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# Modeling a Cloud-Based Smart Parking WLAN Networks Using IEEE802.11AC Technology**

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## ABSTRACT

Due to the increasing number of cars and the difficulty to find vacant parking spots easily, the smart parking system is essential to save time and efforts of drivers and to protect the environment from emissions and air pollution. Wireless sensor networks used in smart parking systems consists of a number of sensors to monitor the events or changes and send the data, cluster head to manage the linked sensors, and base stations to manipulate and forward the data to the end system. All of these devices are used together to monitor a specific area. This paper analyzes the performance of IEEE802.11ac and compares with IEEE802.15.4 and IEEE802.11b using three different scenarios by measuring the average end to end delay and throughput with respect to the number of sensors (manually and automatically). This is done using ThingSpeak cloud (an open IoT platform with MATLAB 2019 analytics) in IEEE 802.11ac and without a cloud setup in IEEE802.15.4 and IEEE802.11b. Three scenarios are considered in this work. First, the sensors are distributed manually in all the standards. Second, the sensors are distributed automatically in IEEE802.11ac and manually in IEEE802.15.4 and IEEE802.11b. Third, the sensors are distributed automatically in IEEE802.11ac along with the cloud. While the sensors are placed manually with grid placement without the cloud in IEEE802.15.4 and IEEE802.11b. Finally, the results show that the IEEE802.11ac gave better results than other standards and it is suitable for applications with very high throughput.

## 1 Introduction

Internet of things (IoT) represents the new technology existing nowadays. The use of IoT has several

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benefits. Any object/device has a unique identity in an IoT setting that enables the controlling and monitoring of the device or the object under consideration. IoT has enabled advanced manufacturing and quality controlling and represented by any object/device which can collect the data to send or receive data through the internet where the data can be extracted and analyzed. The data of these objects and devices can be shown on monitors and control systems. It describes a vision where objects become part of the Internet [1]. The major components of IoT is a physical device, operating platforms, real-time application, and interconnectivity.

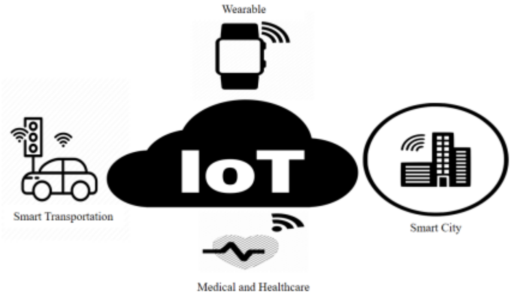

**Figure 1**. Internet of things applications

As shown in Figure 1, the application domains of IoT can be divided into several categories such as a smart city, health care, industry, smart home, and smart transportation. Smart transportation includes a lot of technologies such as smart traffic lights and smart parking systems. For the smart parking systems, the number of cars in the last years sharply increased, and based on previous studies; 30-50% of the drivers search for free vacant parking and spend around 3.5 to 14 minutes to find vacant parking [2]. Effective smart parking systems will help to optimize parking area usage and fetch parking spots that allow the driver to find the parking quickly. Several recent studies have concluded that smart parking systems are necessary in all cities in the world to reduce a lot of problems like air pollution, the amount of fuel used, and congestion. Wireless sensor network (WSN) is becoming increasingly famous with the advent of the IoT [3]. WSN are used in smart parking systems.
As shown in Figure 2, WSNs consist of a number of sensors, cluster head, and base stations working together to monitor the specific environment. The sensor node powered by a battery is connected with others through radio signals to transmit data for the cluster head to a base station which represents an interface between the end-user and the network. A WSN can sense, measure, and gather data using sensors from the environment and relay them to base stations via head clusters [4]. The smart parking system has huge data and requires a lot of storage space to store. Using the cloud is the best choice for people these days. In a cloud, the data is saved in a remote server and is accessible upon logging in. Also, it is safe and can be accessed with a real internet connection. Using the cloud can be subscribed monthly in a company that provided it such as Amazon, Microsoft, etc. or can be used freely in the company such as google drive, ThingSpeak cloud, and so on. This paper uses the ThingSpeak cloud platform to compare IEEE802.11ac, IEEE802.15.4 and IEEE802.11b standards for evaluating the performance by using average end to end delay and throughput via varying the number of sensors and the output generated from the smart parking system. The remainder of the paper is organized as follows: Section 2 provides an overview and the related works. Section 3 presents simulation model structure. Section 4 provides the simulation test scenarios and Section 5 gives the results. Finally, the paper is concluded in Section 6.

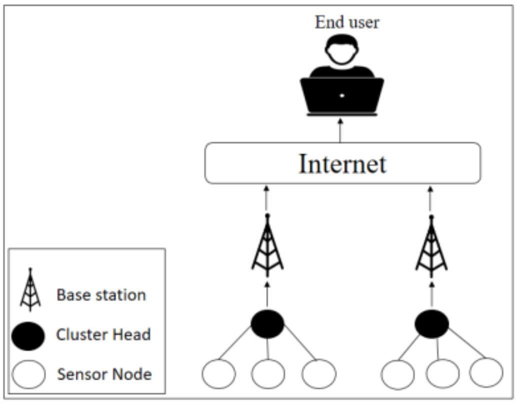

**Figure 2**. Structure of a wireless sensor network

## 2 Overview and Related Works

In this section, IEEE802.11ac, IEEE802.15.4 and IEEE802.11b are discussed in detail. The network performance has some challenges such as reaching an optimal distribution sensor placement and achieving a minimal average end to end delay and high throughput. These challenges can be addressed by adjusting sensor placement to reach the locations of the optimal sensors needed to the highest coverage for the selected area and increase the data access of the system.

### 2.1 IEEE802.11ac

IEEE802.11ac is a wireless LAN and a Gigabit WiFi Standard which and provides very high throughput (VHT). It has high coverage, capacity, less interference, longer battery life, high quality, and uses a wide channel with multiple inputs and multiple outputs. The frequency range is 5 GHz and the maximum data rate is 6.93 Gbps. The modulation schemes used in this standard are binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), and quadrature amplitude modulation (QAM) (4, 16, and 256) [5].

### 2.2 IEEE802.15.4

IEEE802.15.4 is a low rate wireless personal area network (LR-WPANs). It has low cost, low power consumption, and easy installation [6]. It provides three bands 2.4 GHz for worldwide ISM band, 868 MHz band in Europe, and 915 MHz band in America. It covers a short range of 75 m and achieves a low power consumption when the devices sleep. It uses BPSK for Europe and America and 16-ary orthogonal for worldwide communication. Moreover, it has two types of devices: full function device (FFD) and a reduced function device (RFD) [7]. The FFD supports all network functionalities and can be operated in three modes: A personal area network coordinator works as a coordinator and serves simply as a device. The RFD is low on memory capacity and resources and used for simple applications like a sensor node that senses light.

### 2.3 IEEE802.11b

IEEE802.11b was released in 1999 and it is a wireless LAN. The IEEE802.11b uses only the direct sequence spread spectrum (DSSS) modulation technique. The frequency range is 2.4 GHz and it is prone to higher interference due to crowded with carriers. The maximum data rate is 11 Mbit/s and uses carrier sense multiple access with collision avoidance (CSMA/CA) method. Finally, the bandwidth is 22 MHz and the ranges of indoor and outdoor are 35 meter to 140 meter.

### 2.4 Related Work

Several works in the literature discuss and analyze the performance of several standards. In [8] the authors compared IEEE802.11p, IEEE802.11n, and IEEE802.11ac in a vehicular ad hoc network for parameters such as throughput, jitter, and an end to end delay by changing mobility in various network schema. Based on the results, IEEE 802.11ac and IEEE802.11n have a better throughput, while IEEE802.11p has less jitter and end to end delay. In [9], the researchers compared IEEE802.15.4 with IEEE802.11b and used two routing protocols, the first is dynamic source routing and the second is ad hoc on-demand distance vector. The placement models of sensors are in random, grid, and uniform. IEEE802.11b has better performance than IEEE802.15.4 in average jitter, average end to end delay, packet delivery ratio, and throughput. The average energy consumed by each node in IEEE802.11b is less than that in IEEE802.15.4. In [10], the authors create a system called the progressive parking system. The system contains a global positioning system (GPS), Arduino Uno, wemos D1 mini, and wemos server. The wemos D1 mini is installed in every vehicle and emits signals to the server to inform about the occupancy status of the parking location. When the vehicle is parked in progressive parking, the wemos client signal that is on the vehicle chip will be captured by the wemos server signal and access point in the parking spot. The Arduino Uno is connected with GPS to support it by 5V power. The GPS module finds the position of a vehicle in parking. Finally, the goals for creating this system are detecting a vehicle, reservation of parking, and monitoring of the parking area. In [11], the authors propose a new approach that has been developed in an ASP.Net environment. The approach contains two modules: hardware and software. The hardware module obtains the condition of the parking spots and then transmit this data to the internet. The software module selects the nearest vacant parking spot based on magnetic sensors and genetic algorithms. The magnetic sensors determine if the parking spot is available or not while the genetic algorithm finds the route from the current position to the nearest available parking spots. The goal of this approach is to find a minimum distance to the available parking. In [12], the paper used throughput to compare IEEE802.11n and IEEE802.11ac using different spatial streams (SS), different numbers of the clients, and data rates. The results indicate the throughput of IEEE802.11n is similar to the IEEE802.11ac in a BW of 40 MHz, with a client (1-4SS) and the throughput of IEEE802.11ac is more than that of the IEEE802.11n in a BW of 40 MHz, and 2 clients (1-4SS). In [13], the authors proposed a system consisting of an IR sensor, Arduino, Arduino IDE PLX-DAQ, and ThingSpeak cloud. The IR is used as a transmitter and a receiver. A value of zero means no obstacle and a value of one means that there is an obstacle. The value will be exported to an excel file using PLX-DAQ. The excel data is uploaded to ThingSpeaks cloud. In [14], the authors create a website connecting with the cloud to save data in it. Moreover, the system of the parking connects with the website to update it whenever the status of parking changes. The system of the parking contained IR sensors, LED light, LCD, Arduino UNO, personal computer, and motor for opening the gate. Each parking has an IR sensor to detect a car and two LED lights, green and red. The green light means that the parking is empty and the red light indicates that the parking is occupied. The Arduino and WiFi module automatically update the information of the parking slots on a website. When the user arrives at the gate and verification is done, the parking spot is allocated to the vehicle, and the spot identification number is presented on the LCD, and details are updated on a website. In [15], the authors proposed a system based

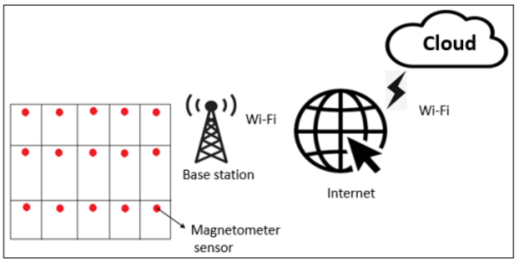

**Figure 3**. A Smart parking model

on the cloud environment using ultrasonic sensors with Arduino to monitor the parking. The Arduino module located in each parking spot is used to send information of the parking spot to the cloud server which shares the data with the user to know the availability of parking. Every parking spot will have a unique name depending on its location to prevent the conflict with another parking spot. The user can be book the parking through an android application and will get the nearest parking spot based on his location and then the status of each parking spot is updated synchronously. In [16], the authors creates a mobile application that allows the user to reserve the nearest parking through the cloud, and then the information regarding the parking space is updated in the mobile application. The authors were using an ultrasonic sensor in each parking to detect the available parking and they also used a camera in every parking to capture the number plates. Moreover, the authors used Raspberry Pi3 as a control data hardware because the camera and sensors are working together. The system has some features such as tracking cars, selecting the nearest parking, and calculate the fee.

## 3 Simulation Model Structure

The proposed system includes three basic parts: parking detection, WSN, and cloud storage (information management).

The parking detection is composed mainly of magnetometer sensors that are installed in all parking spot in each area, these sensors form a WSN to collect and sense the status of all the parking spots (free or busy) and transmit it to the base station. This information is transmitted to the cloud to store it in the database. The cloud is a database where the data is detected and collected from every vehicle location in the parking. Figure 3, show a model of the smart parking system.

## 4 Simulation Test Scenarios

In this section, we present three scenarios using IEEE802.11ac, IEEE802.15.4, and IEEE802.11b to estimate and measure the performance. The Comparison of these three network standards will determine the best solution. IEEE802.11ac has higher coverage, capacity, and data rate. Moreover, the quality is better than other standards and it also has a wide channel. It can improve modulation schema to support more clients but it is costly. The IEEE802.15.4 has features such as low power, maintenance, and complexity. Its drawbacks are low quality and high interference. Table 1 shows the comparison for these three network standards in the smart parking system. The distribution of sensors is done in two ways: manual and automatic. The manual distribution determines the position of the sensors in advance. The automatic distribution is based on the size of area to find the required number of sensors. The paper presents three scenarios, the first scenario is called static deployment; where the number of sensors is determined manually for all standards. The second scenario is automatic deployment where the number of sensors is found based on the size of the area for IEEE 802.11ac. While IEEE802.15.4 and IEEE802.11b use the only manual method. The third scenario called dynamic deployment that is done using the cloud and the sensors are distributed automatically based on the size of the area for IEEEE 802.11ac and manually for IEEE802.15.4 and IEEE802.11b. The data is uploaded to the cloud in IEEE 802.1ac while IEEE802.15.4 and IEEE802.11b have grid placement and do not use the cloud. Average end to end delay is calculated using Equation 1 [17, 18].

**Table 1**. Comparison between networks standards

| **Standard** | **IEEE 802.11ac** | **IEEE 802.11b** | **IEEE 802.15.4** |
|---|---|---|---|
| Range | 200-300 m | 100 m | 75 m |
| Data rate | 6.93 Gbps | 5.5 and 11 Mbps | 20, 40 and 250 Kbps |
| Frequency band | 5.8 Ghz | 2.4 Ghz | 868 Mhz, 915 Mhz and 2.4 Ghz |
| Interference | Less | More | More |
| Cost | High | Low | Low |
| Quality | High | Low | Low |
| Features | Very high throughput, Use wide channel, Improved modulation schema, Better performance and converge | Low cost, Low maintenance | Low complexity, Low maintenance, Low power consumption |

$$\text{Average delay} = \mathrm{d}_{\text{trans}} + \mathrm{d}_{\text{prop}} + \mathrm{d}_{\text{queuing}} + \mathrm{d}_{\text{process}}, \quad (1)$$

$$\text{Transmission delay} = \frac{\text{Packet length}}{\text{Bandwidth}}, \quad (2)$$

$$\text{Propagation delay} = \frac{\text{Length of physical link}}{\text{Propagation speed in medium}}, \quad (3)$$

where transmission delay ($d_{trans}$) is the time to set the data on the transmission link, calculated via the length of packet divided by bandwidth of the channel. Propagation delay ($d_{prop}$) is the time for one bit to transmit from the sender to the receiver. The propagation delay is calculated by dividing the length of the physical link by the propagation speed in the medium. Queuing delay ($d_{queuing}$) is the time spent by the data packet in a queue before execution, and processing delay ($d_{process}$) is the time for the processor to process the data packet. Throughput means how much data can be transferred from one position to another in a given amount of time, it is represented by Equation 4 [19].

$$\text{Throughput} = \frac{\text{Transfer size}}{\text{Transfer time}}. \qquad (4)$$

## 5 Results and Discussion

In this section, we will present the results of all scenarios mentioned in the previous section.

### 5.1 Static Deployment

Performance analysis is done by changing the number of sensors in the network manually. Table 2 shows the simulation parameters of the static deployment.

**Table 2**. Simulation parameters of the static deployment

| **Standard** | **IEEE802.11ac** | **IEEE802.15.4 and IEEE802.1b** |
|---|---|---|
| Area | 1000 m x 1000 m | 1000 m x 1000 m |
| Number of sensors | 10,20,30, 40,50 and 100 | 10,20,30,40,50 and 100 |
| Placement of sensors | Randomly | Grid |
| Routing protocol | N/A | AODV |

**Table 3**. The average end to end results of the standards

| **Number of sensors** | **IEEE802.11ac msec** | **IEEE802.15.4 msec** | **IEEE802.11b msec** |
|---|---|---|---|
| 10 | 0.0291 | 10 | 10.0 |
| 20 | 0.0291 | 20 | 20.00 |
| 30 | 0.0293 | 100 | 30.0 |
| 40 | 0.0290 | 61 | 9.0 |
| 50 | 0.0292 | 58 | 9.1 |
| 100 | 0.0292 | 160 | 8.0 |

#### 5.1.1 Average End to End Delay

The simulation parameters for static deployment are given in Table 2. The average end to end delay performance of IEEE802.11ac, IEEE802.15.4, and IEEE802.11b is done in an area of $1km^2$. The generation of sensors is done manually for IEEE802.11ac IEEE802.15.4 and IEEE802.11b. The sensors are distributed randomly and using a grid. As shown in Figure 4, the average end to end delay of IEEE802.11ac is less than IEEE802.15.4 and IEEE802.11b also, the average end to end delay of IEEE802.15.4 increases while IEEE802.11ac and IEEE802.11b decrease when more sensors are added. The average end to end delay of IEEE802.11ac is very small around 0.0292 msec and less.

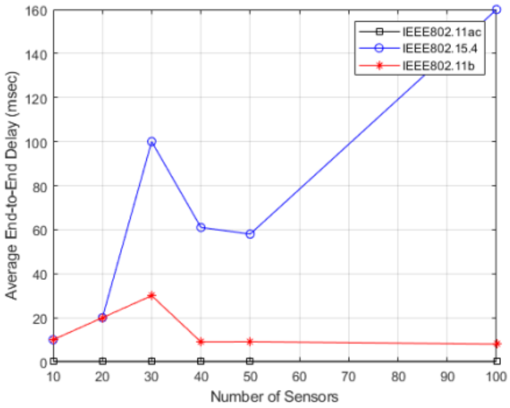

**Figure 4**. Average end to end delay

**Table 4**. The throughput result of the standards

| **Number of sensors** | **IEEE802.11ac bit/msec** | **IEEE802.15.4 bit/msec** | **IEEE802.11b bit/msec** |
|---|---|---|---|
| 10 | 1.101 | 0.0002 | 0.000251 |
| 20 | 1.101 | 0.0001 | 0.000252 |
| 30 | 1.082 | 0.000050 | 0.0002535 |
| 40 | 1.104 | 0.000045 | 0.0002525 |
| 50 | 1.092 | 0.000049 | 0.0002505 |
| 100 | 1.111 | 0.00004 | 0.000251 |

#### 5.1.2 Throughput

The throughput of IEEE802.11ac, IEEE802.15.4, and IEEE802.11b is analyzed in an area of $1km^2$. The generation of sensors is done manually and the placement of sensors is done randomly and on a grid. As shown in Table 4, the throughput of IEEE802.15.4 and IEEE802.11b is very small comparing with IEEE82.11ac. Moreover, the IEEE802.11ac is designed for very high throughput applications for that there is a gap between IEEE802.15.4 with IEEE802.11b and IEEE802.11ac. As seen in Figure 5, increasing the number of sensors for IEEE802.11ac does not have a significant impact on throughput. Finally, throughput for IEEE802.11ac is better than IEEE802.15.4 and IEEE802.11b.

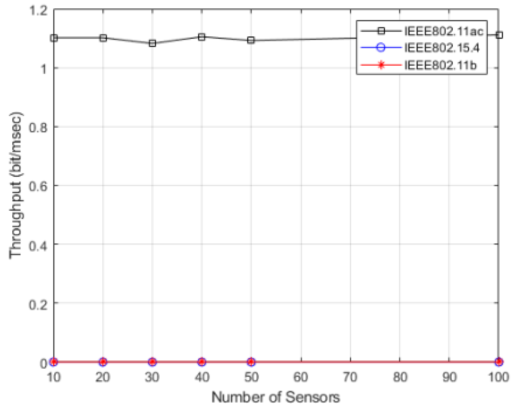

**Figure 5**. Throughput

## 5.2 Automatically Deployment

Performance analysis is done by changing the number of sensors in the network automatically based on the size of the area in IEEE802.11ac and manually in IEEE802.15.4 and IEEE802.11b. Table 5 shows the simulation parameters of the automatic deployment.

**Table 5**. Simulation parameters of the automatic deployment

| **Standard** | **IEEE802.11ac** | **IEEE802.15.4 and IEEE802.1b** |
|---|---|---|
| Area | 1000 m x 1000 m | 1000 m x 1000 m |
| Number of sensors | 100 | 10,20,30,40,50 and 100 |
| Placement of sensors | Randomly | Grid |
| Routing protocol | N/A | AODV |

### 5.2.1 Average End to End Delay

The simulation parameters for automatic deployment are given in Table 5. The average end to end delay performance of IEEE802.11ac, IEEE802.15.4, and IEEE802.11b is done in an area of $1km^2$. For IEEE802.11ac, the generation of sensors is automatic, it depends on the size of the area. The generation of sensors is done manually for IEEE802.15.4 and IEEE802.11b. The sensors are distributed randomly and using a grid. As shown in Figure 6, the average end to end delay of IEEE802.11ac is less than IEEE802.15.4 and IEEE802.11b also, the average end to end delay of IEEE802.15.4 increases while IEEE802.11ac and IEEE802.11b decrease when more sensors are added. The average end to end delay of IEEE802.11ac is very small around 0.02888 msec and less.

**Table 6**. The average end to end delay result of the standards

| **Number of sensors** | **IEEE802.11ac msec** | **IEEE802.15.4 msec** | **IEEE802.11b msec** |
|---|---|---|---|
| 10 | 0.02888 | 10 | 10.0 |
| 20 | 0.02887 | 20 | 20.0 |
| 30 | 0.02887 | 100 | 30.0 |
| 40 | 0.02887 | 61 | 9.0 |
| 50 | 0.02887 | 58 | 9.1 |
| 100 | 0.02886 | 160 | 8.0 |

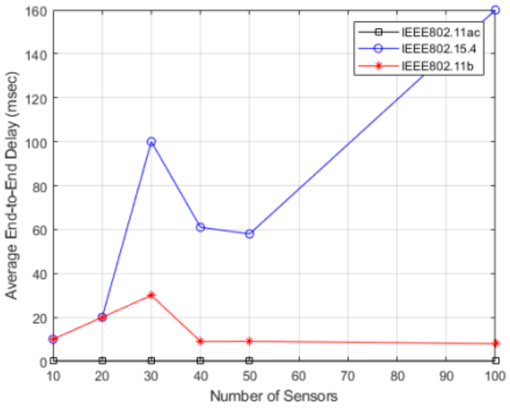

**Figure 6**. Average end to end delay

**Table 7**. The throughput result of the standards

| **Number of sensors** | **IEEE802.11ac bit/msec** | **IEEE802.15.4 bit/msec** | **IEEE802.11b bit/msec** |
|---|---|---|---|
| 10 | 1.106 | 0.0002 | 0.000251 |
| 20 | 1.108 | 0.0001 | 0.000252 |
| 30 | 1.06 | 0.000050 | 0.0002535 |
| 40 | 1.104 | 0.000045 | 0.0002525 |
| 50 | 1.092 | 0.000049 | 0.0002505 |
| 100 | 1.111 | 0.00004 | 0.000251 |

### 5.2.2 Throughput

The throughput performance of IEEE802.11ac, IEEE802.15.4, and IEEE802.11b is done in an area of $1km^2$. For IEEE802.11ac, the generation of sensors is automatic and it relies on the size of the area. The sensors are generated manually in IEEE802.15.4 and IEEE802.11b. The sensors are distributed randomly and on a grid. As shown in Figure 7, the throughput of IEEE802.11ac is very high compared with the other standards. Moreover, as seen in Table 7, the throughput of IEEE802.15.4 and IEEE802.11b is decreased when the number of sensors is increased. The performance of IEEE 802.11ac is better than IEEE802.15.4 and IEEE802.11b in throughput and average end to end delay.

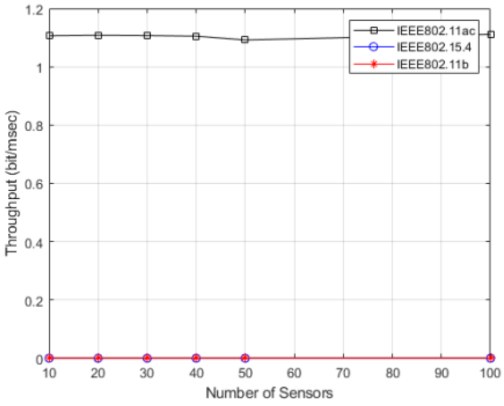

**Figure 7**. Throughput

## 5.3 Dynamic Deployment Using Cloud

Performance analysis is done via distribution of the sensors automatically in IEEE802.11ac with using cloud and manually in IEEE802.15.4 and IEEE802.11b without using the cloud. Table 8 shows the simulation parameters of dynamic deployment.

**Table 8**. Simulation parameters of dynamic deployment

| **Standard** | **IEEE802.11ac** | **IEEE802.15.4 and IEEE802.1b** |
|---|---|---|
| Area | 1000 m x 1000 m | 1000 m x 1000 m |
| Number of sensors | 100 | 10,20,30,40,50 and 100 |
| Placement of sensors | Randomly | Grid |
| Routing protocol | N/A | AODV |

### 5.3.1 Average End to End Delay

The simulation parameters for dynamic deployment are given in Table 8. The average end to end delay performance of IEEE802.11ac, IEEE802.15.4, and IEEE802.11b is done in an area of $1km^2$. For IEEE802.11ac, the generation of sensors is automatic, it depends on the size of the area. The generation of sensors is done manually for IEEE802.15.4 and IEEE802.11b. The sensors are distributed randomly and using a grid. As shown in Figure 8, the average end to end delay of IEEE802.15.4 is increasing if the number of sensors is increasing while in IEEE802.11ac when increasing the number of sensors the average end to end delay will be decreased. Moreover, as seen in Table 9, the average end to end delay of IEEE802.11b not affect too much when more sensors are added.

**Table 9**. The average end to end delay result of the standards

| | | | |
|---|---|---|---|
| 10 | 0.02886 | 10 | 10.0 |
| 20 | 0.02886 | 20 | 20.0 |
| 30 | 0.02886 | 100 | 30.0 |
| 40 | 0.02885 | 61 | 9.0 |
| 50 | 0.02885 | 58 | 9.1 |
| 100 | 0.02884 | 160 | 8.0 |

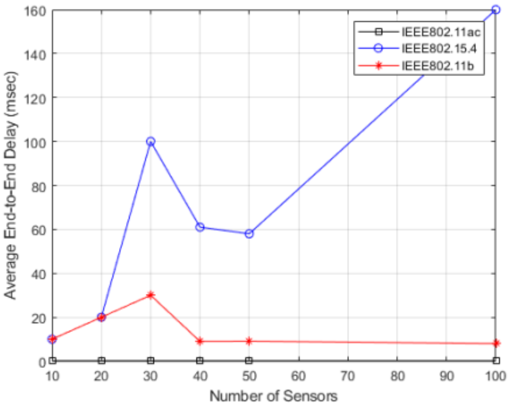

**Figure 8**. Average end to end delay

**Table 10**. The throughput result of the standards

| **Number of sensors** | **IEEE802.11ac bit/msec** | **IEEE802.15.4 bit/msec** | **IEEE802.11b bit/msec** |
|---|---|---|---|
| 10 | 1.11 | 0.0002 | 0.000251 |
| 20 | 1.107 | 0.0001 | 0.000252 |
| 30 | 1.109 | 0.000050 | 0.0002535 |
| 40 | 1.11 | 0.000045 | 0.0002525 |
| 50 | 1.108 | 0.000049 | 0.0002505 |
| 100 | 1.111 | 0.00004 | 0.000251 |

### 5.3.2 Throughput

The throughput performance of IEEE802.11ac, IEEE 802.15.4, and IEEE802.11b is done in an area of $1km^2$. For IEEE802.11ac, the generation of sensors is automatic and it relies on the size of the area. The sensors are generated manually in IEEE802.15.4 and IEEE802.11b. The sensors are distributed randomly and on a grid.As shown in Figure 9, increasing the number of sensors for IEEE802.11ac does not have a significant impact on throughput. Moreover, they have a gap in the value of throughput between the standards because the IEEE802.11ac designs for very high throughput and the maximum data rate are 6.93 Gbps while in IEEE802.11b the maximum data rate is 11 Mbps and in IEEE802.15.4 the maximum data rate is 250 Kbps.

Finally, the performance of IEEE 802.11ac is better than IEEE802.15.4 and IEEE802.11b. The following compares IEEE802.11ac with IEEE802.15.4 and IEEE802.11b in terms of average end to end delay and throughput while varying the number of sensors.

- For IEEE802.11ac the value of throughput increases when the sensors are increased while in

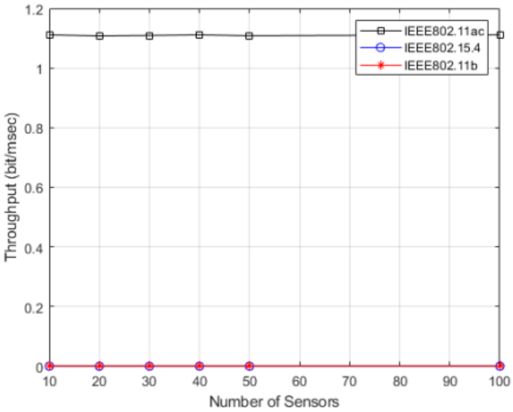

**Figure 9**. Throughput

the other standards the throughput decreases when the number of sensors is increased.

- For IEEE802.11ac average end to end delay decreases when the sensors are increased while in the other standards average end to end delay increases when the number of sensors is increased.
- We see that the throughput of IEEE802.11ac is high compared to IEEE802.15.4 and IEEE802.11b also, the average end to end delay of IEEE802.11ac is low compared to IEEE802.15.4 and IEEE802.11b.
- IEEE802.11ac has better overall performance and the number of sensors should be adjusted automatically based on the size of the area to get optimum results in terms of performance.

## 6 Conclusion

The paper compares the performance of the IEEE802.11ac, IEEE802.15.4, and IEEE802.11b using average end to end delay and throughput by changing the number of sensors (manually and automatically) also, with using the cloud in IEEE 802.11ac and without using the cloud in IEEE802.15.4 and IEEE802.11b. We observed that IEEE802.11ac performs better than IEEE802.15.4 and IEEE802.11b in terms of using cloud also an average end to end delay and throughput. Based on the result, IEEE802.11ac is designed for applications that use a very high throughput. We conclude to use IEEE802.11ac with cloud storage to get the best results.

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