On Some Networks with Mobile Gateway Improving the performance of data sets systems

Sandy Montajab Hazzouri

Faculty of Informatics Engineering , Albaath University, Syria

Email: Samonhaco1994@gmail.com

Abstract

Nowadays, Automatic Meter Reading (AMR) systems are applied in many technologically advanced countries. Many researchers proved that Wireless Sensor Networks (WSN) is one of the most overwhelming technologies for meters information collection systems. In this research, we proposed a network design for the WSN to collect the electric meters information in Jableh city-Syria using mobile gateway. We improved the performance of IEEE 802.15.4 protocol using Guaranteed Time slots (GTS) according to our application need. WE also deduced the mathematical equations that describe the protocol and thus we could get pre-simulation results. We used NS 2.35 and SUMO 0.32.0, and we found that by choosing the appropriate values for the protocol parameters according to our network design and method of collection, we could achieve the reliable collection of electric meters for a gateway speed of up to 70 Km/h which is considered an improvement of the protocol performance compared to other literature studies.

Keywords: AMR; WSN; mobile gateway; GTS; IEEE 802.15.4; NS 2.35; SUMO 0.32.0.

1. Introduction:-

The process of collecting electricity bills in developing countries is done manually, and this is what causes a lot of errors and energy waste

Humanity. Therefore, there is a need for smart grid network systems that support the reading of meter information

Automatic Meter Reading (AMR) is automated, and many AMR technologies have been adopted that rely on

On various connection methods, including: PLC transmission line Cables (Power Line Cable), cellular networks,

Telephone lines, wireless sensor networks (WSNs) and other wireless sensor networks

Techniques [1].

Wireless sensor networks in- general- are a network that includes a set of small low cost devices

The low transmission rate is electrically fed by the battery and distributed either specifically or randomly and

These devices wirelessly send information among themselves right up to the base station. WSNs is one of the most promising solutions

AMR systems are distinguished from other technologies by the low cost of installation and maintenance of the network and its high efficiency. It is done

Doi: https://doi.org/10.54216/PMTCS.020201
Received: January 19, 2023 Revised: April 18, 2023 Accepted: September 14, 2023

Connect each electricity meter (or set of meters)with a wireless sensor, then send the meter readings to node /nodes

An intermediary until it is transferred to the main center where it is processed.

Despite the high population density in cities, it is due to the relatively short transmission range of wireless sensors

We may encounter points where there is no coverage, which weakens the connectivity in the network. So additional nodes are needed to achieve

Higher connectivity, but this causes an increase in cost.

There are many solutions to overcome this problem, including using the mobile portal to collect sensor information

This method has a number of advantages, including [2]: providing the number of nodes

Added wireless, improved network connectivity, and improved reliability because the connection between the nodes of the sensors

And the moving node is done with one jump, as there is less competition, so the chances of collisions and loss of messages are reduced. And since

Communication takes place in one jump, the need for a routing protocol becomes less important, and therefore the size of The FADER is saved

The network layer thus decreases the overall size of the message. On the other hand, the use of the mobile portal to collect

Electric meters the design of the access control layer protocols of the Mac medium is required to take into account the movement

And reliability [4] , [3], without necessarily paying attention to energy saving since the sensors are connected directly to the feed

Electric.

The researchers in the study [5] have designed a home wireless sensor network with a smart electricity meter powered by

Zigbee , where the meter sends the readings to a computer and then analyzes the data to determine the consumption rate

The user. But this design has not been tested for wireless sensors outside the home and on the other hand requires

The system has a computer at the user's end, which increases the cost of equipment. While the researchers in

Dr. [6] designed an automated electricity meter system using wireless sensor networks and based on

The Internet of things is the Internet-of-Things (LOT), but the research was applied to only three counters and this is what puts

A challenge to test it for a wider network. Researchers in the Study [7] proposed a system for collecting electricity and water meters

And gas through a network of wireless sensors with cluster topology, where the electricity sensor and the water sensor are integrated

And a gas sensor with a built-in sensor node called Electric ,Water and Gas Sensor Node (EWGSN)

The first level of the data collection process is data aggregation . The main problem of the system is the cost of

The relatively high integrated nodes, on the other hand the primary focus of the MAC layer protocol is energy saving

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The fact that the water and gas sensors are fed by the battery. While in the study [8], a system for collecting information was proposed

Meters are relatively complicated using wireless sensors based on Wi-Fi technology and therefore the cost of the sensor has increased

Compared to cheaper technologies .

In the reference study [9], the planning of a wireless sensor network for collecting electrical meter information was proposed

In rural areas with sparse topology using mobile sink mobile bank has not been expanded

To include dense topology, the IEEE 802.15.4 protocol has been adopted as a link layer protocol

The data is in the working mode without activating the Beacon non-beacon enabled mode, and this is what causes the rate to increase

Collisions and loss of messages therefore limits the speed of the moving collection node, as no fundamental improvements have been proposed

On the other hand, the size of the packet sent from each sensor, which represents

The information of one counter is 60 Bytes, which is a relatively large volume that has not been reduced by mechanisms to reduce it.

In the study [10], the Emergency Enabled MAC (EE-MAC) protocol was adopted to ensure communication

Real-time reliability in industrial wireless sensor networks. Where the connection is generally made using

The principle of the super frame and TDMA technology to reach the middle. In case of emergency connections, a pause is made

To connect using traditional TDMA, the network coordinator crams several additional time slots with

Higher priority within the TDMA framework . The process of giving a higher priority to some nodes reduces the delay time of their arrival

For the channel, but on the other hand, it increases the delay in the arrival of the lowest priority nodes. The size of the header of this protocol is also high

Relatively. The performance of the protocol was tested by computer simulations and not by a real environment, as it was not tested

In mobile systems.

Wireless sensor networks with moving elements are a solution to many problems of traditional networks, and in

Sometimes their use is necessary. For this, several protocols of the native Mac layer have been adopted

For movement. In the reference book [11], the Mac protocol was proposed to take into account the delay for sensor networks

Scattered wireless with moving elements, where the moving sink wakes up the nodes in the network, and when you take

The transmission node prioritizes MAC layer data depending on the nature of the data and on

Temporary memory capacity. The previous protocol is a development of the 802.11 protocol for mobile environments

This increases the relative cost of sensors, and it also aims to save energy at the expense of delay

Chronology. While in the study [12], the Mobi Disc protocol was adopted as a MAC layer protocol to improve the mechanism of

Discovery of the most suitable nodes for sending data in wireless sensor networks with moving elements. In

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The discovery process is carried out with low power consumption and relatively high latency. As for the pattern

Working First Ack Next-hop (FAN), the detection process is carried out with a low delay at the expense of power consumption,

It is possible for a moving node to detect a node that is closer to the bank than the node that was moving

I started sending packets to her, so she switches to that node and completes the process of sending her packets. Work performance was analyzed

The protocol is in the case when the mobile node sends packets to the bank through stationary nodes and the case of

The fact that the bank is mobile and the process of selecting the receiving node will require a significant increase in the size of the header. In

According to the reference data [13], the MS - SMAC protocol supporting mobility-sensor MAC (MS-SMAC) has been adopted, which reduces the likelihood of disconnection due to a change in speed

Mobile nodes in wireless sensor networks. Where the moving node sends learning packets through it

The nodes that are fixed on how fast and in which direction they are, they respond with a confirmation message that includes their sleep times and sleep times.

The disadvantages of MS-SMAC can be summarized by the following two points:

First: the mechanism of anticipating the movement causes an increase in the size of the header.

Second: the process of predicting the movement is based on the value of

The intensity of the received signal is determined by RSSI and this is what reduces the reliability of the operation. The researchers in the study [14]

Using the MobiXplore protocol to reduce both the reconnection delay and the handover delay in networks

Wireless sensors by giving priority to packets sent by mobile nodes higher than the priority of packets

Fixed nodes, but this mechanism will complicate the process of entering the medium and cause a delay in sending fixed nodes.

2-the importance of research and its objectives:

The research is gaining its importance from the recent increase in trends in the application of automated collection systems for meter information

In many developed countries, the quality of the service received by the consumer is improved by the possibility of including

Information on consumption at peak hours and on possible errors in the network, as well as hand saving

Reduce the rate of human errors during the meter reading process. In this research, an analytical study is presented

To make the IEEE 802.15.4 protocol using GTS in wireless sensor networks with elements

In addition to improving the performance of AMR systems for collecting electrical meter information using the mobile portal

In wireless sensor networks.

The research aims to propose a design model for a wireless sensor network with real dimensions intended for collection

Automated measurement of electric meters using a mobile bank, also aims to improve the protocol layer

MAC IEEE 802.15.4 to take into account mobility, reliability and time delays at the expense of consumption

Energy.

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3-research and materials:

In the research, we used the NS 2.35 program to plan the network of wireless sensors [15], [16] , and we made a model

My design is to improve the performance of network work. The information of the electric meters was collected)each set of which was connected

To a single wireless sensor (using a mobile node representing the network coordinator).

And work has been done to improve the performance of the IEEE 802.15.4 protocol by expanding the IEEE module module

so that it supports communication using GTS [17], and by 802.15.4 adjusting the values of some parameters, including

It fits into the user's application and network layout.

The SUMO 0.32.0 and NETEDIT 0.32.0 programs were used to obtain the dimensions of the suburb neighborhood

In the Syrian city of Jableh and on the sites of the optimal sensors necessary for the collection process with an extension .tcl so after getting

On the neighborhood map from the website www.openstreetmap.org by extension .osm and have been obtained

The coordinator's movement file is within the neighborhood streets by extension tcl.

3-1-using the IEEE 802.15.4 standard:

The IEEE 802.15.4 standard defines the characteristics of the MAC layer and the physical layer of private area networks

Wireless low transmission rate LR-WPAN, and works on low-price and low-consumption devices

Power with a low range and transmission rate [18] . The protocol supports two working modes, one of which is selected by

The two network coordinators are the non-activated beacon Non-Beacon-enabled mode and the activated beacon mode

Beacon-enabled mode .

In the activated beacon mode, data is transmitted between devices by the principle of a macro-Super frame, the formula of which defines

By the network coordinator and this formula is sent to the devices via each beacon frame Beacon frame sends

Periodically by the coordinator so that it occupies the beginning of the total frame. The total frame consists of two periods, the effective period

Active Period consisting of 16 equal time slot slots through which data can be exchanged This is followed by a period of inactivity of the Inactive Period during which the sensors can enter the energy-saving mode, and this is what Shown in Figure (1)

When SO=BO, BI=SD, and the macro framework is always effective, this is what we will adopt during our study.

The effective part of the total frame consists of the Beacon that is sent at the beginning (time slot O) And the access area competition Contention Access Period (CAP)

In which data is exchanged using technology Slotted CSMA/ CA, from the content Free Period (content free Period) (CFP) which consists of

A consecutive set of guaranteed time slots (GTSs) guaranteed Time Slots (GTSs) Guaranteed Time Slots (GTSs) Guaranteed Time Slots (GTSs) Guaranteed Time Slots (GTSs) that are exchanged

The information during which there is no competition between the device and the network coordinator is limited

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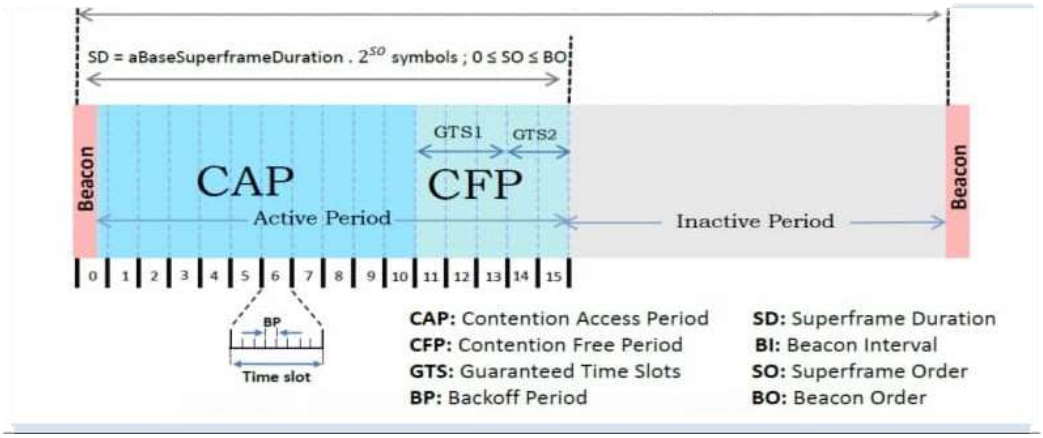

Figure 1: the structure of the overall framework of the IEEE 802 protocol

advantages of connecting using GTS: 3-2-

The IEEE 802.15.4 module has been extended in the NS 2.35 program to include communication using

GTS.

Connecting using GTS is very convenient for sending electric meter information to the mobile node of several

Causes :

1-the IEEE 802.15.4 protocol has been tested for performance in real working environments unlike many other

The proposed protocols whose performance has been tested in simulation software only.

2-the use of-GTS achieves reliability, which is the most important requirement in the application under study.

3-the use of - GTS is convenient in the case of a relatively low data volume and number of nodes, and this is what we have sought

To achieve it through the proposed network model.

Seven devices can use GTS within the same total frame, and each GTS can occupy more than one slot

The device to which the GTS is reserved can only send its data within this GTS [19], [20]

Before starting the transmission process, the device must ensure that the transmission of any data frame (including time)

The interval between long Inter Frame Spacing (LIFS) and sending a receipt confirmation message (Ack will end)

Before the end of the GTS, otherwise the device must wait for the GTS assigned to it in the next macro frame. To achieve

Communication is in the CFP zone, command frames are exchanged through the CAP zone , so the smaller size of the zone

The CAP must not be exceeded, and this puts a restriction on the use of the entire effective area of the overall frame in order to

. [21]CFP

3-3-calculation of the maximum length of the CFP zone:

To find out the maximum number of time zones of the total frame available for use in the CFP zone, you must find out the number of

The time zone that must be used in the CAP ($T_{CAP.Min}$) which must be customized to send a frame

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The $Beacon_{max}$is at the maximum maxeaconb size and for the minimum part of the cap area that cannot be exceeded

CAP any time that must be reserved for an area .aMinCAPDuration

$T_{CAP.Min}$= aMinCAPDuration + $Beacon_{max}$= 440 + 266=706 Symbols 1)(

We can define a dependent Ceiling Which gives us the nearest natural number greater than or equal to the real number to be approximated

In the following form:

⌈x⌉ = min { n ϵ Z ; n ≥ x }

Hence the number of time slots reserved for the CAP zone

$$A_{slots} = \left\lceil \frac{T_{CAP\ Min}}{t_{slot}} \right\rceil \quad 2($$

Where:

t_{slot}= aBaseSlotDuration*2^{SO} Represents the time of a single time space

The maximum number of time slots available in an area is CFP :

=16 - A_{slots} R_{slots}

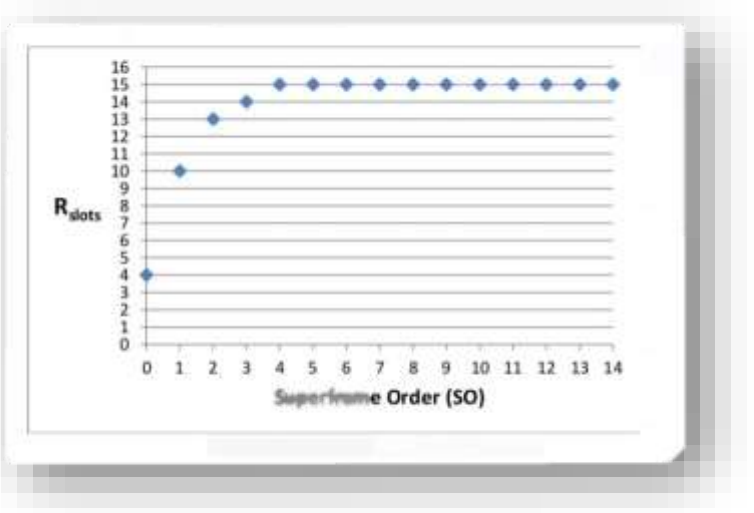

Figure 2: the relationship between SOS and R_{slots}

From Figure (2) we can see that the values of SO=0,1,2, It is inappropriate in our application as it does not allow us Optimal exploitation of an area CFP.

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Proposed design model: 3-4-

We will create a design model for the collection of electrical meter readings using a moving node representing the grid coordinator

According to a specific route and fixed dates in the suburb neighborhood of Jableh city. The suburb district consists of 105 lecturers

Residential, 20 of which are single entrances, i.e. each contains 8 residential apartments, and 65 are purely double entrances, i.e. contain

Each of them has 16 apartments, and 20 are just three entrances, that is, each of them contains 24 apartments, so we have 210 entrances. As

There are 30 villas. We will assume an additional 20 buildings with sponsors for some unorganized buildings.

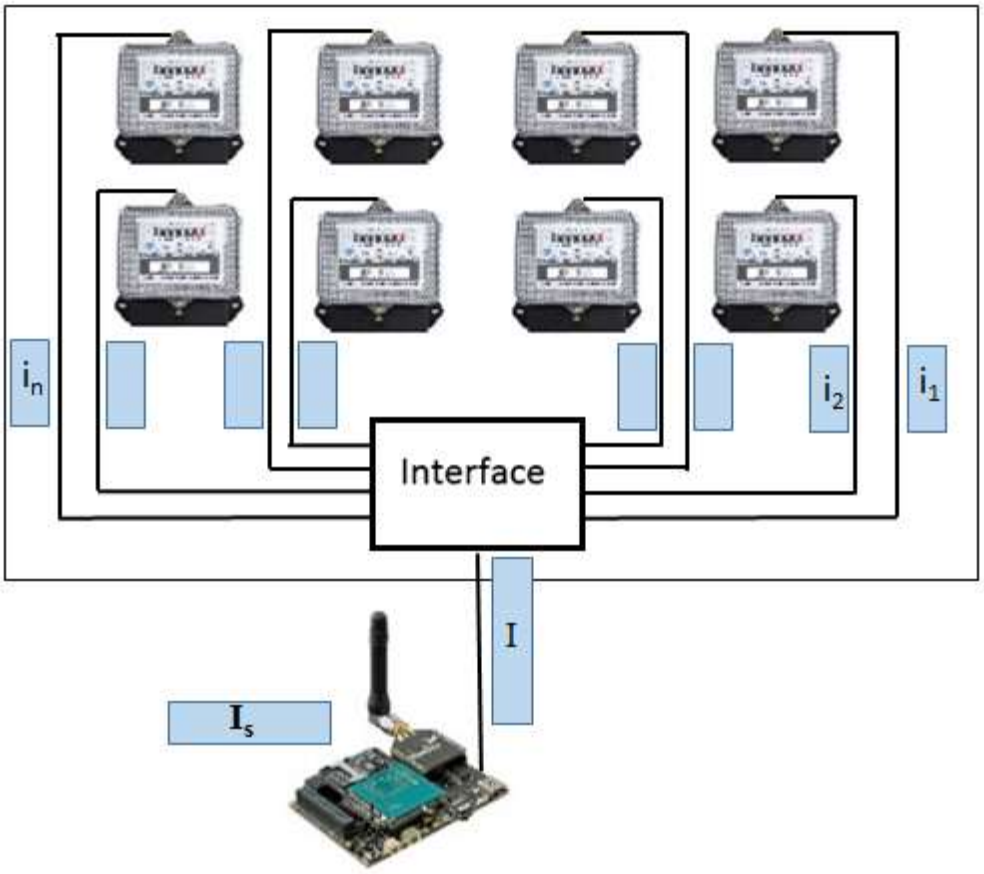
Instead of every electric meter belonging to a residential apartment being connected to a wireless sensor, all entrance meters will be connected

With a single wireless sensor through a convenient circuit in order to save economically on the one hand and increase the efficiency of the collection process from

The other hand. Figure(3) shows this binding process.

We will neglect the stage of assembling the meter readings through the NS circuit when performing the simulation using 2.35

Convenience, and we will deal with the output of this circuit only



Since one record consists of eight apartments, each of which has a counter whose information size is i=4 Bytes, then it will be

The output of the convenience circuit is I =4*8=32 Bytes . I will be passed to the sensor as application layer information, and it must

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To add the headers of the lower layers before sending them. The higher size of the package will mean that it will take longer to

They are sent, and this reduces the efficiency of the system as the rest of the nodes will have to wait a longer period and this puts a limitation

At the speed of the moving node. So we will assume the use of UDP protocol and not TCP because its header size is less,

And we will leave the task of achieving reliability to the MAC layer by activating the Ack receipt confirmation.

The IEEE 802.15.4 protocol imposes a limit on the maximum length of the data frame so that it does not exceed 127 Bytes after adding both the MAC layer header and its tail. The class header must also be taken into account

If the maximum length of the frame transmitted by the sensor becomes 133 bytes, this What the figure shows (6).

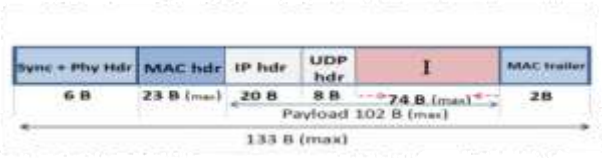

Figure 3: maximum frame length of IEEE 802.15.4.

Since I=32B < 74b, then each packet will be sent with a single frame. That is, the length of the expressed frame will be

The information of the counters of one of the entrances is equal to B 91=l_s where I=32 B , and we will consider during the simulation that the information of

The counters of both villas and random buildings are also equal to B 91=l_s, and the time between frames will always be

It is equal to 40 rpm and represents LIFS (Long Inter Frame Spacing).

Since the total number of entrances is 210, the number of villas is 30 , and the number of additional buildings is 20, then we need 260 sensors, each

From it, a frame will be sent, that is, the total frames that will be transferred when the moving node passes is 260 frames.

The relatively large number of sensors in the neighborhood means that the environment is dense and this will make it difficult to be able to

All these sensors can transmit their frames at relatively high speeds to the collection node without loss

In packages.

So we suggested that one of the record sensors be selected to be a representative of the record and carry out a collection of sensor packages

Other minutes, before the date of passing the mobile node that performs the final collection of packets, in the case of a record

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The output of the sensor representing the record will be three frames, each of which represents

The counters of one of the entrances, and this is shown in Figure (7). Also, several sensor packets are passed, each of which is purely a r to

One of them is only before the date of passage of the moving node, it is chosen depending on the path of movement of the node.

Although the area is dense, we have encountered some areas where there is a break in coverage, and therefore

A sensor or a group of sensors is isolated from the rest of the network, that is, we cannot transfer the information of all sensors to

Central sensor. Accordingly, we were able to reduce the number of sensors that will participate in the process of sending packets in

During the passage of the moving node to 50 sensors, each of which will send a set of frames, most of which cannot be transmitted

His information is transmitted to any sensor except the moving node, since the closest sensors to him are beyond the range of his transmission

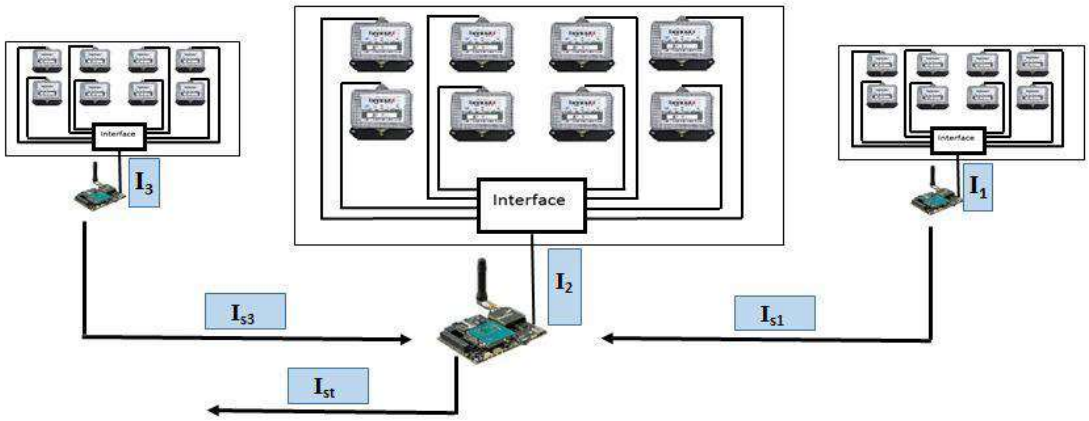

Figure 4: output of the representative sensor of the residential lecturer.

3-5-practical demonstration of the proposed design model:

The map of the Dahiya neighborhood in Jableh city was obtained from the website of the International Open Street Map

By extension .osm [22] and SUMO 0.32.0 and 0.32.0 NETEDIT programs were used to get the path

Animate the node within the neighborhood streets and convert the node path file into a format .TCL [23] so that it can be used

In the program NS 2.35 . Figure (9) shows the neighborhood map of the suburb and the route of the moving node in the program

NETEDIT

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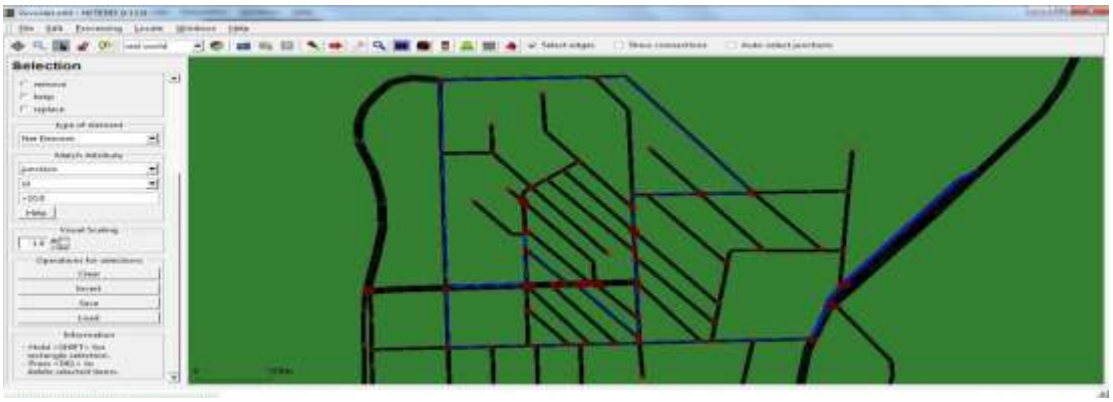

Figure 5: the path of the moving node in the NETEDIT program.

Then we built the network using The NS2.35 program, as shown in Figure (10), depending on the coordinates

The network operation parameters have been adjusted according to the values shown in Table(1)

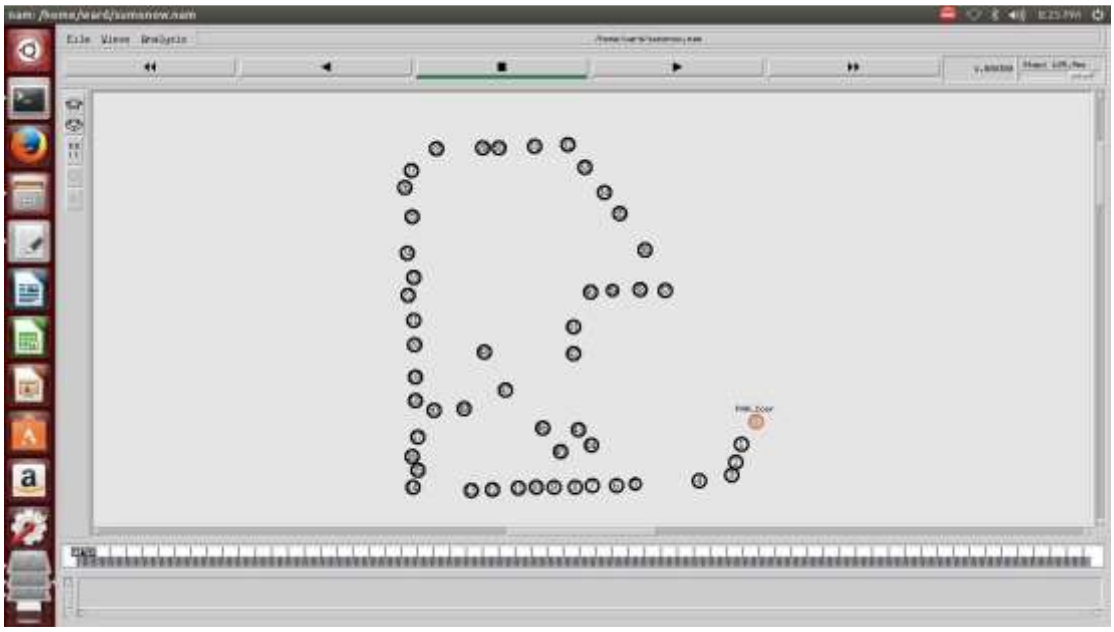

Figure 6: grid layout as shown by Nam editor.

Table 1: simulation parameters using 2.35 NS

The parameter	**The value**
The number of network nodes that represent counters	50
Distance between nodes	30 m<
Coordinator speed	10,15,20,25 m/s
BO = SO	2,3,4,5
GTS length	2,3,4,5,time slot

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Re-scan time	0.1 s
The size of the information frame	91 Bytes
The extent of sending the contract	40 m
Contact range	120 m
Packet frequency / transmission rate	250 Kbps/ 2.4GHz
Network space	500*1000m^2
The protocol used	IEEE 802.15.4 with GTS
Simulation time	Variable depending on the speed of the coordinator

In our design model, the coordinator sends it from us on the frequency channel number 11, while each device scans the channels

The first three of the 2.4 GHz frequency package i.e. channels 11,12,13 in order, in case the device manages to

Discovering the beacon on Channel 11, it will continue to search channels 12,13 in order to assess the best signal in order to

Link to a coordinator [24]. If the device is unable to detect the Beacon during the scanning process, it does these

Process again after waiting for a time of (seconds) assoRetryInterval= 1 as defined by the IEEE 802.15.4 standard in the NS 2.35 program . This last time its main purpose is to save energy, so we will make its value

Equal to zero because the wireless sensors in our application are connected directly to the city's electricity and then we will compare

4-results and discussion:

The simulation results were obtained using the NS 2.35 program according to the parameters described in Table (1), and a graph

Graphing curves and comparing the results according to the following:

Figure a - (11) shows the number of devices that failed to connect to the network as a function of the coordinator speed for two time values

The interval between the two scans, the first is the default value assoIntervalTime = 1 s and the second is the value

Zero cancellation of the time interval between the two scans, with the assumption of different values for .SO=BO

We can see from Figure (11) that the following:

The number of devices that failed to connect to the network is increasing, either because the(SO value increasesso values>4 are not valid

To achieve reliable combination) or(due to the increased speed of the coordinator speeds above 20 m / s are not suitable for reliable combination) or

Due to the increase of both factors, as the figure shows, this number decreases when the assoInterval Time value is made equal to

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For zero The values of so ≥ 5 do not verify that all nodes are connected to the network coordinator, therefore they are not suitable for use according to the model

The design we created. Returning to the results obtained from Figure (2), we can note that

The value SO = 3 and the value SO = 4 are just the right values to determine the total frame length.

5-conclusions and recommendations:

A -In this research, a design model of a wireless sensor network based on real dimensions was proposed

The Dahiya neighborhood in the Syrian city of Jableh, is able to reliably collect electricity meter readings using the coordinator

Mobile in a densely populated area, and through communication using GTS, although this type of Communication does not lend itself in such environments to reliable collection of information.

B- if you set the values of the parameters of the macro frame and the parameters of the connection through the - GTS, and make a value

assoIntervalTime equal to zero, enabled us to achieve reliable combination at coordinator speeds of more than 70 Km/h.

C- we can see that the connection time of a node to the coordinator takes a relatively long time from the total connection time ,

This will negatively affect the performance of the system even if the node manages to link, so we recommend using algorithms

Improved link operation will reduce this time.

D- the connection using - GTS is suitable for networks with a small number of devices, so in the case of dense networks

We will need to develop this type of connection or completely replace the IEEE 802.15.4 protocol. Where the results showed

That when the length of the GTS increases, fewer nodes will be able to succeed in the booking process, so the loss rate will increase

Frames, and at best no more than seven devices can connect at the same time using GTS.

E- we can notice that the header consumes a large part of the size of the information frame, since the transfer process

The information is done in one jump with the coordinator, so we recommend that the nodes represented by the minutes perform a data collection process

data aggregation, which makes the size of frames less, and this will increase the efficiency of the system, but at the cost of

Economic.

The proposed system is limited to the collection of meter readings, however, in smart cities applications, it is necessary

From the collection of other information, such as maximum consumption hours, service quality and others, so it is necessary to

Modify frame sizes and their information, thereby reevaluating network performance

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Received: January 19, 2023 Revised: April 18, 2023 Accepted: September 14, 2023

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Received: January 19, 2023 Revised: April 18, 2023 Accepted: September 14, 2023

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Received: January 19, 2023 Revised: April 18, 2023 Accepted: September 14, 2023