Improvement of End-to-End Delay Distribution in WSNs

Varpe Arti Abaji[1], Aade Kailas Ukala[2]

Department of Electronics and Telecommunication Engineering, G. H. Raisoni College of Engineering & Management, Savitribai Phule Pune University, Pune, India

Professor, Department of Electronics and Telecommunication Engineering, G. H. Raisoni College of Engineering and Management, Savitribai Phule Pune University, Pune, India

Abstract: *The Wireless Sensor Networks (WSNs) is field of research due to its high mobility as well as scalability in several areas working on functions of sensing, monitoring, tracking, control and maintenance. I found many advantages and disadvantages related to WSN in network study. The QoS related with many systems are very sensitive parameters; they are as Average delay, End to end delay, Throughput, Packet loss, Energy consumption, Latency, etc. Due to nondeterministic nature of the wireless channel and queuing mechanisms of nodes, also the probabilistic analysis is necessary. So compared with number of paper, end to end delay parameter is considering for meet a strict deadline on WSN. The previous delay analysis work fail to give the single hop delay distribution, also the congestion traffic is not considered. This paper gives to reader brief idea about, cross-layer analysis framework for performance evaluations. To the best of my knowledge, this is the research work that provides a brief idea behind end-to-end delay distribution in WSNs. It is also comparing average delay and end to end delay for traditional system and cross layer design.*

Keywords: WSN, TCP/IP, CSMA/CA, Cross layer, MAC

1. Introduction

The wireless sensor network (WSN) consists of an autonomous spatially distributed sensors which is useful for cooperatively monitoring environmental as well as physical conditions. Basically, a sensor node is main device in sensor network, which is battery powered and equipped with integrated sensors, data processing capabilities, and short-range radio communications [4]. The sensor nodes are spread randomly over the deployment region for collecting sensor data. With the help of wireless transceivers; the sensor nodes were communicating in between them. The sensor networks are used for a wide variety of applications; considering military sensing application, tracking, environment monitoring, and patient monitoring. The WSNs are popular in these days due to its application in number of areas. The WSN provides not only easily implementable but also cheaper solutions for many real world problems. The attractive features of the WSNs attracted many researchers to work on various issues related to these types of networks. However, while the routing strategies and wireless sensor network modeling are giving more preference. The delay issues are yet to receive extensive focus. In this paper, I explore the end to end delay analysis comparing CSMA protocol with Cross layer protocol.

Recent work has analyzed the latency performance of WSNs in terms of its first-order statistics, i.e., the mean and the variance. However, complex and cross-layer interactions in multi-hop WSNs require a complete stochastic characterization of the delay. Several efforts have been made to provide probabilistic bounds on delay. The concept of network calculus has been extended to derive probabilistic bounds for delay through worst case analysis. However, because of the randomness in wireless communication and the low-power nature of the communication links in WSNs. The worst-case analysis cannot capture the stochastic behavior of end-to-end delay. Moreover, work on real-time queuing theory provides stochastic models for unreliable networks.

2. Literature Review

The goal of MS. Sajjad Ahmad Madani's Ph.D thesis is improve the energy performance by using cross layer design. The goal is achieved using protocol architecture which supports cross layer design and routing protocols [12].The designing energy aware hardware and software for enhancing the energy performance. A reference application, container management system is outlined in this paper for application dependent wireless sensor networks. The position based routing protocol are developed and integrated in the proposed architecture which can increase energy efficiency as well as enhance performance.

Md. Mohiuddin Khan was worked on TCP/IP protocol which is important in wired networks as well as wireless transmission. This poses unique challenges to the well-defined and rigid protocol stack. The well-known layers of the TCP/IP model were very strict in some cases for providing with all the services necessitated by these new domains. These issues distorted the traditional boundaries among layers in different ways to achieve performance gain which is nothing but cross-layer design [10].

A Case Study on Multi-Hop Cross-Layer Design in Wireless Sensor Networks was given by Philipp Hurni, Torsten Braun, Bharat K. Bhargava, and Yu Zhang which is useful for solving various problems of wireless communication systems by introducing basic idea of violation of the OSI architecture. By passing information between different adjacent or non-adjacent layers of one single station's protocol stack; solve an optimization problem and exploiting the dependencies between the layers. This paper proposes not only trades off between advantages and disadvantages of

the proposed multi-hop cross layer design but also energy-efficient power saving protocol [15].

Srajan Raghuwanshi proposed M.Tech Thesis which gives idea about self-created and self-organized WSNs consisting large number of sensor nodes connected to each other by multi-hop wireless paths. In this thesis, they focused on optimizing the energy consumption with novel cross-layer architecture at the network/data-link layer for sensor networks. They developed a scheme for better and improved energy efficiency in WSNs by combining the ideas of energy-efficient cluster formation and medium access together. This work gives good performance in the form of WSN-lifetime, scalability and minimizing network-wide energy consumption by the formation of dynamic clusters functioning with a traffic aware MAC scheme [13].

Also WSNs is field of research on the rise due to its high mobility and scalability in several areas was introduced by Yunbo Wang, Mehmet C. Vuran, and Steve Goddard [16]. For considering design issue of network; Qos is the main which deals with many system sensitive parameters they are average delay, End to end delay, Throughput, Packet loss, energy consumption, latency, etc. Due to nondeterministic behavior of the wireless channel and queuing mechanisms of nodes; the probabilistic analysis is necessaries. The comparison between other delay parameter end to end delay parameter is having great influence on WSN to meet a strict deadline.

In this paper, a cross-layer protocol introduced on TCP/IP model, which gives congestion control. To improve the delay detection reliability, usually timely delivery of a certain number of packets is required. The simulations give the average and end to end delay for both deterministic and random deployments. The previous delay analysis work fails to give the single hop delay distribution, also the congestion traffic.

3. Method To Overcome End to End Delay Disribution

3.1 Quality of Service

WSNs consist of many research aspects such as architecture and protocol design, energy conservation, and locationing, supporting QoS; because of it is different from than traditional networks [17].
1) Application communities: QoS is the quality related by the user/application.
2) Networking community: A measurement of the service quality that the network gives to the applications/users.
3) RFC 2386: An assurance by the Internet to provide a set of measurable service attributes to the end-to-end users/applications.

In this model, the application/users are given with services instead of network management to its sources; for providing the QoS support. To achieve main goal of network community, there is requirement of analysis of the application. Due to increase in popularity of end-to-end parameters in communication; QoS requirements are important. The end-to-end QoS support using a large

number of mechanisms and algorithms in different protocol layers. New QoS parameters are measuring of the delivery of the sensor data in an efficient and effectively [17]. QoS architecture can be exploited by measuring these parameters for the applications.

Different communities may interpret QoS of WSNs in different ways. I can define the number of active sensors as parameters to measure the QoS in WSNs. The failure may be occurred due to the limited functionality of sensors. I can considered observation accuracy, measurement errors as parameters, some information transportation related parameters to measure QoS.

In the network QoS, there are measurements with how the data is delivered to the sink and corresponding requirements. There are three basic data delivery models: event-driven, query-driven, and continuous delivery models. The some factors which are considered for application as End-to-end or non-end-to-end performance, Interactive or non-interactive, May or may not be delay tolerant, May or may not be mission critical

Table 1: Application Requirements

Class	Event-driven model	query-driven model	Continuous driven model
End-to-End	No	No	No
Interactivity	Yes	Yes	No
Delay tolerance	No	Query-specific	Yes

3.2 End to End Network

The Following figure 1 shows a logical network where each node represents a host, a router, an application. A link is nothing but a direct connection between two nodes. The links are bidirectional.
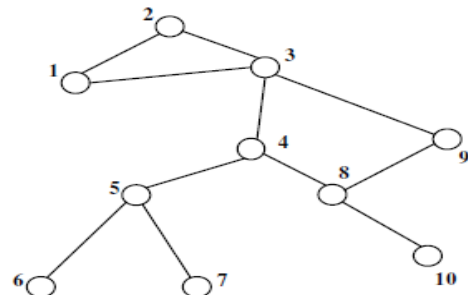

Figure 1: Logical Network

A chain of physical links connected in each logical link by intermediate routers. The Internet can be modeled as:
G = (V; L) …………. An undirected graph …… (1)
Where, V= nodes, L= undirected links

According to definition of G, The locations of the nodes do not considered. Path is formed in between connection of two nodes without a loop. The nodes at the two ends of a path are *external* nodes and the rest of the nodes along the path are *internal* ones which are known as end, intermediate nodes respectively. In Figure 2, the path (1; 2; 3; 4; 5; 6), 1 and 6 are end nodes, and 2, 3, 4, 5 are intermediate nodes. An end-to-end delay in the graph is the packet transmission delay over a path [16].

3.3 End-to-End Delay

The end-to-end is used as hop-by-hop. The data transmission occurs through only two adjacent nodes, but via a path which may include many intermediate nodes. End-to-end delay is the summation of delays experienced at each hop from the starting node to the last node. Each intermediate node has delayed which having three components: Fixed delay, Variable delay and Propagation delay. The sensor nodes reported to a sink through a multi-hop route in the network. There are two different types of network deployments are possible. They are as:

1) Deterministic deployment: The position of sensor nodes is fixed with deterministic locations which are useful to calculate the single hop delay distribution with queuing model.
2) Random Deployment: Uses Poisson point process with log normal fading channel. Queuing model deals with inter arrival distribution and discrete time Markov Process. Locally generated packets gives the local packet information. End to end delay is calculated by the sum of incoming relay traffic rate at each of the next hop.

3.4 Cross Layer Design

The cross layer design is the design where the boundary among the protocol layers is violated by sharing internal information, helping layers to become aware of the changes in the others and hence provide higher QoS to the user. The cross-layer signaling is included in cross layer design; which is not defined in the protocol architecture. These signaling methods should use for reducing the overhead. The crossing the defined boundaries of a well-defined architecture is the fundamental principle of cross-layer design. The sharing cross-layer information is a sensitive issue sometimes which becomes endless when the layer boundary is crossed. Compatibility with the legacy designs and obtaining performance gain are important aspect of cross-layer design. Cross-Layer Designs are divided into three types; according to different combinations. These are as the following:
1)Interaction between physical and link layer
2)Interaction of physical and link layer with the upper layers
3)Merging of layers

1 Interaction between physical and link layer
The lower two layers are mainly responsible for setting up transmitting power, error correction, fragmentation of frames etc. Their functions are so closely related that each of the layers can make good use of the information available in the other [3] describe such a proposal where high level of adaptability is gained through using the cross-layer information. They provide adaptation of both link and physical layer. For link layer, they propose to vary the frame length at medium access control (MAC) layer according to the channel condition and also to vary the FEC/ARQ conditions according to bit-error rate (BER). For physical layer, they propose the adaptability of processing gain and equalization. Applied together, these adaptations bring significant improvement to battle the degraded channel conditions.

2. Interaction of physical and link layer with the upper layers
These types of cross-layer design involve regulating various parameters in the upper three layers based on the lower two layer information. Here, link layer and network layer share information to decide the optimum timing for handoff. A handoff trigger unit is proposed which collects information from the link layer and the network layer. The link layer provides mobile terminal's speed information. The network layer at first discovers the neighboring base stations which may be involved in the forthcoming handoff. Then an estimation of the signaling delays result in the possible handoff to each of the stations is calculated beforehand. Taking these delays and the mobile terminal's speed in consideration, the handoff is initiated at a time which reduces the possibility of the packet loss due to handoff latency.

3. Merging of layers
A more *revolutionary approach*, as named in [8], includes merging of more than one layer to achieve performance improvement. This type of approach is suitable to application areas which have a specific usage. For example, [7] proposes such a design for target tracking in wireless sensor network, which indeed serves a very specific purpose. The authors argue that target tracking, unlike traditional data communication, is not address-centric, rather event and location centric. Hence, they omit network and transport layer and create a three layer design with application, MAC and physical layer.

4. System Developments

4.1 Medium Access Control

In most networks, multiple nodes share a communication medium for transmitting their data packets. The medium access control (MAC) protocol is primarily responsible for regulating access to the common medium. Most sensor networks and sensing applications rely on radio transmissions in the unlicensed ISM (Industrial, Scientific, and Medical) band, which may result in communications significantly affected by noise and interferences. The choice of MAC protocol has a direct bearing on the reliability and efficiency of network transmissions due to these errors and interferences in wireless communications and to other challenges such as the hidden-terminal and exposed-terminal problems. The energy is not only consumed for transmitting and receiving data, but also for sensing the medium for activity. Other reasons for energy consumption include data retransmissions, packet overheads, control packet transmissions, and transmit power levels that are higher than necessary to reach a receiver. It is common for a MAC protocol in WSNs to trade energy efficiency for increased latency or reduction in throughput.

4.2 Carrier Sense Multiple Access

The main difference between CSMA and ALOHA is that, in CSMA, nodes first sense the medium before they begin a transmission. This reduces the number of collisions. In non-persistent CSMA, a wireless node is allowed to immediately transmit data once it finds the medium idle. If the medium is

busy, the node performs a back off operation, that is, it waits for a certain amount of time before attempting to transmit again. In contrast, in *1*-persistent CSMA, a node wishing to transmit data continuously senses the medium for activity. Once the medium is found idle, the node transmits its data immediately. If a collision occurs, the node waits for a random period of time before attempting to transmit again. In CSMA/CA, nodes sense the medium, but do not immediately access the channel when it is found idle.

4.3 AODV Protocol

The example of an *on-demand* or reactive protocol is Ad Hoc On-Demand Distance Vector (AODV) protocol. Compared to proactive routing protocol, reactive protocols do not maintain routes until they are requested and used. A source node, knowing identity or address of the destination node, initiates route discovery process within the network, which completes when at least one route is found or when all possible routes have been examined. A route is then maintained until it either breaks or is no longer needed by the source. AODV relies on a broadcast route discovery mechanism, which is used to dynamically establish route table entries at intermediate nodes. The *path discovery* process of AODV is initiated when a source node needs to transmit data to another node.

4.4 Need of QoS

WSNs have been needed in many applications as a connectivity infrastructure as well as a distributed data generation network due to their ubiquitous and flexible nature. Increasingly, a large number of WSN applications require real-time QoS guarantees. Such QoS requirements usually depend on two common parameters: timing and reliability. The resource constraints of WSNs, however, limit the extent to which these requirements can be guaranteed. Furthermore, the random effect of the wireless channel prohibits the development of deterministic QoS guarantees in these multihop networks. Consequently, a probabilistic analysis of QoS metrics is essential to address both timing and reliability requirements.

In my analysis, I consider a network composed of sensor nodes that are distributed in a 2-D field. The sensor nodes report their readings to a sink through a multihop route in the network. Two different types of network deployments are investigated.

Steps For Implementation Of Project
The scheme of implementation of my project is as follow:
Step1: Create a wireless topology with more number of nodes and transfer a packet among the network.
Step 2: Create a wireless topology with more number of nodes implement CSMA/CA MAC protocol to transmit a packets among the nodes.
Step 3: Delay, End-End delay are measured for CSMA/CA protocol and output is shown using graph.
Step 4: Develop a framework using cross layer analysis for End-End delay distribution in WSNs.
Step 5: Compare proposed cross layer analysis frame work with CSMA/CA regarding measured factor (Delay, End to End delay) and output is shown using graph.

5. Result and Discussion

In this paper, I did literature survey, by going through different research papers. I decided to implement End to End delay distribution in WSN for overcoming it's limitations in real time use. I decided that with data analysis; came to conclusion that the system will be benefited by lower total in-store printing expenses, reduce total cost of ownership, reduce manpower, boost return on investment, and increase customer satisfaction. The simulations with NS2 for Cross layer Protocol shows WSNs for CSMA/CA protocol implemented for calculating average delay between two sensor nodes and End to End delay between networks. The WSNs for Cross layer protocol implemented for calculating average delay between two sensor nodes and End to End delay between networks. The simulation results for Cross layer gives the minimum End to End delay as compared to CSMA/CA. The following table shows comparisons between existing system and cross layer.

Table 2: Results For Comparison

Sr. No.	Parameter	No. of Packets	Cross layer	CSMA
1	Average Delay in ms	30	0.062	0.267
2	End to End Delay in ms	30	0.11008	0.5112
3	Average Delay in ms	80	0.512	0.9843
4	End to End Delay in ms	80	0.2987	0.452

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