REVIEW ON ENERGY EFFICIENT WIRELESS SENSOR NETWORK

NavneetSingh[1] AbhishekPratap Singh[2] Ramesh Mishra[3]
[1,3]Department of ECE Dr R M L Avadh UniversityAyodhya[2]Department of ECE MUIT Lucknow U P

Abstract: Wireless sensor networks (WSN) are becoming one of the most popular research areas among scientists, with the effect of a vision on technical development. Reliability and fault tolerance is a major concern in wireless sensor networks (WSN). Reliability in the WSN shows the ability of a functional unit to meet performance specifications at a specific time and is often expressed as probability or average failure time (MTTF). Fault tolerance in the WSN is the quality or capacity of a functional unit, which consists of performing the necessary function in the presence of certain numbers of faults or errors. The difference is that the first is a characteristic related to a period of time, unless there are no faults, while in the presence of one or more of the following components with faults is related to the performance of the system. Fault tolerance is applied to increase the reliability of a system.

KEYWORDS:communication, energy efficienc Fault tolerance, Wireless Sensor Network

I. INTRODUCTION

A Wireless Sensor network is defined as a collection of sensor nodes and sink nodes which are been connected through wireless communication network. Sensor nodes are portable and inexpensive devices with limited memory and energy resources. Therefore, the main parameters for wireless sensor network nodes are the availability of small sensors and network connectivity. This system would be effective if it is economical and environmentally friendly.

In many elements of wireless sensor network, a common task of the sensor node is to gather information from the environment, process this data locally and send the detected data to the receiving node. Therefore, the efficiency of a wireless sensor network depends on the reliability with which the sensor nodes can deliver data detected to the sump.

To ensure the reliability of data delivery between the sensor node that can deliver data to the sump detected. Ensuring reliable delivery of data between the sensor node and sink into the wireless sensor network is a difficult task as WSN suffer from data loss is high and due to weak wireless transmission means, failure of environmental interference node and the exhaustion of the battery.

The frequent failures within WSN influence the reliability and fault tolerance of the network and make it more difficult to achieve desirable reliability and, therefore, reliability becomes the main concern in wireless sensor networks to ensure the transmission of data within a minimum loss.

The schemes for reliable data transportation in WSNs keeping in view the following aspects of unsuccessful transportation of information at the sink:

(i) Information loss due to hardware (node) failure

(ii) Information loss due to collision when sink receives packets from multiple sources

(iii) Corrupted information delivery due to noisy communication channel

Developments in sensor technology have enabled the widespread deployment of sensor networks consisting of small sensor nodes with the capabilities of detection, computation and transmission. Sensor node collects data from the factors affecting the environment, does the computations locally and finally communicates its results to a data fusion centre via a wireless medium and takes an action in response.

WSN sensors, usually deployed in non-accessible environment, are powered using small batteries along with techniques for power harvesting; replacing batteries is not an option. The limitation of energy supply, however, has inspired a lot of the research on WSNs at all layers of the protocol stack.

II. ROUTING N WSN

For a reliable data delivery trough a communication network a large number of wireless sensor nodes are required, but due o the nature of sensor network designing a reliable data protocol observed a number of challenges which includes large number of nodes, constrained energy, data centric networking and small size of message etc. This paper presents an overview of general reliability issues in the data transfer protocol for wireless sensor network as well as discuss some recent development in the field and proposed data transfer protocol.

Amit Sarkar , et al in 2016 discussed Routing in Wireless Sensor Networks (WSNs) and analysed the literature based on simulation environment and experimental setup, awareness over the Quality of Service (QoS) and the deployment against various applications. Frequent failures in WSN influence the reliability and fault tolerance of the network and make it more difficult to achieve the desired reliability and, therefore, reliability becomes the primary concern in wireless sensor networks to ensure the transmission of data within a minimum loss.Benjie Chen, et al. in 2010 stated that another research direction aimed at achieving energy conservation through load balancing taking advantage of redundancy is Span. Span is a random distributed algorithm that locates between MAC and network layers. It is primarily designed to dynamically choose a subset of nodes as coordinators (Forwarders) of all network nodes to participate in routing while ensuring connectivity is provided. The eligibility rule coordinator is used to select a node to be coordinator.

F. Bouabdallah, et al., in 2008, analysed an efficient routing of the traffic in the graph towards the sink that is investigated to maximize the useful life of the network. To this end of the network, efficient routing configuration with respect to efficient energy consumption (balancing power consumption throughout the network) in which the packets are forwarded through multiple access routes to the sink is proposed. This is achieved through the determination of a set of optimal vectors (a vector represents a fraction utilization of each access path used to send a packet from node v to the sink) that minimize the energy consumption of the greedy sensor node in the net system.Rosberg, et al in 2008 argued that relaying the sender and transmitting redundant data are the two basic ways of providing reliability of transport protocols. Automatic Replay Request (ARQ) is the most commonly used retransmission sender method. In ARQ schemes, the sender will retransmit the packet if the loss occurs and a acknowledgement (ACK) is not received before the expiration of a retransmission timer. Paek et al. propose RCRT 2007, a reliable speed-controlled transport protocol suitable for high-speed wireless sensor network applications. RCRT is designed to reliably transfer large data assemblies from multiple source sensors to multiple sinks without incurring network congestion. RCRT uses explicit NACK end-to-end and retransmissions to recover lost packets and implements a congestion detection and sink rate adjustment function. In RCRT, end-to-end reliability is provided by a NACK-based loss recovery scheme. Each source node mutes each packet that is sent and traces the sequence number from end to end. Once a gap is detected in the sequence numbers, the missing sequence numbers are added to a list of missing packets and the list will be sent at the end of the data stream in a NACK packet to the originating nodes.

H. Lee, et al in 2006 discussed about reliable multi-segment transport (RMST), which is a NACK-based protocol that has mostly trigger mechanisms for automatic trigger loss and repair. It is designed for relatively long data flows from source nodes to a sink node, although it could be applied to other contexts as well. RMST combines both transport layer mechanisms and the MAC layer to achieve reliable data delivery.Paolo Santi in 2005 discussed the local minimum expansion tree protocol that is based on the location-based topology control approach and requires symmetric wireless medium where the node has the same maximum transmission power. It involves the exchange of information in which each node forms a data structure consisting of node ID and location and transmit this message to all neighbours at maximum transmission power. Create a local minimum expansion tree for each node. This message is received by the neighbours within the corresponding range of each node, trying to build their local minimum expansion tree with the help of Algorithm of Prim.

Shah et al. in 2003 have proposed a three-layer architecture. The first layer comprises sensors, while the second layer is a mobile sink (mule) that collects data when it is in the proximity of sensors, and deposits the result at the third layer, which is the access point. In their paper, the motion of mobile sink is random, which is undesirable in some applications, and it is sometimes difficult to determine latency.

Y. Sankarasubramaniam, et al in 2003 discusses congestion in the wireless sensor network. The congestion information may be sent in the form of a congestion notice bit (CN) in the packet header or in a larger format that includes the degree of congestion or data rate allowed. The congestion information can be sent in an explicit control message to notify the relevant nodes. It can also be sent

implicitly by including control information in a regular data packet.
F. Akyildiz, et al in 2002 discussed that a series of strategies can be implemented in communication protocols to reduce energy consumption in sensor networks that includes: reducing the frequency of data transmission, reducing the protocol and overloading the system , apply data compression and aggregation schemes, implement energy management mechanisms, and eliminate the transmission of redundant data.C. Intanagonwiwat, et al in 2002 indicated that failure of a node or severe network congestion can result in route changes that may also be when a new sensor node is added to the existing network. Thus, a well-designed reliable transport protocol must be able to effectively handle the case of route change or node failure and perform robust. Because the proposed protocol uses hop-by hop loss detection and recovery and can initiate the data transmission process without any additional information exchange, a newly attached node (either a newly added node or a hardly available node) in the new route) can be integrated into a route without any prior knowledge of the network.

III ENERGY EFFECIENCY IN WIRELESS SENSOR NETWORK

TifennRault, et al in 2014 indicated that the design of wireless sensor networks (WSN sustainable) is a very difficult topic. On the one hand, sensors with energy limitations are expected to operate autonomously for long periods. However, it can be a prohibitive cost to replace exhausted or even impossible batteries in harsh environments. On the other hand, unlike other networks, wireless sensor networks are designed for specific applications ranging from small-scale health surveillance systems to large-scale environmental monitoring. Therefore, any WSN implementation has to satisfy a series of requirements that vary from one application to another. In this context, a large amount of research work has been carried out in order to propose a wide range of solutions for the problem of energy saving. They presented a top-down survey of the trade-offs between application and life extension requirements that arise in the design of wireless sensor networks.

YaXu in 2001 derived a new algorithm is proposed and identified as GAF (Geographic Adaptive Fidelity). The main purpose of this algorithm is to conserve energy through load balancing. It tries to utilise redundant nodes that are equivalent for routing and alternate between them (activate/deactivate nodes) while the connectivity level is preserved.
Quang Gao et al in 2006 discussed power consumption in wireless sensor networks and focused on the linear topology for two cases. First, for the environment in which the nodes have an equal number of packets; second, where the nodes have a variable number. In addition, both cases, of the equidistance and variable distance between the nodes, have been analysed and the formula for the optimal energy consumption is provided correspondingly. The additional study towards GAF is done and it is shown that dividing the area into unequal lengths and using variable transmission oscillates between the nodes, more energy can be saved.M. Zorzi, et al in 2003 proposed a probabilistic scenario to benefit from node redundancy and achieve load balancing in order to save energy. They are interested in calculating the number of jumps involved that are necessary from the origin to the destination depending on the distance and density of the active nodes. The basic idea of this algorithm is that when the source node has a packet, it transmits to the neighbouring active nodes that are within its transmission range. This package contains the location of its own receivers and intender. After dissemination, the resubmission phase is carried out, during which the focus is on the coverage area closest to the intended destination that is divided into regions.
Xin Guan et al. in 2010 investigated energy saving for the static network when sensors are deployed randomly in an area, where the sink being outside this area. They proposed a load balancing algorithm to save energy. Their algorithm mainly consists of two steps. In the first step, sensors are classified into layers where the closest layer to the sink is labelled as layer 0 and the furthest layer is labelled as layer d. After the step of layer construction, the second step begins. In this step, each node at layer i (for i = 1; : : : ; d) selects one of the parent nodes at layer i - 1 to forward its packet. Interestingly, their formula proposed to select parent nodes for packet forwarding, which is based on the distance between the

two nodes and residual energy.Junchao Ma, et al in 2009 observed that if the consecutive time slots are assigned to the links (children) associated with the parent node, the frequent transient states are reduced substantially which lead to great energy saving and lower latency. In contiguous link scheduling, the parent node needs to start up only twice; first to receive all the data from its children consecutively, and second, to forward the received data to the upstream node. They consider only two different topologies; tree and directed acyclic graph (DAG), in their paper.

Song et al. in 2006 have addressed the problem of scheduling in WSNs for a periodic traffic pattern, and the corresponding time and energy efficient algorithm was presented. They also paid attention to alleviation of energy wastage due to idle listening and provided distributed implementing algorithm.
Marcos Stemm, et al in 2012 argued that once a packet is delivered to a target region, an internal routing scheme begins. Here a recursive forwarding geographic algorithm is generally used to broadcast the data packet to the destination node. In low traffic conditions, when recursive geographic forwarding mechanisms are not applied, since the energy drain starts rotating around the holes with the data packet looking for the destination node, a restricted flood approach is used.
Y. G. Iyer,et al in 2005 stated that with the STCP protocol, the energy cost for providing 100% reliability in a 100-node network for 100ms was 2.78 J, for 75% reliability was 1.06 J, and for 50% reliability was 0.77 J. Energy efficiency can be examined by calculating the total energy spent in the network with a certain percentile of reliability. Y. Zhou, et al in 2005 discussed about the Price-Oriented Reliable Transport Protocol (PORT), which has a design that combines the ideas of multi-path routing, rate control and rate adaptation to avoid network congestion. Based on the observation that different sources make different contributions to improving the sink's knowledge of events, PORT gives each node a price, which is defined as the energy consumed for each packet successfully delivered from the node to the sink, by all the nodes in the corresponding network path. The node price, together with link loss rates, is used to dynamically allocate the outgoing traffic to mitigate congestion.

K. Sohrabi,et al in 2000 stated that a set of algorithms are used for performing organization, management and mobility management in the network so that it avoids overhead of the network traffic. SAR adapts quickly to node failures in the network, by using an handshaking procedure that enforces routing table consistency within the upstream and the downstream neighbour on each path, such that when ever there is an failure in the network the path table gets updated so that the new paths are elected to reduce traffic overheads and loss of data by utilizing more than the required energy

CONCLUSION

In this paper, state of the art literature review on reliability and fault tolerance in WSNs has been presented. This chapter presents the background and terminology for the subjects of Reliable data transportation using load balancing in WSNs has been presented to analyse the reliable delivery of information at the sink. As explained, different techniques have been used to tackle the issue of energy consumption from different perspectives and their pros and cons have been analysed.
This paper deals with study of energy consumption issues in wireless sensor networks with tree topology during data collection, and provides the comprehensive explanation to minimise energy consumption via reducing idle listening.

In the literature, several reasons have been pointed out as the cause for wasted energy. The first one is collisions, which occur when two or more nodes try to transmit their data to the same destination node simultaneously. Indeed, the packets collide with each other and the destination node cannot receive either one correctly.The review states that an algorithm is required to organize and manage the mobility in the network so that it avoids the overhead of network traffic and node failure or severe network congestion may occur if this problem is not properly considered.
A number of strategies are discussed by various authors for the communication protocol to reduce energy consumption in sensor networks including: reduce the data transmitting frequency, reduce the protocol and system overhead, implement data compression and aggregation schemes and implement power management mechanisms.In

this review one of the important finding is that various schemes are proposed by different authors which addressed the problem of scheduling in WSNs for a periodic traffic pattern, and the corresponding time and energy efficient algorithm was presented. They also paid attention to alleviation of energy wastage due to idle listening and provided distributed implementing algorithm.The use of these sensors and the possibility of organizing them into networks have revealed many research issues and have highlighted new ways to cope with certain problems.

This study stated that WSNs are still distrusted on reliability. Monitoring critical structures such as high speed railway bridges requires the monitoring network to be highly reliable. However, there is still a lack of reliability studies of WSNs. No attempt to define an accurate fault model from experimental evidence is yet been in used for the wireless sensor network. The current scenario lacks the fault forecasting methodologies for the wireless sensor network which is been adapted for various other system in communication sector and have achieved remarkable improvements. There are various researches which exists only on the simulation and no experimental model is been standardized for such kind of system where specific applications are concerned.No attempt to make the sensor nodes intelligent enough to recall the information of interest despite of corrupted signal sensed at the destination and hence to enhance the reliability of communication.

The reliability of wireless sensor networks (WSN) is affected by faults that may occur due to various reasons such as malfunctioning hardware, software glitches, dislocation or environmental hazards, e.g. fire or flood. A WSN that is not prepared to deal with such situations may suffer a reduction in overall lifetime or lead to hazardous consequences in critical application contexts. One of the major fault recovery techniques is the exploitation of redundancy, which is often a default condition in WSNs. Another major approach is the involvement of base stations or other resourceful nodes to maintain operations after failures. Energy-efficient routing is of keen interest as evidenced through the development of protocols for Fault Tolerance in WSN utilizing routing techniques to manage energy conservation. To reduce the power associated with communications, data transmission is reduced via data aggregation. A Fault Tolerance data aggregation scheme has been proposed along with a hierarchical approach to data aggregation that is resilient to node failures.

In each of these, energy efficiency and network reliability are key aspects of developing protocols for WSN. Due to the limited power available in sensor nodes for data collection and communication, conserving energy is paramount in extending network life. Eventually, energy resources are depleted leaving the network to manage continued performance in the presence of failed or failing nodes. This in conjunction with the inherent unreliability of wireless communications has endeavoured the research community to cultivate FT mechanisms to improve the probability of successful operation and reduce the inefficiencies in lost or corrupted traffic.

Energy efficient techniques play a significant role in saving the energy. One of the techniques is the topology control mechanism. There are many existing Topology control protocols, each one is having its own advantages as well as disadvantages. After looking through this existing protocol, and decide to the protocol which reduces the total energy consumption in the network and thus maximize the life time of the network. Challenges in wireless sensor network arise in implementation of several services. Thereare so many controllable and uncontrollable parameter by which the implementationof wireless sensor network affected.

This paper thus concludes that there are lots of opportunities and scope of work to be done using fuzzy logic control in Wireless Sensor Network. There is also requirement of model which will also reduce the energy consumption and facilitate the load balancing at the sink which will help to avoid packet collision at sink receiver from the multiple sensor node and hence improve the reliability of the system and the entire network.

REFERENCES

[1] I.F. Akyildiz, W. Su, Y. SankaraSubramaniam and E. Cayirci, " Wireless sensor networks: a survey", Elsevier Computer Network,Volume 38, Issue 4, 15 March 2002, Pages 393-422.

[2]Mohd. Fauzi Othman and KhairunnisaShazali, "Wireless Sensor Network Applications: A Study in Environment Monitoring System",Elsevier Procedia EngineeringVolume 41, 2012, Pages 1204-1210.

[3]Amit Sarkar and T.SenthilMurugan, " Routing protocols for wireless sensor networks: What the literature says?", Elsevier Alexandria Engineering Journal ,Volume 55, Issue 4, December 2016, Pages 3173-3183.

[4] Kemal Akkaya and Mohamed Younis, " A survey on routing protocols for wireless sensor networks", Elsevier Ad Hoc NetworksVolume 3, Issue 3, May 2005, Pages 325-349.

[5]TifennRault, AbdelmadjidBouabdallah and YacineChalla, " Energy efficiency in wireless sensor networks: A top-down survey", Elsevier Computer NetworksVolume 67, 4 July 2014, Pages 104-122.

[6] Bushra Rashid and Mubashir Husain Rehman, " Applications of wireless sensor networks for urban areas: A survey", Elsevier Journal of Network and Computer ApplicationsVolume 60, January 2016, Pages 192-219

[7] Sameer Tilak, Nael B. Abu Ghazaleh and Wendi Hein Zelman, " A taxonomy of wireless micro-sensor network models", ACM SIGMOBILE Mobile Computing and communications , Volume 6 Issue 2, April 2002 , Pages 28 – 36.

[8] Th. Arampatzis, J. Lygeros and S. Manesis, " A Survey of Applications of Wireless Sensors and Wireless Sensor Networks", Proceedings of the 2005 IEEE International Symposium on, Mediterrean Conference on Control and Automation Intelligent Control, 2005.

[9] YaXu, John Heidemann, and Deborah Estrin. Geography-informed energy conservation for ad hoc routing. In Proceedings of the 7th Annual International Conference on Mobile Computing and Networking, MobiCom '01, pages 70-84, New York, NY, USA, 2001. ACM.

[10] Benjie Chen, Kyle Jamieson, Hari Balakrishnan, and Robert Morris. Span: An energy-efficient coordination algorithm for topology maintenance in ad hoc wireless networks. Wireless Networks, 8(5):481-494.

[11] Quang Gao, Keith J Blow, David J Holding, Ian W Marshall, and XH Peng. Radio range adjustment for energy e_cient wireless sensor networks. Ad hoc networks, 4(1):75-82, 2006.

[12]M. Zorziand R.R. Rao. Geographic random forwarding (geraf) for ad hoc and sensor networks: multihop performance. Mobile Computing, IEEE Transactions on, 2(4):337-348, Oct 2003.

[13] Xin Guan, Lin Guan, Xin Gang Wang, and TomoakiOhtsuki. A new load balancing and data collection algorithm for energy saving in wireless sensor networks. Telecommunication Systems, 45(4):313-322, 2010.

[14]Junchao Ma, Wei Lou, Yanwei Wu, Xiang-Yang Li, and Guihai Chen. Energy efficient TDMA sleep scheduling in wireless sensor networks. In INFOCOM 2009. 28th IEEE International Conference on Computer Communications, Joint Conference of the IEEE Computer and Communications Societies, 19-25 April 2009, Rio de Janeiro, Brazil, pages 630-638, 2009.

[15]F. Bouabdallah, N. Bouabdallah, and R. Boutaba. Load-balanced routing scheme for energy-e_cient wireless sensor networks. In Global Telecommunications Conference, 2008. IEEE GLOBECOM 2008. IEEE, pages 1-6, Nov 2008

[16] Wen-Zhan Song, Fenghua Yuan, and R. LaHusen. Time-optimum packet scheduling for many-to-one routing in wireless sensor networks. In Mobile Adhoc and Sensor Systems (MASS), 2006 IEEE International Conference on, pages 81-90, Oct 2006.

[17] Xuewu Dai, Peter E Omiyi, Kaan Bur, and Yang Yang. Interference-aware converge cast scheduling in wireless sensor/actuator networks for active airow control applications. Wireless Communications and Mobile Computing, 14(3):396-408, February 2014.

[18]Xinyu Zhang and Kang G Shin. E-mili: energy-minimizing idle listening in wireless networks. Mobile Computing, IEEE Transactions on, 11(9):1441{1454, 2012.

[19] Rahul C. Shah, Sumit Roy, Sushant Jain, and Waylon Brunette. Data mules: modeling and analysis of a three-tier architecture for sparse sensor networks. Ad Hoc Networks, 1(2-3):215-233, 2003.

[20]Paolo Santi, Topology control in wireless Ad-hoc and Sensor networks, Jhon Wiley and son's publication, 2005.

[21]C. Intanagonwiwat, R. Govindan, D. Estrin, J. Heidemann, and F. Silva. Directed

Diffusion for Wireless Sensor Networking. *ACM/IEEE Transactions on Networking*, 11(1):2--18, Feb. 2002

[22] H. Lee, Y. Ko, and D. Lee. A Hop-by-hop Reliability Support Scheme for Wireless Sensor Networks. In *Proc. PERCOMW '06,* Pisa, Italy, Mar. 2006, pp. 431—439

[23] J. Paek and R. Govindan. RCRT: Rate-Controlled Reliable Transport for Wireless Sensor Networks. In *Proc. ACM SenSys '07*, Sydney, Australia, Nov. 2007, pp. 305--319.

[24]Z. Rosberg, R.P. Liu, A. Y. Dong, L. D. Tuan, and S. Jha. ARQ with Implicit and Explicit ACKs in Sensor Networks. In *Proc. IEEE Globecom '08,* New Orleans, LA, Dec. 2008, pp. 1--6.

[25]Y. G. Iyer, S. Gandham, and S. Venkatesan. STCP: A Generic Transport Layer Protocol for Wireless Sensor Networks. In *Proc. IEEE ICCCN '05*, San Diego, CA, Oct. 2005, pp. 449--454.

[26]Y. Sankarasubramaniam, O. Akan, and I. Akyildiz. ESRT: Event-to-Sink Reliable Transport in Wireless Sensor Networks. In *Proc. MobiHoc '03,* Annapolis, MD, June 2003, pp. 177--188.

[27]Y. Zhou, M. R. Lyu, J. Liu, and H. Wang. PORT: A Price-Oriented Reliable Transport Protocol for Wireless Sensor Networks. In *Proc. ISSRE '05,* St. Malo, France, Nov. 2005, pp. 10--23.

[28]Mark Stemmand Randy H. Katz. "Measuring and reducing energy consumption of network interfaces in hand-held devices". IEICE Transactions on Communications, Special
Issue on Mobile Computing.

[29]N. Rahnavard, and F. Fekri. CRBcast: A Collaborative Rateless Scheme for Reliable and Energy-Efficient Broadcasting in Wireless Sensor Networks. In *Proc. ISPN '06,* Nashville, TN, April 2006, pp. 276--283.

[30]K. Sohrabi, J. Gao, V. Ailawadhi and G.J. Pottie, "Protocols for Self-Organization of a Wireless Sensor Network", IEEE Journal of Personal Communications, vol. 7, issue 5, pp. 16-27, Oct. 2000.

[31] B. Deb, S. Bhatnagar, and B. Nath. ReInForM: Reliable Information Forwarding Using Multiple Paths in Sensor Network. In Proc. LCN '03, Konigswinter, Germany, Oct. 2003, pp. 406—415

[32]A. Dunkels, J. Alonso, T. Voigt and H. Ritter. Distributed TCP Caching for Wireless Sensor Networks. In *Proc. 3rd Annual Mediterranean Ad Hoc Net. Workshop*, Bodrum, Turkey, June 2004, pp. 21—31

[33]D. Estrin. Reliability and Storage in Sensor Networks. Technical Report in CENS, UCLA, Los Angeles, CA, 2005.

[34]E. Felemban, C. Lee, E. Ekici, R. Boder, and S. Vural. Probabilistic QoS guarantee in reliability and timeliness domains in wireless sensor networks. In *Proc. IEEE INFOCOM '05*, Miami, FL, Mar. 2005, pp. 2646--2657.

[35] S. Gobriel, S. Khattab, D. Mosse, J. Brustoloni, and R. Melhem. RideSharing: Fault
Tolerant Aggregation in Sensor Networks Using Corrective Actions. In *Proc. SECON '06,* Reston, VA, Sept. 2006, pp. 595--604.

[36]Y. Gu and T. He. Data Forwarding in Extremely Low Duty-Cycle Sensor Networks with Unreliable Communication Links. In *Proc. ACM SenSys '07*, Sydney, Australia, Nov. 2007, pp. 321--334.

[37]C. Gui and P. Mohapatra. Power conservation and quality of surveillance in target tracking sensor networks. In *Proc. IEEE MobiCom '04*, Philadelphia, PA, Sept. 2004, pp. 129—143.

[38]T. He, John A. Stankovic, C. Lu, and T. Abdelzaher. SPEED: A stateless protocol for real-time communication in sensor networks. In *Proc. ICDCS '03*, Providence, RI, May 2003, pp. 46--55.

[39]C. Intanagonwiwat, R. Govindan, D. Estrin, J. Heidemann, and F. Silva. Directed Diffusion for Wireless Sensor Networking. *ACM/IEEE Transactions on Networking*, 11(1):2--18, Feb. 2002.

[40] H. Karl and A. Willig. *Protocols and Architectures for Wireless Sensor Networks.* John Wiley & Sons, 2005.

[41] S. Park, R. Vedantham, R. Sivakumar, and I. Akyildiz. A Scalable Approach for Reliable Downstream Data Delivery in Wireless Sensor Networks. In Proc. MobiHoc '04, Tokyo, Japan, May 2004, pp. 78--89.

[42] V. Raghunathan, C. Schurgers, S. Park, M. Srivastava, and B. Shaw. Energy-aware wireless microsensor networks. *IEEE Signal Processing Magazine*, 19(2):40--50, 2002.

[43] Y. Sankarasubramaniam, O. Akan, and I. Akyildiz. ESRT: Event-to-Sink Reliable Transport in Wireless Sensor Networks. In *Proc. MobiHoc '03,* Annapolis, MD, June 2003, pp. 177--188.

[44] F. Stann, and J. Heidemann. RMST: Reliable Data Transport in Sensor Networks. In *Proc. SNPA '03*, Anchorage, AK, June 2003, pp. 102--112.
[45] L. Wang, and S. Kulkarni. Proactive Reliable Bulk Data Dissemination in Sensor Networks. In *Proc. PDCS '05,* Phoenix, AZ, Nov. 2005, pp. 773--778.
[46] B. Yu, P. Scerri, K. Sycara, Yang Xu, and M. Lewis. Scalable and Reliable Data Delivery in Mobile Ad Hoc Sensor Networks. In *Proc. AAMAS '06*, Hakodate, Japan, May 2006, pp. 71--83.
[47]Prasankumarsahoo, jang- ping Sheu, Kun-Ying Hsieh, Power control based topology construction for the distributed wireless sensor networks, Computer Communication 30(2007)2774-2785.
[48] Ram Ramanathan, Regina Rosales-Hain, Topology Control of Multihop Wireless Networks using Transmit Power Adjustment, Internetwork research department, BBN Technologies Cambridge, Massachusetts, (IEEE Infocom*2000)* 2000; 404-413.
[49] Paolo Santi, Topology control in wireless Ad-hoc and Sensor networks, Jhon Wiley and son's publication, 2005.
[50] Carlos de MoraisCordeiro, Dharma Prakash Agrawal ,Ad-hoc and sensor networks theory
and application, World Scientific publication,2006.