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Research Article

# Towards Realistic Performance Analysis of IEEE 802.15.4

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***Abstract***

*Nowadays, LR-WPAN i.e. IEEE 802.15.4 is of great use in industrial, residential, medical and military applications. The Low data rate enables it to consume very little power. This Protocol fulfills most of the criteria of good WSN Protocol. In this paper the Performance of IEEE 802.15.4 is studied in various types of WSN by varying the Weather Conditions. Variation in Weather condition is made by covering the sensor nodes by mobile clouds(obstacle) in Qualnet 6.1 Simulator .The QoS parameters which are of concern are throughput, Packet Delivery Ratio, average end-to-end delay and energy consumption are studied.*

***Keywords:*** *WSN, LR-PAN, IEEE 802.15.4, Qualnet 6.1 Simulator.*

## 1. Introduction

Wireless Sensor Network has to face many situations and challenges in Practical approach. One of the big challenge is to provide data for long time as possible i.e. it should consume low energy. This challenge is well fulfilled by IEEE 802.15.4 as it supports low data rate and is intended to serve a set of industrial, residential and medical applications with very low power consumption, relaxed needs of data rate and QoS.

The performance of routing protocols can be evaluated using Simulation Tools like QUALNET, NS-2, MATLAB etc. Simulation Tools provide researchers a number of significant benefits, including Repeatable Scenarios, Isolation of Parameters and Exploration. We want to make these simulations more realistic for WSN, as in practical situations ,it has to face these type of situations.

In this paper various sensor networks performance is being studied by varying Weather Conditions which is done with covering Sensor Nodes by mobile clouds(which act as obstacles) in QUALNET 6.1 Simulator and effect on QoS parameters such throughput, delay, packet delivery ratio and energy consumption.

The paper is divided into six sections. Section 1 includes introduction, LR-WPAN is discussed in Section 2. Simulation setup is included in Section 3.Result and Discussion is specified in Section 4, Section 6 gives the acknowledgement and Section 5 is all about conclusion.

## 2. Overview of LR-WPAN

Among three classes of WPAN, IEEE 802.15.4 technology is a low data rate, low power consumption, low cost; wireless networking protocol. It is designed to provide low cost connectivity for the terminals which needs long battery life or low power consumption, however, the data rate and QoS supported are not compatible with those provided by the IEEE 802.15.3. The equipments associated with LR-WPAN are designed to transmit within a range of 10-75 meters and the specification depends on actual RF environment and the energy consumption required for the real application. IEEE 802.15.4 consists of devices which can be a FFD (Full Function Device) or an RFD (Reduced Function Device). A PAN must contain one FFD which is appointed as PAN coordinator or sink, to which all the data is transported. An FFD, other than PAN coordinator acts as a router and is also called as coordinator. It is responsible for the routing of data from source to the sink. RFDs in a PAN are the source. RFDs cannot communicate with one another, but communication can be made with FFDs. IEEE 802.15.4 supports the physical topologies as Star, Peer to peer, and Cluster-based. In Star topology, data transfer takes place between RFDs and an FFD, which is set as PAN coordinator. All the RFDs or devices are attached to the central coordinator. Applications of this topology are Home Automation and PC peripherals. In peer to peer topology, there is also one PAN coordinator, but there are more than one FFDs which acts as routers in the network. They act as intermediate nodes between the source and the sink. Applications are industrial monitoring & control, wireless sensor networks, and many ones. The last one is Cluster based, in which most of the devices in the network are FFDs and RFDs may joined to the cluster as a leave node of a branch. Out of many FFDs one is appointed as PAN coordinator and the remaining ones help in providing synchronization between RFDs and PAN coordinator. Its applications are Search & Rescue,

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Defence, distributed autonomous systems, and everywhere, if there is need of large area to be covered. IEEE 802.15.4 protocol specification defines two layers, Physical and MAC layers. Physical layer is responsible for the features as activation & deactivation of the radio transceivers, energy detection, link quality indication, channel selection, clear channel assessment and transmitting as well as receiving packets across the physical medium.

## 3. Simulation Setup

IEEE 802.15.4 can be analyzed with different Simulation Scenarios. In this paper IEEE 802.15.4 is analyzed with a concept i.e. variation in weather properties using QualNet Simulator 6.1.Four Wireless Sensor Network scenarios of Star Topology are designed .Scenarios consist of network using RFDs and FFDs. There is one PAN Coordinator in each scenario which is also the FFD and remaining Sensor nodes are RFDs. 4, 9, 14, 19 CBR connections are laid down between sources and sink. All the devices are deployed in a way such there are no hidden devices in the network.

Four Scenarios of 5,10,15,20 nodes are named as WSN1, WSN2, WSN3 and WSN4 respectively. The network routing protocol used is Dymo. The energy model is taken as Mica Z and the battery model which is used is Duracell AA. Other MAC parameters are taken as default values. The simulation setup and weather conditions descriptions are shown in Table 1 and Table 2 respectively.

**Table 1** Simulation setup Parameters

| Parameters | Value |
|---|---|
| Simulator | QualNet 6.1 |
| Channel frequency | 2.4GHz |
| No. of nodes deployed | 5,10,15,20 |
| Physical layer Radio-type | PHY802.15.4 |
| MAC protocol | MAC802.15.4 |
| Routing Protocol | Dymo |
| Packet Size | 70 bytes |
| Application | CBR |
| Topology | Star |
| Energy model | Mica z |
| Battery model | Duracell AA |

**Table 2** Weather Properties

| | |
|---|---|
| Height of Clouds | 1000m |
| No. of Clouds | 5 |
| Intensity | 100 |
| Mobility | Yes |
| Polarization | Horizontal |

After obtaining the simulation results QoS parameters as Packet loss rate, Average end-to-end delay, throughput, and energy consumption are analyzed.

*3.1 Packet Delivery Ratio*

It is the fraction of number of packets received by the network to the total number of packets generated by all the devices in the network. It is the measure of reliability for a particular protocol and network used.

*3.2 Throughput*

Defined as number of successful data packets received at receiver to the total data packets sent by transmitter.

*3.3 End-to-End delay*

It is the time elapsed when a packet is sent from the source node and is successfully received by the destination node. It includes delays as delay for route discovery, propagation time, data transfer time, and intermediate queuing delays.

*3.4 Energy Consumption*

In the scenarios, energy consumption is measure in mWh for three modes, as transmit, receive and idle.

## 4. Results and Discussion

Four WSN Scenarios of 5,10,15,20 nodes have been studied, designed individually and their QoS parameters, which are merged respectively to understand in a better

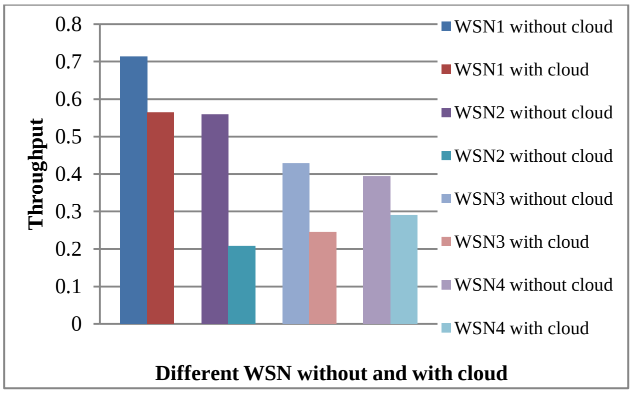


**Fig.1** Throughput vs. Number of nodes covered by cloud

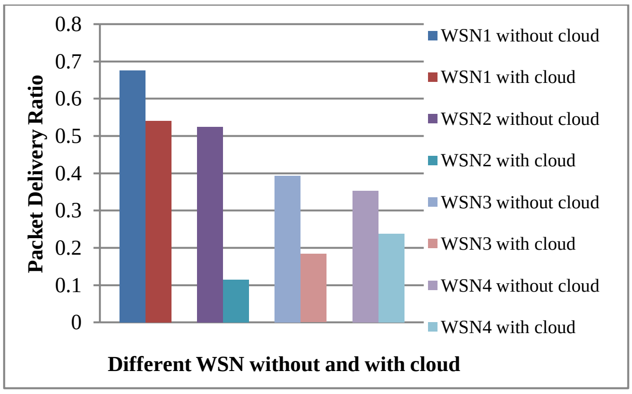


**Fig.2** Packet Delivery Ratio vs. Number of nodes covered by cloud

way. Fig.1 shows the decrease in throughput as the nodes are covered by clouds in all four scenarios. This is due to the fact that, the clouds are causing the rain which restricts the data reception.

In Fig.2 we can clearly see that, in normal condition i.e. without any cloud, the packet delivery ratio is highest for 5 nodes WSN scenario among all the four WSN. Packet delivery ratio also decreases as the nodes covered by mobile clouds.

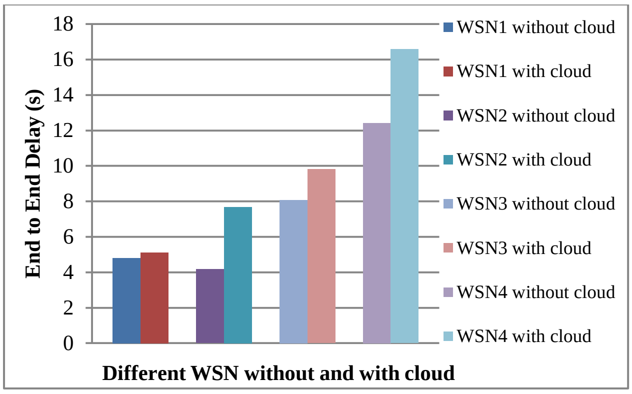


**Fig.3** Avg. End to End Delay vs nodes covered by mobile clouds in different WSN

In Fig.3, the avg. end to end delay increases as the nodes covered by clouds .This is due to the fact that number of packets dropped by the network increases. In normal conditions, avg. end to end delay is maximum for 20 nodes WSN scenario.

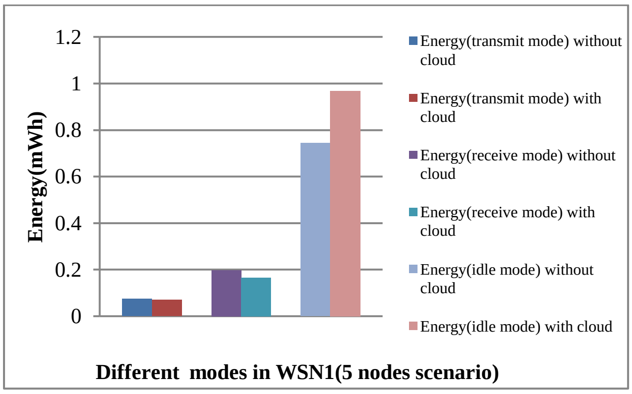


**Fig.4** Energy consumed vs. Number of nodes covered by clouds in 5 nodes WSN

Fig.4 shows the energy consumption in different modes (transmit, receive, idle) without and with clouds in 5 nodes WSN. Energy (transmit mode) and energy (receive mode), both decreases as clouds (obstacle) are included in the scenario, but energy(idle mode) much increases as the WSN nodes covered by clouds(obstacle).The reduction in transmit and receive mode energy may be due to loss in packets. Increase in idle mode energy is due to presence of clouds which act as an obstacle only.

Fig.5, Fig.6 and Fig.7 shows the energy consumption in different modes (transmit, receive, idle) without and with clouds(obstacle) in 10,15,20 nodes respectively. Fig.5 shows increase in idle energy of 165% in presence of cloud (obstacle). Fig.6 shows increase in idle energy mode of 102%.Fig.7 shows 92% increase in idle energy.

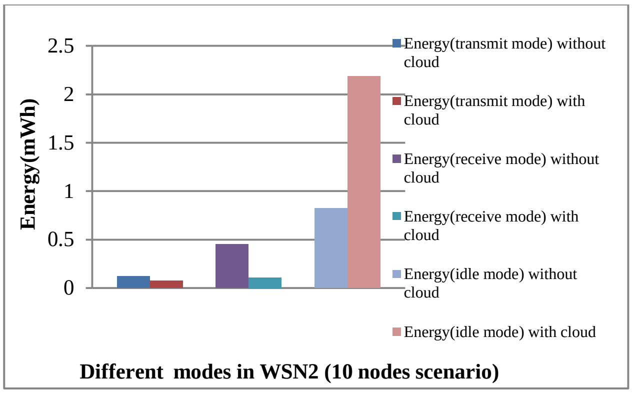


**Fig.5** Energy consumed vs. Number of nodes covered by cloud in 10 nodes WSN

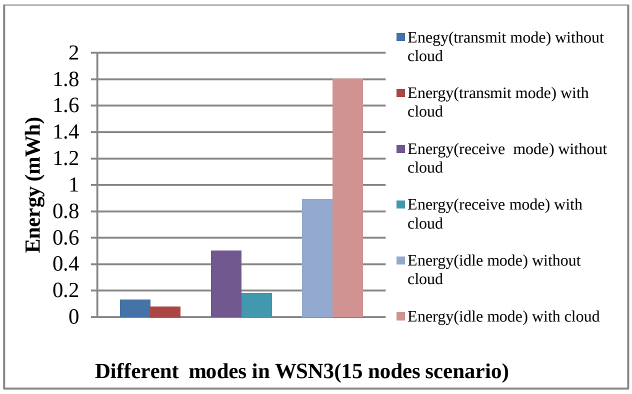


**Fig.6** Energy consumed vs. Number of nodes covered by cloud in 15 nodes WSN

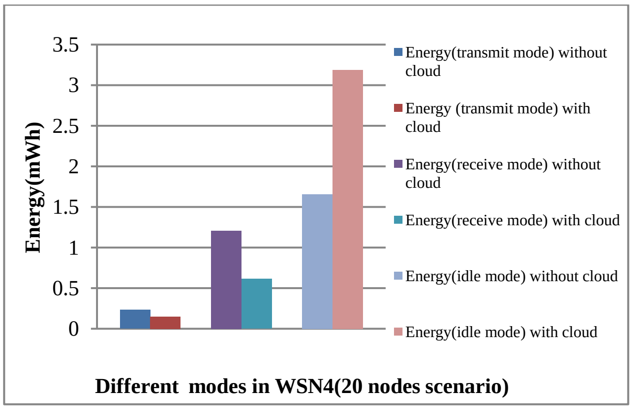


**Fig.7** Energy consumed vs Number of nodes covered by cloud in 20 nodes WSN

## Conclusions

IEEE802.15.4 is been studied in different WSN in different conditions and it has been found that as the clouds covers the nodes in WSN ,the throughput and packet delivery ratio both decreases, and average end to end delay increases which implies that presence of clouds obstructs the communication ,i.e. cloud act as a obstacle in WSN. As different WSN are covered by 5 mobile clouds, they show an average reduction of 38% ,48% in throughput and packet delivery ratio respectively. Average end to end delay increases at an average of 36% for different WSN in presence of cloud (obstacle). Energy consumption increases in idle mode increases in all the four WSN scenarios at an average of 97% .

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