REVIEW ANALYSIS OF THE ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORKS FOR ENERGY OPTIMIZATION

K.LAKSHMI SUDHA
Associate Professor, SIESGST,
Research Scholar, Sathyabama University.
lakshmi.sudha@siesgst.ac.in

Dr. C. Arun
Professor, Department of ECE,
R.M.K. College of Engineering and Technology, Chennai
carunece@gmail.com

Abstract:.Wireless sensor network consists of number of sensors, which collects the information and send to the sink node. Sensor node has limited energy storage and cannot be replaced in certain applications. A significant work has been done on optimization of the protocols in each layer of the sensor network to optimize the energy. In this paper, we are presenting a research review on the network layer protocols for optimum routing, lifetime and energy optimization.

Keywords: Wireless sensor Network, Lifetime, Routing, Energy, Network layer.

1. Introduction

The protocol stack of the Sensor node consists of Physical Layer, Data Link Layer, Network Layer and Transport layer. It also has the three planes namely Power management, Mobility management and Task management [1]. The Physical layer takes care of modulation, encryption, signal detection and Frequency selection. Data link layer provides Medium access control and error control and synchronization. The network layer is responsible for routing the data; the transport layer does the multiplexing, splitting or segmenting. Application layer does login or password checking. The power management plane manages the power level of the node. The mobility management plane detects and registers the movement of the nodes. The task management plane balances and schedules the sensing task at the same time. These planes work together and for using the power efficiently. Routing protocols can be classified as Proactive, Reactive and Hybrid based on the mode of functioning and the type of target applications. Based on participation style of nodes they can be classified into Direct communication, Flat and Clustering protocols. WSNs can be further divided into Data centric routing, hierarchical-based routing and location-based routing depending on the network structure.

2. Comparison of various Routing protocols

2.1. Proactive, Reactive and hybrid routing protocols

Proactive protocols compute all the routes before they are really needed and then store these routes in a routing table in each node, Reactive protocols compute routes only when they are needed. Hybrid protocols use a combination of these two ideas [2].

2.1.1. Proactive protocols

In Proactive Networks, the sensors periodically transmit the value for the sensed attribute. At other times, sensors and transmitters are switched off to save energy. This type of network is most suitable for applications that require periodic examination, namely, monitor machinery for fault detection and diagnosis. The following are the few proactive routing protocols.

- LEACH (Low Energy Adaptive Clustering Hierarchy) [3], is a proactive routing protocol works in a homogenous network. This protocol uses clustering mechanism for routing in the network.
- SEP (Stable Election Protocol) [4] is proactive routing protocol works as heterogeneous-aware protocol to prolong the time interval before the death of the first node (we refer to as stability period), which is crucial for many applications where the feedback from the sensor network must be reliable. SEP is based on weighted election probabilities of each node to become cluster head according to the remaining energy in each node.

- PEGASIS (power-efficient gathering in sensor information systems) is also a proactive protocol uses optimal chain-based protocol that is an improvement over LEACH. In PEGASIS, each node communicates only with a close neighbor and takes turns transmitting to the base station, thus reducing the amount of energy spent per round. Simulation results show that PEGASIS performs better than LEACH by about 100 to 300% when 1%, 20%, 50%, and 100% of nodes die for different network sizes and topologies [5].
- EDEEC(EDEEC- Enhanced Distributed Energy Efficient Clustering) is the extended version of SEP[6]. EDEEC protocol used three types of nodes i.e. normal, advanced and super nodes. These nodes have energies in increasing order i.e. normal, advanced and super respectively and the probabilities of getting elected as cluster head follow the reverse order i.e. super, advanced and normal respectively. Thus higher energy nodes will increase the epoch time for less energy node thus finally increase the stability period of the network. This follows the same procedure for cluster head election and sending of the data as of the LEACH.

2.1.2. Reactive Networks

In Reactive networks sensor nodes continuously sense the environment and transmit the value as soon as the sensed parameter exceeds a user specified threshold value. This enables time critical data to reach the user almost instantaneously, making such a network most suitable for time critical applications. The following are the reactive network protocols.

- TEEN (Threshold sensitive Energy Efficient sensor Network protocol) is well suited for time critical applications and is also quite efficient in terms of energy consumption and response time [7-8]. Advantage of this scheme is that it is eminently suited for time critical data sensing application. Energy consumption in this scheme can be much less than in proactive network because data transmission consumes more energy than data sensing and in this scheme data transmission is done less frequently.
- TADEEC (Threshold Sensitive Advanced Distributed Energy Efficient Clustering) is made to work in a reactive mode in a heterogeneous network. So it basically used the best aspects of both reactive routing mechanism and heterogeneity of the network [9].

The performance analysis of proactive, reactive protocols show that TADEEC performed better with respect of life time and throughput [8].

2.1.3. Hybrid networks

Hybrid network is the combination of the above two to be used in applications in which the user wants time critical data and also wants to query the network for analysis of conditions other than collecting time critical data . The example of such hybrid network protocols are

- APTEEN (Adaptive Periodic Threshold-sensitive Energy Efficient sensor Network Protocol) [10], is an extension of TEEN and aims at both capturing periodic data collections and reacting to time critical events. The architecture is same as in TEEN. In APTEEN once the CHs are decided, in each cluster period, the cluster head broadcasts the parameter such as attributes, threshold, schedule and count time to all nodes [10].
- HEER is a Hybrid Energy Efficient Reactive protocol [11]. In HEER, Cluster Head(CH) selection is based on the ratio of residual energy of node and average energy of network. Moreover, to conserve more energy, we introduce Hard Threshold (HT) and Soft Threshold (ST).

2.2. Direct communication, flat and clustering protocols

2.2.1. Direct communication protocols

In the direct communication the sources directly communicate with their base station and energy on data reception and forwarding can be conserved [12]. In this paper they have presented the some of the direct communication protocols. Communication range of sensor is thus important to make the single-hop communication possible. Strength is inversely related to the distance and perfect conditions without obstacles and good weather are assumed in the free space propagation model used [13].

- Single-hop applications have been used in WSNs. An energy balanced protocol for the single-hop is developed [14].

Single-hop transmission is more efficient, when power consumption of real wireless sensor node's transceivers are taken into account [15]. Results from simulations show that single-hop routing is much more energy efficient than multi-hop routing, using real world WSN transceivers. Besides energy efficiency, single-hop routing can also have advantages for other network parameters.

- The transceiver is the major source of power consumption in the node, optimizing the routing for hop length can extend significantly the lifetime of the network [16]. This paper explores that the multi-hop routing is more energy efficient than direct transmission to the sink and the conditions for which the two-hop strategy is optimal. They have shown that multi-hopping is more energy efficient in comparison to a direct transmission.

2.2.2. Flat protocols

In flat networks, each node typically plays the same role and sensor nodes collaborate together to perform the sensing task. The properties of the flat protocols are Energy dissipation depends on traffic patterns, Energy dissipation adapts to traffic pattern. This category of routing protocols have three types of flat routing schemes, namely, flooding, forwarding and data-centric based routing [17]. In flat topology, all nodes in the sensor network have equal roles in gathering information. They all have the same information about the state of the network. In this type of network, it is not possible to assign a particular identification (ID) to each node due to the large number of sensor nodes. This leads to data-centric routing approach in which the sink sends query to a group of particular nodes in a region and waits for a response. The property of data is specified by an attribute-based naming.

- Flooding and Gossiping are the two classical mechanisms to relay data in sensor networks without using topology maintenance and complex routing algorithms. Flooding [18] can be defined as the process of sending the packets to designated node without prior route calculation. The packets are just passed in great numbers over the network to all other nodes. In this mechanism each sensor node broadcasts its packet to all its neighbouring nodes, then these nodes broadcasts them to other nodes and so on.
- Gossiping is another protocol [19], used to send and receive data over the tiny network devices. In this mechanism the source node selects a random node to transmit the packets of information and sends the packets to this selected node, then the selected node broadcasts the packets to other intermediate nodes and in this way packets reached to the designated place.
- The comparative analysis of Flooding and Gossiping is explained in the paper [20]. The main advantage of gossiping protocol is that it is easy to implement and maintenance and low overhead than flooding. Gossiping consumes less energy than Flooding. It suffers from latency; information propagates slowly, one node at each step [21].

2.2.3. Clustering protocols

Clustering has been widely studied to enhance the lifetime of WSN by reducing the number of packet transmissions. In clustering, the nodes selected as cluster head, often suffer from high overload and thus consume more energy. Re-clustering is eventually performed to talk about the resource intensive cluster head role, which requires global time synchronization.

- Comparison of various clustering is protocols are proposed in [22].
- The performance analysis of the clustering protocols like LEACH, PEGASIS, HGMR, UCMR etc is presented in [23].
- Some basic concepts related to the clustering process in WSN and comparison survey between different clustering protocols is presented in [24].

2.3. Hierarchical protocols, Data centric routing protocols, Location based protocols

2.3.1. Hierarchical routing protocols HRPs

HRPs are more energy efficient and scalable compared to flat routing protocols [25].To overcome the latency problem and promote scalability, some Hierarchical protocols have been proposed. They are namely

- Low-energy Adaptive Clustering Hierarchy (LEACH)
- Threshold Sensitive Energy Efficient Sensor Network (TEEN)
- Adaptive Periodic TEEN (APTEEN)
- Power-efficient Gathering in Sensor Information Systems (PEGASIS)
- Power-efficient Data Gathering and Aggregation Protocol-power Aware (PEDAP-PA)
- The simulation result shows that PEDAP-PA is energy efficient than the others[25].

2.3.2. Data centric routing protocols

Data-centric protocols [26] differ from traditional address-centric protocols in the manner that the data is sent from source sensors to the sink. In address-centric protocols, each source sensor that has the appropriate data responds by sending its data to the sink independently of all other sensors. However, in data-centric protocols, when the source sensors send their data to the sink, intermediate sensors can perform some form of aggregation on the data originating from multiple source sensors and send the aggregated [27] data towards the sink . The following are the data centric protocols.

- SPIN
- Direct Diffusion
- Rumor Routing

SPIN (Sensor Protocols for Information via Negotiation), that efficiently disseminate information among sensors in an energy-constrained wireless sensor network. Nodes running a SPIN communication protocol name their data using high-level data descriptors, called meta-data. They use meta-data negotiations to eliminate the transmission of redundant data throughout the network[28]. SPIN, SPIN-1,M-SPIN are the three extension protocols for SPIN and simulation results show that M-SPIN performs better than other two. M-SPIN is a better approach for the application need quick and reliable response [29].

In directed diffusion, sensors measure events and create gradients of information in their respective neighbourhoods. Unlike SPIN, there is no need to maintain global network topology in directed diffusion. However, directed diffusion may not be applied to applications (e.g., environmental monitoring) that require continuous data delivery to the BS [30].

In Rumor Routing approach, the data collected by the sensor nodes will be sent to its neighbouring nodes and it goes on till reaches the interested region or the end node of the network. At the same time the user interest is also sent through the network. When the two regions meet each other required data are gathered and given to the base station [31]. The comparison of the Direct diffusion, Rumor routing, LEACH and HEED is explained in paper [32].

2.3.3 Location based protocols

Location based routing protocols are used in Wireless Sensor Network (WSN) in which the information about the location of nodes is used for communication. It is also known as geographic routing protocol or position based routing protocols. These protocols reduce the energy consumption and increase the lifetime of the network. The following are the examples of Location based protocols.

Geographic Adaptive Fidelity (GAF) Geographic adaptive fidelity is an energy aware routing protocol. GAF is a type of protocol which was proposed primarily for MANETS and later it was used for wireless sensor networks as well.

- Geographic and Energy-Aware Routing (GEAR) is an energy efficient routing protocol proposed for routing queries to target the regions in the sensor field. The sensors will be equipped with localization hardwares like GPS, localization system.
- Minimum Energy Communication Network (MECN) is a location-based protocol for achieving minimum energy for randomly deployed ad hoc networks, which attempts to set up and maintain a minimum energy network with mobile sensors. It is self-reconfiguring protocol that maintains network connectivity in spite of sensor mobility.
- GAF for Lifetime Elongation in Wireless Sensor Networks is proposed in paper [33]. It improves the networks performance on the nodes' life time and average load for the network. A review analysis is explained in papers [34-35].
- GPSR-S(Greedy Perimeter Stateless Routing for wireless Sensor networks) is based on GPSR, which is one of the most well-known location-based routing protocols for wireless ad hoc networks. The energy efficiency of GPSR by considering nodes' energy level and location information. Simulation results show that GPSR-S performs well in terms of energy efficiency and the number of packets. GPSR-S delivers approximately 10% fewer packets than GPSR, but the lifetime of the network is 10% greater [36].

Many researchers have come up with the new technologies to improve the performance of the routing protocols. Since all layers of protocol architecture influence the energy consumption, exploiting synergies between these layers by a cross layer design will result in an efficient energy utilization of the system. A detailed comparative analysis is given in paper [37] In this paper they have discussed about the importance of Cross Layer Design.

Acknowledgments

We are thankful to all the researchers for their contribution to develop the routing protocols of Wireless sensor Networks.

Conclusion

Energy optimization increases the Life time of the sensor node. Optimized routing protocol is required to fulfill the today's energy demand. We have discussed the classification of the routing protocols in our paper. Since the protocols invented till date are application specific and there is no common protocol to satisfy the requirements, lot of scope is there to improve the performance of the routing protocols.

References

1) Akyildiz, I. F., Weilian Su, Sankarasubramaniam, Y., and Cayirci E., "A survey on sensor networks", IEEE Communications Magazine, vol.40, no.8, pp. 102- 114, August, 2002.
2) Prabhat Kumar, M.P.Singh and U.S.Triar , A Review of Routing Protocols in Wireless Sensor Network , International Journal of Engineering Research & Technology (IJERT) , ISSN: 2278-0181 , Vol. 1 Issue 4, June - 2012 .
3) W.R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient Communication Protocol for Wireless Microsensor Networks", in IEEE Computer Society Proceedings of the Thirty Third Hawaii International Conference on System Sciences (HICSS '00), Washington, DC, USA, Jan. 2000, vol. 8, pp. 8020.
4) G. Smaragdakis, I. Matta, A. Bestavros, "SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor networks", in: Second International Workshop on Sensor and. Actor Network Protocols and Applications (SANPA 2004), 2004.
5) Lindsey, S.; Raghavendra, C.S. PEGASIS: Power-Efficient Gathering in Sensor Information Systems. In Proceedings of the Aerospace Conference, Big Sky, MT, March, 2002; pp. 1125–1130.
6) Parul Saini, Ajay.K.Sharma, "E-DEEC- Enhanced Distributed Energy Efficient Clustering Scheme for heterogeneous WSN", in: 2010 1st International Conference on Parallel, Distributed and Grid Computing (PDGC - 2010).
7) A. Manjeshwar and D. P. Agarwal, "TEEN: a routing protocol for enhanced efficiency in wireless sensor networks," In 1st International Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile Computing, April 2001.
8) Amit K. Kaushik, Performance Evaluation of Proactive and Reactive Routing Protocols in Wireless Sensor Networks, International Journal of Computer Applications (0975 – 8887) Volume 110 – No. 16, January 2015.
9) Anamika Chauhan and Amit Kaushik, "TADEEC : Threshold Sensitive Advanced Distributed Energy Efficient Clustering Routing Protocol for Wireless Sensor Networks," International Journal of Computer Applications (0975 – 8887),Volume 96 No.23 June 2014.
10) AratiManjeshwar and Dharma P. Agrawal, "APTEEN: A Hybrid Protocol for Efficient Routing and Comprehensive Information Retrieval in Wireless Sensor Networks" Parallel and Distributed Processing Symposium, proceedings International, IPDPS 2002, Abstracts, and CD-ROM, pp. 195-202.
11) N. Javaid, S. N. Mohammad, K. Latif, "HEER: Hybrid Energy Efficient Reactive protocol for Wireless Sensor Networks", IEEE international conference on Electronics, Communications and Photonics Conference (SIECPC), 2013.
12) Ittipong Khemapech, Feasibility Study of Direct Communication in Wireless Sensor Networks, 2013 International Workshop on Communications and Sensor Networks, Procedia Computer Science 21 (2013) 424 – 429.
13) Clark MP. Wireless access networks, fixed wireless access and WLL networks – Design and operation. John Wiley & Sons; Reprinted 2001.
14) Bakshi A, and Prasanna VK. Structured communication in single hop sensor networks. In Lecture Notes in Computer Science, SpringerLink, 2004.
15) Uroš M. Pešović, Jože J. Mohorko, Karl Benkič, Žarko F. Čučej, Single-hop vs. Multi-hop – Energy efficiency analysis in wireless sensor networks, Telekomunikacioni forum TELFOR 2010, Srbija, Beograd, novembar 23.-25., 2010.
16) Szymon Fedor, Martin Collier, On the problem of energy efficiency of multi-hop vs one-hop routing in Wireless Sensor Networks, IEEE International Conference on Advanced Information Networking and Applications Workshops (AINAW'07).
17) Hassan Echoukairi, Khalid Bourgba and Mohammed Ouzzif, A Survey on Flat Routing Protocols in Wireless Sensor Networks, The International Symposium on Ubiquitous Networking, Lecture Notes in Electrical Engineering 366, DOI: 10.1007/978-981-287-990-5_25.
18) J.N. Al-Karaki and A.E. Kamal. "Routing techniques in wireless sensor net-works: a survey" in IEEE Wireless Communications Magazine,11(6):628, 2004.
19) S. Hedetniemi and A. Liestman, "A survey of gossiping and broadcasting in communication networks", Networks 18 (4) (1988) 319–349.
20) Anit Kumar, Swimpy Pahuja, A Comparative Study of Flooding Protocol and Gossiping Protocol in WSN, Int.J.Computer Technology & Applications,Vol 5 (2),797-800.
21) Mukta Chandna, Bhawna Singla, Comparative Analysis of Flooding and Gossiping in Wireless Sensor Networks Using SIR, International Journal of Computer Science and Information Technologies, Vol. 6 (4) , 2015, 4020-4023.
22) Santar Pal Singh, S.C. Sharma, A Survey on Cluster Based Routing Protocols in Wireless Sensor Networks, International Conference on Advanced Computing Technologies and Applications (ICACTA), Procedia Computer Science, Volume 45, 2015, Pages 687-695.
23) Harpinder Kaur, Navjot Kaur, Sandeep Waraich, Comparative Analysis of Clustering Protocols for Wireless Sensor Networks, International Journal of Computer Applications (0975 – 8887) Volume 115 – No. 1, April 2015.
24) Liliana M.C. Arboleda ; Nidal Nasser, Comparison of Clustering Algorithms and Protocols for Wireless Sensor Networks, IEEE conference on Electrical and Computer Engineering, 2006. CCECE '06.
25) Zahariah Manap, Borhanuddin Mohd Ali, Chee Kyun Ng, Nor Kamariah Noordin, Aduwati Sali, A Review on Hierarchical Routing Protocols for Wireless Sensor Networks, Wireless Personal Communications,September 2013, Volume 72, Issue 2, pp 1077–1104.
26) Azni, A.H., Madihah Mohd, S., Azreen, A., and Ariff Syah, J., (2009), "Performance Analysis of Routing Protocol for WSN Using Data Centric Approach", World Academy of Science, Engineering and Technology, Vol. 53.
27) Estrin, D., Girod, L., Pottie, G., and Srivastava, M., (2001), "Instrumenting the world with wireless sensor networks", Proc. Acoustics, Speech, and Signal Processing, Vol. 4, pp. 2033– 2036.
28) J. Kulik, W. R. Heinzelman, and H. Balakrishnan, "Negotiation-based protocols for disseminating information in wireless sensor networks," Wireless Networks, Volume: 8, pp. 169-185, 2002.
29) K. Karthikeyan, M.Kavitha, Comparative Analysis of Data Centric Routing Protocols for Wireless Sensor Networks, International Journal of Scientific and Research Publications, Volume 3, Issue 1, January 2013 1 ISSN 2250-3153.

30) Intanagonwiwat, C. Govindan R. and Estrin,D. “Directed Diffusion: A Scalable and Robust Communication Paradigm for Sensor Networks”. In Proceedings of the Sixth Annual International Conference on Mobile Computing and
31) Chakrabarti, S. (2000): Data mining for hypertext: A tutorial survey. SIGKDD explorations, 1(2), pp. 1–11Networks (MobiCOM 2000), August 2000, Boston, Massachusetts.
32) D. Braginsky, D. Estrin," Rumor Routing Algorithm for Sensor Networks," Proceedings of the 1 st Workshop on Sensor Networks and Applications (WSNA'02), Atlanta, GA, Oct.2002.
33) B.Baranidharan, B.Shanthi, A Survey on Energy Efficient Protocols for Wireless Sensor Networks, International Journal of Computer Applications (0975 – 8887) Volume 11– No.10, December 2010.
34) Xiao-gang Qi , Chen-xi Qiu, An Improvement of GAF for Lifetime Elongation in Wireless Sensor Networks, IEEE International conference on Wireless Communications, Networking and Mobile Computing, 2009. WiCom '09.
35) Jitender Grover; Shikha; Mohit Sharma, Location based protocols in Wireless Sensor Network — A review, IEEE International Conference on Computing, communication and Networking Technologies (ICCCNT), 2014.
36) G.V Rama Lakshmi, V. Srikanth, Location-Based Routing Protocol in Wireless Sensor Network- A Survey, International Journal of Advanced Research in Computer Science and Software Engineering, Volume 5, Issue 4, 2015.
37) K.lakshmisudha,dr.c.arun, cross layer designs to optimize the power consumption in wireless sensor networks, Journal of Theoretical and Applied Information Technology, 20th April 2014. Vol. 62 No.2.