International Journal of Contemporary Research in Computer Science and Technology (IJCRCST) ISSN: 2395-5325
Volume 3, Special Issue 1 (February '2017)
Special Issue on 1st National Conference on Advanced Computing and Communication Technologies,
Conference held at Siri PSG Arts and Science College for Women, Sankari,Tamilnadu,India.

A COMPARATIVE STUDY OF QUALITY OF SERVICE ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORKS

V.Vijayalakshmi,
Assistant Professor,
Department of Computer Science,
M.G.R.College,
Hosur,Tamilnadu,India.

Dr.A.Senthilkumar,
Assistant Professor,
Department of Computer Science,
Arignar Anna Govt Arts College,
Namakkal,Tamilnadu,India.

Abstract: A typical Wireless Sensor Network is built of several hundreds or even thousands of sensor nodes. Each node has the ability to communicate with every other node wirelessly, thus a typical sensor node has several components like transceiver, microcontroller. Routing is the fundamental operation in WSN that facilitate the establishment of communication links between Sensor nodes and a packet delivery. Designing such QoS based routing protocol to meet the reliability and delay guarantee of critical events while preserving the energy efficiency is a challenging task. Considerable research has been focused on developing robust energy efficient QoS based routing protocols. In this paper, we present QoS Challenges and compare QoS routing protocols.

Keywords: Wireless Sensor Networks, Quality of Service, Reliability, Energy Efficiency

I. INTRODUCTION

In the recent years, the rapid technological advances in micro electro-mechanical systems, low power and highly integrated digital electronics, small scale energy supplies, tiny microprocessors, and low power radio technologies have created low power, low cost, and multifunction-al wireless sensor devices. These devices can collect the data by sensing the ambient conditions in its vicinity and send the sensed data to the sink or base station along the pre-established routes through multiple wireless hops. These sensor devices run on a small battery, a tiny microprocessor, a radio transceiver, and a set of transducers [1]. Generally these sensors are equipped with data processing and communication capabilities. The emergence of these low cost and small sized wireless sensor devices has motivated intensive research in the last decade that addresses the potential of collaboration among sensors in data gathering and processing, which led to the invention of Wireless Sensor Networks (WSNs). With the increasing deployment of large sensor networks, we envision them to be multipurpose with sensor nodes that exploit their multiple sensing capabilities to serve a wide range of applications such as target tracking for the military [2] habitat monitoring in forests [3, 4] detecting moisture levels in agriculture; monitoring the statistics of the patient in health monitoring[5] vehicular and traffic monitoring [6, 7] building and industrial monitoring; explosion detection; intrusion detection; and so on.

However, the sensor output of each application anticipates a diversified data delivery service from the network infrastructure. For example, the information of a potential chemical leak is more important than knowing that everything is fine, and the information should be highly reliable with a low latency. Similarly, in forest monitoring applications, the sensor data that contains an abnormally high temperature should be delivered to the base station with a high reliability in limited time duration, since it can be a sign of a fire. On the other hand the temperature information that is in the range of normal temperature levels can be delivered to the base station with a certain delay and loss percentage. The real-time application, along with the introduction of imaging and video sensors, has posed additional challenges. For instance, the transmission of imaging and video data requires careful handling in order to ensure that end-to-end delay is within the acceptable range and that the variation in such delays is acceptable. These examples manifest that sensor network applications have periodic (non real time: NRT) and critical data (real time: RT). Critical data is delay sensitive and it has to be delivered to the base station with high reliability so that immediate remedial and defensive actions can be taken. Whereas, period-ic data is delay tolerant and a certain loss percentage is tolerable on delivery. The delay and reliability are the performance metrics and are usually referred to as the QoS requirements of the critical data. Therefore, power constrained sensor networks for real time applications demand energy and QoS aware routing protocol to deliver critical data with low latency and high reliability. Thus, QoS routing is an important topic in sensor network research and the WSN research community has focused on it. This paper briefly reviews the various QoS based routing protocols that have been proposed for the WSN. In Section 2 we present the taxonomy of routing protocols based on the protocol operation. The challenges in implementing those protocols in a resource constrained WSN are discussed in Section 3. In particular, Section 4 lists the various QoS based protocols and their operations. The performance of the SAR, MMSPEED, MCMP, MCBR, and EQSR protocols are compared and analyzed in Section 5, and Section 6 concludes the paper.

II. THE TAXONOMY OF ROUTING PROTOCOLS

Many routing solutions that have been specifically designed for WSNs have been proposed [8, 9]. In these proposals, the unique properties of the WSNs have been taken into account. These routing techniques can be classified according to the protocol operation as negotiation based, query based, QoS based, and multi-path based, as depicted in Fig. 1.The negotiation based protocols have the objective to eliminate the redundant data by including high level data descriptors in the message exchange. In query based protocols, the sink node initiates the communication by broadcasting a query for data over the network. The multipath based protocols were initiated with objectives to provide reliability and to balance the traffic load in the network [10-12]. These protocols use multipaths in order to achieve better energy efficiency and network robustness in case of node failures. Multi-path routing protocols have been discussed in WSN literature for several years now [1

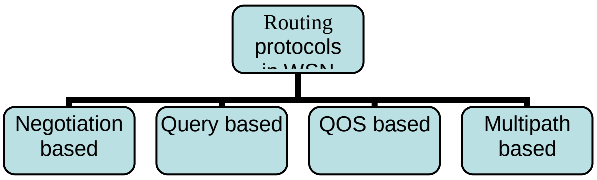

Fig. 1. Classification of routing protocols based on protocol operation in the WSN

QoS based protocols allow sensor nodes to balance between the energy consumption and certain pre-determined QoS metrics, such as delay, energy, reliability, bandwidth, etc., before they deliver the data to the sink node.

III. QOS ROUTING CHALLENGES

However, a wireless sensor network is resource constrained [1] and poses many challenges while designing an efficient routing protocol for deadline-driven traffic. Due to the limited battery power of the sensor nodes, it is extremely important that the routing be energy efficient, in order to increase in the lifetime of the network. Besides limited energy, there are other factors that hinder the goal of transferring time-critical information reliably across the network. In this section, some of the factors of WSNs that challenge QoS provisioning will be further explained in detail below. In addition to energy constraints, each sensor node has low processing capability, low memory power, and limited transmission energy. As a result, these constraints impose an essential requirement on any QoS support mechanisms in WSNs: simplicity. In most WSN applications, traffic mainly flows from a large number of sensor nodes to a small subset of sink nodes. QoS mechanisms should be designed for unbalanced QoS-constrained traffic. WSNs are characterized by high redundancy in the sensor data. However, while the redundancy in the data does help loosen the reliability/robustness requirement of data delivery, it un-necessarily spends a great amount of precious energy. Data fusion or data aggregation is a solution to maintain robustness while decreasing redundancy in the data. However, this mechanism also introduces latency and complicates the QoS design in WSNs. In sensor networks, nodes, as well as sink nodes, frequently change their position and due to the use of power management and energy efficient schemes a node state transition occurs, which leads to node failure, which makes QoS provisioning complex. In order to increase the lifetime of a network, the energy load must be evenly distributed among all sensor nodes so that the energy in a single sensor node or a small set of sensor nodes will not be drained too quickly. QoS support should take this factor into account.

WSNs are designed to collect various types of data. For instance, a sensor network can be de-signed to simultaneously monitor the changes in temperature, pressure, or humidity at a location leading to a different set of QoS parameters defined for each of the sensed data. Therefore, provisioning QoS in case of heterogeneous traffic can become quite complex. The content of the data or a high-level description reflects the criticality of the real physical phenomena and is thereby different criticality or priority with respect to the quality of the applications [14]. QoS mechanisms may be required to differentiate packet importance and to set up priority structure. As a result, QoS support for the network may have to take at least a few of the challenges described above into account when an application is specified.

IV. QOS ROUTING PROTOCOLS

Recently, a few research projects have started to address the support of QoS requirements in WSNs. In this section, we present the state of the research by summarizing work that has already been published and by highlighting the QoS issues that are being addressed. Some QoS oriented routing proposals are surveyed in [15, 16].

Multipath Routing Protocol: Initially, the Multipath based routing protocols proposed in [10-12], tend to enhance the reliability through multiple paths. Rather than using a single path, multiple paths are established between the source-destination pair. This is done in order to support the quality of service. These protocols primarily focus on load balancing, fault tolerance, bandwidth aggregation, and reduced delay. However, even though multipath routing protocol provides these benefits, the main problem associated with multipath routing is route coupling. In [17], the problem of route coupling has been studied and a measure for the coupling between two routes using a correlation factor has been proposed. An N-to-1 multipath discovery protocol is proposed in reference [18], which finds different node-disjoint paths between a sink and a source node. These alternative routes are used to distribute traffic in order to improve the reliability and the security of the data transmission.

SAR Protocol: One of the routing protocols that were proposed early on, which provides some QoS, is the Sequential Assignment Routing (SAR) protocol [19]. The objective of the SAR algorithm is to make the network energy-efficient and fault tolerant. SAR uses multihop routing and maintains routing tables to record information about its neighbors. To create multiple paths from each node to the sink, multiple trees are constructed, rooted from one-hop neighbor of the sink. For path selection, SAR takes into account the energy resource, the QoS on each path, and the priority level of a packet. For each packet in a network, SAR calculates the weighted QoS metric, which is the product of the additive QoS metric and a weight coefficient that is associated with the priority level of that packet. The lower that the average weighted QoS metric is, the higher the QoS level will be. To handle failures within the network, a handshaking

IJCRCST © 2017 | All Rights Reserved

process is used, which enforces routing table consistency between the upstream and downstream neighbors on each path so that any local failure will automatically trigger a recomputation procedure locally.

Energy-Aware QoS Routing Protocol : Energy-aware QoS routing protocol is a cluster based QoS aware routing protocol [20] that employs a queuing model to handle both real-time and non-real-time traffic. The protocol only considers the end-to-end delay. This protocol associates a cost function with each link and uses the K-least-cost path algorithm to find a set of the best candidate routes. Each of the routes is checked against the end-to-end constraints and the route that satisfies the constraints is chosen to send the data to the sink. Furthermore, the transmission delay is not considered in the estimation of the end-to-end delay, which sometimes results in selecting routes that do not meet the required end-to-end delay. However, the problem of bandwidth assignment is solved in [21] by assigning a different bandwidth ratio for each type of traffic for each node.

SPEED Protocol : SPEED [22] is designed to support soft real-time communication service by maintaining the desired delivery speed across the network so that the end-to-end delay is minimized. Each node keeps information only about its immediate neighbors and utilizes geographic location information to make localized routing decisions. Hence, the protocol is called "stateless," as it does not use routing tables, which result in minimal memory usage. Stateless Non-Deterministic Geographic Forwarding (SNGF) is the routing module responsible for choosing the next hop neighbor and it works with 4 other modules at the network layer to achieve the desired delivery speed across the sensor networks. The neighbor beacon exchange module provides the geo-graphic location of the neighbors. The delay estimation module calculates the delay in each node, which helps the SNGF to select the node meeting speed requirements and also helps to deter-mine the occurrence of congestion.

If a node meeting desired speed requirement can't be found, the relay ratio of the node is checked. The relay ratio is provided by the Neighborhood Feedback Loop (NFL) module. The Relay Ratio determines whether the packet is to be dropped or relayed. It is calculated by looking at the miss ratios of the neighbors of the node (the nodes that could not provide the desired speed) and is fed into the SNGF module, where a drop or relay action is taken. If the relay ratio is less than a number between 0 and 1, which is randomly generated, the packet is dropped. The backpressure rerouting module is used to prevent voids i.e., when a node fails to find the next hop node or if congestion occurs , this module sends the message back to the source nodes so that they (they means nodes which are failed to find the next node) can take new routes. Simulation shows that SPEED performs better in terms of the end-to end delay ratio and the miss ratio. The major limitations of the SPEED protocol are that it does not employ any packet differentiation mechanism. It gives the same preference to both real time and non-real time packets. It is not scalable, as it maintains a desired speed for each packet and if the parameter is changed then protocol performance degrades.

MMSPEED Protocol : The MMSPEED (Multi-Path and Multi-SPEED Routing) protocol [23] is an extension of the SPEED protocol. It is designed to provide probabilistic QoS differentiation with respect to timeliness and reliability domains. For the timely delivery of packets, MMSPEED provides multiple delivery speed options for each incoming packet. Each incoming packet is placed into appropriate queues according to its speed class. The packets in the highest speed queue are served on the basis of the FCFS, followed by the next highest speed queue and so on. The prioritization of a packet is done with the MAC layer support. Service differentiation in a reliability domain is achieved by calculating the reaching probability of each packet and then by forwarding the packets through multiple paths whose progress speed is higher than the speed threshold. These decisions are made locally at each node without information about the global network state and end-to-end path setup. Thus, MMSPEED protocol is scalable and adaptable to large networks. The only limitation of the protocol is that the energy metric is not taken into consideration.

MCMP Protocol: A Multi Constrained QoS Multi-Path routing (MCMP) protocol [24] uses braided routes to deliver packets to the sink node according to certain QoS requirements that are expressed in terms of reliability and delay. The problem of end-to-end delay is formulated as an optimization problem, and then an algorithm based on linear integer programming is applied to solve the problem. The protocol objective is to utilize the multiple paths to augment network performance with moderate energy cost. However, the protocol always routes the information over the path that includes the minimum number of hops to satisfy the required QoS, which leads to more energy consumption in some cases.

MCBR Protocol : A Message-Initiated Constrained-Based Routing (MCBR) mechanism is proposed in [25]. MCBR is composed of explicit specifications of constraint-based destinations, route constraints and QoS requirements for messages, and a set of QoS aware meta-strategies. The separation of routing specifications and routing strategies makes it possible for exploring meta routing strategies. This allows for there to be quality-of-service (QoS) requirements in the application layer for individual messages. Through applying general-purpose Meta-routing strategies, a data message is routed from source to destination via a route that satisfies the QoS requirements for that data message. In other words, messages discover and learn their routes on their way to the destinations. MCBR is composed of the following two types of Meta-routing strategies: one is search based and the other is constrained-flooding. However, the extra control packets (because of flooding the network with control packets) are a significant overhead. Same authors have pro-posed QoS aware learning based routing to decrease the complexity of MCBR protocol and to enhance its performance [26].

ECMP Protocol : The Energy Constrained Multi-Path routing (ECMP) protocol [27] extends the MCMP protocol by formulating the QoS routing problem as an energy optimization problem that is con-strained by reliability, play-back delay, and geo-spatial path selection constraints. The ECMP protocol trades between the minimum number of hops and minimum energy by selecting the path that satisfies the QoS requirements and that minimizes energy consumption.

EQSR Protocol : One of the recently proposed QoS based routing protocols, specifically for wireless sensor networks, is an energy efficient and QoS aware multipath based routing (EQSR) [28], which provides service differentiation by giving real-time traffic absolute preferential treatment over the non-real-time traffic. EQSR uses the multi-path paradigm together with a Forward Error Correction (FEC) technique to recover from node failures without invoking network-wide flooding for path-discovery. The EQSR protocol uses residual energy, available buffer size and the signal-to-noise ratio to predict the next hop through the paths construction phase. EQSR splits up the transmitted message into a number of segments of equal size, adds correction codes, and then simultaneously transmits it over multiple paths to increase the probability that an essential portion of the packet is received at the destination without incurring excessive delay. The EQSR protocol handles both real-time and non real-time traffic efficiently. It does so by employing a queuing model that provides service differentiation.

QuEst Protocol : The QoS-based energy-efficient sensor routing (QuESt) protocol [29] determines application-specific, near-optimal sensory-routes by optimizing multiple QoS parameters (end-to-end delay and bandwidth requirements) and energy consumption, based on the Multi-Objective Genetic Algorithm (MOGA). The QuESt protocol is capable of discovering a set of QoS based, near optimal routes even with imprecise network information.

V.COMPARATIVE ANALYSIS OF QOS ROUTING PROTOCOLS

In this paper we compare QOS routing protocols based on the parameters mobility, energy aware, data aggregation, QOS, multipath, Query based and position awareness.

Table 1. Comparison of QOS routing protocols in WSN

Routing protocol	mobility	Energy aware	Data aggregation	QOS	Multipath	Query based	Position awareness
MRP	No	No	No	Yes	No	No	No
SAR	No	Yes	Yes	Yes	No	Yes	No
EAQRP	No	Yes	No	Yes	No	No	No
SPEED	No	No	No	Yes	Yes	Yes	No
MMSPEED	No	No	No	Yes	Yes	Yes	No
MCMP	No	No	No	Yes	Yes	No	No
MCBR	No	No	No	Yes	Yes	No	No
ECMP	No	No	No	Yes	No	No	No
EQSR	No	No	No	Yes	No	No	No
QUEST	No	No	No	Yes	No	No	No

VI. CONCLUSION

In this paper, we presented an overview of the requirements for QoS based routing protocols and factors that are a challenge in implementing these protocols in a WSN . Each routing protocol is discussed along with their solution to meet QoS requirements. The performance of the SAR, MMSPEED, MCMP, MCBR, and EQSR protocols are evaluated and analyzed with respect to different combinations of network and traffic control parameters. Their advantages and disadvantages are discussed and compared. We have also highlighted the reliability, delay, and energy efficiency performances of these protocols.

VII.REFERENCES

[1]. I.Akyildiz,W.Su, Y.Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks," IEEE Communications Magazine, Volume: 40 Issue: 8, August, 2002, pp.102-114.

[2]. Tian He, Sudha Krishnamurthy, John A. Stankovic, Tarek Abdelzaher, Liqian Luo, Radu Stoleru, Ting Yan, Lin Gu "Energy-Efficient Surveillance System Using Wireless Sensor Networks" Mo-biSYS'04, June 6-9, 2004, Boston, Massachusetts, USA.

[3]. Cerpa, J. Elson, D. Estrin, L. Girod, M. Hamilton, and J. Zhao, "Habitat Monitoring: Application Drive for Wireless Communications Technology," Proc. ACM SIGCOMM Workshop Data Comm. In Latin Am. and the Caribbean, April, 2001.

[4]. E. Biagioni and K. Bridges, "The Applications of Remote Sensor Technology to Assist the Recovery of Rare and Endangered Species," Int'l J. High Performance Computing Applications, special issue on distributed sensor networks, April, 2003.

[5]. L. Schwiebert, S. Gupta, and J. Weinmann, "Research Challenges in Wireless Networks of Biomedi-cal Sensors," Mobile Computing and Networking, 2001, pp.151-165.

[6]. H.T. Kung and D. Vlah, "Efficient Location Tracking Using Sensor Networks," Proc. IEEE Wireless Comm. and Networking Conf. (WCNC), March, 2003.

[7]. R. Brooks, P. Ramanathan, and A. Sayeed, "Distributed Target Classification and Tracking in Sensor Networks," Proc. IEEE, Vol.91, No.8, 2003, pp.1163-1171.

[8]. Jamal N. Al-Karaki, Ahmed E. Kamal, Routing techniques in wireless sensor networks: a survey, IEEE Journal of Wireless Communications 11 (6) (2004) 6-28.

[9]. Anahit Martirosyan, Azzedine Boukerche, Richard Werner, Nelem Pazzi, A taxonomy of cluster-based routing protocols for wireless sensor networks, in: The Proceedings of International Symposi-um on Parallel Architectures, Algorithms, and Networks, ISPAN-2008, Sydney, Australia, May, 7-9, 2008, pp.247-253.

[10]. Shah R, Rabaey J. Energy aware routing for low energy ad hoc sensor networks. Proceedings of IEEE WCNC'02,Orlando, FL, March, 2002; 350-355.

[11]. Ganesan D, Govindan R, Shenker S, Estrin D. Highly-resilient, energy-efficient multipath routing in wireless sensor networks. Proceedings of ACM MobiHoc'01, Long Beach, CA, U.S.A., October, 2001.

[12]. Ye Ming Lu, Vincent W.S. Wong, An energy efficient multipath routing protocol for wireless sensor networks, International Journal of Communication System 20 (7) (2007) 747-766.

[13]. Jack Tsai, Tim Moors, A review of multipath routing protocols: from wireless adhoc to mesh net-works, in: The Proceedings of ACoRN Early Career Researcher Workshop on Wireless Multihop Networking, Sydney, Australia, July, 17-18, 2006.

[14]. S. Bhatnagar, B. Deb, and B. Nath, "Service Differentiation in Sensor Networks, " In *Proceedings of Fourth International Symposium on Wireless Personal Multimedia Communications*, September, 2001.

[15]. Kemal Akkaya, Mohamed Younis, A survey on routing protocols for wireless sensor networks, Jour-nal of Ad Hoc Networks 3 (3) (2005) 325-349.

[16]. D. Chen, P.K. Varshney, QoS support in wireless sensor networks: a survey, in: The Proceedings of the International Conference on Wireless Networks, ICWN-2004, Las Vegas, Nevada, USA, June, 2004, pp.227-233.

[17]. Kui Wu, Janelle Harms, On-demand multipath routing for mobile ad hoc networks, in: Proceedings of 4th European Personal Mobile Communication Conference, EPMCC, Vienna, Austria, February 20-22, 2001.

[18]. Lou W. An efficient n-to-1 multipath routing protocol in wireless sensor networks. Proceedings of IEEE International Conference on Mobile Ad-hoc and Sensor Systems (MASS), Washington, DC, November, 2005.

[19]. K. Sohrabi, J. Pottie, Protocols for self-organization of a wireless sensor network, IEEE Personal Communications 7 (5) (2000) 16-27.

[20]. K. Akkaya, M. Younis, An energy aware QoS routing protocol for wireless sensor networks, in: The Proceedings of the

[21]. 23rd International Conference on Distributed Computing Systems Workshops, Providence, RI, USA, May, 19-22, 2003, pp.710-715.

[22]. M. Younis, M. Youssef, K. Arisha, Energy aware routing in cluster based sensor networks, in: The Proceedings of the 10th IEEE International Symposium on Modeling, Analysis, and Simulation of Computer and Telecommunication Systems, MASCOTS-2002, Fort Worth, Texas, USA, October, 11-16, 2002, pp.129-136.

[23]. T. He, et al., SPEED: A stateless protocol for real-time communication in sensor networks, in: The Proceedings of the International Conference on Distributed Computing Systems, Providence, RI, USA, May, 19-22, 2003, pp.46-55.

[24]. E. Felemban, C.G. Lee, E. Ekici, MMSPEED: multipath multispeed protocol for QoS guarantee of reliability and timelines in wireless sensor networks, IEEE Transactions on Mobile Computing 5 (6) (2006) 738-754.

[25]. X.Huang, Y. Fang , Multiconstrained QOS multipath routing in wireless sensor networks, Journal of Wireless Networks 14(4) 465-478, 2008.

[26]. Y. Zhang, M. Fromherz, Message-initiated constraint-based routing for wireless adhoc sensor net-works, in: The Proceedings of the First IEEE Consumer Communication and Networking Conference, CCNC-2004, LasVegas, Nevada, USA, January, 5-8, 2004, pp.648-650.

[27]. José-F. Martinez, Ana-B. Garcia, Ivan Corredor, Lourdes Lopez, Vicente Hernandez,Antonio Dasilva, Trade-Off Between Performance and Energy Consumption in Wireless Sensor Networks, in: Lecture Notes in Computer Science (LNCS), 4725/2007, Springer-Verlag, Berlin, Heidelberg, 2, pp.264-271, ISBN:978- 3-540-74916-5, 2007.

[28]. A.B. Bagula, K.G. Mazandu, Energy constrained multipath routing in wireless sensor networks, in: The Proceedings of the 5th International Conference on Ubiquitous Intelligence and Computing, UIC-2008, Oslo, Norway, June, 23- 25, 2008, pp.453-467.

[29]. Jalel Ben-Othman , Bashir Yahya " Energy efficient and QoS based routing protocol for wireless sensor Networks", J.Parallel Distributed computing (70), P-849-857, March, 2010.

[30]. N. avrati Saxena , Abhishek Roy, Jitae Shin " QuESt: a QoS-based energy efficient sensor routing protocol", Journal of Wireless Communications and Mobile Computing, Vol.9, No.3, 2009, pp.417-426.