Two performance measures are evaluated. The throughput (Mbps) is defined as the total number of errorless data bits that reach their destinations per second. The data delivered per Joule (Mbits delivered per joule) is defined as the total number of errorless data bits that reach their destinations divided by the total amount of energy expended in the transmission of all data and control packets by all radios in the network. i.e. the energy used in the transmission of RTS, CTS, or ACK packets is included in the determination of this metric.

In these simulations, we consider two scenarios: single flow single-hop and two sources two flows sharing same transmission medium. In the first scenario, there is one sender and one destination. Where as in the second scenario, there are two senders wishing to communicate to their corresponding destinations respectively at the same time. These two senders sharing the same transmission medium.

5.2 Simulation Results for the Single Flow Single-hop Scenario

Fig. 8 shows the throughput obtained from the simulation for the single flow single-hop. The distance between two sender and the destination nodes varies and sender node generates traffic at the rate of 1 Mbps. The figure shows the comparison of the throughput of power control IEEE 802.11b with various data rates, adaptive rate and our proposed scheme. It is clearly shown that, only the 1 Mbps will not be able to provide the maximum throughput required at distances <230m but its performance is better than other rates as the distances increases toward the maximum transmission range . Even the data rate is same as the traffic rate but due to MAC and PHY overheads, the throughput will reduce. Whereas all other rates, adaptive rate and our protocol will be able to achieves the traffic rate. Excluding the 1 Mbps rate since its throughput is low, our scheme is more energy efficient compares to others as shown in Fig. 9. The new protocol adaptively selects the rate-power combination that can improve the throughput and energy conservation performances of the network.

The TSRP control technique adaptively selects the rate that can save more energy. While the adaptive rate scheme always follow the highest rate that satisfy the measured SNR. The proposed protocol always tries to use the rate such that ratio of power to rate is minimum. As the rate increases its transmit power also increases and vice versa. This phenomenon is clearly indicated in Fig. 10. This Fig. shows the transmit power used in single flow single-hop to achieve the throughput and data delivered per joule shown in Fig. 8 and Fig. 9 respectively.

We also simulate the single flow single-hop by fixing the communication distance and varying the traffic load. Fig. 11 and Fig. 12 show the throughput and its corresponding data delivered per joule in case of single flow single-hop considering such situation. In this case, the simulations perform by fixing the distance between the sender and the destination at 20 m whereas the traffic rate changed. Since the distance is small that means the measured SNR is large. For that the throughput curves of the 11 Mbps, adaptive rate and our protocol are overlapped as shown in Fig. 11. The benefits of our designed protocol compare to others can be clearly notice in Fig. 12. Since TSRP control scheme did not select the highest rate as in the case of the adaptive rate but it select the rate sufficient to deliver all the packets with minimum delay and should be able to save energy as possible. As shown in Fig. 12, The TSRP scheme will adaptively changes the rates according to the traffic load. At any traffic load, this new scheme will conserve energy while achieving maximum throughput. At higher traffic load the performance of our scheme, adaptive rate and 11 Mbps will be exactly same.

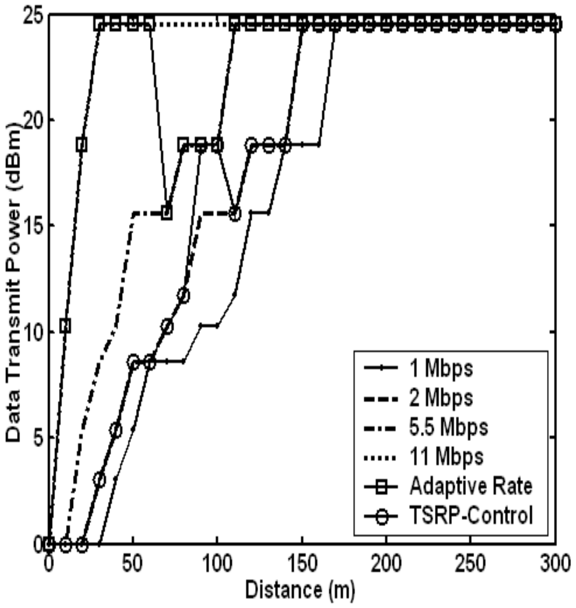

Fig. 10 Average data transmit power (dBm) comparisons at 1 Mbps traffic load in case of single flow single-hop.

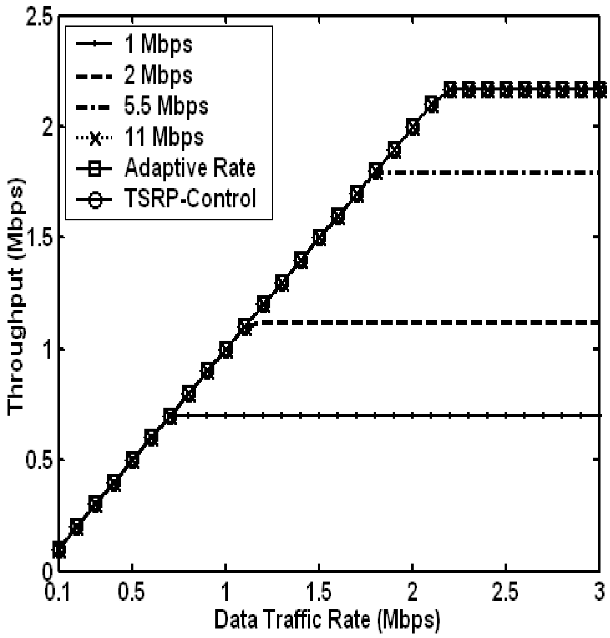

Fig. 11 Throughput comparisons in case of single flow single-hop by varying traffic load at a distance of 20 m.

5.3 Simulation Results for the Two Sources Two Flows Sharing Same Transmission Medium Scenario

In this scenario we considered the case when two sources two flows sharing the same transmission medium. In this case, each source is in the RTS-CTS ranges of the outgoing transmission carried by the other source or it is in the carrier sensing range of the other source. Each source generates the CBR traffic at rate of 100Kbps. Since the traffic load is low compare to the data rate specified by the IEEE 802.11b standards. The aggregate throughput of 1 Mbps, adaptive rate and our proposed scheme are the same. As for 11 Mbps, 5.5 Mbps and 2 Mbps the throughput falls respectively as the transmission range increases. Fig. 13 represents the advantage of the TSRP control MAC protocol among the adaptive rate and the various data rates supported by IEEE 802.11b. The total data delivered per joule is always remains maximum compared to others as its curve remains always at the top. Therefore, this new scheme is able to save more energy.

We have evaluated our scheme under various traffic rate and different packet size. All the simulation results show that our new protocol design performs better than others but it is not possible to include all the results in the paper due to space limitation.

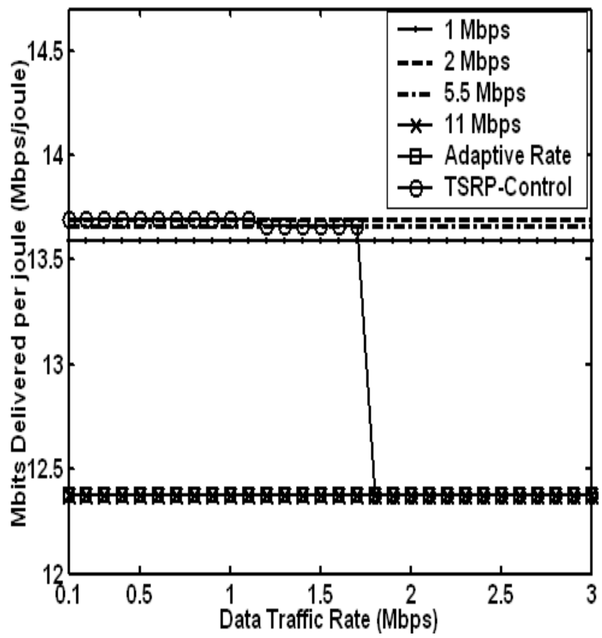

Fig. 12 Total data delivered per joule comparisons in case of single flow single-hop by varying traffic load at a distance of 20 m.

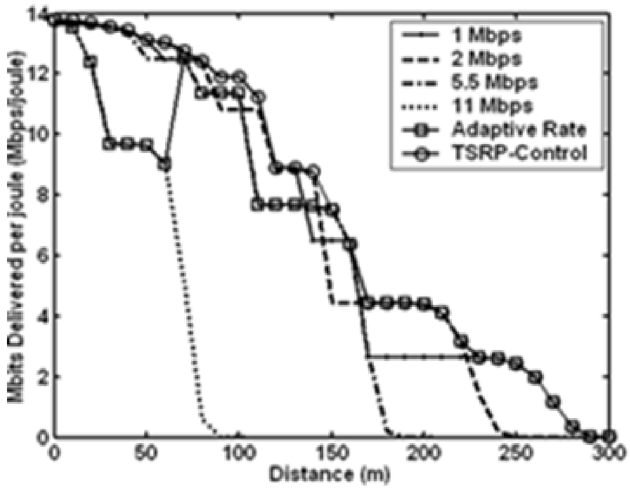

Fig.13 Total data delivered per joule comparisons at 100 Kbps traffic load in case of two sources two flows.

6 Conclusion

In this paper we have proposed and evaluated the performance of a new adaptive rate-power control MAC protocol for wireless ad hoc networks. The design of this new protocol takes the traffic load and the packets waiting in its queue into consideration. The protocol senses the outgoing traffic flow and selects efficient rate-power combination that can maximize the network throughput and save more power. This protocol called Traffic Sensing adaptive Rate Power (TSRP) control MAC protocol. The initial operation of this new protocol is quite similar to the adaptive rate MAC protocols. But instead of selecting the highest data rate that satisfies the channel condition, it selects the energy efficient rate-power combination that can maximize the network throughput.

We have compared the performance of the IEEE 802.11b based TSRP control scheme with the IEEE 802.11b with its various rates and adaptive rate with power control technique. We investigated its performance under two different scenarios, different traffic loads and various communication distances. Our simulation results showed that the TSRP control scheme achieves more total data delivered per joule while maintaining maximum throughput. This means that the new scheme can achieves a high reduction in the energy consumption. The TSRP control protocol is mainly designed to achieve the same throughput that can obtain by the adaptive rate protocol with minimum power consumption.

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Yaser Mahmood A. Hamid

Received his B.E degree from University of Aden, Yemen in 1995 and the M.E degree in Communication Systems from Indian Institute of Technology (IIT), Roorkee, India in 2001. He received Ph.D. degree in Computer Science from the School of Computer & Systems Sciences, Jawaharlal Nehru University, New Delhi, India in 2008. He is currently a Faculty at the University of Aden, Yemen. His current research area is wireless ad hoc networks especially energy conservation in mobile wireless ad hoc networks.

Daya K. Lobiyal

Received his Bachelor of Technology in Computer Science from Lucknow University, India, in 1988 and his Master of Technology and PhD both in computer science from Jawaharlal Nehru University, New Delhi, India, 1991 and 1996, respectively. Presently, he is an Associate Professor in the School of Computer and Systems Sciences, Jawaharlal Nehru University, New Delhi, India. His areas of research interest are Mobile Ad hoc Networks, Vehicular Ad Hoc Networks, Wireless Sensor Network and Video on Demand, Natural language Processing.