Analysis of Energy Efficient IEEE 802.11 MAC Protocol for Wireless Sensor Network

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ABSTRACT

Energy Consumption in Wireless sensor networks is one of the main challenges for researchers. Many researchers have been done for extending the overall network lifetime by minimizing the power consumption of sensor nodes. Most of the work is done over the MAC layer of network in which different kinds of MAC protocol used by sensor networks.. End users typically desire to deploy hundreds to thousands of sensor nodes randomly Producing simple, small, and inexpensive devices also limits the energy resources available for sensor node operation. Replacing or renewing energy resources after deployment becomes infeasible or too costly in most cases, so the protocols and applications must make judicious use of the finite energy resources. As medium access control (MAC) has a significant effect on the energy consumption, energy efficiency is one of the fundamental research themes in the design of MAC protocols for WSNs. In this paper, we described an energy efficiency of IEEE 802.11 protocol which is a standard MAC protocol. The paper presents simulation results of IEEE 802.11 performance on a sensor node with different scenarios. NS-2 is used for simulation purpose.

INTRODUCTION

Wireless sensor networks have emerged as one of the first real applications of ubiquitous computing. It has become a hot issue in research, and it is regarded as one of the ten influencing technologies in the 21st century . A WSN is defined as being composed of a large number of nodes, which are deployed densely in close proximity to the phenomenon to be monitored. WSNs communicate via a radio interface instead of being wired to a control station. Sensors themselves are normally not equipped with a radio interface. Therefore, a simple signal processor and a radio are packaged together with one or more sensors into what is called a wireless sensor node. This is an emerging technology that has a wide range of potential applications including event tracking, environment monitoring, smart spaces, medical systems, agriculture, robotic exploration, traffic surveillance, military surveillance, fire detection, structure and earthquake monitoring, disaster relief, search and rescue, etc. WSNs can be deployed extensively in the physical world and spread throughout our environment. They can be sited far from the actual occurrence and can still be used for data aggregation and collection from a remote location far away from the phenomenon. The WSNs comprise of a large number of application-specific wireless sensor nodes (typically in hundreds of thousands in number) spread over varying topographies. This kind of random placement of the sensor nodes does not follow any fixed pattern and the density of nodes is not dependent on any factor. Once they are deployed in the environment (under scrutiny where sensing needs to take place), these hundreds and thousands of nodes have to organize themselves in the network by listening to one another. They self-organize themselves by creating multi-hop wireless paths through mutual co-operation. The nodes work collectively and collaborate together on common tasks of sensing/data-collection / communications etc. to provide good network-wide performance in terms of network life-time, latency, and uniform density of available nodes for sensing.

WSNs offer unique benefits and versatility with respect to low-power and low-cost rapid deployment for many applications that do not need human supervision. Some of these applications include disaster recovery, military surveillance, health administration, environmental & habitat monitoring, target-tracking etc. Due to the large numbers of nodes involved in the WSN deployment new benefits to the afore-mentioned sensing applications including:

- Extended range of sensing
- Robustness and fault-tolerance
- Improved accuracy
- Lower cost

However to be able to realize all the discussed specifications we need to design protocols that can provide appropriate support and allow the wide-spread use of WSNs.

1 Evaluation performance metrics:

The performance of the WSN MAC protocols was evaluated based upon network lifetime, energy consumption per bit, throughput, end-to-end delay, and node sleep percentage. These performance metrics are defined as follows:

1.1 Network Lifetime:

Network lifetime is a measurement that can be categorized as either the time from network deployment to the first node failure or the time when the wireless sensor network connectivity becomes partitioned. This measurement provides a fair evaluation of how all nodes work together as a network system to extend network longevity. Network lifetime is expressed in days, and the performance rating increases with a higher number of days.

1.2 Energy Consumption/bit:

Energy consumption/bit is a measurement of how much total energy it takes to deliver the network data bits. In addition to transmitting and receiving the data bits, protocols also expend energy performing functions such as processing network information, exchanging control messages, and listening to an idle channel. The energy/bit performance measurement compares protocol energy efficiency to the data traffic loads. Energy consumption/bit measures the average energy consumed per bit in a successful packet transaction in joules / bit, and the performance rating increases with a lower energy consumption/bit.

1.3 Throughput:

Throughput is a measurement of how quickly data information flows across the channel or network. Throughput has physical limits, and protocol overhead, data encoding schemes, error detection and correction processes, or message retransmissions can slow down the data flow. Throughput was measured in bits/second and packets/second, and the performance rating increases with higher rates.

1.4 End-to-End Delay:

End-to-end delay is a measurement of the network delay on a packet and is measured by the time interval between when a message is queued for transmission at the physical layer until the last bit is received at the receiving node. Ns-2 measures this period as the average elapsed time between source transmission and sink reception. The end-to-end delay was measured in seconds, and the performance rating decreases with increasing time.

Simulation Setup

In simulation scenario 50 nodes uniformaly distributed in terrain area 750m X 750 m . for this study used random waypoint mobility model . In random way point is a mobility model that use random based mobility of mobile devices in a wireless communication System.

Table 1: Simulation Parameter

Parameter	Value
Initial Energy	1000 J
MAC Layer	802.11
Max. packet in interface queue	250 bytes
Radio Transmission Range	30 m
Data Rate (Radio Bandwidth)	2Mbps
Idle Power	0.2 w
Receiver Power	0.5 w
Transmit power	1.0 w

2. Simulation Results:

Simulations were done using networks consisting of 10 and 20 mobile nodes. This was done to evaluate the total energy consumed by nodes, throughput, end-to-end delay and network life time

2.1 Simulation topology: -

The following diagram Figure. 2.1 shows the topology used to simulate the procedure described in the thesis. 20 mobile nodes were used in the simulation.

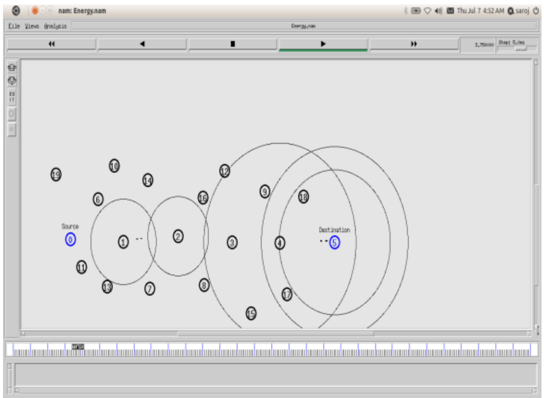

Figure 2.1

2.2 Result of nodes energy:

The following graph Figure.2.2 shows the energy consumed of the individual nodes involves in the communications by using IEEE 802.11 MAC Protocol while data transferring from source node to the destination node. the simulation time is 30 m. sec.

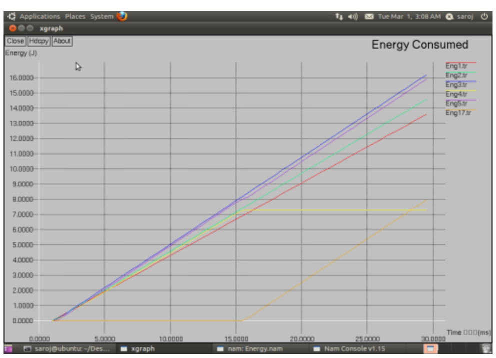

Figure 2.2

2.3 Result of total Energy for 20 nodes:

The following graph Figure.2.3 shows the summation of energy consumed of all the nodes involved in the communication process by using 802.11 MAC protocol while data transferring from source node to the destination node and simulation time is 30 m. seconds. 20 mobile nodes were used in the simulation.

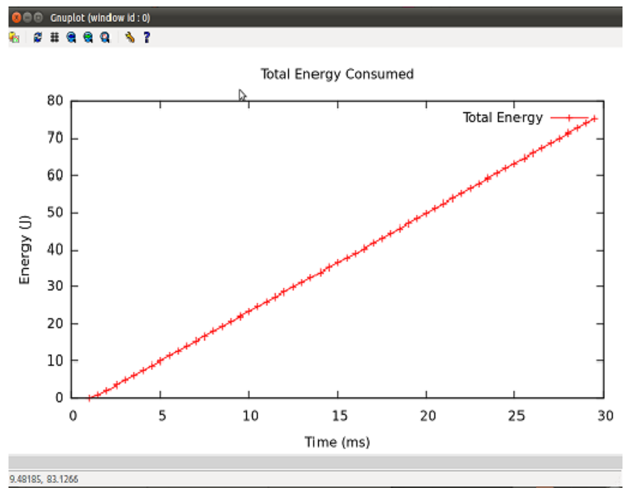

Figure 2.3

2.4 Result of End-to-end delay:

The following graph Figure. 2.4 shows the end-to-end delay of individual nodes involved in the communication process while transferring data from source node to destination node by using 802.11 MAC Protocol.

Figure 2.4

Conculsion

The minimization of the energy consumption is aimed to WSNs because the capacity of the power supply is limited of the sensor nodes. There is no single MAC protocol as universally minimized energy consumption for WSN, the need of protocols may vary depending on the network applications. This thesis shows the various results of energy consumption and their lifetime behavior of the various nodes of sensor networks. IEEE 802.11-MAC in ns-2.34 is simulated and found out the internal operations of packet transmission.

The results present clearly indicate that with increase in the number of nodes the energy consumption of the network also increases and the lifetime of the network decreases.

References

[1] "21 ideas for 21st century", Business week pp 78-167. Aug 30 1999.

[2] Feng ZHAO and Leonidas GUIBAS 2005"WIRELESS SENSOR NETWORKs", Morgan Kaufmann Publishers first Indian reprint ISBN: 81-8147-642-5.

[3] Chong, Chee-Yee; Kumar, S.P.; Allen Hamilton, Booz; " Sensor networks: evolution, opportunities, and challenges", in Proceedings of the IEEE, vol. 91, issue 8, pp 1247 – 1256, Aug. 2003.

[4] Khan, J.M.; Katz, R.H.; and Pister, K.S.; "Mobile networking for smart dust," in the ACM/IEEE International conference on mobile computing and networking (Mobi.com), vol. 11, pp. 2-16, February 2003.

[5] "10 emerging technology that will change the world" Technology review vol. 106, no. 1 pp 33-49, 2003.

[6] Stallings, W.; "Data & Computer Communications", 6th ed., Prentice Hall, New Jersey, p. 453, 2000.

[7] Akyildiz, I.F.; Su, W.; Sankarasubramaniam, Y.; and Cayirci, E.;"Wireless sensor networks: A survey", Computer Networks (Elsevier), vol. 38, pp. 393-422, 2002.

[8] Hoblos, G.; Staroswiecki, M.; and Aitouche, A.;"Optimal Design of Fault Tolerant Sensor Networks", Proceedings of the IEEE International Conference on Control Applications, Anchorage, USA , pp. 467- 472, 2000.

[9] LaMaire, R.O.; Krishna, A.; Bhagwat, P.; Panian, J.; "Wireless LAN and mobile networking: standards and future directions", communication magazine IEEE, vol. 34, issues 8, pp. 86-94, 1996.

[10] Karayannis,G; "Emerging Wireless Standards: Understanding the Role of IEEE 802.15.4 and ZigBee in AMR and Submetering", Boston, USA, pp. 56 – 67, August 2000.

[11] Mahajan, Leena; Kaur,Simarpreet; "Medium Access Control optimization for WSNs", IJCST vol. 1, issue 1, 2010 ISSN: 0976-8491.

[12] Shakshuki, E.M.; Sheltami, T.R.; Malik, H.; Chuoxian Yang; "Investigation and Implementation of Bord er Nodes in S-MAC", IEEE Conference pp. 350-357, 2009.

[13] Ji-Jun, Zhao; Xiang, Sun; " A MAC Protocol Based on T-MAC Multihop Reservation for Short-Latency Wireless sensor network", IEEE international conference on communication Technology, pp. 114-117, 2008.

[14] Lin, P.; Qiao, C.; and Wang, X.; "Medium access control with a dynamic duty cycle for sensor networks", IEEE Wireless Communications and Networking Conference, Volume: 3, Pages: 1534 - 1539, 2004.

[15] Lu, G.; Krishnamachari, B.; Raghavendra, C.S.; "An adaptive energyefficient and low-latency MAC for data gathering in wireless sensor networks", Proceedings of 18th International Parallel and Distributed Processing Symposium, Pages: 224, 26-30 2004.

[16] Jamieson, K.; Balakrishnan, H.; and Tay, Y. C.; "Sift: A MAC Protocol for Event-Driven Wireless Sensor Networks," MIT Laboratory for Computer Science, Tech. Rep. 894, May 2003.

[17] Rajendran, V.; Obraczka, K.; Garcia-Luna-Aceves, J.J.; "Energy- Efficient, Collision-Free Medium Access Control for Wireless Sensor Networks", Proc. ACM SenSys 03, Pages: 181 - 192, 2003.

[18] Hoiydi, El; "Spatial TDMA and CSMA with preamble sampling for low power ad hoc wireless sensor networks", Proceedings of ISCC 2002, Seventh International Symposium on Computers and Communications, Pages: 685 - 692, 2002.

[19] Burttner, M.; Yee, G. V.; Anderson, E.; and Han, R.; "X-MAC: A short preamble

mac protocol for duty cycled WSNs". In proc. Sensys' 06, 2006.

[20] Liu, Sha; Fan, Kai-wei; and Sinha, Prasun; "An energy efficient MAC layer Protocol using convergent packet forwarding for WSNs", IEEE SECOND-2007.

[21] Polastre, J.; Hill, J.; and Culler,V; "Versatile low power media access for WSNs" In the second ACM conference on Embedded Networked sensor systems. Pp. 95-107, 2007.

[22] Rhee, Injong; Warrier, Ajit; Aia, Mahesh; and Min, Jeongki; "Z-mac: a hybrid MAC for wireless sensor networks", In Proceedings of the 3rd ACM SenSys Conference, pp. 90101, San Diego, CA, USA, 2005.

[23] Ye, W.; Heidemann, J.; Estrin, D.; "Medium Access Control With Coordinated Adaptive Sleeping for Wireless Sensor Networks", IEEE/ACM Transactions on Networking, Vol. 12, Issue: 3, pp. 493 - 506, 2004.

[24] Federal Communications Commission, "Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz," Title 47, Vol. 1, U.S. Government Printing Office via GPO Access, October 2001.

[25] German, R.;"Simulation and Modeling" I Lecture Notes in Computer Science. Erlangen- Nürnberg University, Erlangen, Winter Term 2003/2004.

[26] Intae, K.; and Poovendran, R.; "Maximizing static network lifetime of wireless broadcast ad hoc networks", in Proceeding of the IEEE International conference on communications, Anchorage, USA, vol. 3, pp.2256-2261, 2003.

[27] Karn, P.; "MACA -a new channel access method for packet radio," In 9th ARRL Computing Networking Conference, pp. 134–140, 1990.

[28] Bharghavan, V.; Demers, A.; Shenker, S.; and Zhang, L.; "MACAW: a media access protocol for wireless sensor LANs," In Conf. on Communications Architectures, Protocols, and Applications, pp. 212-225, London, 1994.

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