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Performance Evaluation and Comparison of IEEE 802.11 and IEEE 802.15.4 ZigBee MAC Protocols Based on Different Mobility Models

Elmustafa S.Ali Ahmed[1], Bakhita El.Sheikh Ali[2], Eman Omer Osman[3] and Tagwa Amin M. Ahmed[4]

[1]Electrical and Electronics Engineering Department, Red Sea University, Sudan
[1]elmustafasayed@gmail.com, [2]neshesha93@gmail.com, emee0211@gmail.com, [4]taaminta55@gmail.com

Abstract

Wireless systems continue to rapidly gain popularity. This fact is extremely true for data networks in the local and personal areas. Media Access Control (MAC) layer protocols have a critical role in making a typical Mobile ad hoc network and Personal ad hoc network more reliable and efficient. Choice of MAC layer protocol and other factors including number of nodes, mobility, traffic rate and playground size dictates the performance of a particular WLAN and WPAN. The aim of this paper is to analysis the performance of mobility models in IEEE802.11 MAC and IEEE 802.15.4 ZigBee MAC using NS2.34.These mobility models are RPGM, RWM, Freeway mobility and city section mobility model. Then extraction of the simulation results based on the performance metrics to calculate a Packet Delivery Ratio, data loss, end-to-end delay and Throughput.

Keywords*: MANET, Mobility Models, MAC 802.11, MAC 802.15.4, Freeway, RPGM, RWP, City Section*

1. Introduction

Mobile ad hoc network (MANET) is a type of wireless ad hoc network, and is self-configuring network of mobile devices connected by any number of wireless links [1].IEEE 802.11 is contention based medium access control protocol for implementing wireless local area network (WLAN). It avoids collisions in data packets through carrier sensing and randomized back-offs techniques. Its main characteristics include simplicity, flexibility and cost effectiveness. IEEE 802.15.4 is uniquely designed for low rate wireless personal area networks (WPAN). It focuses on low data rate, low power consumption and low cost wireless networking and offers device level wireless connectivity [2]. Mobility models are used to simulate and evaluate the performance of mobile wireless systems and the algorithms, protocols at the basis of them [3].

2. Medium Access Control (MAC) Protocol

In Mobile Ad-Hoc Network and Personal Ad-Hoc Networks, various mobile nodes share a medium whose access is facilitated by using a MAC protocol. Medium Access Control protocol is a one of sublayers of Data Link layer in OSI model. MAC layer provides the reliability and efficiency for MANET and PANET. Medium Access Control Logic as show in figure 1 below.

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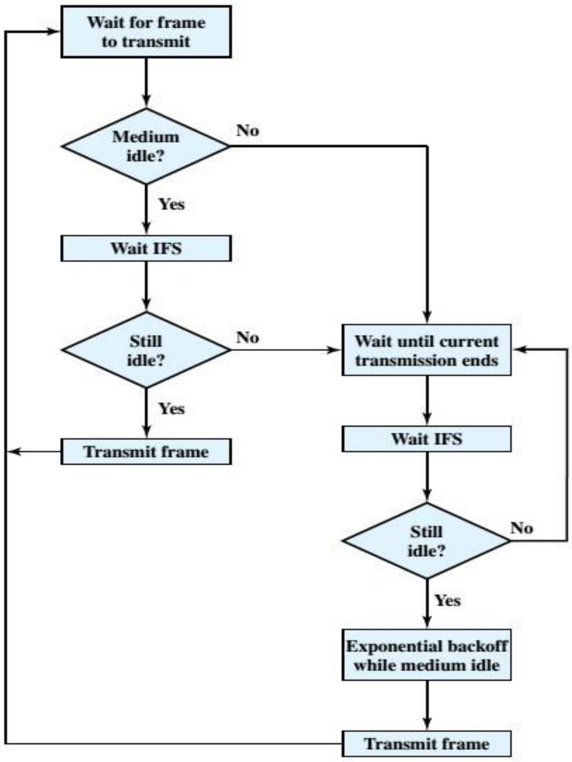


Figure 1. Medium Access Control Logic

MAC is responsible for channel access policies, scheduling, buffer management and error control [4]. There are many type of MAC techniques used in Mobile Ad-Hoc network (MANET) and Personal Ad-Hoc Network (PANET), such as, WIFI, Bluetooth, Bluetooth ZigBee and WiMAX. More of the popular MAC layer protocols are briefly discussed as in the following section.

2.1 .The IEEE 802.11 MAC Protocol

The 802.11 MAC protocol as shown in Figure 1, designed with two modes of communication, Distributed Coordination Function (DCF) and Point Coordination Function (PCF). The DCF protocol based on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) mechanism and is mandatory, while PCF is defined as an option to support time-bounded delivery of data frames. The DCF protocol in IEEE 802.11 standard defines how the medium is shared among stations. DCF which is based on CSMA/CA, consists of a basic access method and an optional channel access method with request-to-send (RTS) and clear-to-send (CTS) exchanged [5].

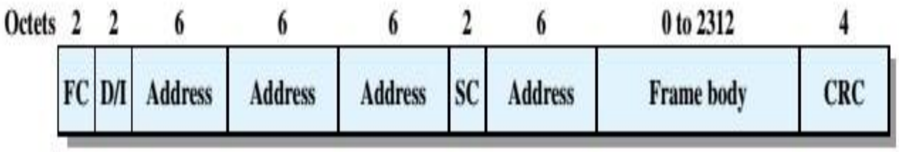


Figure 2. IEEE 802.11 Mac Frame Format

2.2 .The IEEE 802.15.4 MAC Protocol

The MAC layer defines how multiple 802.15.4 radios operating in the same area will share the airwaves. IEEE 802.15.4 supports low rate wireless personal area networks working in beacon mode by use of super-frames. The frame structures have been designed to keep the complexity to a minimum while at the same time making them sufficiently robust for transmission on a noisy channel [6]. The IEEE 802.15.4 MAC sub layer has two operational modes. They are: (a) Beacon-enabled mode: In this mode, beacons are periodically sent by the PAN or Coordinator to synchronize nodes that are associated with it. This mode uses super frame which have contention access and contention free period which is divided into different guaranteed time slots (GTS). (b) Non beacon –enabled mode: In this mode PAN coordinator does not transmit beacons. It does not support GTS and uses unslotted CSMA/CA MAC protocol. The IEEE802.15.4 allows the optional use of a super-frame structure. The format of the super-frame is defined by the coordinator. It is defined between two beacon frames and has an active period and an inactive period [7]. Structure of super-frame as shown in figure 3.

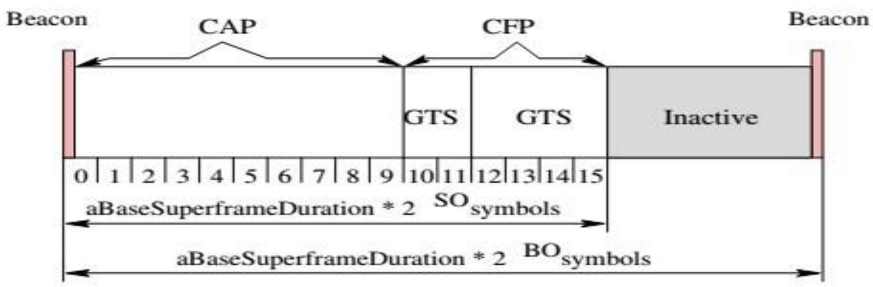


Figure 3. The Typical Structure of a Super-Frame

3. Mobility Models

Mobility model accurately represents the mobile nodes (MNs) that will eventually utilize the given protocol [8]. Every protocol acts differently in different mobility scenarios. For researchers to weigh mobility models effect on mobile ad hoc networks. In this paper, we studied the behavior of the four different mobility models such as Random Waypoint mobility, Reference Point Group mobility, City Section and Freeway mobility model [9].

3.1. Random Way Point Mobility Model

RWP is one of the prominent and well-known mobility modal. According to the internal operation of this model, a specific node starts its motion from initial point and goes towards the destination with specific speed within simulation area. After reaching the destination, specified node wait for some time (pause time) and then randomly select other direction to move. The topological situation of RWP is dependent on two parameters, pause time and speed. If a node moves with high speed having short pause time then the topology is said to be more dynamic [9].

3.2. Reference Point Group Mobility Model (RPGM)

The Reference Point Group Mobility Model depicts the random motion of a group of mobile hosts and the random motion of each individual host in the group. The movement of the group is based on the path travelled by a logical center for the group [10].

3.3. Freeway Mobility Model

This mobility model includes the spatial, high temporal dependencies and imposes strict geographical restriction. The mobile node velocity is temporally dependent on its previous velocity and also the velocity of a mobile node is also influenced with other mobile node moving in the same lane inside certain radius (spatial dependence). All mobile nodes movement are imposed strict geographical restriction [11].

3.4. City Section Mobility Model

In this model, simulation area represents streets within a city. By using map, mobile node can move along the grid of streets on the map. Such models are placed in real or imaginary city map. This model has certain limitations in terms of speed and unidirectional [12].

4. Simulation Models

The simulation results are carried out from NS-2 Network Simulator. In our simulation, we used 25 mobile nodes, traffic pattern was CBR and AODV routing protocol .The comparison of the performance of 802.11 and 802.15.4 ZigBee network on the basis of different mobility models (RWP, RPGM, freeway, city section) was simulated under several pause times from 10sec to 80 sec with total simulation time of 100 sec. The performance metrics chosen are Packet Delivery Ratio, Average end to- end delay, throughput and loss.

5. Results and Discussion

In our simulation we compared the performance of all mobility models mentioned above in networks based IEEE802.11 and IEEE802.15.4. The results of simulation are divided into four scenarios based on the types of mobility models as follows.

5.1. Scenario One: Random Mobility Model

This scenario present the simulation experiments and results of the performance comparison for IEEE802.11 and IEEE802.15.4 based on RWP mobility model using AODV routing protocol, the results we obtained are illustrated in the following figures.

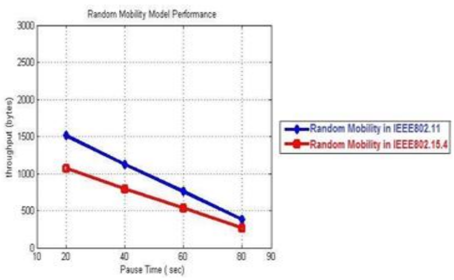


Figure 4. Throughput of RWP

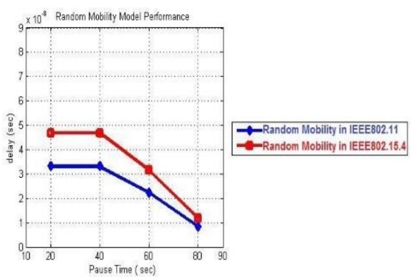


Figure 5. Delay of RWP

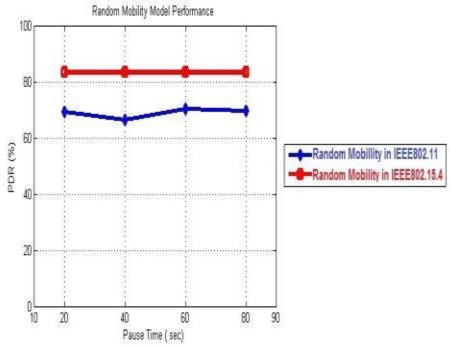


Figure 6. PDR of RWP

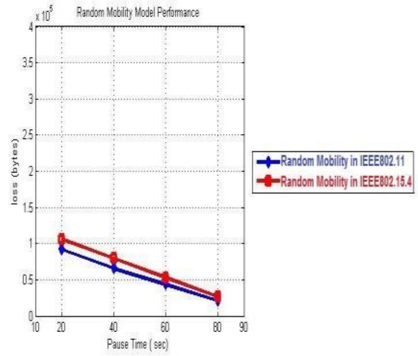


Figure 7. Data Loss of RWP

For throughput according to our simulation results for the RWP as shown in figure 4. It is observed from graph that the performance of IEEE802.11 is better than performance of IEEE802.15.4. This could be because IEEE802.11 has more transmission bandwidth and longer transmission range than IEEE802.15.4 ZigBee. For end-to-end delay according to our simulation results for the RWP as shown in figure 5. The transmission time for IEEE802.15.4 is longer than IEEE802.11 because of the lower data rate (250 Kbit/s). For this reason, we infer that the delay in IEEE802.11 less than a delay in IEEE802.15.4.

The simulation results of RWP in terms of packet delivered ratio (PDR) show in figure 6, observes that the PDR in IEEE802.15.4 is greater than the PDR in IEEE802.11, because the nodes are close to each then the PDR be the largest in IEEE802.15.4. For data loss according to our simulation results as shown in figure 7. Is observed that IEEE802.11 has lower dropped packets as compared to IEEE802.15.4.

5.2. Scenario Two: Group Mobility Model

In scenario two, the simulation experiments and results of the performance comparison for IEEE802.11 and IEEE802.15.4 networks based on RPGM mobility model given as in the following figures.

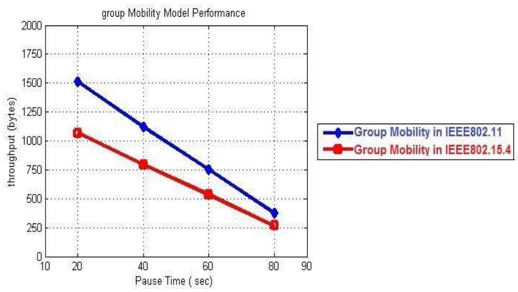


Figure 8. Throughput of RPGM

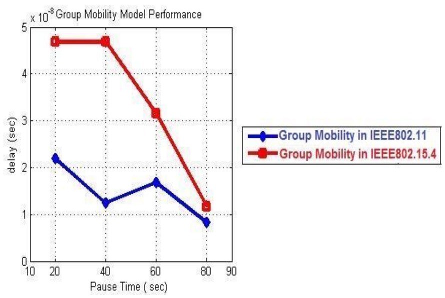


Figure 9. Delay of RPGM

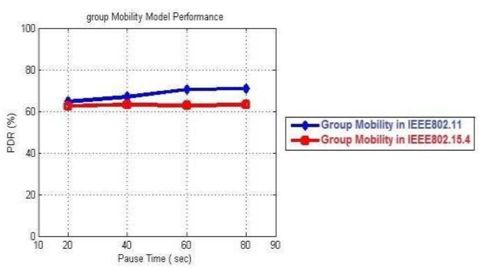


Figure 10. PDR of RPGM

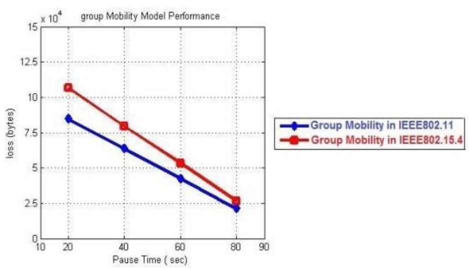


Figure 11. Data Loss of RPGM

Throughput according to the simulation results RPGM as shown in figure 8, is observed that the throughput in IEEE802.11 greater than the throughput in IEEE802.15.4. End-to-End delay as shown in figure 9, it is observed that IEEE802.11 protocol has given the lowest packet delay while IEEE802.15.4 has given up the largest delay of packets and at pause time 20sec the delay is high for both. Either for packet delivered ratio the simulation as shown in figure 10, the performance of IEEE802.11 is better than the performance of IEEE802.15.4. The result has shown that the PDR of IEEE802.11 yields about 65% while that of IEEE802.15.4 is about 62%, because when the two groups moves away from each other the link between them weakens. Data loss in the RPGM as shown in figure 11, is observed that IEEE802.11 has lower dropped packets as compared to IEEE802.15.4. This reason is due to the transmission in IEEE802.15.4 network needs more hops that are prone to more link failure.

5.3. Scenario Three: Freeway Mobility Model

Scenario three present the simulation experiments and results of the performance comparison for IEEE802.11and IEEE802.15.4 networks based on freeway mobility model. According to the results obtained, the comparison performance given as shown in the following figures.

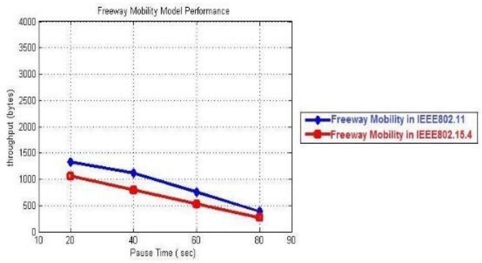


Figure 12. Throughput of Freeway

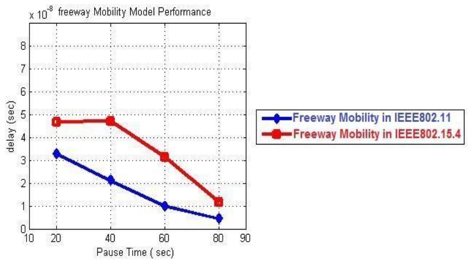


Figure 13. Delay of Freeway

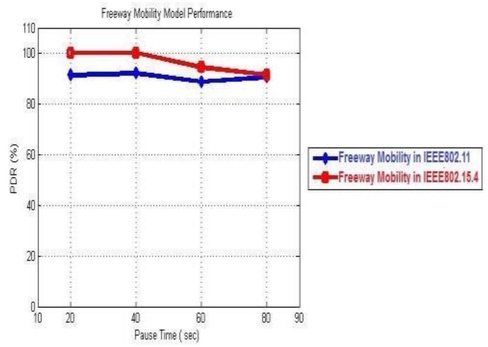


Figure 14. PDR of Freeway

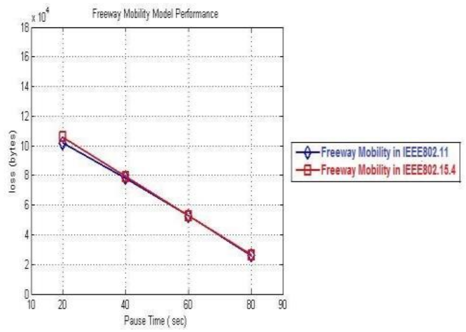


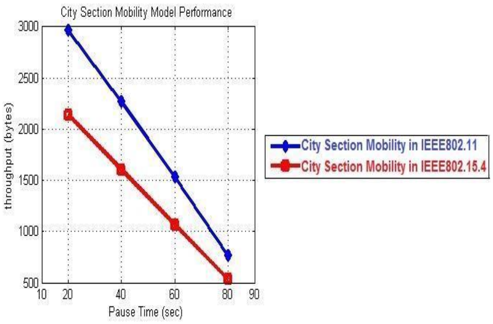
Figure 15. Data Loss of Freeway

For throughput according to our simulation results as shown in figure 12, we found that IEEE802.15.4 has the lowest throughput while IEEE802.11 has the highest throughput. For end to end delay according to our simulation results as shown in figure 13 the delay begin with a high value when pause time 20sec because the time it takes the packet to arrive to the destination be large and decreases when increasing the pause time, note that the delay in IEEE802.11 less than the delay in IEEE802.15.4.

For packet delivered ratio the simulation results as shown in figure 1, IEEE802.11 has given the lowest packet delivery ratio while IEEE802.15.4 has given up the highest packet delivery ratio. Because the distance in freeway too small so the performance of IEEE802.15.4 is the best. Either for data loss according to our simulation results as shown in figure 15 in the loss the performance of IEEE802.15.4 very nearby of performance of IEEE802.11.

5.4. Scenario Four: City Section Mobility Model

Scenario four present the simulation experiments and results of the performance comparison for IEEE802.11 and IEEE802.15.4 networks based on city section mobility model. The results we obtained are shown in the following figures.



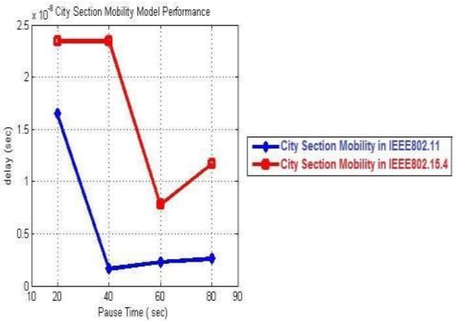
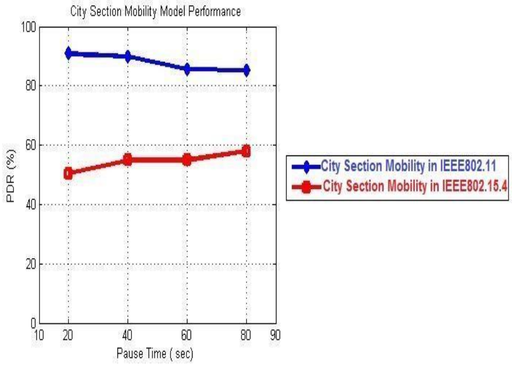


Figure 16. Throughput of City Section **Figure 17. Delay of City Section**



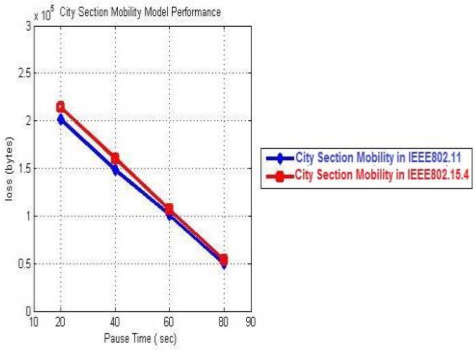


Figure 18. PDR of City Section **Figure 19. Data Loss of City Section**

For throughput according to our simulation results as shown in figure 16 the performance of IEEE802.11 is better than performance of IEEE802.15.4 because when mobility increases in pause time 20sec, the throughput in IEEE802.11 is greater than throughput in IEEE802.15.4, as well as when mobility decreases in pause time 80sec. As shown in figure 16 the throughput begin with a high value and then decreased, because increase in the pause time. For time end-to-end delay according to our simulation results as shown in figure 17 the delay begin with a high value when pause time 20sec and reduced until it reaches its lowest value when the pause time 80sec, delay in IEEE802.11 less than a delay in IEEE802.15.4.

For packet delivered ratio, the simulation as shown in figure 18 the performance of IEEE802.11 is better than performance of IEEE802.15.4. This due to the nature of the mode, the performance of IEEE802.15.4 network very weak in this model. Either for data loss according to our simulation results as shown in figure 19 performance of IEEE802.15.4 and IEEE802.11 almost is similar.

6. Conclusion

In this paper, we compared between IEEE802.11 and IEEE802.15.4 ZigBee networks based on different mobility models. The networks has been studied intensively and obtained the results by using various performance metrics like throughput, end to end delay, packet delivery ratio and data loss, then we compared between these networks. We found that the RWP, RPGM, freeway and city section mobility models shown high data loss in IEEE802.15.4, but less in IEEE802.11. In addition, with high throughput in IEEE802.11. In city section and RPGM models, IEEE802.15.4 gives poor performance when compared with IEEE802.11 in all metrics, gives high packet loss and delay. But in RWP and freeway models, the performance of two networks IEEE802.11 and 802.15.4 are closed together specially in packet delivered ratio and data loss metrics. Generally we realized that the IEEE802.15.4 based networks are more suspected to be affected by the mobility models of the mobiles in the networks, but IEEE802.11 based networks had a stable behaviors with different mobility models.

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Authors

Bakhita El.Sheikh Ali, She is presently doing B.Sc. degree with honors in red sea university faculty of Engineering, complete her graduate research in September 2015. Her research interest on field MANETs and Wireless Networks.

Eman Omer Osman, She is presently doing B.Sc. degree with honors in red sea university faculty of Engineering, complete her graduate research in September 2015. Her research interest on fieMANETs and Wireless Networks.

Tagwa Amin M. Ahmed, She is presently doing B.Sc. degree with honors in red sea university faculty of Engineering, complete her graduate research in September 2015. Her research interest on field MANETs and Wireless Networks.

Elmustafa Sayed Ali Ahmed, he received his M.Sc. degree in electronics engineering, Telecommunication in 2012, and B.Sc. (Honor) degree in electrical engineering, Telecommunication in 2008. He was a wireless networks (Tetra system, Wi-Fi and Wi-Max, and CCTV) engineer in Sudan Sea Port Corporation for four years and a head department of electrical and electronics engineering, faculty of engineering in Red Sea University for one year. He published papers, chapters, and books in wireless communications, computer and networking in peer reviewed academic international journals. His areas of research interest include MANETs, wireless networks, VANETs, image processing and computer networks.