SCENARIO BASED STUDY OF ON-DEMAND REACTIVE ROUTING PROTOCOL FOR IEEE-802.11 AND 802.15.4 STANDARDS

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Abstract

Routing data from source to destination is hard in Mobile Ad-Hoc Networks (MANET) due to the mobility of the network elements and lack of central administration. The main method for evaluating the performance of MANETs is simulation. In this paper performance of Ad-hoc On-demand Distance Vector (AODV) reactive routing protocol is studied by considering IEEE 802.11 and IEEE 802.15.4 standards. Metrics like average end-to-end delay, packet delivery ratio, total bytes received and throughput are considered for investigating simulation scenario by varying network size with 10 mps node mobility. Also simulation has been carried out by varying mobility for scenario with 50 nodes.

Keywords: AODV, End-to-end delay, IEEE 802.11 standard, IEEE 802.15.4 standard, MANETs, Packet delivery ratio, Performance evaluation, Qualnet 5.0.2. simulator, Reactive routing, Throughput.

I. Introduction

The advancement in information technology and the need for large-scale communication infrastructures has triggered the era of Wireless sensor networks (WSNs). Mobile ad-hoc network (MANET) is a network of wireless mobile nodes which communicate with each other without any centralized control or established infrastructure. Routing is the process of selecting paths in a network along which data is to be sent, it is a critical task in MANET where the nodes are mobile. Dynamic and reliable routing protocols are required in the ad-hoc wireless networks, as they have no infrastructure (base station) and their network topology changes. There are various protocols for handling the routing problem in the ad-hoc wireless network environment [1]. In recent years, the progress of communication technology has made wireless devices smaller, less expensive and more powerful. The rapid technology advance has provoked great growth in mobile devices connected to the Internet. Hence various wireless network technologies such as 3G, 4G of cellular network, ad-hoc, IEEE 802.11 based wireless local area network (WLAN) and Bluetooth are used. IEEE 802.15.4 is a very important technology of ubiquitous WSN [2]. In MANET links between the nodes can change during time, new nodes can join the network and other nodes can leave it [3]. The set of applications for MANETs is diverse, ranging from small static networks that are constrained by power sources to large-scale, mobile, highly dynamic networks. MANET is expected to be of larger size than the radio range of the wireless antennas, because of this fact it could be necessary to route the traffic through a multi-hop path to give two nodes the ability to communicate.

A key challenge in ad-hoc network design is to develop a high quality and efficient routing protocol which can be used to communicate using mobile nodes [3]. Unfixed topology in ad-hoc networks resulting in finding the delivery path dynamically, maintain the integrity and stability of the path during data delivery process. This ensures the data packets are transferred to the destination node completely. The traditional routing mechanisms and protocols of wired network are inapplicable to ad-hoc networks, which initiated the need to use a dynamic routing mechanism in ad-hoc network [4].

In this paper focus is given on studying the performance of AODV reactive routing protocol using Qualnet 5.0.2 simulator [5]for different node density and node mobility for IEEE 802.11 WLAN and IEEE 802.15.4 WSN standards. The rest of the paper is organized as follows. The overview of Routing Protocol, AODV [3-4], 802.11 WLAN and IEEE

802.15.4 WSN standards are summarized in section II and in section III related work is discussed. The simulation environment and results are discussed in section IV and conclusion in section V.

2. Routing Protocol Description

There are two types routing protocols for wireless networks, namely proactive and reactive. In proactive routing, each node has one or more tables that contain the latest information of the routes to any other node in the network. Various table-driven protocols differ in the way how the information propagates through all nodes in the network when topology changes. The proactive routing protocols are not suitable for larger networks as they need to maintain each and every node entries in the routing table. This causes more overhead in the routing table leading to consumption of more bandwidth. Examples of such schemes are the conventional routing schemes: Destination Sequenced Distance Vector (DSDV), Optimized Link State Protocol (OLSR) etc.

In reactive routing, route table is set on demand and it maintains active routes only. If a node wants to send a packet to another node then reactive protocol searches for the route in an on-demand manner and establishes the connection in order to transmit and receive the packet. The route discovery usually occurs by flooding the route request packets throughout the network. Examples of reactive routing protocols are the Dynamic Source Routing (DSR), Adhoc On-demand Distance Vector routing (AODV). Wireless sensor network involves frequent movement of nodes, which needs reactive routing protocol for its operation.

Reactive routing techniques, also called on-demand routing, take a very different approach to routing than proactive protocols. On-demand routing approaches deviate from traditional Internet routing approaches by not continuously maintaining a route between all pairs of network nodes. Instead, routes are only discovered when they are actually needed. When a source node needs to send data packets to some destination, it checks its route table to determine whether it has a valid route. If no route exists, it performs a route discovery procedure to find a path to the destination. Hence, route discovery becomes on-demand. These routing approaches are well known as Reactive routing. The route discovery typically consists of the network-wide flooding of a request message. Once a route has been established, it is maintained by some form of route maintenance procedure until either the destination becomes inaccessible along every path or until the route is no longer desired. Reactive routing protocol includes DSR protocol and AODV protocol [4].

AODV routing protocol

This protocol performs route discovery using control messages route request (RREQ) and route reply (RREP) whenever a node wishes to send packets to destination. The forward path sets up an intermediate node in its route table with a lifetime association RREP. When source node receives the route error(RERR) message, it can reinitiate route if it is still needed. Neighbourhood information is obtained from broadcast hello packet.

AODV is a flat routing protocol which does not need any central administrative system to handle the routing process. AODV tends to reduce the control traffic messages overhead at the cost of increased latency in finding new routes. AODV has great advantage in having less overhead over simple protocols. The RREQ and RREP messages which are responsible for the route discovery do not increase significantly the overhead from these control messages. AODV reacts relatively quickly to the topological changes in the network. It updates the hosts that may be affected by the change, using RERR message. The hello messages are responsible for the route maintenance and are limited so that they do not create unnecessary overhead in the network. The AODV protocol is a loop free and uses sequence numbers to avoid the infinity counting problem which are typical to the classical distance vector routing protocols [3].

AODV discovers routes whenever it is needed by route discovery process using traditional routing tables; one entry per destination. AODV uses a broadcast route discovery algorithm and then the unicast route reply massage for finding the route.

Route Discovery in AODV

When a node wants to send a packet to some destination node and does not have a valid route in its routing table for that destination, it initiates a route discovery process. Source node broadcasts a route request (RREQ) packet to its neighbours, which then forwards the request to their neighbours and so on. Nodes generate a RREQ with destination address, Sequence number, Broadcast ID and sent it to its neighbor nodes. Each node receiving the route request sends a route back (Forward Path) to the node as shown in the figure 1.

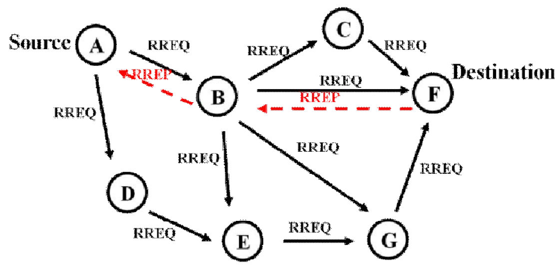

Figure 1: Route Requests and Reply in AODV

When the RREQ is received by a node that is either the destination node or an intermediate node with a fresh enough route to the destination, it replies by unicasting the route reply (RREP) towards the source node. As the RREP is routed back along the reverse path, intermediate nodes along this path set up forward path entries to the destination in its route table and when the RREP reaches the source node, a route from source to the destination established. Figure 1 indicates the path of the RREP from the destination node to the source node.

Route Maintenance in AODV

A route established between source and destination pair is maintained as long as needed by the source. When a link break in an active route is detected, the broken link is invalid and a RERR message is sent to other nodes. These nodes in turn propagate the RERR to their precursor nodes and so on until the source node is reached. The affected source node may then choose to either stop sending data or reinitiate route discovery for that destination by sending out a new RREQ message.

IEEE 802.11 Overview

It is an amendment to the IEEE 802.11 specification that added a higher data rate of up to 54 Mbit/s using the 5 GHz band. It has seen widespread worldwide implementation, particularly within the corporate workspace. The amendment has been incorporated into the published IEEE 802.11-2007 standard.802.11 is a set of IEEE standards that govern wireless networking transmission methods. They are commonly used today in their 802.11a, 802.11b, 802.11g and 802.11n versions to provide wireless connectivity in the home, office and some commercial establishments.

The 802.11a amendment to the original standard was ratified in 1999. The 802.11a standard uses the same core protocol as the original standard, operates in 5 GHz band, and uses a 52-subcarrier orthogonal frequency-division multiplexing (OFDM) with a maximum raw data rate of 54 Mbit/s, which yields realistic net achievable throughput in the mid-20 Mbit/s. The data rate is reduced to 48, 36, 24, 18, 12, 9 then 6 Mbit/s if required. 802.11a originally had 12/13 non-overlapping channels, 12 that can be used indoor and 4/5 of the 12 that can be used in outdoor point to point configurations. Recently many countries of the world are allowing operation in the 5.47 to 5.725 GHz Band as a secondary user using a sharing method derived in 802.11h. This will add another 12/13 Channels to the overall 5 GHz band enabling significant overall wireless network capacity enabling the possibility of 24+ channels in some countries. 802.11a is not interoperable with 802.11b as they operate on separate bands, except if using equipment that has a dual band capability. Most enterprise class Access Points have dual band capability.

Using the 5 GHz band gives 802.11a a significant advantage, since the 2.4 GHz band is heavily used to the point of being crowded. Degradation caused by such conflicts can cause frequent dropped connections and degradation of service. However, this high carrier frequency also brings a slight disadvantage: The effective overall range of 802.11a is slightly less than that of 802.11b/g; 802.11a signals cannot penetrate as far as those for 802.11b because they are absorbed more readily by walls and other solid objects in their path. On the other hand, OFDM has fundamental propagation advantages when in a high multipath environment, such as an indoor office, and the higher frequencies enable the building of smaller antennas with higher RF system gain which counteract the disadvantage of a higher band of operation. The increased number of usable channels (4 to 8 times as many in FCC countries) and the near absence of other interfering systems (microwave ovens, cordless phones, baby monitors) give 802.11a significant aggregate bandwidth and reliability advantages over 802.11b/g [6].

IEEE 802.15.4 Overview

The IEEE 802.15.4 defines the physical layer (PHY) and medium access control sub layer (MAC) specifications to support energy constraint simple devices to work in wireless personal area networks(WPANs).To provide the global availability, the IEEE 802.15.4 devices use the 2.4 GHz industrial scientific and medical (ISM) unlicensed band. The standard offers two PHY options based on the frequency band. Both are based on direct sequence spread spectrum (DSSS). The data rate is 250 kbps at 2.4 GHz with offset quadrature phase shift keying (OQPSK), 40 kbps at 915 MHz and 20 kbps at 868 MHz with binary phase shift keying (BPSK). There is a single channel between 868 and 868.6 MHz, 10 channels between 902.0 and 928.0 MHz, and 16 channels between 2.4 and 2.4835 dBm for 868/915 MHz. These accommodate over air data rates of 250 kbps in the 2.4 GHz band, 40 kbps in the 915 MHz band and 20 kbps in the 868 MHz band. A total of 27 channels are allocated in 802.15.4, including 16 channels in the 2.4 GHz band, 10 channels in the 915 MHz band and 1 channel in the 868 MHz band. Physical layer provides means for bit stream transmission over the physical medium. The key responsibilities of PHY are activation and deactivation of the radio transceiver, frequency channel tuning, carrier sensing, received signal strength estimation (RSSI & LQI) , data coding and modulation and Error correction etc.

IEEE 802.15.4 supports two different device types that can communicate in low range-WPAN network: a full-function device (FFD) and a reduced-function device (RFD). The FFD can operate in three modes to serve as a PAN coordinator, a coordinator, or a device. An FFD can communicate to RFDs or other FFDs, while an RFD can communicate only to an FFD. RFD does not have the capability to relay data messages to other end devices. It is mainly used for applications that are extremely low resource in capability like a light switch or a passive infrared sensor. They would only be associated with a single FFD at a time to transfer data. Depending on the application requirements, an IEEE 802.15.4 LR-WPAN may operate in either of two topologies: the star topology or the peer-to-peer topology. In star topology, devices are interconnected in form of a star in which there is a central node PAN coordinator and all the network nodes (FFDs and RFDs) can directly communicate only to the PAN. In the star topology the communication is established between devices and a single central controller, called the PAN coordinator. The PAN coordinator is the primary controller of the PAN. All devices operating on a network have unique 64-bit addresses. This address may be used for direct communication within the PAN, or a short address may be allocated by the PAN coordinator when the device associates and used instead. The PAN coordinator might be mains powered, while the devices will most likely be battery powered. Applications that benefit from a star topology include home automation, industry automation, personal computer (PC) peripherals, toys, games and personal health care systems [6].

3. Related Work

A number of wireless routing protocols are already proposed to provide communication in wireless environment using open source simulators. Performance comparison among some set of routing protocols are already performed by the researchers such as among PAODV, AODV, CBRP, DSR, and DSDV [7], among DSDV, DSR, AODV, and TORA [8], among SPF, EXBF, DSDV, TORA, DSR, and AODV [9], among DSR and AODV [10], among STAR, AODV and DSR [11], among AMRoute, ODMRP, AMRIS and CAMP [12], among DSR, CBT and AODV [13], among DSDV, OLSR and AODV [14] and many more. These performance comparisons are carried out for ad-hoc networks. For this reason, evaluating the performance of wireless routing protocols in mobile WiMAX environment is still an active research area.

J. Zheng and M.J. Lee [15] implemented the IEEE 802.15.4 standard on NS2 simulator and provided the comprehensive performance evaluation on 802.15.4. The literature comprehensively defines the 802.15.4 protocol as well as simulations on various aspects of the standard. It mainly confined to performance of IEEE 802.15.4 MAC. Similarly in [16] the authors provided performance evaluations of IEEE 802.15.4 MAC in beacon-enabled mode for a star topology. The performance evaluation study revealed some of the key throughput-energy-delay tradeoff inherent in IEEE 802.15.4 MAC. J.S.Lee [17] attempted to make a preliminary performance study via several sets of practical experiments, including the effects of the direct and indirect data transmissions, CSMA-CA mechanism, data payload size, and beacon-enabled mode.

T.H.Woon and T.C.Wan [18] extended existing efforts but focuses on evaluating the performance of peer-to-peer networks on a small scale basis using NS2 simulator. The author analyzed the performance metrics such as throughput, packet delivery ratio, and average delay. In addition, they proposed ad-hoc sensor networks (AD-WSNs) paradigm as part of the extension to the IEEE 802.15.4 standard. In [19] the authors presented a novel mechanism intended to provide Quality of Service (QoS) for IEEE 802.15.4 based Wireless Body Sensor Networks (WBSN) used for pervasive healthcare applications. The mechanism was implemented and validated on the AquisGrain WBSN platform[20].

On the other hand in this paper the scenarios selected demonstrate the adynamic behaviour of the mobile ad-hoc networks wireless sensor networks. An effort is made to study the performance of on-demand reactive routing protocol for different node density and also for various speeds of nodes using Qualnet 5.0.2. Network simulator.

4. Simulation and Results

The overall goal of this simulation study is to evaluate the performance of reactive routing protocol AODV for different node density and various speeds of nodes for both IEEE 802.11 and IEEE 802.15.4 standards. The simulations have been performed using

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QualNet 5.0.2network simulator [5]software that provides scalable simulations of Wireless Networks. The simulation is carried out in two simulation scenarios A and B.

Simulation Scenario-A:

The performance of AODV routing protocol is evaluated by keeping the network speed (10mps) and pause time (30s) constant, while the network size (number of mobile nodes) is varied from 10 to 50 nodes. Table 1 shows the simulation parameters used in the evaluation.

Table 1. Simulation Parameters

Area	1000m X 1000m	1000m X 1000m
Simulation Time	200 second	200 second
Nodes	10,20,30,40,50	10,20,30,40,50
Nodes placement	Grid	Grid
Path loss Model	Two Ray	Two Ray
Mobility Model	Random Way Point	Random Way Point
Pause Time	30 second	30 second
Minimum Speed	10mps	10mps
Traffic	CBR	CBR
Packet size	512 bytes	50 bytes
MAC layer	802.11	802.15.4
Energy Model	Mica motes	Mica motes
Battery Model	Linear Model	Linear Model

Figure 2 shows the representative snapshot of Qualnet 5.0.2 network simulator for simulation scenario – A for 20 nodes with speed of 10mps for AODV routing protocol. The variation of Average End-to-End Delay, Packet delivery ratio (PDR), Throughput and Bytes received with varying the network size are shown in figure 3,4,5 & 6 respectively.

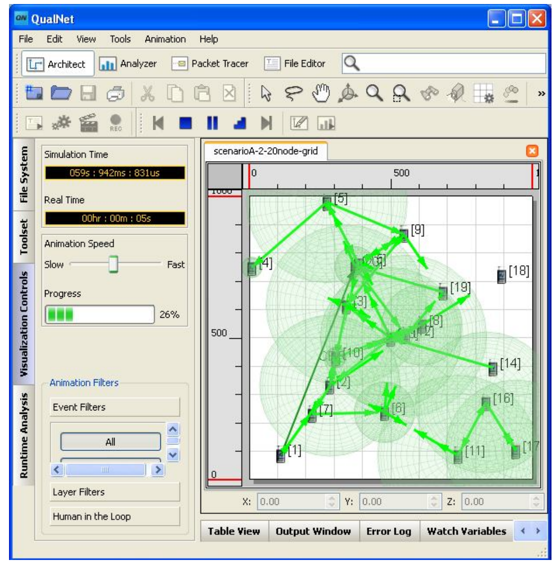

Figure 2 : Snapshot of simulation scenario-A for 20 nodes

It is clear from the figures 3, 4, 5 & 6 that in WSN as the node density increases overhead increases which results in increase in average end-to-end delay and decrease in PDR, Throughput and Bytes received respectively as compared to WLAN. It is also observed from figure 4 that as the node number increases the variation in PDR is almost minimum in WLAN as compared to WSN, which shows a steep fall in its value with increase in node density.

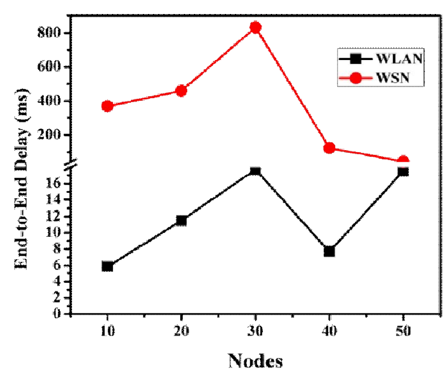

Figure 3 : Variation of End-to-End delay with varying node density

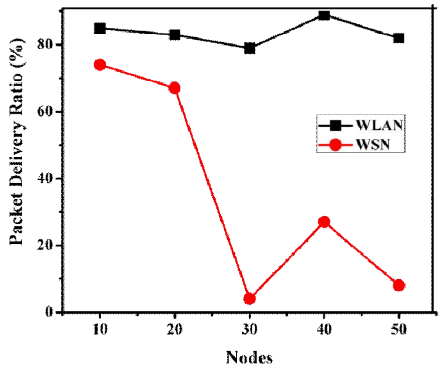

Figure 4 : Variation of Packet delivery ratio with varying node density

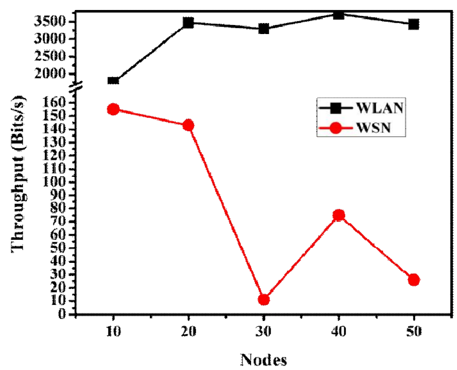

Figure 5 : Variation of Throughput with varying node density

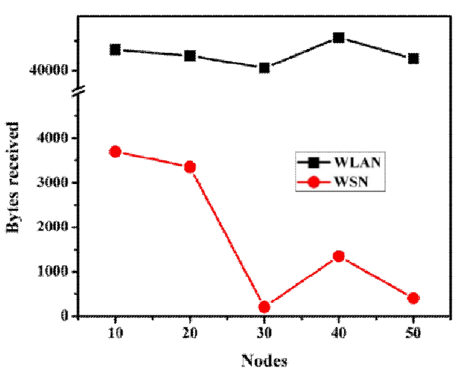

Figure 6 : Variation of Total bytes received with varying node density

Simulation Scenario-B:

The performance of AODV routing protocol is evaluated by keeping the network size (50 nodes) and pause time (30s) constant by varying the maximum speed of the nodes from 20mps to 100mps. Table 2 shows the simulation parameters used in the evaluation. Figure 7 shows the representative snapshot of Qualnet 5.0.2 simulation scenario – B for 50 nodes with mobility speed of 80mps.

Table 2. Simulation Parameters		
Area	1000m X 1000m	1000m X 1000m
Simulation Time	200 second	200 second
Nodes	50	50
Nodes placement	Grid	Grid
Path loss Model	Two Ray	Two Ray
Mobility Model	Random Way Point	Random Way Point
Pause Time	30 second	30 second
Minimum Speed	20,40,60,80, 100mps	20,40,60,80, 100mps
Traffic	CBR	CBR
Packet size	512 bytes	50 bytes
MAC layer	802.11	802.15.4
Energy Model	Mica motes	Mica motes
Battery Model	Linear Model	Linear Model

The variation of Average End-to-End Delay, Packet delivery ratio (PDR), throughput and bytes received by varying maximum speed of the nodes is shown in figures8, 9, 10 and 11 respectively.

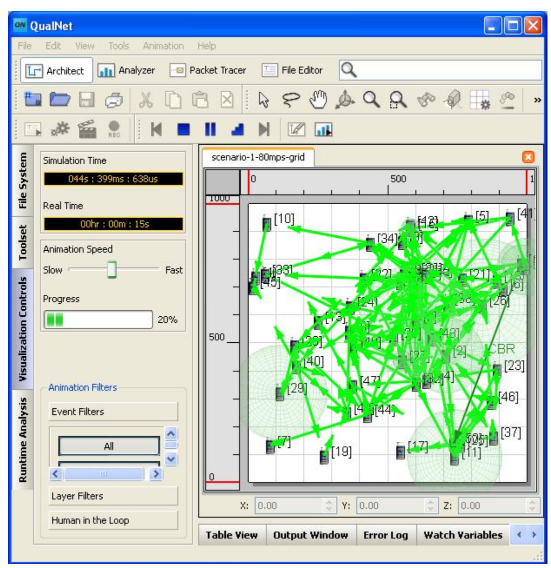

Figure 7: Snapshot of simulation scenario-B for 80mps speed

From figure 8 it is observed that, in WSN as the mobility increases overhead increases which results in increasing the average end-to-end delay as compared to WLAN.

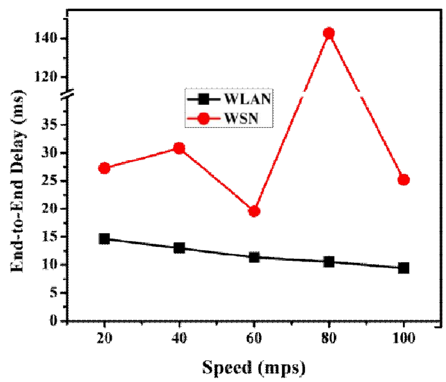

Figure 8: Variation of End-to-End delay with varying node speed

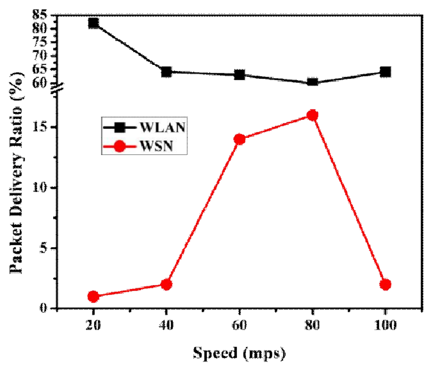

Figure 9: Variation of Packet delivery ratio with varying node speed

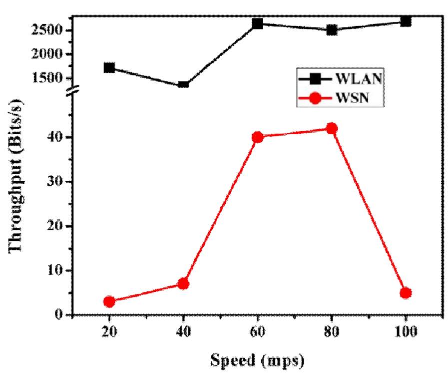

Figure 10: Variation of Throughput with varying node speed

It is also observed from the figure 9, 10 and 11 that as the PDR, Throughput and Bytes received decreased for WSN as compared to WLAN respectively.

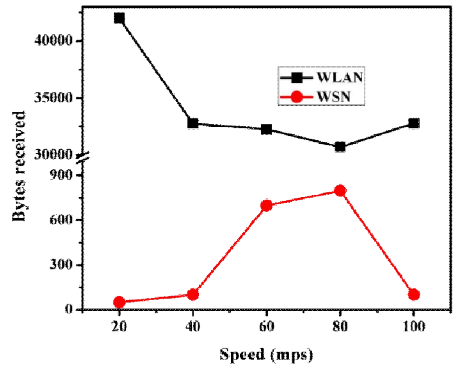

Figure 11: Variation of Total bytes received with varying node speed

5. Conclusion

The performance of AODV reactive routing protocol is studied by considering IEEE 802.11 and IEEE 802.15.4 standards for the metrics average end-to-end delay, packet delivery ratio, total bytes received and throughput by varying network size with 10 mps node mobility. Simulation has also been carried out by varying mobility for scenario with 50 nodes. The simulation results shows that AODV achieves better performance in IEEE 802.11WLANenvironment as compared to IEEE 802.15.4 WSN. This is due to the limitations in range and power for WSN. However, when the node placement is unattended then it is essential to chose WSN environment only.

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