MULTIMEDIA QOS AND WIRELESS NETWORK SECURITY: A META-ANALYSIS

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Abstract

Many routing protocols have been proposed for wireless sensor networks. These routing protocols are almost always based on energy efficiency. However, recent advances in complementary metal-oxide semiconductor (CMOS) cameras and small microphones have led to the development of Wireless Multimedia Sensor Networks (WMSN) as a class of wireless sensor networks which pose additional challenges. The transmission of imaging and video data needs routing protocols with both energy efficiency and Quality of Service (QoS) characteristics in order to guarantee the efficient use of the sensor nodes and effective access to the collected data. In order to analyze QoS parameters for various WSN hardwares this paper proposes a QoS testbed with a developed application, designed for estimating critical QoS parameters. Demonstration of the proposed QoS testbed is performed on XBee WSN modules where the basic set of measurements and modeling is presented.

***Keywords**: WSN, wireless multimedia sensor network (WMSN), quality of service (QoS), routing protocols.*

Introduction

The network routing protocols in WSNs perform similar objectives in order to distribute network reach ability information. They may share the complete routing table or exchange particular information. Most existing routing approaches use dynamic information, but in some cases, static information is more suitable. However, the major objectives of introducing routing protocols for WMSNs are for prolonging the sensor network battery lifetime, ensuring the connectivity under several scenarios, enhancing the network survivability, handling energy consumption efficiently, reducing complexity and latency, improving WMSN performance, etc. Routing protocols differ due to their scalability and performance features. From another perspective, WMSNs face several restrictions due to their limited power supply and computing capability, high traffic volume and limited bandwidth. There are several performance factors that affect and influence WMSN routing protocol design, such as data aggregation, network deployment, data delivery models and network dynamic. These design factors consume excess energy as well as affect the scalability and QoS.

Real-time exchange of multimedia content using WSN presents a demanding challenge primarily due to the fact that WSNs are not designed for transferring large quantities of multimedia data in real-time with desired Quality of Service (QoS). To solve these problems various authors have addressed this problem through different aspects such as the impact of the network layer and the routing of data on the QoS, impact of packet size on network performance all the way to designing new transport protocols in order to accommodate QoS requirements. On the other hand, the majority of work in this area is focused strictly on mathematical modeling and computer simulations of QoS rather than

real life measurements and modeling on existing WSN equipment.

Quality of Services (QoS) and Security

Providing the required QoS is one of the important elements of designing and realizing multimedia networks. One of the QoS definitions that can be found in the literature is the following: "QoS represents a set of such qualitative and quantitative characteristics of a distributed multimedia system needed to realize the desired functionality of the application." The multimedia communications forum document under MMCF / 95-010 describes QoS requirements for applications, networks and services in multimedia telecommunications.

In this document, QoS is defined as "a set of service features that determine the degree of customer satisfaction provided by the telecommunication service". QoS, defined in this way, is determined by a set of service-related factors: providing service support, features of service operability, service access characteristics, and service integrity characteristics. In general, QoS is defined by a set of parameters that can be measured objectively. A set of relevant parameters, as well as the values of these parameters corresponding to the acceptable QoS, depend to a great extent on the type of multimedia application and its purpose. Several elements of importance for securing QoS in multimedia networks can be distinguished:

- Understanding the characteristics of multimedia traffic in order to define and implement the QoS requirements;
- Translation between QoS parameters that implies the distribution of system and network resources;
- Establish the appropriate QoS architecture that can provide the required QoS guarantees for multimedia applications.

The quality and efficiency of QoS management depend largely on the nature of multimedia traffic. Multidimensional modeling models are ranked according to appropriate groups; from those with constant bit rate (CBR) to those with variable bit rate (VBR). VBR traffic, which is characterized by compressed audio / video transmission, is sensitive to delays and has the "bursty" traffic characteristics.

The differences between multimedia traffic and traffic in traditional networks are primarily related to:

- Requirements for the transmission of continual media (audio and video transmission) in real time;
- Significantly larger flows of individual media;
- Distributed-oriented applications.

In traditional telecommunication networks, such as packet switched networks, QoS provision is on a qualitative basis, rather than providing services based on quantitative QoS requirements for each particular application. Real-time multimedia applications do not tolerate large variations in terms of delays and bandwidths.

Classification of Quality of Service Routing Protocols

Based on the research issues, we have classified QoS routing protocols into two categories, which are probabilistic and deterministic, which in trun include soft real time and hard real time QoS routing protocols. This will help researchers

choose the best QoS routing protocol according to the requirements of the application in order to reduce energy consumption and obtain better throughput as given in Figure 1. In probabilistic routing protocols, the routing between sources and destinations depends on the probability of the last lower rebroadcasted rate. In the probabilistic approach, the sensor node transmits the message with a known probability. The transmission probability involves different factors such as hop-distance from source to destination, the number of hops a packet has already traveled, time in which sensor node already forwarded the packets, number of neighbor nodes, etc.

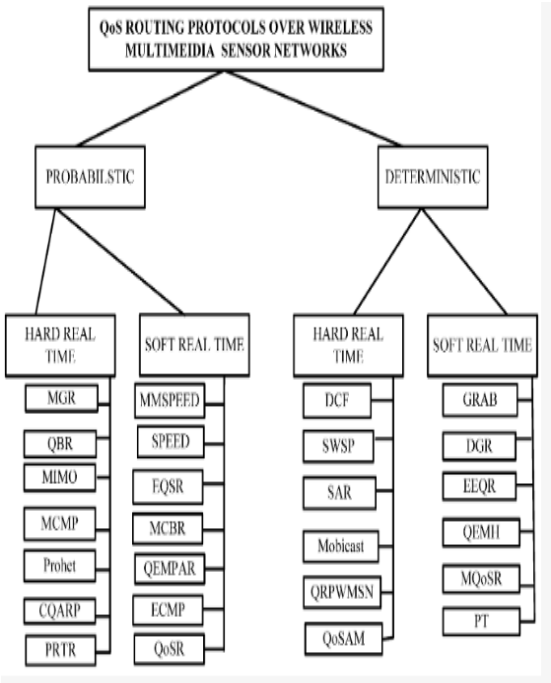

Figure: Classification of real-time quality of service (QoS) routing protocols

Probabilistic Routing Protocols

Multimedia Geographic Routing (MGR) introduces a new architecture called Mobile Multimedia Sensor Network (MMSN), that is based on the Mobile Multimedia Geographic Routing (MGR) scheme. In this scheme, the mobile multimedia sensor node (MMN) is used to improve the sensor network ability for event description. The purpose of this protocol is to reduce energy consumption in order to satisfy limitations on an average end-to-end delay of specific applications in MMSNs. The main goal of this protocol is to handle the delay to guarantee the priority for QoS provisioning. The protocol continuously attempts to reduce the energy consumption in order to prolong the sensor life time. This helps to exploit the energy delay adjustments for design of this protocol. However, the key operation of this protocol is to choose the suitable location of the current node for the next hop. In order to complete this, MGR estimates the distance of the desired hop for the next hop selection that can be obtained by dividing the distance between current to the sink node.

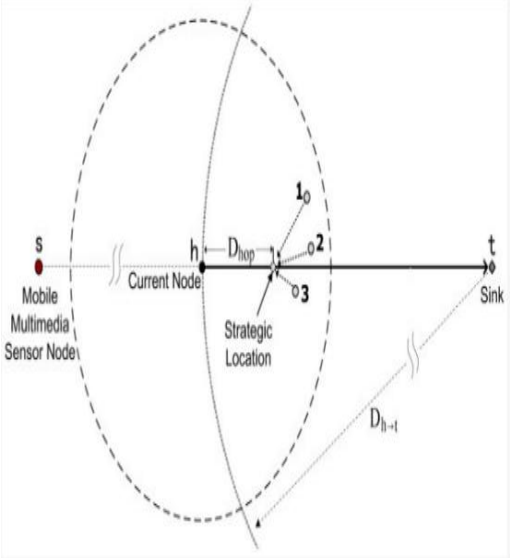

Figure: The Strategic Location Selection in MRG

The QoS-based routing (QBR) protocol is a real-hard probabilistic-based routing protocol introduced to support event and periodic-based data reporting. QBR is composed of the features of geographic

routing with QoS provisioning. The data packets are forwarded in the network based on the type of the packet. QBR sets different priorities levels for each type of data packet. Thus, multiple transmission queues are introduced for handling the priorities of data packets. In addition, the node is picked based on residual energy, high link quality and the path with minimum load. The selection process of nodes consists of one-hop neighbor nodes that help reduce additional energy consumption.

PROPOSED TESTBED FOR QOS ANALYSIS IN WSN

The proposed testbed was set up with basic WSN configuration, consisting of a central coordinator node and one (or multiple) end node. In order to test multimedia streaming the proposed testbed targets the data flow in the direction towards the coordinator - coordinator is the data sink. If multiple nodes are present in WSN all the data streams are targeted towards the coordinator node. In order to measure and calculate the required QoS parameters, information retarding the exact time of the packet transmission/reception needs to be present at the receiver application.

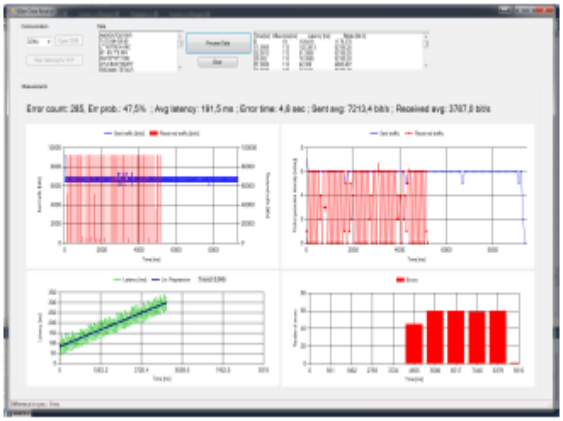

Figure: Developed WSN QoS Application

From the figure the application consists of several charts that represent communication and calculated QoS parameters from the data. Throughout this paper an analysis with the proposed application in combination with MATLAB was performed. Future work on the testbed includes integrating MATLAB data procession within the proposed application, enabling extensive testing, measurements and modeling of the QoS parameters for multimedia streaming in WSN.

Results and Discussion

As defined in Section II, various parameters define QoS in a network. These parameters are often obtained through network simulations, where the QoS is estimated from given parameters. As opposed to the most commonly found simulation, the proposed testbed in this paper enables real life measurements of the QoS parameters for estimating multimedia streaming capabilities in WSN.

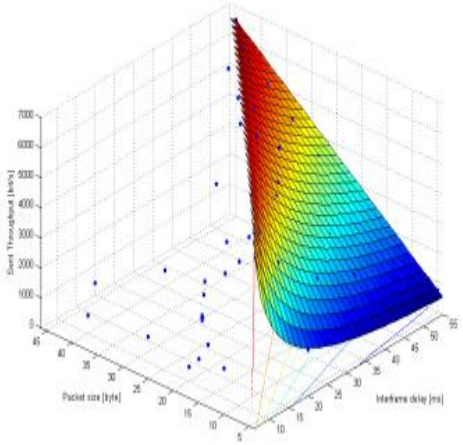

Figure: Modeled throughput and measured throughput [bit/s] versus Packet size [byte] and Inter-frame delay [ms]

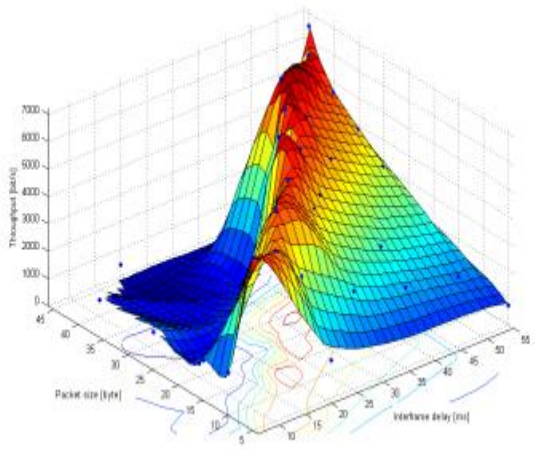

Figure: Surface plot of Throughput [bit/s] versus Packet size [byte] and Inter-frame delay [ms]

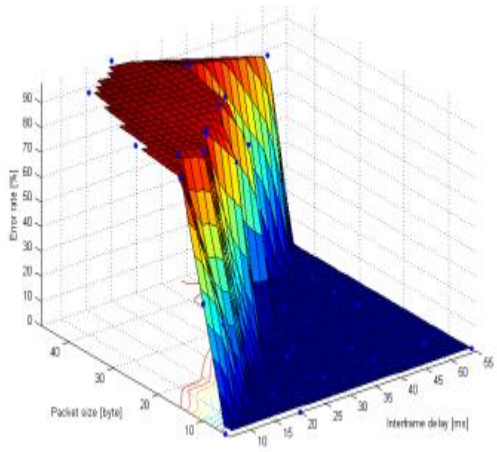

Figure: Surface plot of Error rate [%] versus Packet size [byte] and Interframe delay [ms]

The testing of the proposed testbed and a basic set of measurements is performed using the proposed application in combination with MATLAB processing. Three main QoS parameters were analyzed in the forthcoming measurements: Throughput, Latency and Error rate in respect to Packet size Npack and Inter-frame delay tf rame. From mathematical point of a view throughput can be easily modeled as

$$Throughput = \frac{N_{pack} * 8bit}{t_{frame}}$$

where Npack is the size of the data packet in byte and tf rame is delay between frames or time interval between consecutive frames. If the measurement of the throughput is performed using the proposed testbed for various combinations of values tf rame and Npack, three dimensional plot can be shown for the modeled throughput (surface plot) versus measured values.

Conclusion

In this paper we have conducted a comprehensive survey of QoS routing protocols in WMSNs. The QoS routing protocols are classified into deterministic and probabilistic categories. In addition, we have also reviewed QoS routing protocols with strength and weaknesses in WMSNs. This study proposes a testbed designed for estimating QoS and measuring relevant QoS parameters in WSN. Due to the lack of related work that focuses on measurement and estimating QoS in Wireless (Multimedia) Sensor Networks this paper proposes a testbed designed for estimating QoS parameters for multimedia streaming in existing WSN equipment. The testbed consists of WSN interface hardware and developed application designed for measuring and estimating critical parameters that affect QoS in WSN. Due to the fact that the application is composed out of two separate applications one of the main prerequisite for measuring QoS parameters is establishing the clock synchronization between operating systems running the proposed application.

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