802.15.4 PHY Zigbee (Physical Layer):

It is the lowest layer and performs the process of modifying the outgoing signals and extracting the incoming signals. It also allows for channel selection to avoid radio interference, in addition to exchanging data with the higher layer (MAC)[7-13]. The IEEE 802.15.4 PHY standard at the physical layer supports two types of services:

- **Data Services**: Allows the transmission and reception of physical layer protocol data units. (PPDU: Physical Protocol Data Unit) over dedicated radio channels.
- **Management services**: These are related to sending pilot frames by nodes programmed as multi-access coordinators, and they have priority to start sending these frames using a timer that ensures the accuracy of the transmission timing.

formations (star, tree, mesh, etc.). It is also considered a low-cost technology compared to other technologies, in addition to its high, accurate and flexible performance.

Wireless sensor networks designed using sensors such as ZigBee provides high flexibility and diverse capabilities in all scientific and engineering fields. Using these networks, information can be transferred from one area to another at a low cost and with low energy consumption. The advantages of choosing ZigBee include:

- It expands the industry and processing systems and enables constant supervision and control that increases management and thus labor productivity.
- Supervising the work and thus saving personal effort and public safety.
- Get accurate readings, do precise work, and detect problems before they happen.
- Eliminates the need for manual monitoring and thus reduces the occurrence of unwanted errors.

5. Protocol structure of ZigBee

The technology ofZigBee has its own four-layer model, each with its own function, as in the OSI model. It includes:

5-1 Application layer:

Application layer ZigBee consists of:

- A sub-application layer that connects two devices based on services and the need to route messages.

4. Technique ZigBee in Wireless Sensor Networks

The latest technology Wi-Fi is a revolution in the field of wireless networks, as it has made it easier for us to connect to internal networks when we are outside [4-5]. This technology has also made it easier for us to connect between devices, as it has greatly reduced the number of cables. This has led to companies' interest in this technology. But at that time, there were many companies and institutions suffering from the problem of energy consumption and the cost of building projects with these technologies [5-13]. Faced with the demand for low-power consumption and cost-effective wireless communication, engineers sought inspiration from nature. The collective behavior of bees offered a compelling model: despite their simplicity, bees can achieve complex tasks by sharing energy and communicating through distinctive movements such as the "waggle dance." This natural system of efficient, decentralized coordination inspired the creation of ZigBee technology. Developed to support low-data-rate, low-power wireless networks, the idea of ZigBee emerged in 1998. After nearly a decade of standardization and refinement, the first full specification was finalized in early 2007 [5] and [7]. Therefore, it is a grid connection technology designed specifically for applications that require long-term operation without the need for electrical power supply between short periods. This technology is equipped with batteries with a life span of up to 360 days of continuous operation without the need to charge it more than once. It is also specially designed for uses that require high service availability so that there is a direct alternative in the event of a device failure. Its features include the ability to control hundreds of peripheral devices over long distances. Up to 70 meters and the possibility of forming the network in several ways and

3.2. The standard IEEE802.15.1:

- Also known asBluetooth is a personal area network (PAN) for transferring data from one device to another.
- It features lower power consumption than the previous standard.
- It supports tree formation and can connect several devices together, and only 8 devices, one master device and the rest are slaves, and for a maximum distance of 10 meters.

3.3. The standard IEEE802.15.4:

- This standard was designed as an evolution of the previous two standards for control and monitoring operations in wireless network applications. It is the most flexible standard that supports multiple data transmission rates and multiple communication frequencies in addition to multiple network configurations (tree, star, etc.).
- The most useful thing about this standard is the low power consumption because many devices are activated and deactivated at certain periods and as needed.
- This standard ensures the design of flexible and low-cost networks.
- This standard operates based on several frequencies and different data transfer rates:
  20Kbps for 868MHZ frequency
  40Kbps for 902MHZ frequency
  250Kbps for 2.4GHZ frequency
- The protocol ZigBee falls under this standard and is the most widely used protocol.”

location that work together to monitor a studied phenomenon to obtain the required information and pass it to the required location.

These networks have enabled the creation and innovation of a large number of applications in all civil and military fields [2-10].. By civil, we mean everything that is useful in our lives, such as monitoring, facilitation, work and protection methods, such as designing smart homes for the elderly, tracking and detecting vehicles and cars, detecting and monitoring car theft, managing and monitoring traffic. fire-fighting, Agricultural environmental control and monitoring operations such as measuring temperature, humidity, etc. in medical, industrial and commercial fields [14]. Military applications include monitoring targets and early detection of nuclear and chemical attacks, etc.

3. Standards used in wireless network protocols

As mentioned in [4] and [5] there are several standards adopted and used in wireless networks, which can be explained as follows:

3.1 Standard IEEE802.11:

- Also known as wifi is a standard designed for public wireless networks.
- Its standard communication range is 30 meters inside a building and 90 meters as line of sight.
- Based on this standard, the data rate is (1-150) megabits per second.
- This standard causes high power consumption but high transmission rate.

1. Introduction

Wireless sensor networks (Wireless Sensor Network (WSN) is a scientific revolution in the field of wireless communications and embedded and deployed systems as a result of the rapid development we are witnessing today. It has opened the way for the innovation of a new generation of applications in various fields such as the environment and weather monitoring, health monitoring, building and facility safety inspection, and security such as intruder detection and restricted area intrusion, traffic and fire detection. These applications are mainly related to the remote monitoring and control of various and multiple sensory (or physical) events such as temperature, pressure, light, sound, etc [10]. through small wireless devices. These devices contain sensors that capture and collect the information sensed in the monitored environment, and then send it wirelessly from one device to another in cooperation with each other to a monitoring station, which is a computer that collects information from the scattered wireless sensor devices, processes it, and analyzes it. In this project, we will discuss the use of these modern networks in the agricultural field, specifically in greenhouses, monitoring them, and controlling the workflow in them, as continuous monitoring and controlling the environment inside the greenhouse here is of great importance, i.e. controlling the temperature, humidity, lighting, and gas percentage.CO_2 and protection from harsh climate [1-13].

2. Wireless Sensor Networks and Protocol ZigBee

The term wireless sensor network, or WSN, is used for short.WSN) is a network consisting of a large number of sensor nodes spread in a specific

المستخلص

تُعدّ البيوت المحمية ذات أهمية كبيرة في المجال الزراعي، حيث توفر البيئة المناسبة والمهمة لنمو وإنتاج مختلف النباتات بغض النظر عن الظروف البيئية المحيطة. ويُعتبر مراقبة هذه البيوت والسيطرة عليها أمرًا ضروريًا وهامًا من أجل توفير البيئة المطلوبة والحصول على أفضل إنتاج. لذا، فإن هدف هذا المشروع هو دراسة مراقبة هذه البيوت والتحكم فيها باستخدام شبكات المستشعرات اللاسلكية، والتي تُعد من الطرق الحديثة والبسيطة نظرًا لدقتها وقلة الجهد الذي تتطلبه، وبالتالي تؤدي إلى إنتاج أفضل. وستتناول الدراسة عدة تشكيلات وتصاميم لنموذج البيت المحمي، بالإضافة إلى محاكاته باستخدام شبكة OPNET لتحديد أي التصاميم أفضل من حيث الأداء على أرض الواقع.

تُظهر هذه الدراسة تأثير زيادة عدد العقد في الشبكة إلى 240 عقدة، وكذلك تأثير وجود جهاز تنسيق واحد أو أكثر، مع فترات التوليد بين الحزم، مع تحديد أثر ذلك على تقليل عدد الحزم المتلفة. كما توضح هذه الدراسة كيفية زيادة الإنتاجية اعتمادًا على عدد أجهزة التنسيق لاستقبال جميع الحزم.

الكلمات المفتاحية:

زيقبي (Zigbee)، أوبنت (OPNET)، الإنتاجية (Throughput)، التأخير (Delay)، لاسلكي (Wireless)، شبكة (Network).

Abstract

Greenhouses are of great importance in the agricultural field as they provide the appropriate and important environment for the growth and production of various plants regardless of the surrounding environmental conditions. Monitoring and controlling these houses are considered necessary and important in order to provide the required environment and obtain the best production. Therefore, the aim of this project is to study the monitoring and control of these houses using wireless sensor networks, which are considered modern and simple methods due to the accuracy of work and little effort they provide, and thus better production. The study will be for several formations and designs for the greenhouse model and simulation using the program OPNET to determine which designs are best for better performance on the ground .This study shows the effect of increasing the number of nodes in the network to 240 nodes, as well as the effect of having one or more coordinating devices with the time between packet generation periods, while determining the effect of this on the decrease in the number of discarded packets. So This study also shows how to increase productivity depending on the number of coordinators to receive all packages.

Keywords: Zigbee, OPNET, Throughput, Delay, Wireless, Network.

Empirical Research of A Greenhouse Monitoring and Controlling System Using ZigBee Protocol / Original article

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تجارب عملية لنظام المراقبة والتحكم في البيوت الزجاجية باستخدام بروتوكول ZigBee