International Journal of Advanced Trends in Computer Applications
www.ijatca.com

A Survey on Energy Efficient Routing Techniques in Wireless Sensor Networks

[1]Satvinder Kaur, [2]Khushboo Bansal
[1,2]Department of Computer Science & Engineering
DeshBhagat University, MandiGobindgarh, Punjab, India
[1]satvinderkaur30@gmail.com

Abstract: *Sensor networks have become an emerging new tool for habitat monitoring in nature preserves, it monitors and grouping events in unhealthy environments, it does the work of buildings surveillance, monitoring the enemy activities in a fight field environment. Sensor nodes have less storage capacity, limited energy resources and they are energy constrain. To designing the efficient routing protocol is difficult in order to prolong the lifetime of the sensor nodes. Sensor networks are mainly designed for controlling and reporting events though sensor nodes are application dependent, designing a single routing protocol cannot be effective for sensor networks for all applications. In this paper, we first analyze the requirements, closeness and distinguish between sensors networks and MANETs (Mobile Ad hoc Networks). Cluster formation reduces the nodes involved in transmission &conserves the energy. The cluster based protocols are energy efficient & prolong the network lifetime when compared to other protocols.*

Keywords: *Wireless Sensor Networks, Cluster, Energy Efficient, Routing Protocols.*

I. INTRODUCTION

Wireless Sensor Networks (WSNs) is belongs to the wireless ad hoc networks in which sensor nodes gather, process, and communicate data get from the physical environment to an external Base-Station (BS). Future WSNs are envisioned to restructure a maintenance free and fault-tolerant platform for gathering and processing information in diverse environments. A main technical challenge for WSNs, however, lies in the node energy constraint and its less computing resources, which may produce a fundamental limit on the network lifetime[1].Therefore, innovative techniques to remove energy in efficiencies that would otherwise reduce the life time of the network are highly needed.

In various applications of WSNs (e.g., military battlefields, target field imaging, intrusion detection, surveillance, and inventory control), many sensors collects the data on the basis of common phenomena and therefore there is a high probability that this data has some redundancy (or correlation). Because of the correlation exist in the sensors' readings, it is expected that communication approaches that take into account this correlation, e.g., data aggregation and in-network processing, will better perform traditional approaches. The main idea of the data aggregation and in-network processing approaches is to merge the data coming from different sources (sensor nodes) at certain aggregation points (or simply aggregators) en route, remove redundancies by performing simple processing at the aggregation points, and reduce the total amount of data transmission before sending data to the external BS.

Eliminating redundancies results in transmitting fewer numbers of bits, and therefore minimize energy consumption and maximize the lifetime of sensor nodes. A lot of studies that compared aggregation scheme, e.g., [2–5] give the result that enhanced network throughput and more potential energy savings are highly possible using data aggregation and in-network processing in WSNs. A side from the task of efficient design of data aggregation algorithms, the task of searching and maintaining routes in WSNs is also nontrivial [2], especially when it adds the selection of aggregation points and giving the route through those points. Many routing and data distribution with aggregation protocols have proposed for WSNs (a comprehensive survey of the routing techniques in WSNs can be found in [2]). In [3], Intanagonwiwat et al. proposed a data aggregation paradigm for WSNs, called Directed Diffusion (DD) where aggregation is used to minimize the communication costs.

II. RELATED WORK

There is a large number of current works, as well as efforts that are on the go, for the development of routing protocols in WSNs. These protocols are developed based on the application needs and the architecture of the network. However, there are factors that should be taken into consideration when developing routing protocols for WSNs. The most important factor is the energy efficiency of the sensors that directly affects the extension of the lifetime of the network. There are several surveys in the literature on routing protocols in WSNs and an attempt is made to present below and discuss the existing differences between them and our work.

In [5], Heinzelman et al. studied a hierarchical clustering algorithm for WSNs, called Low Energy Adaptive Clustering Hierarchy (LEACH). LEACH is a protocol which is based on cluster where ClusterHead (CH) nodes reduce data coming from nodes that relates to the respective cluster, and send an aggregated packet to the BS. Using these protocols, many other studies focused on the routing problem [6–8]. Among these, [9] introduced a linear programming formulation to solve the problem optimal routing problem WSNs. The objective was to increase the network life time, and the life time was explained as the network operational time until one of the nodes fails. Necessary, but not sufficient, conditions or rules for the existence of a solution under arbitrary traffic generation processes were produced. A heuristic solution was also presented. However, no aggregation was assumed.

In [10], aggregation was brought into account, but only full aggregation was considered. That is, regardless of the number of packets to be aggregated, a single packet will always be produced. This simplifies the problem of aggregation significantly. A special case of half aggregation, in which the aggregated data size is equal to the less of the original data, and a maximum size, was considered in [11]. A heuristic was used for this case.

In [12], heuristics as well as an approximation algorithm were used to select the minimum number of sensors which would form the minimum connected correlation dominating set. these a set is used to infer readings from other sensors (with an acceptable error), and also send data towards the data collection center. The network lifetime was not explicitly addressed in this paper. The authors in [13] proposed a Voronoi detection method that utilizes distributed Voronoi diagram and genetic algorithms to gather data in WSNs, while [14] considers maximizing large scale Wireless Sensor Networks lifetime under energy constraint via connection relay deployment and adaptation. In [15], many lossless aggregate repacking algorithms for cluster-model Wireless Sensor Networks were presented. In [16], an energy-efficient data gathering scheme that prolongs the lifetime of battery-powered sensor nodes is considered. The proposed scheme makes a spanning tree which is based on breadth-first search and has more leaf nodes in network.

Kalpakis et al. [17] presented algorithms for the Maximum Lifetime Data Aggregation (MLDA) problem with the objective of increasing the system lifetime. A near optimal algorithm for solving the MLDA problem was proposed in [17]. Since this algorithm is computationally expensive for large sensor networks, authors proposed a clustering based heuristics approaches (CMLDA) for MLDA in large scale WSNs. Experimental results of MLDA demonstrated enhanced system lifetime of WSNs. A recent survey of strategies and protocols for routing correlated data can be found in [18]. To the best of our knowledge, the joint optimization of the routing and data aggregation functions were not carried out in the literature, especially for the general case of partial aggregation.

In [19], the authors make a comprehensive survey on design issues and techniques for WSNs (2002). They describe the physical constraints of sensor nodes and the proposed protocols concern all layers of the network stack. Moreover, the possible applications of sensor networks are discussed. However, the paper does not make a classification for such routing protocols and the list of discussed protocols is not meant to be complete, given the scope of the survey. Our survey is more focused on the energy efficiency on WSNs providing at the same time a classification of the existing routing protocols. We also discuss a number of developed energy-efficient routing protocols and provide directions to the readers on selecting the most appropriate protocol for their network.

In [20], a survey on routing protocols in WSNs is presented (2004). It classifies the routing techniques, based on the network structure, into three categories: flat, hierarchical, and location-based routing protocols. Furthermore, these protocols are classified into multipath-based, query-based, negotiation based, and QoS-based routing techniques depending on the protocol operation. It presents 27 routing protocols in total. Moreover, this survey presents a good number of energy efficient routing protocols that have been developed for WSNs and was published in 2004. It also presents the Routing Challenges and Design Issues that have to be noticed when using WSNs. Thus, limited energy supply, limited computing power and limited bandwidth of the wireless links connecting sensor nodes are described. Also, the authors try to highlight the design tradeoffs between energy and communication overhead savings in some of the routing paradigm, as well as the advantages and disadvantages of each routing technique. On the contrary, in our work we focus on the energy efficiency issues in WSNs. We provide details and comprehensive

comparisons on energy efficient protocols that may help researchers on their work. Also, in this paper we expand the classification initially proposed by Al-Karaki in order to enhance all the proposed papers since 2004 and to better describe which issues/operations in each protocol illustrate/enhance the energy-efficiency issues.
The survey in [21] discusses few routing protocols for sensor networks (24 in total) and classifies them into data-centric, hierarchical and location-based (2005). Although it presents routing protocols for WSNs it does not concentrate on the energy efficient policies. On the contrary, we focus mainly on the energy-efficient routing protocols discussing the strengths and weaknesses of each protocol in such a way as to provide directions to the readers on how to choose the most appropriate energy-efficient routing protocol for their network.

In [22], authors provide a systematical investigation of current state-of-the-art algorithms (2007). They are classified in two classes that take into consideration the energy-aware broadcast/multicast problem in recent research. The authors classify the algorithms in the MEB/MEM (minimum energy broadcast/multicast) problem and the MLB/MLM (maximum lifetime broadcast/multicast) problem in wireless ad hoc networks. Typically, the two main energy-aware metrics that are considered are: minimizing the total transmission power consumption of all nodes involved in the multicast session and maximizing the operation time until the battery depletion of the first node involved in the multicast session. Moreover, each node in the networks is considered to be equipped with an omni-directional antenna which is responsible for sending and receiving signals.
The survey in [23], presents a top-down approach of several applications and reviews on various aspects of WSNs (2008).It classifies the problems into three different categories: internal platform and underlying operating system, communication protocol stack, network services, provisioning, and deployment. However, the paper neither discusses the energy efficient routing protocols developed on WSNs nor provides a detailed comparison of the protocols. Our work is a dedicated study on energy-efficient routing protocols and provides directions to the readers on selecting the most appropriate protocol for their network.

In [24], the authors present a survey that is focused on the energy consumption based on the hardware components of a typical sensor node (2009). They divide the sensor node into four main components: a sensing subsystem including one or more sensors for data acquisition, a processing subsystem including a micro-controller and memory for local data processing, a radio subsystem for wireless data communication and a power supply unit. Also the architecture and power breakdown as the solution to reduce power consumption in wireless sensor networks is discussed. They provide the main directions to energy conservation in WSNs. The paper is focused on the description of the characteristics and advantages of the taxonomy of the energy conservation schemes. The protocols are classified into duty-cycling, data-driven and mobility based. In the next protocols, more details and discussion are presented of this classification. Moreover, they provide observations about the different approaches to energy management and highlight that the energy consumption of the radio is much higher than the energy consumption due to data sampling or data processing. However, many real applications have shown the power consumption of the sensor is comparable to, or even greater than, the power neededby the radio. They conclude that the sampling phase may need a long time especially compared to the time needed for communications, so that the energy consumption of the sensoritself can be very high as well. Also they observe an increasing interest towards sparse sensor network architecture. In our work, we basically focus on the energy-efficient protocols and we discuss the strengths and weaknesses of each protocol that can provide directions to the readers about the most appropriate energy-efficient routing protocol for their network.

In [25], the design issues of WSNs and classification of routing protocols are presented (2009). Moreover, a few routing protocols are presented based on their characteristics and the mechanisms they use in order to extend the network lifetime without providing details on each of the described protocols. Also, the authors do not present a direct comparison of the discussed protocols. In our work we do not only focus on the energy-efficient protocols but we also discuss the strengths and weaknesses of each protocol in such a way as to provide directions to the readers on how to choose the most appropriate energy-efficient routing protocol for their network.

In [26] authors proposed the concept of constructing minimum spanning tree among the various nodes that are dispersed in the wireless sensor field. They claimed to consume minimum energy by constructing minimum spanning tree among the sensor nodes & thus reducing the cost of transmission between the nodes. This method increased system lifetime to great extent because of equal distribution of load among the sensor nodes & hence it is going to increase system’s stable lifetime too. This protocol’s architecture is suitable for both the scenarios when BS is placed inside as well as outside the sensor field.

The paper in [27] presents the challenges in the design of the energy-efficient Medium Access Control (MAC) protocols for the WSNs (2009). Moreover, it describes few MAC protocols (12 in total) for the WSNs emphasizing their strengths and weaknesses, wherever possible. However, the paper neither discusses the energy-efficient routing protocols developed on WSNs nor provides a detailed comparison of the protocols. Our survey is concentrated on the energy-efficient routing protocols discussing the strengths and weaknesses of each protocol in such a way as to provide directions to the readers on how to choose the most appropriate energy-efficient routing protocol for their network.

In [28], few energy-efficient routing techniques for Wireless Multimedia Sensor Networks (WMSNs) are presented (2011).Also the authors highlight the performance issues of each strategy. They outline that the design challenges of routing protocols for WMSNs followed by the limitations of current techniques designed for non-multimedia data transmission. Further, a classification of recent routing protocols for WMSNs is presented. This survey discusses some issues on energy efficiency in WSNs. However, it is mostly based on the energy efficient techniques combining QoS Assurance for WMSNs. Although, there are a good number of surveys for sensor networks, or routing and MAC algorithms for WSNs ([19-27]), this paper provides an analytical survey emphasizing on the energy-efficient routing protocols in WSNs. Our survey is focused on the energy efficient routing protocols in WSNs that can provide directions to the readers on how to choose the most appropriate energy efficient routing protocol for their network. Moreover, our work reflects the current state of the art in routing research by including a comprehensive list of recently proposed routing protocols. Moreover, we discuss the strengths and weaknesses of each protocol making a comparison between them including some metrics (scalability, multipath, mobility, power usage, route metric, periodic message type, robustness and QoS support).

Here is a list of the most common factors affecting the routing protocols design [29]:

• Node Deployment: Node Deployment is an application-dependent operation which affects the routing protocol performance, and it can be either deterministic or randomized.

• Node/Link Heterogeneity: The existence of heterogeneous set of sensors increase many technical problems which is belongs to data routing and they have to be overcome.

• Data Reporting Model: In Data Reporting Model, Data sensing, measurement and reporting in WSNs rely on the application and the time criticality of the data reporting. Data reporting can be either time-driven (continuous) or event-driven, query-driven, and hybrid.

• Energy Consumption without Losing Accuracy: In this case, energy-conserving mechanisms of data communication and processing are more than necessary.

• Scalability: WSNs routing protocols should be scalable enough to respond to events, e.g. large increase of sensor nodes, in the environment.

• Network Dynamics: Mobility of sensor nodes is important in many applications, because most of the network architectures assume that sensor nodes are stationary.

• Fault Tolerance: The overall task of the sensor network should not be affected by the failure of sensor nodes.

• Connectivity: The connectivity of sensor node depends on the random distribution of nodes.

• Transmission Media: In a multi-hop WSN, communication among nodes takes place by wireless medium. One approach of MAC design for sensor networks is to use TDMA based protocols that conserve more energy compared to contention-based protocols like CSMA (e.g., IEEE802.11).

• Coverage: In WSNs, a given sensor's view of the environment is limited both in range and in accuracy; it can only cover a limited physical area of the environment.

• Quality of Service: Data should be delivered within a certain period of time. However, in a good number of applications, conservation of energy, which is directly related to network lifetime, is considered relatively more important than the quality of data sent. Hence, energy aware routing protocols are required to capture this requirement.

• Data Aggregation: it is the collection of data from different sources according to a certain aggregation function, e.g. duplicate suppression.

ROUTING TECHNIQUES IN WSNS - CLASSIFICATION

Routing in WSNs may be more useful than other wireless networks, like mobile ad-hoc networks or cellular networks. Due to the following reasons:

• Sensor nodes needs a careful resource management because of their severe constraints in energy, processing and storage capacities.

• Most applications of WSNs require the flow of sensed data from number of sources to a specific base station.

• Design requirements of a WSN depend on the application, because WSNs are application-specific.

• The nodes in WSNs are mostly stationary after their deployment which results in predictable and non-frequent topological changes.

• Position awareness of sensor nodes is necessary for collecting the data under normal condition and based on the location. The position of the sensor nodes is identifying by using methods based on triangulation e.g. radio strength from a some known points. Global Positioning System (GPS) hardware used for timing purpose. Moreover, it is favorable to have solutions independent of GPS for the location problem in WSNs [30].

• In WSNs, there is a high probability that collected data may produce some undesirable redundancy which is required to be exploited by the routing protocols to improve energy and utilization of bandwidth.

III.NETWORK STRUCTURE SCHEME

A. Flat Networks Routing Protocols

The WSNs Flat Networks Routing Protocols can be categorized into three main different categories according to the routing schema: Pro-active protocols, Re-active protocols and Hybrid protocols [31]. All these protocols different in various ways and do not have the same characteristics, although they designed for the same underlying network. According to another classification presented in the literature, Flat Networks routing protocols for WSNs can be classified Table-driven and Source-initiated (or Demand-driven) (Pro-active and Re-active routing protocols).

B. Hierarchical Networks Routing Protocols

In flat protocols each node has its unique global address and all the nodes are peers, in hierarchical protocols, nodes are collected into clusters. Each cluster has one cluster head. The cluster head is chosen based on various election algorithms. The cluster heads are choose for higher level communication, decrease the traffic overhead. Clustering can be extended to more than just two levels having the same concepts of communication in every level. Various advantages to using routing hierarchy. It decreases the size of routing tables producing better scalability.

C. Comparison of Flat and Hierarchical Protocols

The simulation results in [32] show that WRP gives about 50 percent improvement in the convergence compared to the Bellman-Ford. A TORA protocol decreases its complexity as compared to WRP. In TORA, first node is run out of power at 205sec and all nodes die at 800sec at the network. The simulation results in [33] show that TORA was found to have a better delivery ratio and better delay, ranging from 0,0025 to 0,00125 seconds, compared toWRP.

But E-TORA compared to TORA can balance effectively energy consumption of each node and maximize the lifetime of the network [34]. Moreover, the first node at the network runs out of power at 210sec.On the other hand, the simulation results in [35] present that Flooding has a delivery ratio up to 100 percent and the delay varies from 100ms to 180ms. However, the TBRPF get up to a 98 percent decrement in communication cost in a 20-node network and the ZRP can decrease up to 95 percent the control packets compared to Flooding. One of the most useful protocol, the gossip, requires no structure to operate [36]. This makes it particularly appealing to apply in dynamic systems, where topology changes are common. Therefore, it appears particularly well fit to operate in wireless self-organizing networks.

RR is another protocol which delivers 98.1 percent of all queries, with an average cost of 92 cumulative hops per query or about 1/40 of a network flood and can get significant savings over event flooding [37]. If the number of queries per event is less than ten, a smaller setup cost is better than a smaller per-query delivery cost. On the other hand, if we want to send more queries for example 40, a larger investment in path building yields will take better results. The delivery is guaranteed, as undelivered queries are flooded.

IV. CONCLUSION

WSNs have greatly expanded from early days playing an important role for the data efficient selection and their delivery. The energy efficiency is a very important issue for the networks especially for WSNs which are characterized by less battery capabilities. The complexity and reliance of corporate operations on WSNs need the use of energy-efficient routing techniques and protocols, which will guarantee the network connectivity and routing of information with the limited required energy.

In this paper, we study on the energy efficient protocols that have been developed for WSNs. We categorized them in flat & hierarchical techniques for transmission of data. The flat protocol is an ideal solution for a small network with fixed nodes. However, in a large network they become infeasible because of link and processing overhead. The hierarchical protocols try to solve the infeasible problem of large network and to present scalable and efficient solutions. They classify the network into clusters and to efficiently maintain the energy consumption of sensor nodes and perform aggregation and fusion on data in order to decrease the number of transmitted messages to the sink. The clusters are made based on the energy reserve of sensors and proximity of sensors to the cluster head. Thus, hierarchical protocols are suitable for sensor networks with excessive load and broad coverage area. On the other hand, the location based protocols are useful for high dynamic networks as they do not require a state in routers nor in packet header and it do not cause flood in the search. They use location information to calculate the distance among nodes, thus decreasing the energy consumption and extend the lifetime of the network.

Therefore, the application of the proper routing protocol will increase the network lifetime and at the same time it will ensure the network connectivity and efficient data delivery.

REFERENCES

[1] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, E. Cyirci, Wireless sensor networks: a survey, Computer Networks 38 (4) (2002) 393– 422.

[2] S. Madden, M. Franklin, J. Hellerstein, W. Hong, TAG: a tiny aggregation service for ad hoc sensor networks, OSDI 2002, Boston MA, December 2002.

[3] J.N. Al-Karaki, A.E. Kamal, Routing techniques in wireless sensor networks: a survey, IEEE Wireless Communications 11 (6) (2004) 6– 28. Dec..

[4] C. Intanagonwiwat, R. Govindan, D. Estrin, Directed diffusion: a scalable and robust communication paradigm for sensor networks, in: Proceedings of ACM MobiCom'00, Boston, MA, 2000, pp. 56–67.

[5] B. Krishnamachari, D. Estrin, S. Wicker, Impact of data aggregation in wireless sensor networks, in: International Workshop on Distributed Event-Based Systems, Vienna, Austria, July 2002.

[6] W.R. Heinzelman, A. Chandrakasan, H. Balakrishnan, Energy efficient communication protocol for wireless microsensor networks, in: Proceedings of HICSS'00, January 2000.

[7] A. Manjeshwar, D.P. Agarwal, TEEN: a routing protocol for enhanced efficiency in wireless sensor networks, in: First International Workshop on Parallel and Distributed Computing-Issues in Wireless Networks and Mobile Computing, April 2001.

[8] A. Manjeshwar, D.P. Agarwal, APTEEN: a hybrid protocol for efficient routing and comprehensive information retrieval in wireless sensor networks, in: Proceedings of IEEE IPDPS 2002, pp. 195–202.

[9] J.H. Chang, L. Tassiulas, Maximum lifetime routing in wireless sensor networks, IEEE/ACM Transaction on Networking 12 (4) (2004) 609–619. Aug..

[10] K. Kalpakis, K. Dasgupta, P. Namjoshi, Maximum lifetime data gathering and aggregation in wireless sensor networks, in: Proceedings of IEEE Networks, 2002.

[11] C. Buragohain, D. Agrawal, S. Suri, Power aware routing for sensor databases, in: Proceedings of IEEE Infocom, 2005.

[12] H. Gupta, V. Navda, S. Das, V. Chowdhary, Efficient gathering of correlated data in sensor networks, in: Proceedings of ACM MobiHoc'05, pp. 402–413.

[13] J. Hung-Chin, H. Lee, Efficient energy management to prolong wireless sensor network lifetime, in: Third IEEE/IFIP International Conference in Central Asia on Internet, 26–28 September 2007, pp.1–4.

[14] F. Sun, M. Shayman, Prolonging network lifetime via partially controlled node deployment and adaptive data propagation in WSN, in: Annual Conference on Information Sciences and Systems, 14–16 March 2007, pp. 226-231.

[15] S. Basagni, A. Carosi, E. Melachrinoudis, C. Petrioli, Z.M. Wang, A new MILP formulation and distributed protocols for wireless sensor networks lifetime maximization, in: IEEE International Conference on Communications, vol. 8, June 2006, pp. 3517–3524.

16] J. Chen, L. Gong, P. Zeng, Y. Yang, Several repacking algorithms for data aggregation in wireless sensor network, in: IEEE International Conference on Information Acquisition, 2006, pp. 632–637.

[17] J.N. Al-Karaki, A.E. Kamal, Efficient virtual-backbone routing in mobile ad hoc networks, Elsevier Computer Networks 52 (2) (2008) 327–350.

[18] H. Luo, Y. Liu, S.K. Das, Routing correlated data in wireless sensor networks: a survey, IEEE Network 21 (6) (2007) 41–47.

[19] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, E. Cayirci, "Wireless Sensor Networks: A Survey," Computer Networks, 2002, Vol. 38, Issue 4, pp. 399-422.

[20] Al-Karaki, A. Kamal, "Routing Techniques in Wireless Sensor networks: A Survey," Security and Networks, 2004, Vol. 11, Issue 6, pp.6-28.

[21] K. Akkaya, M. Younis, "A Survey on Routing Protocols for Wireless Sensor Networks," Ad Hoc Network, Elsevier, 2005, Vol. 3, Issue 3, pp. 325-349.

[22] S. Guo, O. Yang, "Energy-Aware Multicasting in Wireless Ad hoc Networks: A Survey and Discussion," Computer Communications, Elsevier, 2007, Vol. 30, Issue 9, pp. 21292148.

[23] J. Yick, B. Mukherjee, D. Ghosal, "Wireless Sensor Network Survey," Computer Networks, 2008, Vol. 52, Issue 12, pp. 2292-2330.

[24] G. Anastasi, M. Conti, M. Francesco, A. Passarella, "Energy Conservation in Wireless Sensor Networks: A survey," Ad Hoc Networks, 2009, Vol. 7, Issue 3, pp. 537-568.

[25] R .V. Biradar, V. C.Patil, S. R. Sawant, R. R. Mudholkar, "Classifiacation and Comparison of Routing Protocols in Wireless Sensor Networks," Special Issue on Ubiquitous Computing Security Systems, 2009, Vol. 4, Issue 2, pp. 704-711.

[26] Gaurav Bathla, Gulista Khan, "Energy- efficient Routing Protocol for Homogeneous Wireless Sensor Networks", International Journal on Cloud Computing: Services and Architecture (IJCCSA), Vol. 1, No. 1, May 2011, page 12-20.

[27] R. Yadav, S. Varma, N. Malaviya, "A Survey of MAC Protocols for Wireless Sensor Networks," UbiCC Journal, 2009, Vol. 4, Issue 3, pp. 827-833.

[28] S. Ehsan, B. Hamdaoui, "A Survey on Energy-Efficient Routing Techniques with QoS Assurances for Wireless Multimedia Sensor Networks," IEEE Commun. Surveys Tuts., 2011, Vol. 14, Issue 2, pp. 265-278.

[29] L. Junhai, X. Liu, Y. Danxia, "Research on Multicast Routing Protocols for Mobile ad-hoc Networks," Computer Networks, 2008, Vol. 52, Issue 5, pp. 988-997.

[30] A. Savvides, C. Han, M. Srivastava, "Dynamic Fine-Grained Localization in Ad-Hoc Networks of Sensors," In Proc. 7th ACM Annual International Conference on Mobile Computing and Networking (MobiCom), Italy, 2001, pp. 166-179.

[31] P. Arce, J. Guerri, A. Pajares, O. Lazaro, "Performance Evaluation of Video Streaming Over Ad Hoc Networks Using Flat and Hierarchical Routing Protocols," Book:Mobile Networks and Applications, 2008, pp. 324-336.

[32] S. Murphy, L. Aceves, "An Efficient Routing Protocol for Wireless Networks," Mobile Networks and Applications,

ACM Journal, USA, Hingham, 1996, Vol. 1, Issue 2, pp. 183-197.

[33] S. Giannoulis, C. Antonopoulos, E. Topalis, S. Koubias, "ZRP versus DSR and TORA: A comprehensive survey on ZRP performance," In Proc. 10th IEEE Conference on Emerging Technologies and Factory Automation, Catania, 2005, pp. 1017-1024.

[34] F. Yu, Y. Li, F. Fang, Q. Chen, "A New TORA-Based Energy Aware Routing Protocol in Mobile Ad Hoc Networks," In Proc. 3rd IEEE/IFIP International Conference in Central Asia on Internet (ICI), Tashkent, 2007, pp. 1-4.

[35] H. Lim, C. Kim, "Flooding in Wireless Ad Hoc Networks," Computer Communications, 2001, Vol. 24, Issue 3, pp. 353-363.

[36] S. Hedetniemi, A. Liestman, "A Survey of Gossiping and Broadcasting in Communication Networks," Book:Networks, 1998, Vol. 18, Issue 4, pp. 319-349.

[37] D. Braginsky, D. Estrin, "Rumor Routing Algorithm for Sensor Networks," In Proc. 1st ACM International Workshop on Wireless Sensor Networks and Applications, USA, Atlanta, 2002, pp. 22-31.