# Productivity Analysis of Reactive Routing Protocol for IEEE 802.11e standard using QualNet Simulator

**Dharam Vir*, Dr. S.K.Agarwal**, Dr. S.A.Imam*****

*Department of Electronics Engineering, YMCA University of Science & Technology, Faridabad, India
**Department of Electronics Engineering, YMCA University of Science & Technology, Faridabad, India
***Department of Electronics & Comm. Engineering, Jamia Millia Islamia, New Delhi, India

## ABSTRACT

**The continuous improvement of sensor skill and wireless communication is encouraging wireless sensor networking. The IEEE 802.11e Medium Access Control (MAC) is upcoming standard of IEEE to support Quality of Service (QoS). The IEEE 802.11e MAC enhances the basic 802.11 MAC to provide quality-of-service support for audio and video streams. The 802.11e MAC defines a new Hybrid Coordination Function (HCF), which provides an Enhanced Distributed Channel Access (EDCA) method and an HCF Controlled Channel Access (HCCA) method. Some recent work can prove that 802.11e Hybrid Coordinate Function (HCF) can improve significantly the quality of service (QoS) in 802.11 networks. The HCF scheduling algorithm is only for Constant Bit Rate (CBR) characteristics.**

**In this paper we investigate the performance of 802.11e through computer simulations. We design a scenario and analysis the performance metrics of Ad-hoc On-demand Distance Vector (AODV) and Dynamic Source Routing (DSR) protocols for IEEE 802.11e standards. Performance metrics like throughput, average end-to-end delay, average jitter, energy consumed in transmit and received modes, which is carried out using QualNet simulator.**

**Keywords** - *AODV, DSR, Average End-to-end delay, IEEE 802.11e standard, QualNet*

## I. INTRODUCTION

In recent years, the progress of communication technology has made wireless devices smaller, less expensive and more powerful. The IEEE 802.11 as the standard for wireless local area networks (WLANs) has given reliability to the concept that WLANs may soon form a large part of multi service communication networks [1]. IEEE 802.11 based wireless local area networks have become more and more popular due to low cost and easy deployment, they can only provide best effort services and do not have quality of service supports for multimedia applications. Recently, a new standard, IEEE 802.11e, has been proposed, which introduces a so-called hybrid coordination function (HCF) containing two medium access mechanisms: contention based channel access and controlled channel access. The primary obstacle to the use of IEEE 802.11 in multi service wireless networks is a need of quality-of-service (QoS) functionality that is demanded by real-time voice and video applications. To overcome this, the IEEE 802.11 Working Group created Task Group E to design medium access control (MAC) layer QoS enhancements to the 802.11 standard [2]. The attraction of the 802.11e standard is the hybrid coordination function (HCF). HCF provides an efficient mechanism for centrally coordinated medium access and uses the enhanced distributed coordination function (EDCF) for distributed coordination of medium access. EDCF provides service differentiation amongst different traffic priorities and is backward compatible with legacy 802.11 DCF [3].

We illustrate that the 802.11e standard provides a very powerful platform for QoS supports in WLANs. The IEEE 802.11 standard adopts the 802.11e as the medium access protocol and 802.11n-based products, which utilize multiple-input-multiple-output (MIMO) transmission systems. The medium access collision avoidance of IEEE 802.11e, even with IEEE 802.11n at the physical layer, still utilizes the enhanced distributed coordination function (EDCF) mechanism. It is known that collisions cause significant performance degradation in IEEE 802.11e EDCF-based systems [3][4]. In this paper we focus on the performance of AODV and DSR reactive routing protocol using QualNet 5.0 simulator for IEEE 802.11e MAC, PHY and Energy model WLAN standards. The rest of the paper is organized as follows. The overview of IEEE 802.11e PHY/MAC and Energy Models are summarized in section II. Brief description of AODV and DSR reactive Routing Protocol discussed in section III and in section IV Implementation of related work and simulation results and conclusion in section V.

## II. OVERVIEW OF IEEE 802.11E PHY/MAC AND ENERGY MODELS

In 1997, IEEE standardized the first Wireless Standard: 802.11. This comprised both Medium Access Control (MAC) layer and Physical layer. While the IEEE 802.11e standard and all the later extensions provide extensive information regarding different aspects of the communication, in this section we briefly describe the concepts in MAC layer, Physical layer, Propagation Model and

Energy Model for an extensive behavior of the standard (MAC and PHY layers) [5].

### A. IEEE 802.11e Overviews:

IEEE 802.11e is an enhanced version of the 802.11 MAC in order to support quality of service (QoS). IEEE 802.11e supports quality of service by introducing priority mechanism. All types of data traffic are not treated equally as it is done in the original standard, instead, 802.11e supports service differentiation by assigning data traffic with different priorities based on their QoS requirements. IEEE 802.11e introduces a new coordination function, called Hybrid Coordination Function (HCF), to provide QoS support. Subsequent sections describe HCF together with the detailed description of its service differentiation mechanism [6].

MAC layer, as its primary purpose, has the functionality of providing reliable data delivery mechanism over the unreliable wireless air interface. It is the layer who manages station access to the shared wireless medium. The original standard utilizes Carrier Sense Medium Access with Collision Avoidance (CSMA/CA) as the access mechanism. Point Coordination Function (PCF):

It is another basic coordination function which is defined only in infrastructure mode, where stations are connected to an access point. Access point is the element in control of access in the network and it uses two periods to enforce its policies. There is a Contention Period, in which, DCF method is used. The second period is the Contention Free Period, in which AP basically allows stations, by sending them a special authorization, to send packets. IEEE 802.11e standard addressed the existing limitations in DCF and PCF. It particularly addressed the problem of QoS provisioning in the network by introducing a new coordination function: Hybrid Coordination Function – HCF [6][7].

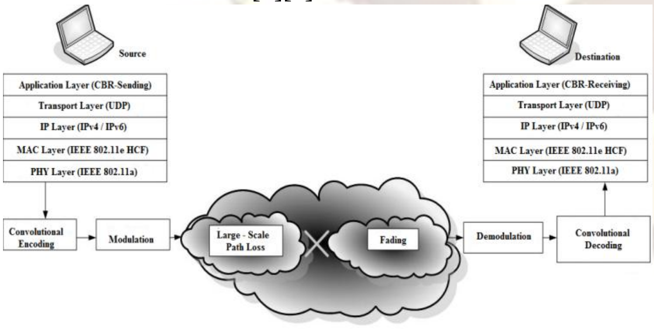


Figure1. Overall view of IEEE 802.11e Modelling.

#### 1) Enhanced DCF Channel Access (EDCA):

EDCA is an IEEE 802.11e method of channel access within the HCF. An EDCA is basically a QoS enabled DCF. This is done by introducing the notion of traffic classes, by giving priority, in channel access, to real-time data, compared to delay-tolerant data [8].

**HCCA-IEEE 802.11e:**

The EDCA is a QoS enabled PCF. It also uses EDCA during the Contention Period. Stations transmit the information about their queues status and traffic classes to the AP and, based on this information, AP coordinates access to the medium between the stations.

### B. IEEE 802.11 PHY Layer:

IEEE 802.11 Physical layer is the interface between MAC layer and the air interface. The frame exchange between Physical layer and MAC is under the control of Physical Layer Convergence Procedure (PLCP). Physical Layer is the entity in charge of actual transmission using different modulation schemes over the air interface. It also informs the MAC layer about the activity status of the medium. Currently, there are four standards defining the physical layer: IEEE 802.11a, 802.11b, 802.11g and 802.11n. Among these, IEEE 802.11n is the newest which is still under standardization. It utilizes Multiple-Input-Multiple-Output (MIMO) technology to achieve significantly higher rates. [8].

### C. Propagation Models:

In this section, we explore both concepts of Large-scale Path Loss and Fading. We introduce three models of Large-scale Path Loss which account for the large-scale attenuation of signal based on distance: Free-Space, Two-Ray and Lognormal Shadowing [6].

#### 1) Free-Space Model:

This model is used to predict the signal strength when the transmitter and the receiver have a clear, unobstructed line-of sight (LOS) path between them. It predicts that the received power decays as a function of Transmitter-Receiver distance raised to some power typically to the second power [6].

#### 2) Two-Ray Model:

This model, which is a more realistic model than the Free-Space model, addresses the case when we consider a ground reflected propagation path between transmitter and receiver, in addition to the direct LOS path. This model is especially useful for predicting the received power at large distances from the transmitter and when the transmitter is installed relatively high above the ground [6].

#### 3) Log-normal Shadowing Model:

The average loss for a given distance is expressed using a Path Loss Exponent. For taking into account the fact that surrounding environmental clutter can be very different at various locations having the same Transmitter-Receiver distance, another parameter is incorporated in the calculation of path loss.

**D. Fading Model:**

The term Fading is used to describe the rapid fluctuations of the amplitudes, phases, or multipath delays of a signal over a short period of time or distance. It is caused by interference between multiple versions of the transmitted signal which arrive at the receiver at slightly different times.

**1) Fast Rayleigh fading model:**

The fast Rayleigh fading model is a statistical model to represent the fast variation of signal amplitude at the receiver due to the motion of the transmitter/receiver pair.

**2) Rayleigh fading model:**

Rayleigh fading model is a statistical model to represent the fast variation of signal amplitude at the receiver. In wireless propagation, Rayleigh fading occurs when there is no line of sight between the transmitter and receiver.

**3) Ricean fading model:**

This model can be used for scenarios where there is line of sight communication and the line of sight signal is the dominant signal seen at the receiver [8].

## III. AODV AND DSR REACTIVE ROUTING PROTOCOL

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. 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), Ad-hoc On demand Distance Vector routing (AODV) [12] [13].

### A. AODV (Ad-hoc On demand Distance Vector routing):

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.

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 [9] [10]. Each node receiving the route request sends a route back (Forward Path) to the node as shown in the fig. 2

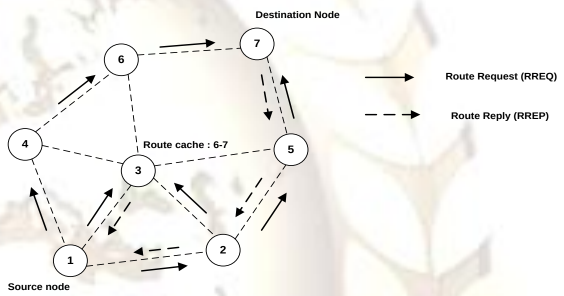


Figure2. Route discovery in AODV

### B. DSR (DYNAMIC SOURCE ROUTING):

DSR is a fairly simple algorithm based on the concept of source routing, in which a sending node must provide the sequence of all nodes through which a packet will travel. Each node maintains its own route cache essentially in a routing table. Source nodes determine routes dynamically and only when needed. There are no periodic broadcasts from routers. Fig.2 illustrates the DSR algorithm's route discovery/ route reply cycle. A source node that wants to send a packet first checks its route cache. If there is a valid entry for the destination, the node sends the packet using that route; if no valid route is available in the route cache, the source node initiates the route discovery process by sending a special route request (RREQ) packet to all neighboring nodes. The RREQ propagates through the network, collecting the addresses of all nodes visited, until it reaches the destination node or an intermediate node with a valid route to the destination node. This node in turn initiates the route reply process by sending a special route reply (RREP) packet to the originating node announcing the newly discovered route. The destination node can accomplish this using inverse routing or by initiating the route discovery process backwards. The protocol can also easily be improved to support multiple routes to the same destination. DSR's main drawback is the large bandwidth [11].

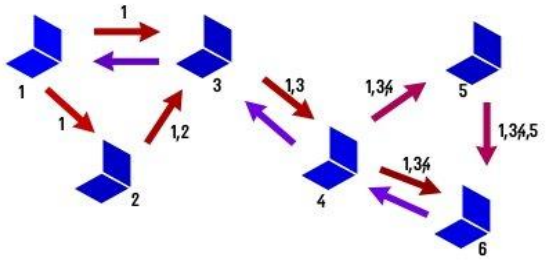

Figure3. Dynamic source routing

### C. Energy Consumption Model:

In our work we have assuming an energy supply of 5V. The value corresponds to a 2,400MHz Wave LAN implementation of IEEE 802.11e. When a node sends and receives a packet, the network interfaces of the node, decrements the available energy according to the following parameters: characteristics of network, the size of the packets and the used bandwidth. The following equations represent the energy used (in Joules) when a packet is transmitted or received; packet size is represented in bits:

$$\text{Energy tx} = (330*5*\text{Packet size})/2*10^6$$
$$\text{Energy rx} = (230*5*\text{Pocket size})/2*10^6$$

Although actual equipment consume energy not only when sending and receiving but also while listening, we assume in our model that the listen operation is energy free, since all the evaluated ad hoc routing protocols will have similar energy consumption due to the node idle time. Finally, note that when a packet is transmitted, a percentage of the consumed energy represents the Radio Frequency (RF) energy. This energy is used for the propagation model in QualNet 5.0 to determine the energy with which the neighbours' interface nodes will receive the packet, and consequently determine the successful or wrong packet reception. In our simulation we maintain this RF values in 281.8 mW, which corresponds to the RF energy required to model a radio range of 250 meters [14].

#### 1) Energy Consumption (mJoule):

The MICAZ Mote devices are in the following four states: transmitting, receiving, idle and sleep. Energy consumption is the quantity of energy consumed by mote during the above mentioned states of the device. The unit of energy consumption used in the simulations is mJoule.

## IV. SIMULATIONS AND RESULT

### A. Designing of Scenario:

The aim of these simulations is to analyze the selected routing protocols (DSR and AODV) for their efficiency in terms of energy, throughput as well as network life time. The basic methodology consists of simulating with a basic scenario and then by varying selected parameters, simulates the generated scenarios. The selected parameters are sources, pause time, nodes, area, sending rate and mobility speed etc. The traffic sources used in the simulations generated constant bit rate (CBR) data traffic. The TCP sources are not being chosen because it adapts to the load of the network. For the same data traffic and movement scenario, the time of sending the packet of a node will be different in case of TCP, hence will become difficult to compare the performance of different protocols. The energy model taken is as used by. The values used correspond to 2,400 MHZ Wave LAN implementation of IEEE 802.11e. The radio frequency value is set as 0.2818 W for transmission range of 250 m [15].

#### 1) Table 1 Simulation Parameters:

| | |
|---|---|
| Channel type | Wireless channel |
| Radio-propagation model | Two Ray Ground |
| Antenna type | Omni Antenna |
| Network interface type | Phy/ Wireless Phy |
| MAC type | IEEE 802.11e |
| Topological area | 1500 x 1500 sq. m |
| Tx Power | 1.65 W |
| Rx Power | 1.15 W |
| Idle Power | 1.0 W |
| Initial energy of a Node | 1000.0 Joules |
| Routing protocols | DSR/ AODV |
| Number of mobile nodes | 40 |
| Maximum speed | 15 m/s |
| Rate | 4 Packet/ s |
| Pause time | 5,10,15,20, 25 sec. |
| Simulation time | 500 sec. |
| Energy Model | MICAZ |

We have implemented the above table 1 parameters and compile the results to the EDCF. All the simulations have been done using the QualNet 5.0 network simulator designed by Scalable Networks Inc. For carrying out the simulation we have taken 40 nodes in a 1500mX1500m area. The random distribution model has been followed. The nodes are fully independent and are operating in a distributed environment [15].

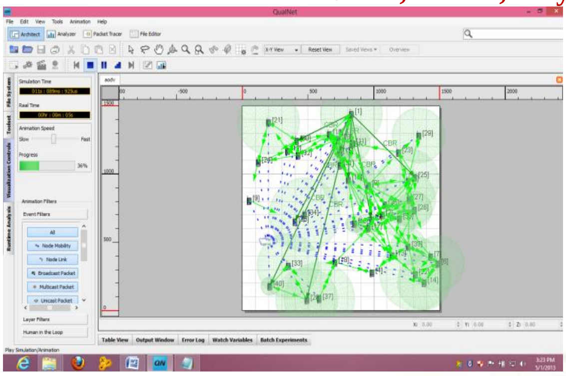

Figure4. Shows the outcome of running scenario of IEEE 802.11e AODV routing protocol CBR.

### B. Performance metrics:

Design and performance analysis of routing protocols used for mobile ad hoc network (MANET) is currently an active area of research. To judge the merit of a routing protocol, one needs metrics both-qualitative and quantitative- with which to measure its suitability and performance metrics. Specifically, this paper evaluates the performance comparison of AODV and DSDV routing protocols with IEEE 802.11e MAC. The following performance metrics are used to compare the performance of these routing protocols in the simulation:

#### 1) Average Jitter:

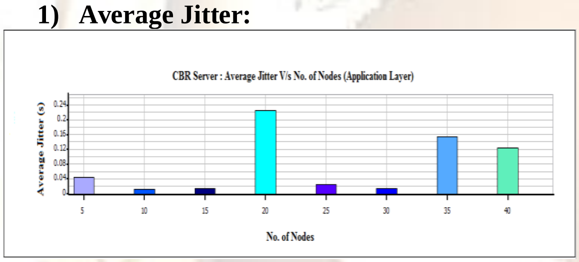


Figure5. Shows the Average jitter in application layer of IEEE 802.11e AODV routing protocol CBR.

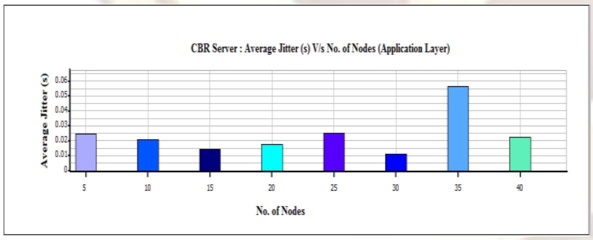


Figure6. Shows the Average jitter in application layer of IEEE 802.11e DSR routing protocol CBR.

In the above graph the effect of the average jitter value is higher for DSR routing protocol as compare to AODV in effect of EDFC. There is a consistent improvement in the average jitter value for any no. of packets sent.

#### 2) Average End-To-End Delay:

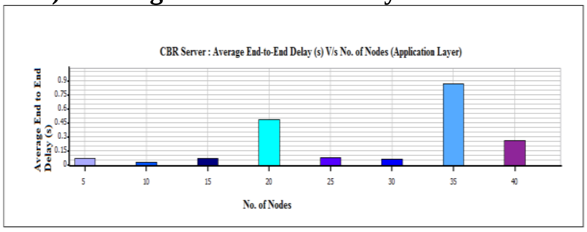


Figure 7 Shows the Average End to End Delay (s) in application layer of IEEE 802.11e AODV routing protocol CBR

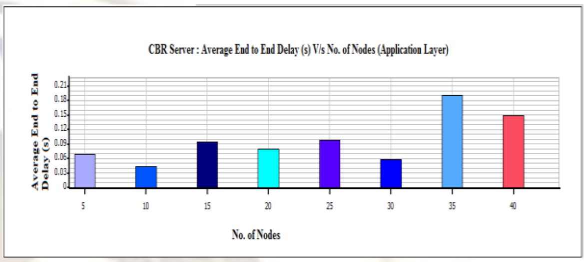


Figure 8 Shows the Average End to End Delay (s) in application layer of IEEE 802.11e DSR routing protocol CBR.

Average End-to-End delay (seconds) is the average time it takes a data packet to reach the destination. This metric is calculated by subtracting time at which first packet was transmitted by source from time at which first data packet arrived to destination. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, propagation and transfer times. This metric is significant in understanding the delay introduced by path discovery. The above Fig. shows the variation comparisons of average end to end delay between AODV and DSR routing protocols.

#### 3) Throughput:

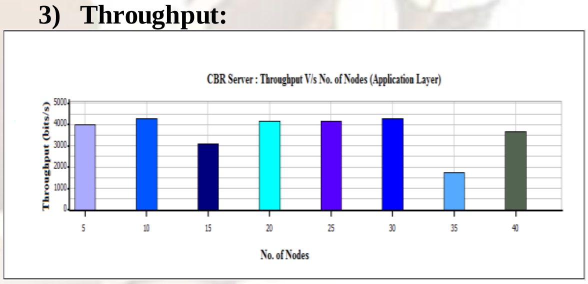


Figure. 9 Shows the Throughput (s) in application layer of IEEE 802.11e AODV routing protocol CBR.

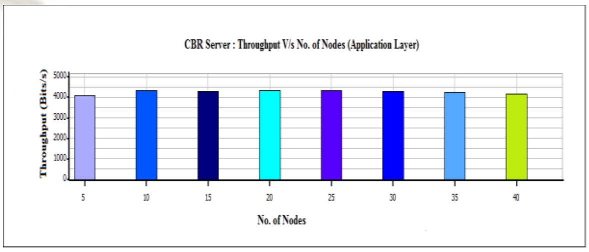


Figure 10 Shows the Throughput (s) in application layer of IEEE 802.11e AODV routing protocol CBR.

The throughput of the protocols can be defined as percentage of the packets received by the destination among the packets sent by the source. It is the amount of data per time unit that is delivered from one node to another via a communication link. The throughput is measured in bits per second (bit/s or bps).

### 4) Energy Consumed in Transmit Mode:

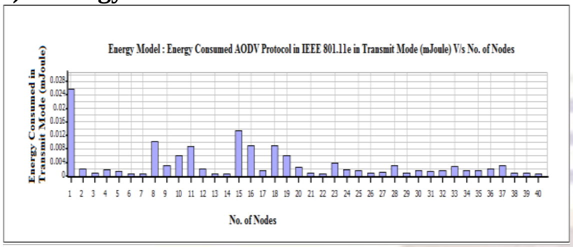


Figure 11 Energy Consumed (in mjoules) in Transmit mode with variation in nodes in Physical layer taking AODV routing protocol CBR.

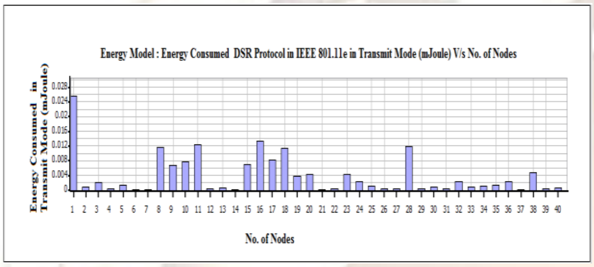


Figure 12 Energy Consumed (in mjoules) in Transmit mode with variation in nodes in Physical layer taking DSR routing protocol CBR.

### 5) Energy Consumed in Receive Mode:

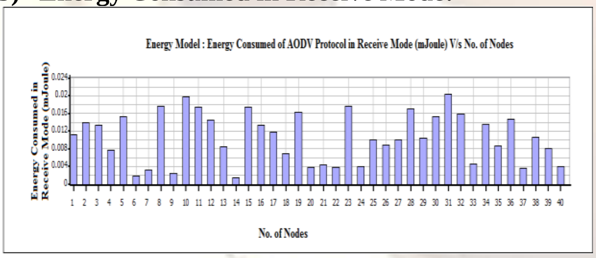


Figure 13 Energy Consumed (in mjoules) in receive mode with variation in nodes in Physical layer taking AODV routing protocol.

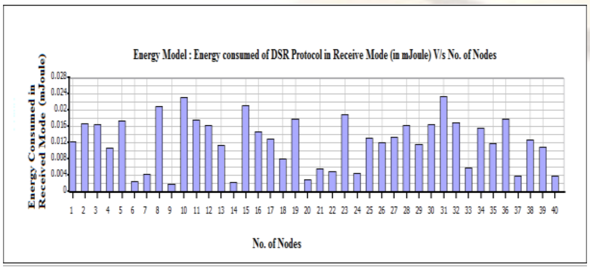


Figure 14 Energy Consumed (in mjoules) in receive mode with variation in nodes in Physical layer taking DSR routing protocol.

The energy consumption between source to destination in receive mode is higher when the collision rate increases between nodes. The efficiency also decreased at high traffic conditions collision rate.

### 6) Energy Consumed in Ideal Mode:

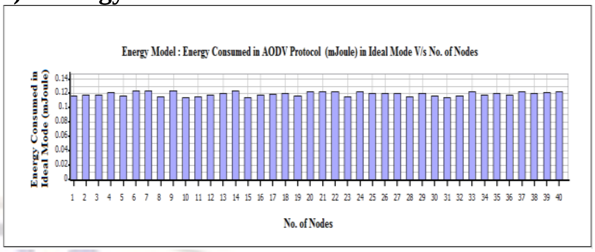


Figure 15 Energy Consumed (in mjoules) in ideal mode with variation in nodes in Physical layer taking AODV routing protocol.

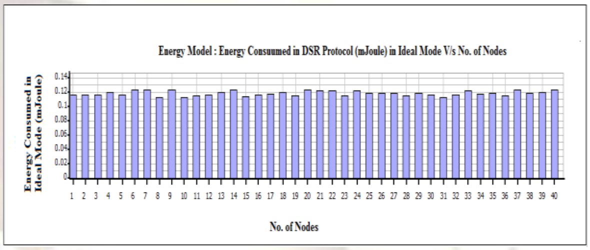


Figure 16 Energy Consumed (in mjoules) in ideal mode with variation in nodes in Physical layer taking DSR routing protocol.

The performance of 802.11e EDCF in ideal mode of energy consumption which supports the use of both basic and RTS/CTS access mechanisms. The collision contention period between nodes is very less because of the AODV routing protocol consumes less energy as compare to DSR in ideal mode.

## V. CONCLUSION

In this paper, we analysis the productivity based performance metric analysis of IEEE 802.11e which is contention-based channel access scheme for QoS support, called the EDCF, of the emerging 802.11e MAC. Based on the simulation, we analysis the productivity of inheritance the 802.11e EDCF to show that the EDCF can provide differentiated channel access among different energy priority traffic. We also evaluated the performance metric such as average Jitter, average throughput, End to End delay, Energy consumed in transmit, receive and ideal mode is shown above.

## REFERENCES

[1] Mayank Mishra and Anirudha Sahoo. An 802.11 based MAC Protocol for Providing QoS to Real Time Applications. *IEEE 10th International Conference on Information Technology*, 6:615-619,2007

[2] Jamal N. AL-Karaki, Ahmed E.Kamal, "Routing techniques in Wireless Sensor

networks: A Survey" IEEE Wireless Communication, December 2004.

[3] Lamia Romdhani, Qiang Ni, and Thierry Turletti.Adaptive EDCF: enhanced service differentiation for IEEE 802.11 wireless ad-hoc networks. *Wireless Communications and Networking, 2003.* WCNC 2003. 2003 IEEE, 2(1):1373-1378, March 2003.

[4] A. Chen,D.Lee,G. Chandrasekaran,and P. Sinha, "HIMAC: High Throughput MAC Layer Multicasting in Wireless Networks," *Proc. IEEE Int'l Conf. Mobile Adhoc and Sensor System (MASS'06)*,2006.

[5] Bilal Rauf, M Faisal Amjad, Kabeer Ahmed, Performance Evaluation of IEEE 802.11 DCF in comparison with IEEE 802.11e EDCA. "*Natinal University of Sciences and Technology, Pakistan*"

[6] Stefan Mangold, Sunghyun Choi, Peter May, Ole Klein, Guido Hiertz, and Lothar Stibor, "IEEE 802.11e Wireless LAN for Quality of Service," *in Proc. European Wireless '02, Florence, Italy, February 2002*.

[7] Heegard, C. and Coffey, J. and Gummadi, S. and Murphy, P. A. and Provencio, R. and Rossin, E. J. and Schrum, S. and Shoemake, M. B., High- Performance Wireless Ethernet, *IEEE Comm. Magazine , vol. 39, no. 11*, Nov. 2001.

[8] J.Q. Bao and L. Tong, A performance comparison between ad hoc and centrally controlled CDMA wireless LANs, *IEEE Transactions on Wireless Communications, Vol.1 (Oct 2002)* pp. 829-841.

[9] Fasee Ullah, Muhammad Amin and Hamid ul Ghaffar " Simualting AODV and DSDV For Adynamic Wireless Sensor Networks", IJCSNS International Journal of Computer Science and Network Security, VOL.10 No.7,July 2010.

[10] Charles E. Perkins, Elizabeth M. Belding-Royer, S. Das, "AdHoc on Demand Distance Vector (AODV) routing, Mobile Ad Hoc Networking Working Group" July 2003, Internet-Draft.

[11] D. Johnson, Y. Hu, and D. Maltz. The Dynamic Source Routing Protocol (DSR) for Mobile Ad Hoc Networks for IPv4. RFC 4728 (Experimental), Feb. 2007.

[12] R. Castanneda, J.yan and S. R. das, "Simulation based Performance Evaluation of Routing Protocols for Mobile Ad Hoc Networks," Department Of Compute Science, University Of Taxas, San Antonia, U.S.A, 2000.

[13] S. Azad, A. Rahman and F. Anwar, "A Performance Comparison of Proactive and Reactive Routing Protocols of Mobile Ad-hoc Network (MANET)," Journal of Engineering and Applied Sciences 2(5), 2007, pp 891-896.

[14] Marco Zimmerling "An Energy-Efficient Routing Protocol for Linear Wireless Sensor Networks",IEEE International conference,2007,pg no:264-273,April 2007.

[15] Scalable Network Technologies, QualNet for Network design and Research, Online(2003) http://www.scalable-networks.com

[16] Qualnet, http://www.scalablenetworks.com

**AUTHORS:**

DharamVir the M.Tech Degree form MDU Rothak (Haryana) and B.E Degree in Electronics and Communication Engg.from Jamia Millia Islamia, Central University, New Delhi 2008, 2004 respectively. He started his carrier as R&D Engineer in the field of computers and networking, since 1992, he is the part of YMCA University of Science & Technology as Head of Section (Electronics & Inst. Control) in the Department of Electronics Engineering. He is pursuing Ph.D in the field of Power aware routing in Mobile Ad hoc Networks.

Dr. S.K. Agarwal the M.Tech Degree from Delhi Technical University.New Delhi and PhD degree in Electronics Engg. From Jamia Millia Islamia, Central University, New Delhi in 1998 and 2008, respectively,since 1990. He has been part of YMCA University of Science & Technology Faridabad (Haryana), as Dean and Chairman in Department of Electronics Engineering.

Dr. Sayed Akthar Imam the B.E Engg. degree (Electrical Engg) from Jamia Millia Islamia, M. Tech (Instrumentation & Control System) from AMU, Aligarh and PhD degree in Electronics & Comm. Engg from Jamia Millia Islamia (a Central University), New Delhi, in 1990, 1998, and 2008, respectively. Since 1990, he has been part of Jamia Millia Islamia University, where he is Assistant Professor in the Department of Electronics and Communication Engineering.