IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661, p-ISSN: 2278-8727
PP 49-52
www.iosrjournals.org

Multi-path and Multi-source QOS Control Algorithm for Maximizing the System Lifetime of Query-Based WSN

S T Pirjade[1] Vinod kumar Kumar Bhutnal[2]Ramachandra H V[3]
** Asst. Professor, Department of Computer Engineering, RajarshiShahu College of Engineering,Tathawade, Pune-33, India.*
*** Asst. Professor, Department of Computer Engineering, RajarshiShahu College of Engineering,Tathawade, Pune-33, India.*
**** Asst. Professor, Department of Computer Engineering, RajarshiShahu College of Engineering,Tathawade, Pune-33, India.*

Abstract: *In this paper, we develop multi-path and multi-source quality of service (QoS) control algorithms based on hop-by-hop data delivery utilizing "source" and "path" redundancy, with the goal to satisfy application QoS requirements while prolonging the lifetime of the sensor system.*
We discover that there exists optimal "source" and "path" redundancy under which the lifetime of the system is maximized while satisfying application QoS requirements.
Index Terms: *Wireless sensor networks, reliability, timeliness, query processing, redundancy, energy conservation,* QoS mean time to failure.

I. Introduction

A WSN can be either source-driven or query-based depending on the data flow. In source-driven WSNs sensors initiate data transmission for observed events to interested users, including possibly reporting sensor readings periodically. An important research issue in source driven WSNs is to satisfy QoS requirements of event-to-sink data transport while conserving energy ofWSNs. In query based WSNs, queries and data are forwarded to interested entities only. In query-based WSNs, a user would issue a query with QoS requirements in terms of reliability and timeliness.

Retrieving sensor data such that QoS requirements are satisfied is a challenging problem and has not been studied until recently [3], [4], [5], [6], [7], [8]. The general approach is to apply redundancy to satisfy the QoS requirement. In this paper, we are also interested in applying redundancy to satisfy application specified reliability and timeliness requirements for query-based WSNs. Moreover, we aim to determine the optimal redundancy level that could satisfy QoS requirements while prolonging the lifetime of the WSN. Specifically, we develop thenotion of "path" and "source" level redundancy. When given QoS requirements of a query, we identify optimal path and source redundancy such that not only QoS requirements are satisfied, but also the lifetime of the system is maximized. We develop multi-path and multi-source QoScontrol (MMQC) algorithms based on hopby- hop data delivery to achieve the desired level of redundancy and to eliminate energy expended for maintaining routing paths in the WSN.

The rest of the paper is organized as follows: In Section 2, we survey related work. InSection 3, we discuss the WSN system model. In Section 4, we develop proposed model for computing the lifetime of a querybased WSN as a function of "path" and "source" redundancy being employed, defined as the number of queries that the system is able to execute successfully in terms of QoS satisfaction before failure. We also discuss extension to the data aggregation**.** Finally, Section 5 concludes the paper and discusses future work.

II. Related Work

Existing research efforts related to applying redundancy to satisfy QoS requirements inquery-based WSNs fall into three categories: traditional end-to-end QoS, reliabilityassurance, and application-specific QoS [3]. Traditional end-to-end QoS solutions arebased on the concept of end-to-end QoS requirements. The problem is that it may not be feasible to implement end-to-end QoS in WSNs due to the complexcity and high costof the protocols for resource-constrained sensors. An example is Sequential Assignment Routing (SAR) [4] that utilizes path redundancy from a source node to the sink node. Each sensor uses a SAR algorithm for path selection. It takes into account the energy and QoS factors on eachpath, and the priority level of a packet. For each packet routed through the network, aweighted QoS metric is computed as the product of the additive QoS metric and a weight coefficient associated with the priority level of that packet. The objective of the SAR algorithm is to minimize the average weighted QoS metric throughout the lifetime of the network. The algorithm does not consider the reliability issue. ESRT [9] has been proposed to address thisissue with reliability as the QoS metric. ReInForM has been proposed [5] to addressend-to-end reliability issues. ReInForm considers information awareness and adaptability to channel errors along with a differentiated allocation strategy of network resources based on the criticality of data. The protocol sends multiple copies of a packet along multiple paths from the source to the sink such that data is delivered with the desired reliability. It uses the concept ofdynamic packet state to control the number of paths required for the desired reliability using local knowledge of the channel error rate and topology. The protocol observes that for uniform unit disk graphs, the number of edge-disjoint paths between nodes is equal to the average node degree with a very high probability. This protocol results in the use of the disjoint paths existing in a thin band between the source and the sink. However, the protocol only concerns QoS in terms of reliability.

In [6], M. Perillo and Heizelman provide application QoS with the goal of maximizing the lifetime of WSNs while satisfying a minimum level of reliability. This maximization is achieved through the joint optimization of scheduling active sensor sets and finding paths for datarouting. The lifetime is defined as the sum of the time that all sensor sets are used. Theapproach uses the strategy of turning off redundant sensors for periods of time to saveenergy while considering the trade-off between energy consumption and reliability. This approach can extend the lifetime of a network considerably compared with approaches that do not use intelligent scheduling. However, this approach is not scalable and QoS is limited to application reliability only. Recently, a multipath and multispeed routing protocol calledMMSPEED is proposed in [7] which takes into account both timeliness and reliabilityas QoS requirements. The goal is to provide QoS support that allows packets to choosethe most proper combination of service options depending on their timeliness and reliability requirements. For timeliness, multiple QoS levels are supported by providing multiple data delivery speed options. For reliability, multiple reliability requirements are supported by probabilistic multipath forwarding. The protocol provides end-to-end QoS provisioning by employing localized geographic forwarding using immediate neighbor information withoutend-to-end path discovery and maintenance. It utilizes dynamic compensation which compensates for inaccuracy of local decision as a packet travels toward its destination.The protocol adapts to network dynamics. However, MMSPEED does not considerenergy issues. Our work considers energy consumption, in addition to reliability andtimeliness requirements as in MMSPEED. Further, we also consider network dynamicsdue to sensor failures, energy depletion, and sensor connectivity. Utilizing hop-by-hopdata delivery, the MMQC algorithmdeveloped in our work specifically formsmp redundancy paths for path redundancyand ms sensors for source redundancy tosatisfy the imposed QoS requirements,facilitating the determination of the best(mp, ms) that would maximize the lifetimeof the WSN.

In [8], QoS is defined as the optimumnumber of sensors that should be sendinginformation to the sinks at any given time.The protocol utilizes the base station tocommunicate QoS information to each ofthe sensors using a broadcast channel. Itexploits the mathematical paradigm of theGur Game to dynamically adjust to theoptimum number of sensors. The objectiveis to maximize the lifetime of the sensornetwork by having sensors periodically powered down to conserve energy, and atthe same time, having enough sensorspowered up and sending packets to the sinksto collect enough data. The protocol allowsthe base station to dynamically adjust theQoS resolution. This solution requires thedetermination of the amount of sensors thatshould be powered up a priori to maintainare solution. QoS metrics for data deliverysuch as reliability and timelines are notconsidered.Clustering SN prolongs the system lifetimeof a WSN [1], [2] because clustering reducescontention on wireless channels [10] andsupports data aggregation and forwarding atcluster heads (CHs). HEED [1] increasesenergy efficiency by periodically rotatingthe role of CHs among SNs with equalprobability such that the SN with the highestresidual energy and node proximity to itsneighbors within a cluster area is selected asa CH. In LEACH [2], the key idea is toreduce the number of nodes communicatingdirectly with the base station by forming asmall number of clusters in a self-organizingmanner. LEACH uses randomization withequal probability in cluster head selection toachieve energy balance. REED [11]considers the use of redundancy to copewith failures of SNs in hostile environments.We also consider cluster-based WSNs forenergy reasons. Our approach of satisfyingapplication reliability and timelinessrequirements while maximizing the systemlifetime is to determine the optimal level ofredundancy at the “source” and “path”levels. The source-level redundancy refers tothe use of multiple sensors to return therequested sensor reading. The path-levelredundancy refers to the use of multiplepaths to relay the reading to the sink node.Since WSNs are constrained with resources,the MMQC algorithm developed in thispaper utilizes hop-by hop data delivery anddynamically forms multiple paths for datadelivery, without incurring extra overhead tofirst formulate multiple paths before datadelivery. Our contribution is that we identifythe best level of redundancy to be used toanswer queries to satisfy their QoSrequirements while prolonging the lifetimeof query-based WSNs.

III. System Model

A WSN consists of a set of low-powersensor nodes (SNs) typically deployedthrough air-drop into a geographical area.SNs are homogeneous and indistinguishablewith the same initial energy level. . Aclustering algorithm (e.g., [1], [2]) that aimsto fairly rotate SNs to take the role of CHshas been used to organize sensors intoclusters for energy conservation purposes, asillustrated in Fig. 1. A CH is elected in eachcluster. The function of a CH is to managethe network within the cluster, gather sensorreading data from the SNs within the cluster,and relay data in response to a query. Theclustering algorithm is executed periodicallyby all SNs.Routing in the WSN is based on geographicforwarding (e.g., [6]). No path informationneeds to be maintained by individual SNs toconserve energy. Essentially, only thelocation information of the destination SNneeds to be known by a forwarding SN forany source-destination communication. Wenote that when a CH is elected periodically,the location information is broadcast to theWSN to let other CHs know its location.Also, SNs within a cluster know the locationof their CH, and vice versa, as part of theelection process. A source CH must relaysensor data information to the PC inresponse to a user query, and thus, canconsume more energy than an SN within itscluster. The energy consumed by the systemfor data forwarding in response to a querydepends on the total length (in terms of thenumber of hops) of the paths connecting msSNs within a cluster to the source CH forsource redundancy, and the total length ofthe mp paths connecting the source CH andthe processing center (the destination CH)for path redundancy.To save energy, SNs operate in power savingmode. At this mode, an SN operates either inactive mode, i.e., transmitting or receiving, or insleep mode.

IV. Proposed Model

The multi-path and multi-source QoScontrol (MMQC) algorithm developed inthis paper takes two forms of redundancy.The first form is path redundancy. That is,instead of using a single path to connect asource cluster to the processing center, mpdisjoint paths may be used. The second issource redundancy. That is, instead ofhaving one sensor node in a source clusterreturn requested sensor data, ms sensornodes may be used to return readings tocope with data transmission and/or sensorfaults. Fig. 1 illustrates a scenario in whichmp ¼ 2 (two paths going from the CH to theprocessing center) and ms ¼ 5 (five SNsreturning sensor readings to the CH).If thisdistance is more than per-hop distance,asensor will take a multihop route to transmitsensor data to the CH.A query response is transmitted froman SN performing sensing to the PC throughthe CH hop-by-hop. As a query result isforwarded hop-by-hop through geographicalrouting, the expression above represents theminimum per-hop transmission speed totransmit the query results from an SN to thePC in order not to miss the deadline. Here,we note that queuing delay is ignoredbecause not much cross-traffic is anticipatedin a query-based WSN; so, queuing delay isconsidered small compared withtransmission delay.

We develop a hop-by-hop datadelivery scheme to implement the desiredlevel of redundancy to achieve QoS. Forpath redundancy, we want to form mp pathsfrom a source CH to the processing center,as illustrated in Fig. 2. This is achieved byhaving mp nodes on the first hop relay thedata, and only one single node relay the dataper receiving group in all subsequent hops.For source redundancy, we want each of thems sensors to communicate with the sourceCH through a distinct path. Here, we notethat a WSN is inherently broadcast-based.However, an SN can specify a set of SNs inthe next hop (that is, mp in the first hop and1 in a subsequent hop) as the intendedreceivers and only those SNs will forwarddata. It has been reported that the number ofedge-disjoint paths between nodes is equalto the average node degree with a very highprobability[6].

4.1 Data Aggregation

The analysis performed thus far assumesthat a source CH does not aggregate data.The CH may receive up to ms redundantsensor readings due to source redundancybut will just forward the first one received tothe PC.

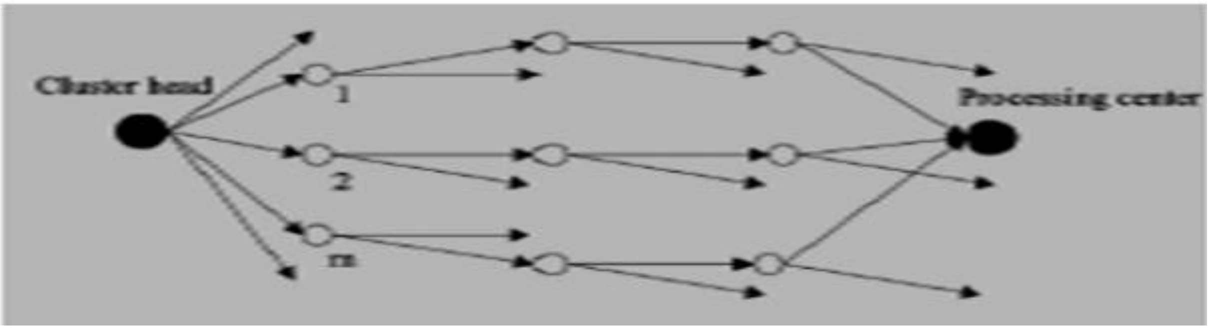

Figure 1: Hop-by-hop Data Delivery in MMQC.

Thus, the data packet size is the same. Formore sophisticated scenarios, conceivablythe CH could also aggregate data for queryprocessing and the size of the aggregatepacket may be larger than the average datapacket size. We extend the analysis to dealwith data aggregation in two ways. The firstis to set a larger size for the aggregatedpacket that would be transmitted from asource CH to the PC. This will have theeffect of favoring the use of a smallernumber of redundant paths (i.e., mp)because more energy would be expended totransmit aggregate packets from the sourceCH to the PC. The second is for the CH tocollect a majority of sensor readings from itssensors before data are aggregated andtransmitted to the PC.

V. Conclusion And Future Work

In this paper, we have developed an multipath and multi-source QoS control (MMQC)algorithm which incorporates path andsource redundancy mechanisms to satisfyquery QoS requirements while maximizingthe lifetime of query-based sensor networks.We discussed how these mechanisms can berealized using hop-by-hop packet datadelivery. and amount of energy consumedper query. When given a set of parametervalues characterizing the operating and workload conditions of the environment, weidentified the optimal (mp, ms) setting thatwould maximize the MTTF whilesatisfying the application QoS requirements.

In the future, we plan to provide a moredetailed analysis of the effect of networkdynamics on MTTF, such as more energymay be consumed by some SNs over othersor some SNs may fail earlier than others.Finally, we plan to consider the use ofacknowledgment and timeout mechanismsin our hop-by-hop data delivery scheme atvarious levels, such as hop-by-hop or end-toend, and identify the optimal (mp, ms) thatminimizes MTTF, as well as conditionsunder which no-ACK is better than ACKbaseddata delivery schemes, or vice versa.

References

[1]. O. Younis and S. Fahmy, “HEED: AHybrid Energy Efficient, DistributedClustering Approach for Ad Hoc SensorNetwork**,”** IEEE Trans. Mobile Computing,vol. 3, no. 3, pp. 366-379, Oct.-Dec.2004.

[2]. W. Heinzelman, C. Chandrakasan, andH. Balakrishnan, “An Application-SpecificProtocol Architecture for WirelessMicrosensor Networks**,”** IEEE Trans.Wireless Comm., vol. 1, no. 4, pp. 660- 670,Oct. 2002.

[3]. D. Chen and P. Varshney, “QoS Supportin Wireless Sensor Networks: A Survey,”Proc. Int’l. Conf. Wireless Networks, pp. 21-24, June 2004.

[4]. K. Sohrabi, J. Gao, V. Ailawadhi, and G.Pottie, “Protocol for Self- Organization of aWireless Sensor Network,” IEEE PersonalComm., pp. 16-27, Oct. 2000.

[5]. B. Deb, S. Bhatnagar, and B. Nath,“ReInForM: Reliable InformationForwarding Using Multiple Paths in SensorNetworks,” Proc. 28th Ann. IEEE Conf.Local Computer Networks, Oct. 2003.

[6]. M. Perilo and W. Heinzelman,“Providing Application QoS throughIntelligent Sensor Management,” Proc. FirstIEEE Int’l. Workshop Sensor NetworkProtocols and Applications, May 2003.

[7]. E. Felemban, C.G. Lee, and E. Ekici,“MMSPEED: Multipath Multi-SPEEDProtocol for QoS Guarantee of Reliabilityand Timeliness in Wireless SensorNetworks,” IEEE Trans. Mobile Computing,vol. 5, no. 6, pp. 738-754, June 2006.

[8]. R. Iyer and L. Kleinrock, “QoS Controlfor Sensor Networks,” Proc. IEEE Conf.Comm., May 2003.

[9]. Y. Sankarasubramaniam, O.B. Akan, andI.F. Akyildiz, “ESRT: Event-to-SinkReliable Transport in Wireless SensorNetworks,”Proc. Fourth ACM MobiHoc, pp.177-188, June 2003.

[10]. G. Bravos and A. Kanatas, “EnergyConsumption and Trade-Offs on WirelessSensor Networks,” Proc. IEEE 16th Int’lSymp. Personal, Indoor and Mobile RadioComm., vol. 2, pp. 1279-1283, Sept. 2005