ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 10, October 2015

Maximum Bandwidth and Self-Adaptable Back-off Mechanism Based Reliable Energy Efficient Routing Protocol (REERP) for Fully Connected Wireless Ad Hoc Networks

M. Thenmozhi[1]

Assistant Professor, Department of Information Technology, Faculty of Engineering, Avinashilingam Institute for Home Science and Higher Education for Women Coimbatore, Tamil Nadu, India[1]

Abstract: The paper aims to propose a maximum bandwidth and self-adaptable back-off mechanism based reliable energy efficient routing protocol (REERP) for fully connected wireless ad hoc networks. The proposed protocol makes use of the mechanism to uncover maximum MAC throughput that a wireless link can achieve regardless of interfering traffic along with a back-off mechanism is applied with binary exponential back-off that has the capability to progress the reliability of the protocol. The simulations are accepted with varying traffic loads along with scalable network scenario. Performance metrics such as aggregate throughput, energy consumption and average packet delay are taken into account for comparing the proposed REERP. NS2 simulation proved that the proposed protocol performs results are better in terms of delay, energy consumption and throughput.

Keywords: Wireless ad hoc network, back-off mechanism, bandwidth, x routing, fully connected.

1. INTRODUCTION

In the past decade, the number of mobile devices and also the demand for multimedia system applications which needs high rate and low packet transmission delay is increasing considerably. Wireless local area networks (WLANs), have a shorter transmission range when compared with cellular networks, which provides a lot of economical and energy effective transmission for hot-spot mobile transmissions. The mobile devices in nearby space are connected by Wi-Fi and provide a link to make use of the internet through access points (APs). The set of mobile devices and APs are a kind of wireless ad hoc network. The effective mobile communication needs establishing high output, low latency and energy efficiency wireless ad hoc networks. The radio interface is the key cause of energy consumption of mobile devices like laptops and smart phones that will swiftly duct the device's restricted battery capability. The Wi-Fi radio for example consumes more than 70% of total energy in a Smartphone once the screen is turned off.

IEEE 802.11 distributed coordination function (DCF) [11] has been regarded as the basic medium access control (MAC) protocol for wireless ad hoc networks. It also provides a combination of the carrier sense multiple accesses with collision avoidance (CSMA/CA) and the binary exponential back off (BEB) to resolve channel contentions. In the meantime it defines two channel access mechanisms, i.e., the basic access mechanism and the request-to-send/clear-to-send (RTS/CTS) handshaking mechanism. Due to the conservative nature of CSMA/CA, the DCF protocol exhibits inadequate performance in terms of overall throughput in multi-hop network environments [12].

The rest of this paper is organized as follows: Section 2 reviews related works carried out in the corresponding research problem. The proposed work of MAC protocol is presented in Section 3. Then the simulation settings and metrics to calculate the performance of the proposed protocol is discussed in section 4. The NS2 simulation results are shown in Section 5 to demonstrate performance of the proposed protocols in comparison with existing MAC protocols. Conclusion of the paper is shown in Section 6.

2. LITERATURE REVIEW

In [2] the authors stated that it is possible that nodes at different locations or the same node in different time will generate different flows, so a MAC protocol for wireless sensor network must be able to adapt to the unbalanced network traffic. In [3] the authors have proposed LCT-MAC protocol with collision avoidance and self-adaptive traffic. Based on CSMA and TDMA-based traffic self-adaptive hybrid MAC protocol, the mechanism of broadcast was introduced in the MAC protocol, which can reduce the cross-talks, idle interception and data collision to the minimum [4]. In [5] an RA-ZMAC protocol is proposed by adding energy control and traffic self-adaptive mechanism to Z-MAC protocol, which can change the contention window and back-off time according to residual energy of nodes and traffic change. The authors of [6] proposed a self-adaptive medium access control protocol with dynamic data slot allocation to improve the reliability of data transmission by estimating the data slot length of dynamic adjustment nodes of link quality. In [7], the authors proposed a new MAC protocol

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 10, October 2015

called self-adaptive duty cycle MAC (SEA-MAC) by introducing a self-adaptive scheduling (AS) mechanism and a self-adaptive duty cycle mechanism. By improving the DRAND algorithm, an energy-balanced MAC protocol based on Z-MAC is proposed in [8]. Traffic self-adaptive hybrid MAC protocol (Z-MAC) [10] is a mixed MAC protocol which integrates the merits of CSMA and TDMA. It realizes self-adaptive mixture of CSMA and TDMA modes, improves channel utilization rate, reduces the delay and decreases collisions and cross-talks by predicting the mechanism's follow-up of network load and collision changes, utilizing DRAND algorithm in data slot allocation, applying CSMA to solve channel contention among nodes under low operation, and applying TDMA to solve channel contention among nodes under high operation [9].

3. PROPOSED WORK

The maximum medium access bandwidth denoted by B_{max} is the maximum MAC throughput a link can achieve regardless of interfering traffic. A simultaneous transmission cycle has been setup in order to be the time taken for a successful packet transmission on a wireless link, and B_{max} is derived on the basis of the simultaneous medium access control specification. Considering Nodes S and R are the sender and recipient of the link (S, R), respectively. The following notations are adapted:

- t_{DIFS} is the length of a distributed interframe space;
- t_{SIFS} is the length of a short interframe space;
- t_B is the average duration of the back off procedure;
- t_{CG} is the length of a control gap;
- t is the length of a simultaneous transmission cycle;
- L_{Frame} is the size of a frame, which may be RTS, CTS, DATA, or ACK;
- t_{Frame} is the transmission duration of a frame, which may be RTS, CTS, DATA, or ACK.

A simultaneous transmission cycle is created by using three different time intervals. Interval 1 (t_{I1}) is t_{DIFS}, the back off time and the duration for the control packet exchange. Interval 2 (t_{I2}) refers to t_{SIFS} and t_{CG}, during which other transceiver pairs can reserve the channel by sending request – to – send / clear – to – send (RTS/CTS) handshaking mechanism and bring into line their data or acknowledgement (DATA/ACK) transmission phases with that of link sender, receiver (S, R). The Length of the control gap is decided by the transmission rate of the node. After the three intervals of simultaneous transmission cycle the wireless link acquires the maximum MAC throughput of B_{max}. Hence, B_{max} can be derived as

$$B_{max} = \frac{L_{Data}}{t} \quad (1)$$

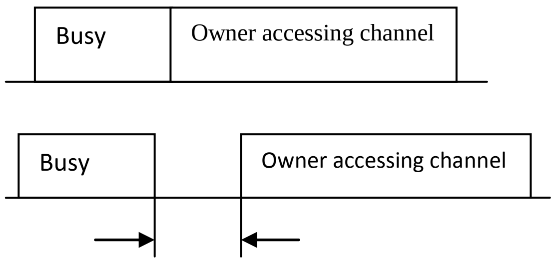
The proposed reliable energy efficient routing protocol (REERP) make use of CSMA/CA as the basic access mode, and the back-off mechanism applies binary exponential back-off algorithm (BEB algorithm) [1]. The basic thought of this algorithm is a random back-off time interval being used by accessed channel nodes to realize back-off before data transmission, and the value range of the random back-off time interval is from 0 to contention window CW (CW_{min}<CW<CW_{max}). During the data transmission process the link with the maximum bandwidth is chosen using (1). During the transmission fails, back-off window CW will be get doubled. During the transmission is successful the back-off window will be set as the minimum CW_{min}. When the node transmits data packet for the first time, CW is also set as the minimum CW window is CW_{min}, that is:

$$\begin{cases} CW(s) = Min(2*CW, CW_{max}), \text{failed to send} \\ CW(s) = CW_{min}, \text{send success} \end{cases} \quad (2)$$

The application of back-off window is to provide an equal channel access mechanism in which the size of window will affect the quality of communication, especially in the fully connected wireless ad hoc network that consists of wireless nodes. If the selection of contention window is extensive, data will generate serious delay in each node. But if the selection is narrow, the probability of data collision will increase. Considering the shortcomings of BEB algorithm [1], a modified equal back-off strategy is proposed in this research work, namely multiplicative increase and decrease self-adaptable contention window back-off mechanism. The detailed description of this back-off mechanism is as follow:

$$\begin{cases} CW(s) = Min(a*(CW+1), CW_{max})(a>1), \text{failed to send} \\ CW(s) = Max(b*CW+1), CW_{min})(0<b<1), \text{send success} \end{cases} \quad (3)$$

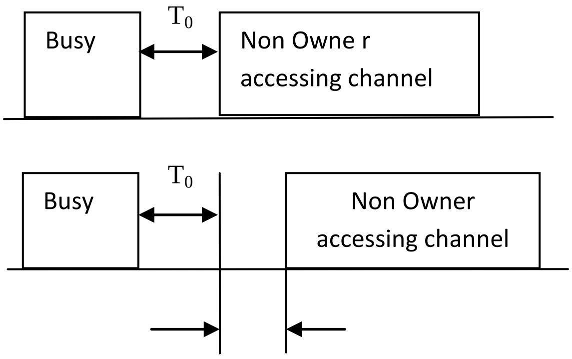
Where, a and b are the modifiable parameters. In the proposed work REERP, a modified back-off mechanism is employed. During node successfully transmits data, the value of back-off window will decrease linearly (0<b<1). If the value of b is reasonable, the back-off window will not significantly decrease, which can in turn guarantee that all wireless nodes have basically equal chances of accessing the channel in subsequent contention and the relative equality. Then again, during failed transmission or data collision, the back-off window in the algorithm will increase multiplicatively a times (a>1), which means the scope of the contention window expands a times, which can reduce the probability of another channel collision. By selecting different a and b values, it is possible that when the value of a and b is 2 and 0.5 respectively, the performance index of the wireless ad hoc network significantly increased. The back-off mechanism of self-adaptable adjustment contention window is shown in Figure 1. Wherein, T_0 is the initial back-off time.



(a) Contention window back-off mechanism of owner of data slot

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 10, October 2015



Random back-off (Contention window)

(b) Contention window back-off mechanism of no-owner of data slot

Fig1. Back-off mechanism of self-adaptable adjustment contention window

3.1. Conventions of Data Transmission in REERP

Once when the broadcast mechanism and self-adaptable back-off mechanism are incorporated, data transmission conventions of REERP protocol are as follows: when the wireless node has data to be transmitted, it initially checks whether the owner of the present data slot, and then adopts various modes of execution. The detailed description is revealed in Figure 2 as follow:

1. When the corresponding wireless node is the owner of the current data slot, its size at the initial fixed window is T_0, in which random back-off needs to be executed within the initial time interval. When the random back-off time comes to an end, wireless node starts listening to the wireless channel. When the wireless channel is idle or unoccupied, it broadcasts the MAC control frame which will begin to notify the targeted receiving node in prior and then data transmission will be started. When the data transmission is successful, self-adaptable back-off mechanism will be executed, and then the next data transmission is impending. If the wireless channel is accessed, the wireless node will wait and transmit in delay, till when the channel becomes unoccupied again, and the above said process will be repeated.

2. When the wireless node is not the owner of the current data slot, the neighboring

3. Wireless nodes within the two hops fail to transmit t_{ECN} data, and the channel is unoccupied, then the wireless node manages and accesses data slot according to the priority, the one who successfully accesses data slot will start random back-off within the initial contention time window T_0. During when the random back-off ends, the wireless node performs unoccupied wireless channel will be checked for its status. Once the wireless channel is in unoccupied state or idle state, the MAC Control frame is broadcasted and initiated to notify the targeted receiving node in prior, and then data transmission starts. During when the data transmission task is carried out successfully, self-adaptable back-off mechanism is performed. If the wireless channel is still accessed, the wireless node will continue to stay await, till the channel becomes unoccupied again.

The above mentioned process stated above will be repeated.

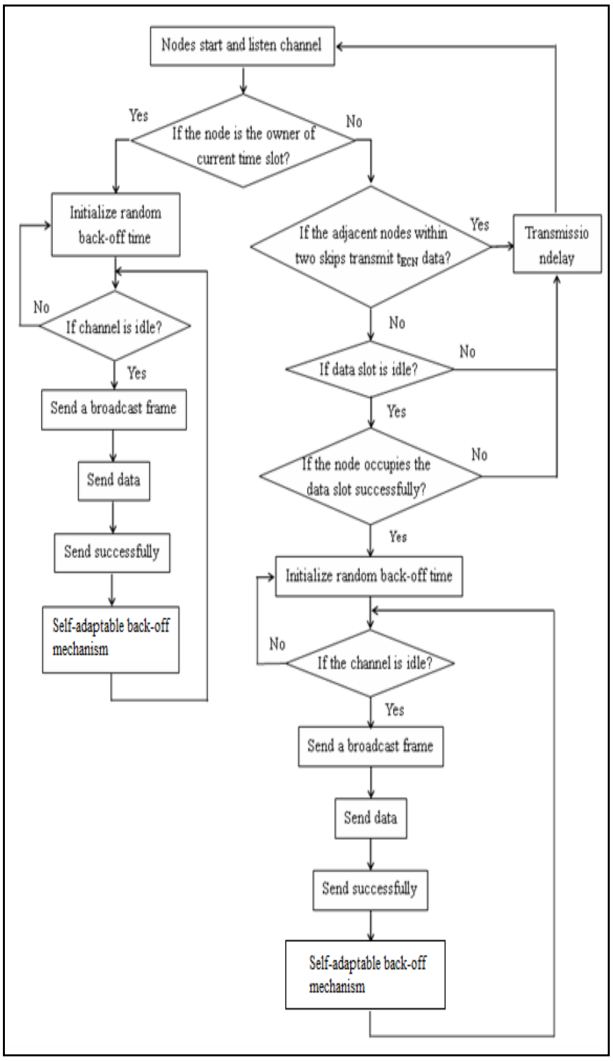


Fig2. Conventions of Data Transmission of REERP

4. When the node is not the owner of the current data slot, the nearby neighboring nodes within the two hops will transmit t_{ECN} data, then the node delays transmission, till idle data slot comes up again or the node becomes the owner of data slot, then the above mentioned 1 or 2 steps has to be repeated.

4. SIMULATION SETTINGS AND PERFORMANCE METRICS

4.1. Simulation Settings

The total number of wireless sensor nodes is set up to 100 meters of transmission range in the terrain space of 1500 meters X 1500 meters. The constant bit rate (CBR) method is followed with 256 kilo bits per second. The initial energy of each sensor node is set up to 2 joules. Simulation has been carried out using NS2 for 100 seconds based on pause time with constrained transmission range of 100 meters. The simulation settings are depicted in Table 1.

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 10, October 2015

Table 1 Simulation Settings

Terrain Size	1500 X 1500 meters
Pause time	20, 40, 60, 80 and 100 seconds
Bit Rate	256 Kbps, Constant Bit Rate
Number of Nodes	200
Initial Energy	2.0 joules
Transmission Range	100 meters

4.2. Performance Metrics

- Aggregate throughput, defined as the total number of transmitted packets per second in the network;
- Energy consumption, is the average energy consumption per packet, and is calculated as the ratio of total energy consumption to the total number of transmitted packets in the network;
- Average packet delay, is the packet delay averaged over all the data packets transmitted in the network with packet delay being the duration from the instant that a packet is ready for transmission to the instant that the packet is successfully received at the receiver.

5. RESULTS AND DISCUSSIONS

The following Table 2 depicts the simulation results of the proposed REERP when compared to the existing protocol [13].

Table.2 Aggregate Throughput

Number of Nodes→ / Network Load in kbps	Existing [13]			REERP		
	10	20	50	10	20	50
200	200	190	188	208	194	189
400	400	396	385	407	397	386
600	600	597	591	605	598	593
800	800	778	773	802	779	775
1000	800	785	782	803	788	784
1200	800	792	780	805	795	781
1400	800	795	792	807	797	793

Table.3 Energy Consumption

Number of Nodes→ / Network Load in kbps	Existing [13]			REERP		
	50	20	10	50	20	10
200	0.016	0.015	0.012	0.014	0.013	0.011
400	0.014	0.014	0.014	0.013	0.012	0.011
600	0.014	0.014	0.014	0.012	0.011	0.010
800	0.014	0.014	0.014	0.012	0.011	0.010
1000	0.014	0.014	0.014	0.012	0.010	0.009
1200	0.014	0.014	0.014	0.012	0.010	0.009
1400	0.014	0.014	0.014	0.012	0.010	0.009

The Fig.3, Fig.4 and Fig.5 illustrate the performance analysis of aggregate throughput with 10, 20 and 50 numbers of wireless nodes respectively. It is evident that the aggregate throughput has been slightly increased when compared to the existing energy efficient MAC protocol [13].

This happens due to the deployment of bandwidth in REERP. Since all the wireless nodes are having almost same bandwidth the throughput has been increased a little bit.

Table4. Average Packet Delay

Number of Nodes→ / Network Load in kbps	Existing [13]			REERP		
	50	20	10	50	20	10
200	0.09	0.07	0.06	0.08	0.05	0.04
400	0.09	0.07	0.06	0.08	0.03	0.03
600	0.09	0.07	0.06	0.08	0.02	0.02
800	0.05	0.03	0.02	0.04	0.01	0.01
1000	0.07	0.05	0.04	0.06	0.03	0.03
1200	0.08	0.07	0.06	0.03	0.05	0.04
1400	0.9	0.08	0.07	0.5	0.06	0.03

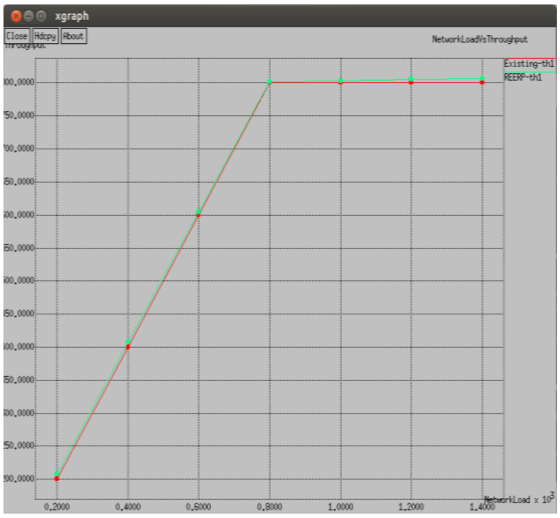


Fig.3 Comparison of Network Load Vs Throughput with 10 Numbers of Nodes

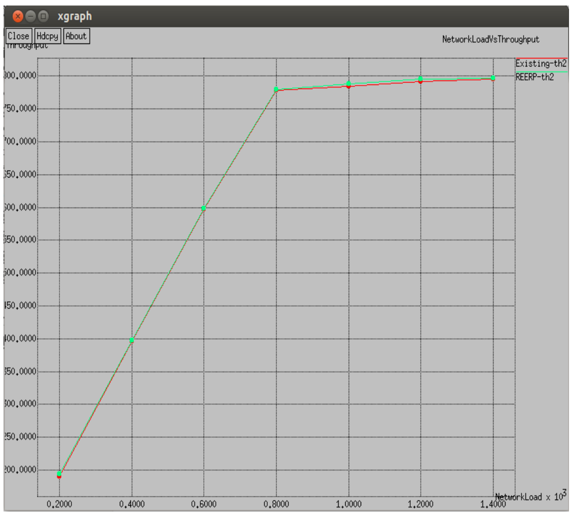


Fig.4 Comparison of Network Load Vs Throughput with 20 Numbers of Nodes

The Fig.6, Fig.7 and Fig.8 illustrate the performance analysis of energy consumption with numbers of 50, 20 and 10 wireless nodes respectively.

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 10, October 2015

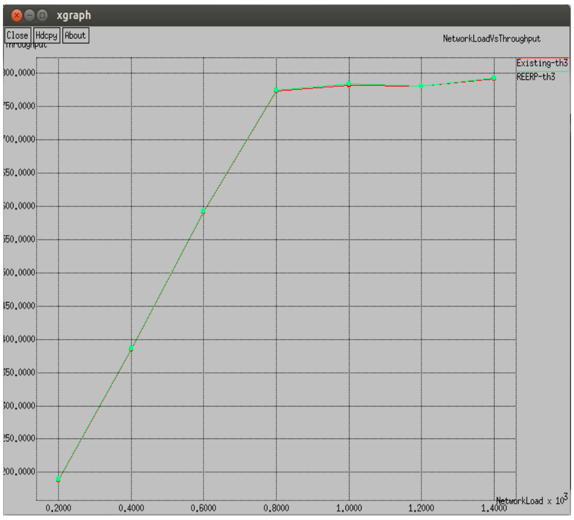


Fig.5 Comparison of Network Load Vs Throughput with 50 Numbers of Nodes

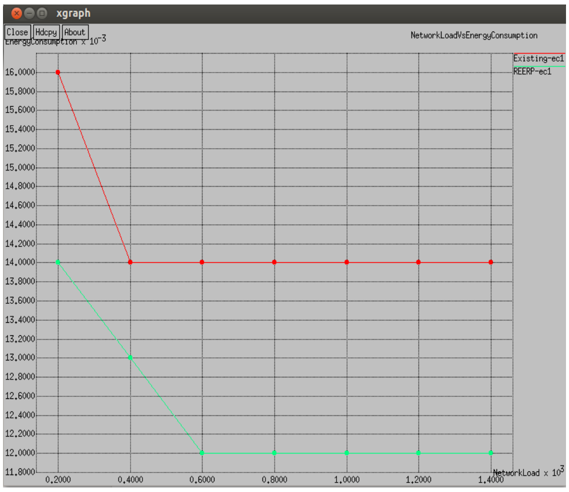


Fig.6 Comparison of Network Load Vs Energy Consumption with 50 Numbers of Nodes

It is evident that the energy consumption has been significantly decreased when compared to the existing energy efficient MAC protocol [13].

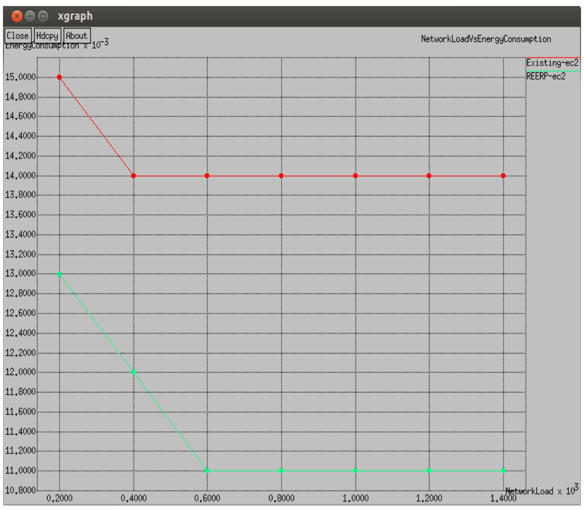


Fig.7 Comparison of Network Load Vs Energy Consumption with 20 Numbers of Nodes

With due course of the multiplicative increase and decrease self-adaptable contention window back-off mechanism the energy consumption has been decreased significantly.

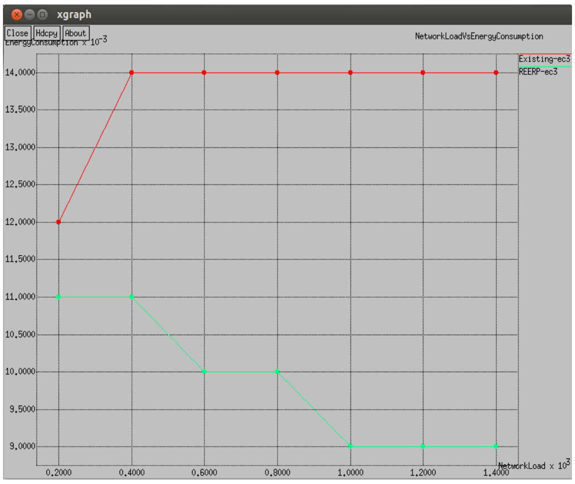


Fig.8 Comparison of Network Load Vs Energy Consumption with 10 Numbers of Nodes

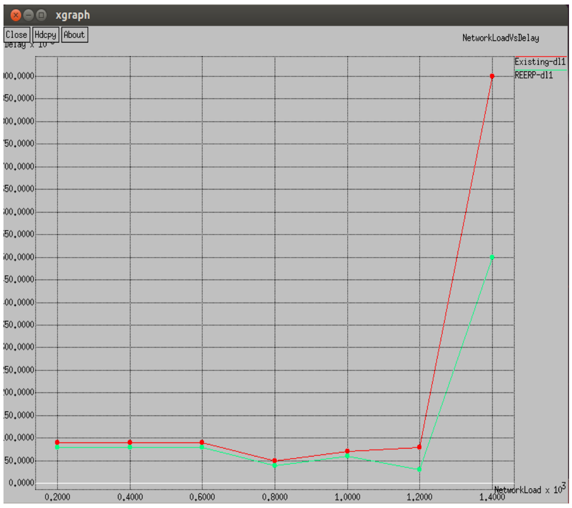


Fig.9 Comparison of Network Load Vs Delay with 50 Numbers of Nodes

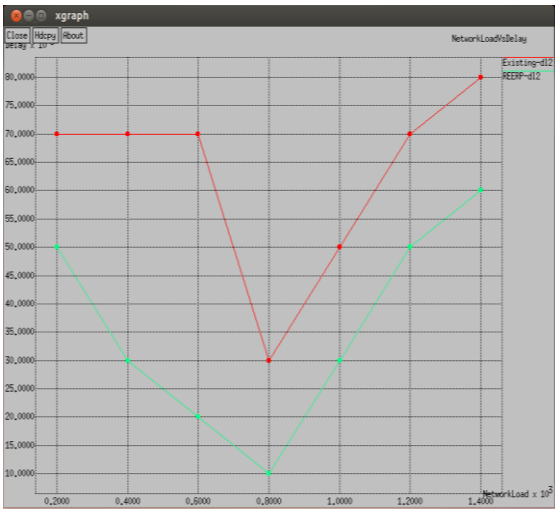


Fig.10 Comparison of Network Load Vs Delay with 20 Numbers of Nodes

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 10, October 2015

The Fig.9, Fig.10 and Fig.11 portray the performance analysis of delay latency time with 50, 20 and 10 numbers of wireless nodes respectively. It is noteworthy that the delay latency time has been considerably reduced when compared to the existing energy efficient MAC protocol [13]. As the scope of the contention window expands it reduce the probability of channel collision that results in the delay latency time reduction.

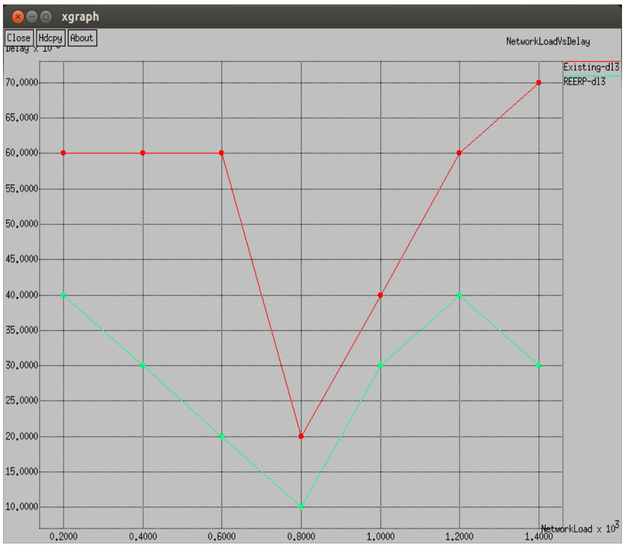


Fig.11 Comparison of Network Load Vs Delay with 10 Numbers of Nodes

6. CONCLUSIONS

This paper proposed maximum bandwidth and self-adaptable back-off mechanism based reliable energy efficient routing protocol (REERP) for fully connected wireless ad hoc networks. REERP contains a mechanism to find maximum MAC throughput that a wireless link can achieve regardless of interfering traffic. Also a back-off mechanism is applied with binary exponential back-off algorithm which has the ability to improve the reliability of the protocol. The simulations are carried out with varying traffic loads along with scalable network scenario. Performance metrics such as aggregate throughput, energy consumption and average packet delay are taken into account for comparing the proposed REERP. From the simulation results it is proved that the proposed protocol outperforms in terms of delay, energy consumption and throughput.

REFERENCES

[1] Mu Y., Liu R., and Wang Q., "Based on node residual energy and flow adaptive hybrid MAC protocol," Microelectronics, vol. 29, no. 6, pp. 123-129, 2012.
[2] Liao Z., Zhang L., and Yan H., "Adaptive MAC protocol based on the dynamic duty period traffic," Computer Engineering, vol. 37, no. 6, pp. 85-87, 2011.
[3] Hu Q., Tian Q., and Tang Z., "RP-MAC: A passive MAC protocol with frame reordering for wireless sensor networks," International Journal of Wireless Information Networks, no.20, pp.74–80, 2013.
[4] Wang L., "E-ZMAC: An energy-balanced MAC protocol for wireless sensor networks based on Z-MAC," in Proceedings of 2011 3rd IEEE International Conference on Information Management and Engineering, Zhengzhou, pp. 352-356, 2011.
[5] Zhang L., and Liao Z., "Broadcast mechanism based on traffic adaptive hybrid MAC protocol," Journal of Chinese Computer System, vol. 33, no. 4, pp. 843-846, 2012.
[6] Zhao Y., Miao C., and Ma M., "An energy-efficient self-adaptive duty cycle MAC protocol for traffic-dynamic wireless sensor networks," Wireless Personal Communications, no.68, pp. 1287-1315, 2013.
[7] Pantazi A., and Antonakopoulos T. "Reprint equilibrium point analysis of the binary exponential back off algorithm," Computer Communications, vol.24, no.8, pp. 1759-1768, 2001.
[8] Xu L., Fu J., and Su W., "DSA-based adaptive MAC protocol for wireless sensor networks research," Transducer and Microsystems Technologies, vol. 32, no. 3, pp. 11-14, 2013.
[9] Mammeri S.and Beghdad R., "On Handling Real-Time Communications in MAC Protocols," The International Arab Journal of Information Technology, vol.9, no.5, pp.428-435, 2012.
[10] Peng C., and Huang H., "With collision avoidance and traffic-adaptive MAC protocol for low-power listening," Application Research of Computers, vol.30, no. 9, pp. 123-129, 2013.
[11] L. Dai, and X. Sun, "A Unified Analysis of IEEE 802.11 DCF Networks: Stability, Throughput and Delay," IEEE Trans. Mobile Compute. vol. 12, no. 8, pp. 1558-1572, Aug. 2013.
[12] C. Huang, C.-T. Lea, and A. K.-S. Wong, "A joint solution for the hidden and exposed terminal problems in CSMA/CA wireless networks," Compute. Netw., vol. 56, no. 14, pp. 3261-3273, Sept. 2012.
[13] Kamal Rahimi Malekshan, Weihua Zhuang, Yves Lostanlen, "An energy efficient MAC protocol for fully connected wireless ad hoc networks", IEEE Transactions on Wireless Communications, vol. 13, no. 10, pp. 5729 – 5740, 2014.