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Increasing Quality of Service (QoS) in Wireless Sensor Networks (WSN) by Using Timestamp Optimization Scheme

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Abstract—**In this paper, we study various factors affecting the Quality of Service (QoS) of wireless sensor networks (WSNs) including the current research and the future directions. This paper presents a new Timestamp Optimization Technique to improve and maintain the QoS in WSN. To describe the proposed scheme, both analytical and mathematical models are presented. Assumptions are made for applicability of the scheme in networks. For instance, the proposed scheme formulizes the given scenario by considering only the sensor nodes that are one-hop distant to the sink node.**

Keywords: Wireless sensor networks; QoS, scalable systems; time optimization

I. INTRODUCTION

In recent years, the rapid development in miniaturization, low power wireless communication, micro sensor and microprocessor hardware have made wireless sensor networks (WSN) is new technological vision [1, 6, 7]. Wireless Sensor Network (WSN) is one of the area in which a lot of research is going on. It has a great scope for research. We are going to analyze ways of improving Quality of Service of a WSN, particularly to scalable networks.

Wireless sensor Network is a network of typically small, battery-powered, wireless devices that have three essential capabilities. These are Sensing, on-board processing and communication.

1) Sensing: Sensing of physical parameters, e.g. temperature, pressure, humidity etc.

2) On-board processing: Microcontrollers with low power consumption are used.

3) Communication: Radio communication with low power dissipation is used for data transfer.

Applications of WSN include environmental monitoring, wildlife exploration, surveillance, military application and healthcare research. Quality of Service (QoS) has been defined as the optimum number of sensors that should be sending information at any given time [2, 8]. Various factors contributing to QoS are accuracy, bandwidth, fault-tolerance, lifetime, energy-efficiency and scalability.

A scalable network is one that has provision of inclusion of more sensor nodes in the existing network. There is a growing demand of QoS in WSN (see Fig 1).

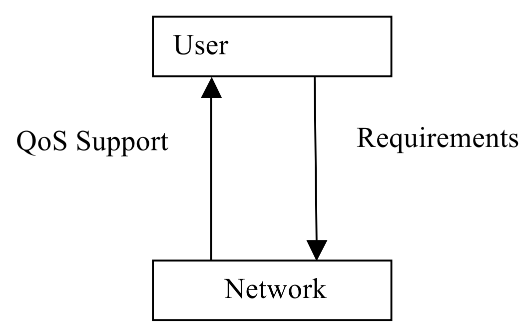

Fig 1: A simple QoS model

A. Problem Identification

In a scalable system, when the number of sensor nodes increase, QoS tend to decrease. Routing algorithms and techniques for improving/maintain QoS is desirable. There are few factors to be noted while considering QoS in WSN. Firstly, applications in WSNs are no longer end-to-end applications. Second, bandwidth is not the main concern for a single sensor node. However, bandwidth may be an important concern for a group of sensors for certain time periods due to the burst nature of sensor traffic. Third, packet losses in traffic generated by one single sensor node can be tolerated to a certain extent because there is always much redundancy in the data. Finally, most applications in WSNs are mission critical, which reflects the importance of applications [10].

A wireless Sensor Network is envisioned as consisting of hundreds or thousands of sensor nodes distributed across geographical locations. Therefore, QoS support designed for WSNs should be able to scale up to a large numbers of sensor nodes. QoS support should not degrade quickly when the number of nodes increases. While WSNs inherit most of the QoS challenges from generic network, their particular characteristics pose unique challenges. The focus of this paper is to analyze and propose techniques for improving the QoS in a scalable WSNs.

II. Related Work

Sequential Assignment Routing (SAR) [3, 9] is the first protocol for WSNs that includes a notion of QoS. Assuming multiple paths to the sink node, each sensor uses a SAR algorithm for path selection. It takes into account the energy and QoS factors on each path and the priority level of a packet. For each packet routed through the network, a weighted QoS metric is computed as the product of the additive QoS metric and a weight coefficient associated with the priority level of that packet for purposes of performance evaluation. The objective of the SAR algorithm is to minimize the average weighted QoS metric throughout the lifetime of the network.

Y. Sankarasubramaniam *et al.* in [4, 10] propose a reliable transport scheme (ESRT) for WSNs. ESRT is a novel transport solution developed to achieve reliable event detection in WSN with minimum energy expenditure. More importantly, their solution is based on a non-end-to-end concept. The solution includes a congestion control component that serves the dual purpose of achieving reliability and conserving energy, and the reliability of event detection is controlled by the sink which has more power than sensors. It is worth noting that their paper brings up the concept of non-end-to-end service. However, their solution only resides in an individual transport layer. Further, it does not consider other important QoS factors.

In [5], M. Perillo *et al.* provide application QoS through the joint optimization of sensor scheduling and data routing, which can also extend the lifetime of a network considerably compared to approaches that do not use intelligent scheduling, even when combined with power-aware routing algorithms. Their goal is to balance the application reliability with efficient energy consumption. A comprehensive discussion on the future applications of WSNs is presented in [11].

III. Time Stamp Optimization Scheme

Network traffic is one of the important factors affecting Quality of Service of a network. WSN are extremely constrained in terms of bandwidth available. An attempt to reduce network traffic for same information from sensor node to sink node would be a good idea. Reducing packet size helps in many ways. Less energy needed for data transmission, faster communication and effective utilization of available bandwidth. If data packet is routed through many intermediate nodes, the advantage of reducing packet size is additive.

A data packet consists of two main parts: packet header and payload. Packet header contains important information like the address of sensor node, timestamp and error correction information. Payload is the actual data collected by sensor (sensor) node as sample.

Unlike multimedia networks, packets in WSN have relatively smaller payload than header. This is mainly because of the sample information (e. g., temperature, humidity can easily be contained in one byte). We propose a model in which we can reduce the header size of data packet.

A. Analytical Model

Header portion of a data packet consists of different information like address, timestamp, error correction etc. We propose a scheme where the timestamp can be reduced to use lesser number of bytes. This reduces the data header size resulting in a smaller data packet for the same information. The overall effect would be the reduction in network traffic, which in turns improves the QoS of the network. In case of scalable network, this will maintain QoS and prevent quick degradation of QoS when more sensor nodes are added to the system.

Often, a complete timestamp contains information for Seconds, Minutes, Hour, Day, Date, Month and Year. We need one byte each to represent Seconds, Minutes, Hour, Day, Date and Month. However, we need two bytes to represent Year. Therefore, altogether, a timestamp size is 7 bytes.

Two bytes of sequence number are introduced instead of 7 bytes of bulky timestamp. Each time the sensor node sends data, it increments the timestamp sequence number (TSN; our terminology). The TSN is reset by the request of sink node before it overflows. To prevent TSN overflow, the sink node has to have knowledge of at what interval should it send signal to all sensor nodes for resetting TSN. The idea is explained with the help of an example.

Example:

We present an example where we use 2 bytes for TSN and that the sensor nodes are expected to send data every 10 seconds.

Two bytes of sequence number can represent 65,536 numbers (0 – 65,535). Therefore, the available sequence numbers are 0-65,535. The sensor nodes are to send data every 10 seconds. For 7 days, this can be quantified as: 7 X 24 X 60 X 60 = 604,800seconds, 60,480 sequence numbers are needed. Hence the valid TSN are 0 to 60,479. The sink node needs to initialize the TSN in each sensor nodes only once a week. Initialization here has negligible overload in the network.

The Exact timestamp is recovered at the sink node by using the time sequence number. For example, a data packet with TSN = 534 has a timestamp of week's time value + (534 *10) seconds. Recovery of timestamp is error-free.

Reduction in packet size is 7-2 = 5 bytes in this case. This varies according to the size of TSN used.

B. Mathematical Model

Let us first define the terms used in our derived equation.

- *C* represents the number of bytes used by the constant fields of header e.g. address field, error correction bits etc.
- *T* represents the number of bytes used by usual timestamp.
- *S* represents the number of bytes used by timestamp sequence.
- *P* represents the Payload

Packet size according to normal timestamp can be approximated as: $C+T+P$

Packet size using TSN according to Timestamp Optimization technique is: $C + (T - S) + P$

Reduction in packet size is: $(T - S)$

Percentage reduction in packet size is calculated as:
{(*Reduction in packet size*) / (*Size of old data*)} *100%

This gives our formula for calculating percentage reduction in size as:

Percentage reduction in size = **[(*T-S*) / (*C+T+P*)] *100 %**

C.Numerical Results

For demonstration purpose, Assuming T=7, S=2 and P=1, for different C, we have, different percentage reduction in traffic.

C (Bytes)	T-S (Bytes)	C+T+P (Bytes)	% Reduction in packet size
10	5	18	27.78%
15	5	23	21.74%
20	5	28	17.86%
25	5	33	15.16%
30	5	38	13.16%

Fig. 2: Tabular result showing Percentage reduction in data packets for different C's.

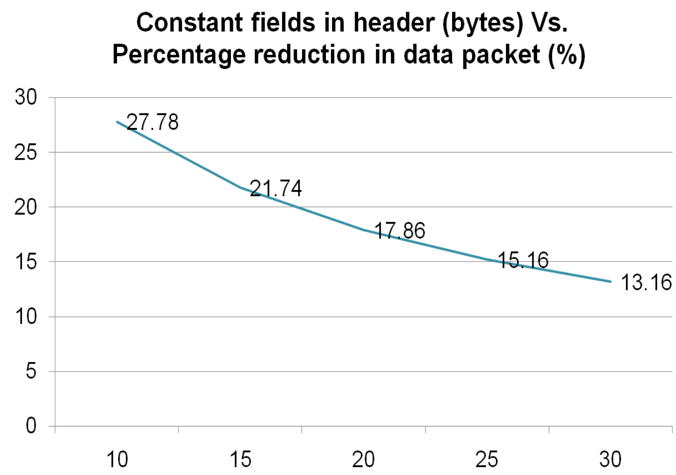

Fig. 3: Graphical result showing Percentage reduction in data packets for different C's.

Fig. 2 shows the numerical calculations based on the above assumptions. Fig. 3 shows the percentage reduction in data packets.

IV. CONCLUSION

With timestamp optimization technique implemented, there is always an advantage of reduced packet size. Also, it is observed that the optimization scheme produces impressive numerical results when the constant fields itself are small. The scheme here considers only the sensor nodes that are one-hop distant to sink node. Future study on this paper can be done for networks consisting of many intermediate nodes.

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