International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-1 Issue-6, August 2012

Ambient Data Collection with Modeling and Implementation of QoS in Wireless Sensor Networks

Arun Kumar Shukla, Sudhanshu Tripathi, Charlie Eapen, A. Ashok

Abstract- One of the most important applications for wireless sensor networks (WSNs) is Data Collection, where sensing data are collected at sensor nodes and forwarded to a central base station for further processing. Since using battery powers and wireless communications, sensor nodes can be very small and easily attached at specified locations without disturbing surrounding environments. This makes WSN a competitive approach for data collection comparing with its wired counterpart. With these features in mind, we then discuss issues and prior solutions on the data gathering protocol design. Our discussion also covers different approaches for message dissemination and problem of Quality of Service (QoS) provisioning to assess the relevance of using multipath routing to improve the reliability and packet delivery in wireless sensor networks while maintaining lower power consumption levels, which is a critical component for network control and management and greatly affects the overall performance of a data collection WSN system.

Keywords:- Wireless Sensor Network (WSN), Quality of Service(QoS), Dynamic Source Routing (DSR), Ad hoc On-demand Distance Vector (AODV), ECMP.

I. INTRODUCTION

Wireless sensor networks have been applied to many applications since emergence. Among them, one of the most important applications is data collection, where sensing data are continuously collected at each sensor node and forwarded through wireless communication to a central base station for further processing. In a WSN, each sensor node is powered by a battery and uses wireless communications.

This results in the small size of a sensor node and makes it easy to be attached at any location with little disturbances to the surrounding environment. Such flexibility greatly eases the costs and efforts for deployment and maintenance and makes wireless sensor network a promising approach for data collection comparing with its wired counterpart. In fact, a wide range of real-world deployments have been witnessed in the past few years.

Manuscript published on 30 August 2012.
* Correspondence Author (s)
Arun Kumar Shukla, Assistant Professor in the Computer Science and IT Department in SHIATS, Allahabad (U.P.), India
Sudhanshu Tripathi, Assistant Professor in the Department of Electrical and Electronics Engineering, SHIATS, Allahabad (U.P.), India
Charlie Eapen, Assistant Professor in the Department of Electronics and Communication Engineering, SHIATS, Allahabad (U.P.), India
A. Ashok, Assistant Professor in the Department of Electronics and Communication Engineering, SHIATS, Allahabad (U.P.), India

The unique features of WSNs, however, also bring many new challenges. For instance, the lifetime of a sensor node is constrained by the battery attached on it, and the network lifetime in turn depends on the lifetime of sensor nodes, thus, to further reduce the costs of maintenance and redeployment, the consideration of energy efficiency is often preferred in a WSN design. Moreover, these challenges are complicated by the wireless losses and collisions when sensor nodes communicate with each other. In addition, the requirements specified by data collection applications also raise issues that need to be considered in the network design. First of all, to accurately acquire different types of data (such as temperature, light, and vibration), different sensors with different sampling rates may be deployed at different locations. Also as being relayed toward the base station, more and more sensing data will be accumulated along the delivery path. These issues may cause unbalanced energy consumptions over a WSN and significantly shorten the network lifetime if not handling carefully. In this paper, we present a survey on recent advances of tackling these challenges. By comparing with both wired data collection networks and other applications of WSNs, we first highlight the special features of data collection in WSNs. With these features in mind, we then discuss issues and previous works on the data gathering protocol design. In addition, we discuss different approaches for message dissemination, which acts as an indispensable component for network control and management and can greatly affect the overall performance of a WSN system for data collection. Sensor Networks (SNs) are a family of networks which are currently deployed in our daily living environment to achieve different sensing activities with the objective of delivering services to both civil and military applications. These activities include seismic, acoustic, chemical, and physiological sensing to enable different applications such as battlefield surveillance and enemy tracking, habitat monitoring and environment observation and forecast systems, health monitoring and medical surveillance, home security, machine failure diagnosis, chemical/biological detection, animal tracking, plant monitoring, and precision agriculture. Sensor networks can be deployed using a fixed infrastructure called fixed sensor network (FSN) where the packets of information collected from sources are routed to the destination by having the sensor nodes connected to endpoints of a fixed network such as an ADSL or Ethernet network.When connected to a wireless infrastructure, the nodes of the SN referred to as wireless sensor network (WSN) communicate wirelessly using radio wave, satellite or light.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

While FSNs are usually energy-rich networks that rely on a stable and constant power supply, WSNs are energy-poor networks operating unattended sometimes in harsh environmental conditions with intermittent power supply. As depicted by A typical WSN deployment scenario consists of placing sensor devices into a given environment to sense what is happening in that environment and report the results wirelessly to a processing place where appropriate decisions are taken about the environment being controlled. This can be applied, for example, in Precision agriculture by using sensors to measure the humidity and temperature levels at different points of the ground and take appropriate irrigation decisions. These devices are networked to build a smart road network infrastructure used to make roads safer, reduce congestion, help people find the nearest available parking space in an unfamiliar city, achieve routing assistance, or provide early warnings on weather-related road conditions. The efficiency of such deployments may be measured by the lifetime of theWSN often expressed by the time spanning from the outset of the WSN and the time when the first sensor is battery depleted, second the throughput expressed by the proportion of the information sensed in the environment which has successfully reached the gateway, and third the delay and time taken by the information collected by the WSN to travel from the sensing area to the gateway where the information is processed.

Wireless Sensor Networks. as a type of newly emerged network, WSN has many special features comparing with traditional networks such as the Internet, wireless mesh network, and wireless mobile ad hoc network. First of all, a sensor node after deployed is expected to work for days, weeks, or even years without further interventions. Since it is powered by the attached battery, high efficient energy utilization is necessary, which is different from the Internet as well as wireless mesh and mobile ad hoc network, where either constant power sources are available or the expected lifetime is several order of magnitude lower than it is for WSNs. Although a sensor node is expected to work through a long time, it is often not required to work all the time, that is, it senses ambient environment, processes and transmits the collected data; it then idles for a while until the next sensing processing transmitting cycle. To support fault tolerance, a location is often covered by several sensor nodes. To avoid duplicate sensing, while one node is performing the sensing-processing-transmitting cycle, other nodes are kept in the idle state. In these cases, energy consumption can be further reduced by letting the idle nodes turn to *dormant* state, where most of the components in a sensor node are turned off. When the next cycle comes these components are then waken up back to the normal (*active*) state again. Define *duty cycle* as the ratio between active period and the full active/dormant period. A low duty-cycle WSN clearly enjoys a much longer lifetime for operation. This feature has been exploited in quite a few research works. However, as will be shown later in this paper, the new working pattern Single path (SP) routing approaches using different schemes have been proposed as TE approaches for energy efficient communication in wireless networks. Some are based on data-centric routing schemes such as directed diffusion using the flooding of interest by sinks to allow gradients to be set up within the wireless network. Other approaches rely on routing metrics (costs) such as the distance to the destination or the node residual energy level to reduce energy consumption in WSNs. A protocol is proposed which, given a communication network, computes a sub-network such that, for every pair (u, v) of nodes connected in the original network, there is a minimum-energy path u and v in the subnetwork where a minimum-energy path is the one that allows messages to be transmitted with a minimum use of energy. However, though appearing simple, flexible, and scalable, SP routing might result in the faster depletion of the nodes energy supply and subsequent shorter lifetime, higher transmission delays and are unreliable. Multipath routing is a TE strategy which provides the potential to increase the likelihood of reliable data delivery of information from source to destination by sending multiple copies of the same data along different paths. Multipath routing algorithms minimizing the energy consumption to extend the lifetime of a network while satisfying the QoS traffic requirements such as delay and reliability are important parameters upon which the wide deployment of WSNs depend. The routing protocols proposed use multiple path routing with network reliability as design priority. They are implemented by having data transmission relying mostly on an optimal primary path and an alternative path reserved as an emergency path used only when the nodes on the primary route fail. By using a sensor node routing table where every neighbor is associated with a given transmission probability computed based on the cost of the path passing through it, the scheme maintains multiple paths but uses only one of them at a time, in order to avoid stressing a particular path and extend the network lifetime. Since this energy can adversely impact the lifetime and the performance of a sensor network, they have considered a slightly different kind of multipath, Alternate paths in a braid are partially disjoint from the primary path, not completely node-disjoint. The works presented in revisit multipath routing to extend the Dynamic Source Routing (DSR) and Ad hoc On-demand Distance Vector (AODV) routing protocols to improve the energy efficiency of ad hoc networks using frequency of route discovery reduction. Using a retransmission probability function to reduce redundant copies of the same event data, Directed transmission is proposed as one of the probabilistic routing techniques built around the flooding mechanism. Assuming sources transmitting data packets at a constant rate, proposes a multipath routing scheme formulated as a linear programming problem with the objective of maximizing the time until the first sensor node runs out of energy. The work presented in uses a multipath routing algorithm where the routing process is formulated as a constrained optimization problem using deterministic network calculus. The issue of sensor coverage as a major challenge in wireless sensor network through the investigation of two algorithms that address the energy efficient communication in wireless sensor network using multipath routing while preserving coverage. Our work reveals through an illustrative example the relevance of integrating energy-awareness in the routing process and adds to the MCMP model a new constraint which translates into an efficient path set selection.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Using extensive simulation, we demonstrate the robustness of our model and expand the initial work done on several performance parameters. These include the assessment of the tradeoff between delay and reliability constraints and the impact of the sensing intensity on the network performance.

II. METHODOLOGY

A. WSN QoS Implementation.

Multipath routing has been widely studied for wireless ad hoc networks. However, it is widely known that multipath routing solutions proposed for ad hoc network do not apply to sensor networks since while the former can be implemented with global identity (ID), wireless sensor networks lack global ID. Furthermore, the complexity of QoS models proposed for wireless sensor networks may become a limiting factor for the implementation of these solutions in real-world sensor network platforms. Building upon the breadth-first routing nature of the ECMP solution, we propose a simple and easy to implement packet forwarding protocol solution and discuss its implementation in modernWSN platforms. The proposed traffic engineering model is, to the best of our knowledge, a first step towards QoS routing implementation in real world testbed platforms.

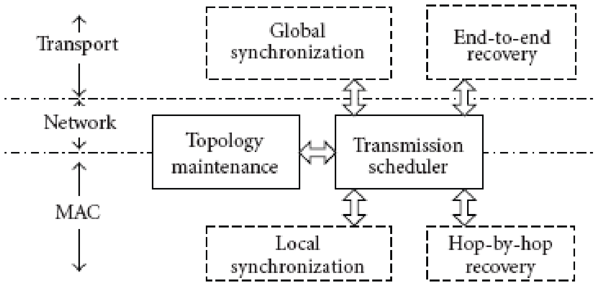

Figure: 1 Generic Architecture of Data Gathering Approach

B. Data Gathering Approaches and Issues

Data gathering approaches consider issues such as how to deliver sensing data from each sensor node to the base station. To achieve high efficiency, a cross-layer design is often involved, where the MAC, network, and transport layers are considered together to achieve multiple goals such as energy efficiency as well as reliability. Figure 1 illustrates a generic architecture for data gathering approaches. To collect data from sensor nodes, two mandatory components are topology maintenance and transmission scheduler. The transmission scheduler then schedules packet transmissions based on information from other components so as to reduce collisions and energy costs. Given different QoS requirements such as throughput, latency, and reliability, different optional components may be added. We will discuss recently proposed data gathering approaches categorized by the major QoS requirement being considered.

One of the prior works designed a data gathering approach with a stress on the reliability and proposed a hybrid scheme for reliable data delivery using both hop-by-hop and end-to-end recoveries. Specifically, each node keeps tracking sequence numbers of packets it receives from a source node. A gap in the sequence numbers of received packets indicates packet loss. The sequence number of the missing packet and its source node ID are then stored in a missing list and piggybacked when a packet is forwarded. The node that previously relayed the missing packet will then schedule a retransmission when it overhears the piggybacked information. And to afford the retransmission in the hop-by-hop recovery, each newly received packet is cached for a short period. Thus, an end-to-end recovery scheme is necessary to such situations. In particular, if a node overhears a piggybacked missing list and finds some missing packets in the list sharing the same sources with those packets in its own packet cache, it then adds these packets into its own missing list and goes on to piggyback their information in its transmissions. By this means, missing packet information will trace back hop-by-hop until reaching the sources.

C. Latency

Since wireless communications consume a significant portion of energy budget on sensor nodes, MAC protocols have been proposed to reduce idle listening and turn the radio of the sensor node to sleep mode to save more energy. Such general designs, however, if being used for data collection without careful consideration, may introduce extra latencies and even more energy costs. To reduce such sleeping latencies, one approach is to let a node overhear for possible transmissions so as to temporarily increase its active duration for potential incoming packets. However, this would make all nodes that overhear a transmission spend extra time being active and consume more energy while only several of them really participate in the traffic relaying. The main idea is shown in Figure 2. Based on the network topology, sensor nodes along a delivery path from a source node to the base station will turn to receiving, sending, and sleep mode one after one in a sequential orderFor the case that a receiver has more than one sender, on receiving a packet from one sender, the receiver predicts that there are packets from other senders and turns to receiving mode. And if nothing sleep mode. Another work proposed in also targeted on minimizing latency and reducing energy costs.is heard, it As the main traffic in a WSN for data collection is from all sensor nodes to the base station, the closer a sensor node is to the base station, the more packets it needs to relay. turns

The main idea is to adopt a TDMA protocol within the traffic intensity region which is assumed within the coverage of the base station's transmission power. By monitoring the arriving traffic from each path within the region, the base station assigns time slots according to the traffic load. To keep synchronization, each time frame is started by a beacon from the base station, followed by the time slot assignment and then time slots for packet transmission. To facilitate emergency and control traffic,

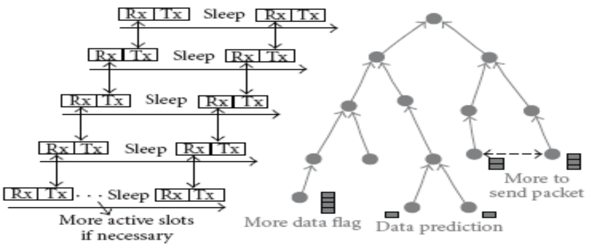

Figure: 2 Data Collection

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

some time slots are reserved for transmissions by a CSMA protocol. In addition, the base station dynamically adjusts the size of the intensity region to exactly one hop smaller than the size that saturates all available time slots. Given a routing tree topology, each node measures its average rate *r* at which packets can be sent. Then this *r* is evenly divided by the number of sources in the descendants of the node (including itself). The result is then compared with the rate assigned by its parent and the smaller one is selected and broadcast to its children if no congestion happens. Otherwise, the selected rate is further decreased before being sent out. To achieve fairness, a node keeps the number of sources in the descendants of each child and uses these numbers as a weight to determine the packet from which child should be forwarded next.

D. Message Disseminations & Modeling Algorithm

Routing consists of moving information across an internetwork from a source to a destination using a multi-hop process where at least one intermediate node is used as transit along the way to the destination. The topic of routing has been covered in computer science literature for more than two decades, but for WSN, routing is just emerging as a main concern because of the need for the deployment of relatively large-scale wireless sensor networks. There are two basic activities involved in the routing process: optimal routing paths determination using routing algorithms and packets transportation using the optimal routing paths found through the paths determination process. Routing protocols are used to implement these two processes by having the paths determination using routing algorithms and packets transportation implemented using a packet forwarding algorithm. In both fixed and wireless networks, the paths determination lead to the creation of routing tables and the packet forwarding to the creation of forwarding tables, both used to determine the next hop that packets coming from a given source to a destination will follow. While proposed only an algorithmic solution to the paths selection process, our work takes the QoS problem some steps ahead by both looking at the algorithmic path finding solution and proposing an implementation model revealing how to build the sensor nodes forwarding. The ECMP and MCMP problems are deterministic linear zero-one problems which can be solved using several methods proposed by the literature.

The ECMP key features.

(1) Use of a simple ad hoc routing protocol which creates a breadth-first spanning tree rooted at the sink through recursive broadcasting of routing update beacon messages and recording of parents.

(2) The beacon messages are
   (a) broadcasted at periodic intervals called epochs.
   (b) propagated progressively to neighbors, and
   (c) received by a few nodes which are in the vicinity of the source of the beacon message.

(3) The transmission of the beacon is build around a source marking, progressive propagation to neighbors and rebroadcasting progress which sets up a breadth-first spanning tree rooted at the sink.

(4) The energy-aware routing is integrated into the process by selecting a subset of neigbhors which is sorted by distance and includes only a minimum number of close neighbors.

E. The Implementation Model

The ECMP algorithm uses a breadth-first model which can be implemented using a simplified table-driven approach based on a many-to-one data-centric routing paradigm. The ECM forwarding protocol follows the main steps described in Algorithm 1. Note that current generation sensor nodes may be broadly classified into two types: some being endowed with a high hardware processing capabilities and a rich set of software instructions allowing them to compute complex functions such as those involved in the constraints used in this paper while other have poor hardware processing capabilities with only a set of software instructions allowing to compute only an elementary set of functions. While our implementation model fits well for the former, the set of steps proposed above may be used in a more elementary processing context assuming some approximations to the functions used in the constraints.

III. CONCLUSION

In this paper, we studied that, Wireless sensor networks have been applied to many applications since emerging. And data collection is one of the most important applications among them. In a data collection WSN, sensing data are continuously collected at each sensor node and forwarded through wireless communication to a central base station for further processing. Bearing these features in mind, we discussed issues and solutions on the design of data gathering protocols. In addition, we discussed approaches for message disseminations, which are a critical component for network control and management and thus also greatly affects the overall performance of data collection WSNs. ECMP algorithm selects its forwarding links based on a location-aware model that uses preferably the closest neighbors to reduce transmission power with the expectation of routing packets on the least energy consuming paths. As modelled in this paper, the ECMP algorithm minimizes energy consumption through closest neighbour selection to reduce the transmission power. We also proposed the first steps for the implementation of the model in terms of a simple packet forwarding protocol which is built upon the breadth-first nature of the ECMP model. It is expected that further energy improvements may be achieved by the ECMP by including into the ECMP picture the remaining energy of receiver in order to energy balance the wireless sensor network. The design and implementation of such an energy balancing algorithm/protocol has been reserved for future research work. As traditionally deployed, sensor nodes are energy- and range-limited devices sharing a single communication channel to achieve energy saving and scalability. Multi-path routing in wireless sensor networks may lead to different issues and provide different results depending on whether multi-channel or single-channel deployment has been considered.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

REFERENCES

[1] L. Selavo, A. Wood, Q. Cao, et al., "LUSTER: wireless sensor network for environmental research," in *roceedings of the 4th International Conference on Embedded Networked Sensor Systems (SenSys '07)*, ACM, 2007.

[2] G.WernerAllen, K. Lorincz, J. Johnson, J. Lees, and M.Welsh, "Fidelity and yield in a volcano monitoring sensor network," in *Proceedings of the 7th symposium on Operating Systems Design and Implementation (OSDI '06)*, USENIX, 2006.

[3] S. Kim, S. Pakzad, D. Culler et al., "Health monitoring of civil infrastructures using wireless sensor networks," in *Proceedings of the 6th International Symposium on Information Processing in Sensor Networks (IPSN '07)*, pp. 254–263, ACM/IEEE, April 2007.

[4] C. Hartung, R. Han, C. Seielstad, and S. Holbrook, "FireWxNet: a multi-tiered portable wireless system for monitoring weather conditions in wildland fire environments," in *Proceedings of the 4th International Conference on Mobile Systems, Applications and Services (MobiSys '06)*, vol. 2006, pp. 28–41, ACM, 2006

[5] H. Zhang and J. C. Hou, "Is deterministic deployment worse than random deployment for wireless sensor networks?" in *Proceedings of the 25th IEEE International Conference on Computer Communications (INFOCOM '06)*, April 2006.

[6] Y. Gu, J. Hwang, T. He, and D. H.-C. Du, "μSense: a unified asymmetric sensing coverage architecture for wireless sensor networks," in *Proceedings of the International Conference on Distributed Computing Systems (ICDCS '07)*, IEEE, 2007.

[7] X. Huang and Y. Fang, "Multiconstrained QoS multipath routing in wireless sensor networks," *ACM Wireless Networks*, vol. 14, no. 4, pp. 465–478, 2008.

[8] A. B. Bagula and K. G. Mazandu, "Energy constrained multipath routing in wireless sensor networks," in *Proceedings of the 5th International Conference on Ubiquitous Intelligence and Computing (UIC '08)*, vol. 5061 of *Lecture Notes in Computer Science*, pp. 453–467, Oslo, Norway, June 2008.

[9] O. D. Incel, *Multi-channel wireless sensor networks: protocols, design and evaluation*, Ph.D. thesis, Pervasive Systems Research Group, Faculty of Electrical Engineering, Mathematics and Informatics, University of Twente, Twente, The Netherlands, March 2009.

[10] N. Burri, P. Von Rickenbach, and R. Wattenhofer, "Dozer: ultra-low power data gathering in sensor networks," in *Proceedings of the 6th International Symposium on Information Processing in Sensor Networks (IPSN '07)*, pp. 450–459, ACM/IEEE, April 2007.

[11] F. Wang, D. Wang, and J. Liu, "EleSense: high-rise structure monitoring with wireless sensor networks," Tech. Rep., Simon Fraser University, 2010.

Arun Kumar Shukla is currently working as Assistant Professor in the Computer Science and IT Department in SHIATS, Allahabad. He has done his Bachelor of Engineering from Jawaharlal Institute of Technology from Khargone (M.P.) in the year 2006 and Mater of Engineering from I.E.T. –D.A.V.V., Indore in the year 2011.
EMAIL – aks.jit@gmail.com

Sudhanshu Tripathi is working as an Assistant Professor in the Department of Electrical and Electronics Engineering, SHIATS, Allahabad. He received his B.Tech degree from UPTU, Lucknow, and M.Tech degree in Digital Communication, from MANIT, Bhopal. His present research area is Wireless Communication.
EMAIL – manitsudhanshu@gmail.com

Charlie Eapen is working as an Assistant Professor in the Department of Electronics and Communication Engineering, SHIATS, Allahabad. He received his B.Tech degree from AAIDU, and M.Tech degree in Communication System Engineering, from SHIATS, Allahabad. His present research area is on Signal Processing Techniques in Wireless Sensor Network.
EMAIL – roger.4lee@gmail.com

A. Ashok is working as an Assistant professor in the Department of Electronics and Communication Engineering, SHIATS, Allahabad. He received his B.E degree from Anna University, Chennai and completed his M.Tech in Communication System Engineering, from SHIATS, Allahabad. His research is focus on Digital Signal Processing & its Applications.
Email –ashok.ece86@gmail.com

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)