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Performance analysis of IEEE 802.15.4 based WSNs using energy efficient DYMO protocol

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Abstract: Wireless Sensor Networks (WSNs) are an emerging field of engineering with various applications. IEEE 802.15.4 is the basis for the ZigBee enabled WSNs. The IEEE 802.15.4 standard is adopted as a communication protocol for Low Rate Wireless Personal Area Networks (LR-WPAN) which supports low data rate, low power consumption and short transmission distance. The IEEE 802.15.4 standard specifies the PHYsical (PHY) and Medium Access Control (MAC) layers and the ZigBee specifies the network and application layers in the IEEE 802.15.4 based WSNs. The Dynamic MANET On-demand (DYMO) routing is simple and the fast routing protocol used in IEEE 802.15.4 based WSNs and it is an enhanced version of Ad hoc On-demand Distance Vector (AODV). In this paper, performance analysis of IEEE 802.15.4 based WSNs using energy efficient DYMO protocol is done by varying speed and pause time of mobile nodes.

Key words: IEEE 802.15.4, ZigBee, DYMO

I. INTRODUCTION

Wireless Sensor Networks (WSNs) [1, 2] have gained the largest attention because of recent advances in Micro Electro Mechanical Systems (MEMS). Sensor networks consist of low power, low cost and multifunctional sensor nodes in small size which can observe the environmental conditions such as pressure, temperature and sound etc. and provides the overall sensed information. Sensors nodes may equipped with one or more sensors, power supply, actuators and transceivers.

There are two types of sensor networks [3]. They are: structured and unstructured, each structure consists of few to several hundreds of sensor nodes. In structured sensor networks, the deployment of nodes is pre planned, and once the network is deployed, it is left unattended to perform transmitting and reception functions. In unstructured sensor network, the deployment of nodes is random and needs the network maintenance. In this network, the detection of failures is difficult and the energy consumption of the network is more. To reduce the energy consumption, energy efficient routing protocols are developed. In this paper, an attempt has been made to analyze the performance of energy efficient DYMO protocol for IEEE 802.15.4 based WSNs.

The rest of the paper is organized as follows: Section I deals with introduction of WSNs. In section II, IEEE 802.15.4/ZigBee network is discussed. Section III deals with DYMO routing protocol of IEEE 802.15.4 based WSNs. In section IV, energy efficient DYMO protocol is explained. Section V discusses about the simulation results. Conclusion and future work are dealt in Section VI.

II. IEEE 802.15.4/ZIGBEE

ZigBee specifications are firstly developed by ZigBee alliance in 2003. [4], [5]. ZigBee network supports star, mesh, tree and Mobile Adhoc NETwork (MANET) topologies. Zigbee network is defined as LR-WPANs which have the advantage of easy installation, reliable data transfer and short range of operation, energy efficient for long battery life. LR-WPANs also maintain simple and flexible protocol stack for upper layers.

In ZigBee network, there are different types of devices[6]. They are ZigBee coordinator, ZigBee router and ZigBee end device. Coordinator and Router are called as Full Function Devices (FFDs) and End Devices are considered as Reduced Function Device (RFDs). Coordinator functions the route of the network and there is exactly one Coordinator in each ZigBee network. Router behaves like its name and also acts as intermediate node to pass the data from one to other device. End Device has the ability to communicate with the parent node.

III. DYMO

DYMO [7], [8] is a successor of AODV routing protocol and it is the current focus for routing in the Internet Engineering Task Force (IETF) MANET. This will operates similarly as AODV [9] routing protocol, simply called as extended or upgraded version of AODV routing protocol.

DYMO is a reactive type of routing protocol to ensure the uses of fresh and loop free routes. The DYMO[10] routing protocol is a protocol defined in an IETF in its version 21 recently and still work in progress. It has two main operations; one is route discovery and the other one is route maintenance. The node only discovers the route to the destination when it has packets to send. In this case it updates its table with the destination node's route. The source node floods message RREQ into the network. When an intermediate node receives the RREQ, it records the address to the source node of the RREQ and forwards the message to the neighboring nodes. When the final

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destination receives the RREQ message with its address as a new destination, it initiates a route reply message RREP with the source node as destination and unicasts that message in the network. The intermediate nodes update their routing tables and forward the RREP message to the destination. The route maintenance occurs when the route to a specific node is broken and is used to send the packets to the specified node through the alternate path maintained by the routing table. DYMO has unified packet routing format which also has simplified RERR algorithm and multiple interface utilization.

IV. ENERGY EFFICIENT DYMO

The IEEE 802.15.4 based WSNs is utilized to transmit low data rate over WPANs. It is very difficult to charge the batteries of sensor nodes. So the network has to be operated with the limited energy resources. For dynamic network, routing is very difficult and further this network will consume more energy.

The network will also consume more energy for computational processes, when nodes are moving. So the energy efficient DYMO routing protocol is to be developed to improve the WSN life time by reducing the energy consumption.

Energy efficient DYMO is to make an efficient route selection on the basis of the remaining battery capacity of the nodes involved in routing process. In this, the transmission is done by selecting the route which consumes less energy consumption. The charge consumed by the nodes in the sensor network is calculated as the Total Charge Consumption (TCC) according to the below formula. The operation involved in energy efficient DYMO protocol is described in the form of flow chart illustrated in Fig.1.

When a source node wants to communicate with the sink node in the network, then it sends the RREQ which will carry the battery capacity (energy) of the node and it will be used to calculate the charge consumed by the node. And at the sink node, when the sink receives the RREQ it will calculate the load of the path and energy consumption by the nodes and it will chose the route with less load factor value.

$$\text{Total charge consumed} = \sum_{1}^{N} (IB_i - FB_i)$$

IB_i = initial battery capacity of node i in mAhr
FB_i = final battery capacity of node i in mAhr

V. SIMULATION RESULTS AND DISCUSSIONS

The simulation work is performed in QualNet Network simulator of version 6.1 [11], by considering the DYMO as routing protocol for IEEE 802.15.4 based WSNs. Simulation of IEEE 802.15.4 based WSNs is done by varying mobile speeds and pause times with the consideration of simulation time as 800 sec and 2hrs. Mobility model used is Random Way Point (RWP). In RWP, mobile nodes are placed randomly in the scenario. The scenario is tested for 500 packets with traffic as ZigBee application. In this simulation, the performance namely Total charge consumption is determined and analysed**.**

Total Charge Consumption (mAhr): It indicates the total charge spent in each node for each individual task.

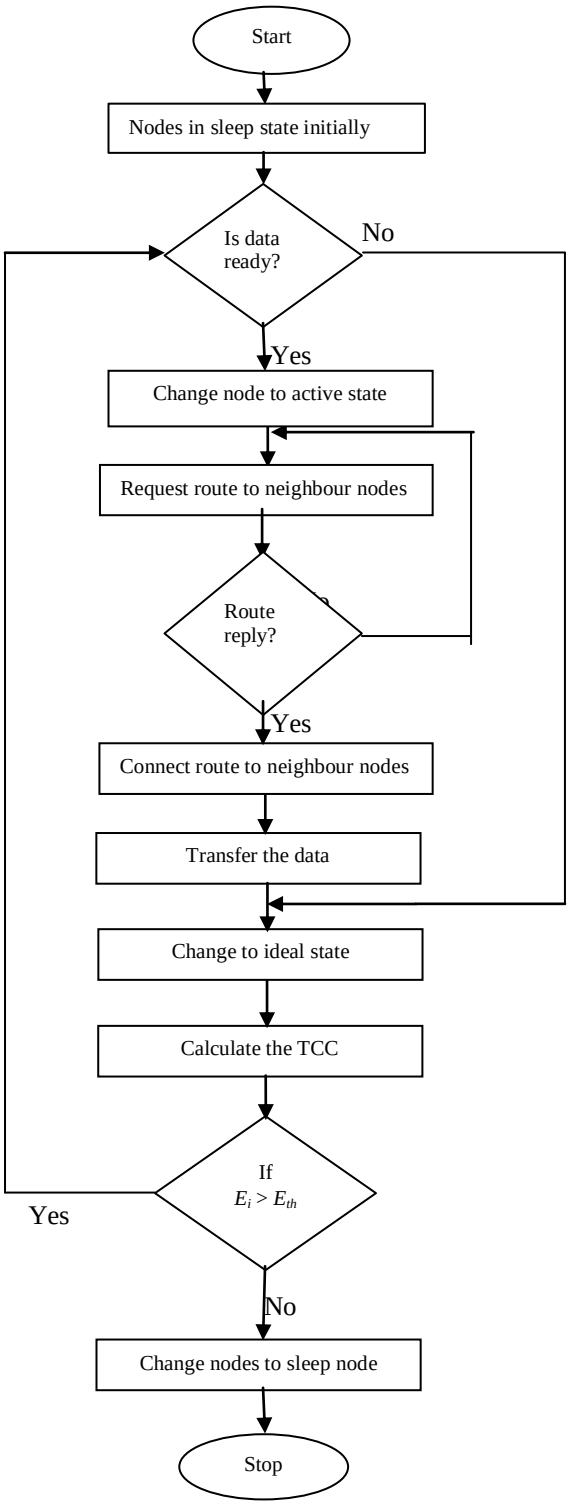

Figure 1: Flow chart indicating the operations of energy efficient DYMO protocol

E_i - energy of the i^{th} node
E_{th} - threshold energy of a node

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The snapshot of the simulation is shown in fig 2. It illustrates the scenario of IEEE 802.15.4 based WSN network having 100 nodes in the terrain size of 400 X 400 m^2 with 10 nodes as mobile nodes. The parameters used in the simulations are given in Table I.

Table I: Simulation Parameters

Parameters	Value
Terrain size	400 X 400 m^2
Number of nodes	100
Number of mobile nodes	10
MAC protocol	MAC 802.15.4
Routing protocol	DYMO
Mobility model	Random Way Point
Mobile speed (mps)	10, 20, 30 and 40
Pause time (sec)	1, 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50
Items send	500 packets
Simulation time	800sec , 2hrs

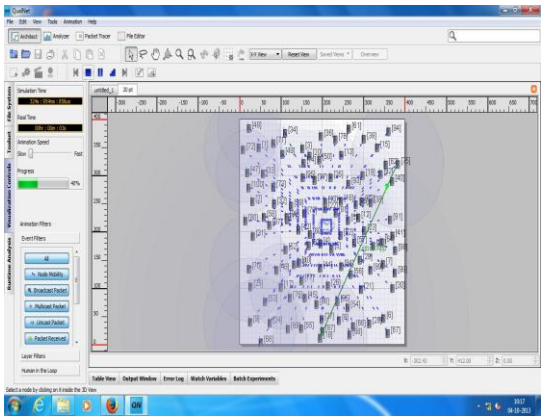

Figure 2: Scenario of IEEE 802.15.4 based WSN using QualNet 6.1

A. Performance Analysis of Total charge consumption with respect to speed and pause time

The total charge consumed is calculated for the simulation time of 800 sec and 2 hrs by varying pause time and speed. From figure 3 and figure 4, it is observed that total charge consumed by the nodes is increased for increased pause time and speed for the simulation time of 800sec.

It is also verified through the simulation results shown in figure 5 and figure 6 that total charge consumption is increased for increased speed and pause time for 2 hrs simulation. The reason is due to the involvement of more hops between source and destination for increased speed which in turn increases the charge consumption.

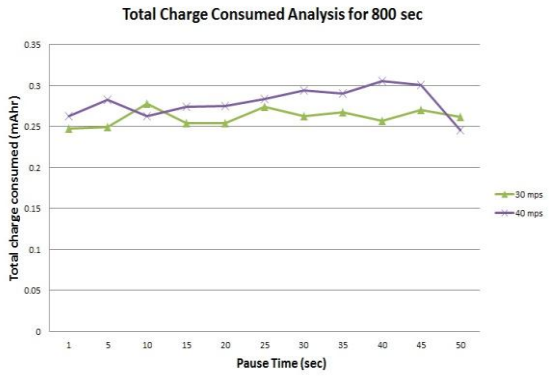

Figure 3: Pause Time vs. Total charge consumption Analysis for 800 sec

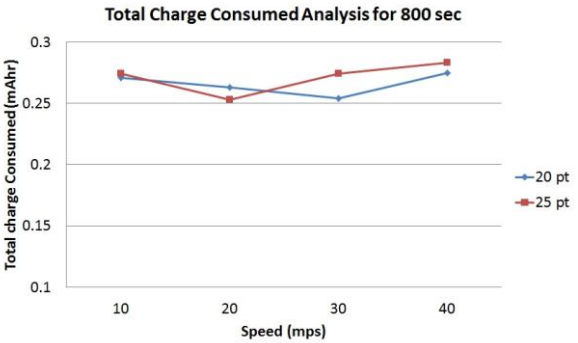

Figure 4: Speed vs Total Charge Consumption Analysis for 800 sec

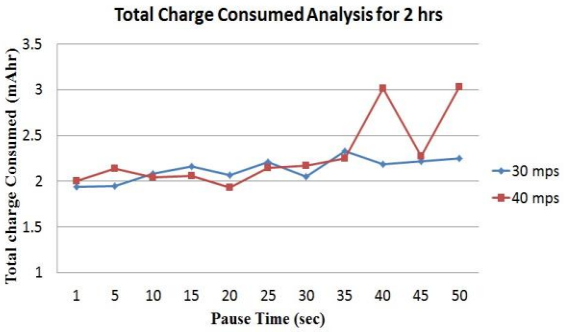

Figure 5: Pause Time vs. Total charge consumption Analysis for 2 hrs

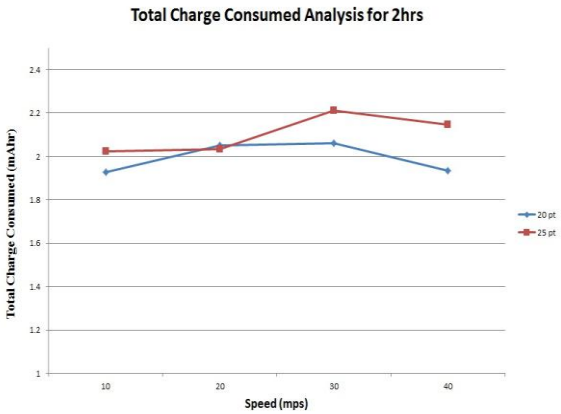

Figure 6: Speed vs. Total charge consumption Analysis for 2 hrs

VI. CONCLUSION

Various researches have been carried out in the routing protocols of IEEE 802.15.4 based WSNs. In this paper, the performance analysis of IEEE 802.15.4 based WSNs using energy efficient DYMO routing protocol is done by using QUALNET network simulator. The simulation is done by varying pause time and speed with the consideration of mobility model as random waypoint. From the simulation results, it is observed that the total charge consumption is increased for increased pause time and speed. However, the work is limited to terrain size. The work can be extended by incorporating the various mobility models in energy efficient DYMO protocol to enhance the performance. Further the work can be modified by appending security algorithms in the energy efficient protocol to mitigate the effect of attacker or threats in the sensor network. And it may be extended by enabling the duty cycle operation in the network to reduce the power consumption of sensor network.

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BIOGRAPHIES

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