

Congestion Control Protocols for Wireless Multimedia Sensor Networks

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Abstract: *Wireless Sensor Network(WSN) are now evolved as Wireless Multimedia Sensor networks(WMSN) which are used to collect audio video data in various applications. Multimedia applications have become an essential part of our daily lives. In WMSN large amount of multimedia data is transmitted over network. The growing interest in WMSN applications increases challenges in congestion control protocols in these networks. To support quality of service (QoS) requirements for multimedia applications having a reliable and fair transport protocol is necessary. Congestion control is one of the main objectives of the transport layer in WMSNs. In event-driven applications, it is critical to report the detected events in the area, resulting in sudden bursts of traffic, causing loss of data. In WMSNs, Congestion control techniques are based on detection of congestion and recovery, but they cannot eliminate or prevent the occurrence of congestion. In this paper different congestion control protocols are discussed for multimedia communication in WMSN. A content aware cross layer congestion control protocol is suggested to avoid and control congestion.*

Keywords: WMSN, Congestion Control, Transport Layer, Multimedia Communication

1. Introduction

Wireless Multimedia sensor network is collections of wireless sensors that transmits multimedia data as well as scalar data from environment to its data collection node. The reason behind the low quality of multimedia data is that congestion in the network and high packet loss rate. One more issue taken into consideration is that energy consumption and battery lives of these devices is crucial. Most of the research before WMSN is concerned with scalar sensor networks that measure physical phenomena, such as pressure, temperature, humidity, or location of objects that can be transmitted through low bandwidth and delay-tolerant data streams. Recently, the research is focusing towards delivery of multimedia content, such as audio and video streams, as well as scalar data.

Now a day's Wireless Multimedia Sensor Networks (WMSNs) are attracting considerable attention from both academic and industrial research groups. WMSN has a wide range of applications in both civilian and military areas, which processes visual and audio information, such as a surveillance sensor network, environmental and industrial monitoring, intelligent traffic congestion control, health-care, and others multimedia digital entertainment, or green city applications. A Wireless Multimedia Sensor Network (WMSN) is a special WSN made up of several multimedia sensor nodes, specially designed to retrieve multimedia content such as video and audio streams, still images, and scalar sensor data from the environment. Currently, research challenges in designing multimedia applications on WSNs include, but are not limited to the following:

- QoS requirements - Streaming media, system snapshots, audio/video store and playback applications have different requirements with respect to delay, jitter, and loss tolerance.

- Bandwidth- WMSNs require a bandwidth that is orders of magnitude higher than that supported by currently available sensors.
- Power- Compared to traditional WSNs, power consumption is greater in multimedia applications because of high volumes of data, high transmission rates, and extensive processing.
- Cross-layer design- An effective optimization of all the above parameters involve cross layer protocol design ranging from Application to Physical Layer.
- New hardware design to better manage the energy with high QoS (i.e. power supply, microcontroller (MCUs) architectures and energy harvesting).

Following Fig. 1 shows general scenario of WMSN

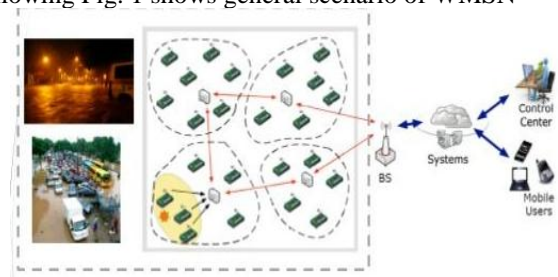


Figure 1: General Scenario of WMSN

A. Motivation

The applications of WMSNs include current applications that make use of audio and visual sensors with perhaps the most common being video surveillance, Industrial Process Control etc.

Since these applications cover remote and real-time monitoring systems, their implementation requires higher expectations in Quality-of-Service (QoS). In wireless multimedia sensor network, when the traffic load being offered exceeds the available capacity of sensor nodes

congestion occurs. In these applications, every sensor node senses event and send data to a sink node. This operation makes the sensors closer to the sink, resulting in congestion. The congestions without any control protocol being implemented results in more packets drop and more energy wastage. The congestion occurring in a node may result in a quick decline of a network throughput.

There are two types of congestion in wireless sensor network

- 1) **Node level congestion** is occurred at particular node when the packet inter arrival rate is greater than the scheduling rate, this result in packet loss, increasing queuing delay and requires retransmission of packets.
- 2) **Link level congestion** is occurred due to channel contention, interference, and packet collision due to accessing transmission medium simultaneously by multiple active sensor nodes.

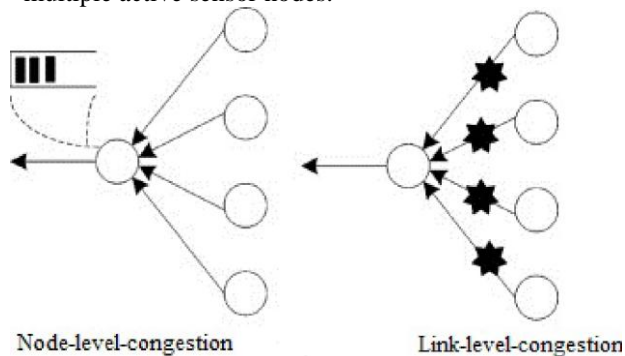


Figure 2: Types of congestions in WMSN

Congestion in WMSN affects the quality of multimedia data. There is different congestion control protocols designed for scalar sensor networks. Scalar sensors sense non multimedia data such as temperature or humidity; they are not designed to provide high multimedia quality in WMSNs. These congestion control protocols are not content aware, this is the main reason for low multimedia quality provided by them. In other words, they treat multimedia packets similar to regular data packets, whereas in multimedia communication some packets are more important than other packets. For instance, in the case of video, packets which carry I-frames have the highest priority compared to the other frame types. Moreover, the rate adjustment techniques that are deployed in congestion control protocols, only try to adjust the output sending rate of source nodes without considering the distribution of inter-arrival packets (inter-arrival process of the packets) that can have a great impact on number of lost packets in WSNs.

2. Literature Review

Congestion control generally follows three steps: congestion detection, congestion advertisement, and transmission rate adjustment. In this section few congestion control protocols are considered.

WCCP [1] proposes a congestion control protocol for wireless Multimedia sensor network. In this paper the protocols are categorized in to four categories 1) queue assisted protocols 2) Priority aware protocols 3) Topology formation protocols and 4) Resource control protocols The queue assisted protocols are focus on the queue length and

rate adjustment technique. The congestion control protocols are not aware of content of multimedia data. They treat all multimedia packet same as the regular packet.

The multimedia packets carry three types of frame i.e. I-frame, P packet and B frames. The packet who carry I frame has highest priority than others. This paper proposes two stage WMSN congestion control protocol. In this protocol first stage is the Source Congestion Avoidance Protocol (SCAP) is deployed on the source which helps to predict congestion using Group of Picture (GOP) size method. It also adjusts the distribution of the leaving packet along with the sending rate of source node. The second stage uses the Receiver Congestion Control Protocol (RCCP) is deployed on the intermediate node it detects the congestion in the networks and informs the source node and other nodes. RCCP uses queuing model to detect the congestion in the network.

In [2] a new method is introduces called reliability and congestion control protocol. This protocol can be used as mechanism to reduce congestion in the network by free resources sets to accurate rate and priority data needs. In this the source node sets the priority of data packet. The protocol helps to increase lifetime of network and increase packet transfer rate. This paper also proposes an algorithm which uses a priority mechanism and used to solve the problem associated with delay. Congestion detection mechanism uses two indexes first is for queuing delay and second is for packet loss. After settlement of these two indexes the algorithm can be applied.

In [3] improvement is suggested in existing Datagram Congestion Control Protocol (DCCP) and also validation of improvements in DCCP. After analysis of DCCP-CCID3 this paper mainly emphasizes on performance factors like throughput, loss event rate and Round Trip Time (RTT). The paper use ACK arrival rate in order to detect loss event and assign the loss of ACK computation rate. For the improvement in the RTT estimation the delay needs to be taken into consideration. The delays are MAC delay and Queuing delay. To improve the calculation of RTT the value estimated in transport layer with the theoretical computed value.

The paper [4] proposes a design framework for TCP and Media friendly rate control algorithm for multimedia streaming algorithm. To fulfill media friendly property, the frameworks is start with TFRC (TCP Friendly Rate Control) transmission rate and then alter this transmission rate so that it tracks the media friendly characteristics of the stream.

In this paper authors proposed three theorems that provide guidelines for choosing media friendliness. It will give congestion control with TCP friendly. The media friendly function can be static or dynamic on the basis of parameters. In static parameters are defined before the session starts and dynamic parameter are computed during the stream. The proposed Utility Driven TCP-Friendly Rate Control UTFRC depends on TFRC for achieving TCP friendliness and media friendliness.

In gap analysis we analyze the various parameters of algorithm against our proposed algorithm. The paper [1] proposes Media-friendly and TCP-friendly Rate Control Protocols for Multimedia Streaming. The advantage of this protocols are congestion control mechanism in multimedia data. It works with VBR data. It performs static as well as dynamic part and it shares virtual bandwidth. The disadvantage with this approach is that it consumes more energy. The paper [2] proposes TCP congestion avoidance algorithm. This paper suggest how DCCP can be used where the Path characteristics and Path RTT are dynamic in nature. This algorithm works for congestion avoidance at the node. In this algorithm classification decision are depends on the training data set. It uses machine learning approach in which we find interesting patterns in order to make better decision making. Because of machine learning approach it consumes more energy.

The paper [3] describes about an improved transport algorithm over DCCP in wireless ad hoc networks. After analysis of DCCP-CCID3 this paper mainly emphasizes on performance factors like throughput, loss event rate and Round Trip Time (RTT). It provides congestion control mechanism using RTT parameter. It also calculates accurate data transfer rate. The data rate depends on theoretical value. The paper [4] gives a new mechanism for congestion control in wireless multimedia sensor networks for quality of service and network life time.

In this congestion control protocol congestion control is done by assigning priority to the data packet. We need to make provision that data packet with highest priority should not dropped in congestion. It Works well only for nodes near base station. The paper [5] describes about WCCP protocol it helps to reduce network congestion and energy consumption. It Also works for improving video quality. The disadvantage of this approach is that it reduces throughput of the system.

Table 1 shows brief comparison of the above discussed congestion control protocols.

3. Proposed Methodology

A. Problem Statement

The growing interest in applications of Wireless Multimedia Sensor Networks (WMSNs) imposes new challenges on congestion control protocols in such networks. A content aware cross layer protocol is proposed to control congestion. The main objective of this system is to -

- 1) Reduce network congestion
- 2) Reduce energy consumption
- 3) Improve throughput

B. Proposed System

Table 1: Gap Analysis

<i>Sr No</i>	<i>Paper</i>	<i>Congestion Detection and control</i>	<i>Drawbacks</i>
1	Media-friendly and TCP- friendly Rate Control Protocols for Multimedia Streaming	Multimedia supported congestion control Works with VBR data Perform with static and dynamic part and virtual bandwidth sharing	More energy consumption
2	TCP Congestion Avoidance Algorithm Identification	This work for congestion avoidance	Classification decision depend on training data set. More energy consumption because of machine learning
3	An Improved Transport Algorithm over DCCP in Wireless Ad Hoc Networks	Congestion control using RTT parameter and calculate accurate data rate	Data rate depends on theoretical value.
4	A New Mechanism for Congestion Control in Wireless Multimedia Sensor Networks for Quality of Service and Network Life Time	Congestion control Data priority	Works well only for nodes near base station
5	WCCP: A congestion control protocol for wireless multimedia communication in sensor networks	Reduce network congestion and energy consumption. Also works for improving video quality Packet priority	Reduce network throughput

The proposed system is divided into three components first one is source component second is destination component and third is communication network component. At the source node source congestion avoidance protocol requires for the avoidance of congestion. GOP size helps to detect the congestion in the network. When we detect the congestion in the network then we have two options either adjust the sending rate or distribute the packets among all the nodes. In the adjustment scenario sender adjust its sending rate according to receiver's acceptance rate. It will lead to avoid congestion in the network.

At the receiver end Receiver Congestion control protocol works. In this scenario the receiver monitors the queue and detects the congestion after detection of congestion it sends

notification to sender for adjustment of the sending rate. At the network end the traffic model is required to analyze the network congestion.

The Fig. 2 shows the system architecture. Nearly all congestion control protocol has congestion detection phase. Packet loss in wireless communication network is hardly avoidable because of source level congestion and link level congestion. If congestion is detected, then the notification of congestion is send to all child nodes. At the same time rate adjustment is done by asking the maximum allowable rate to the child node. After that we need to adjust the system threshold value for system load.

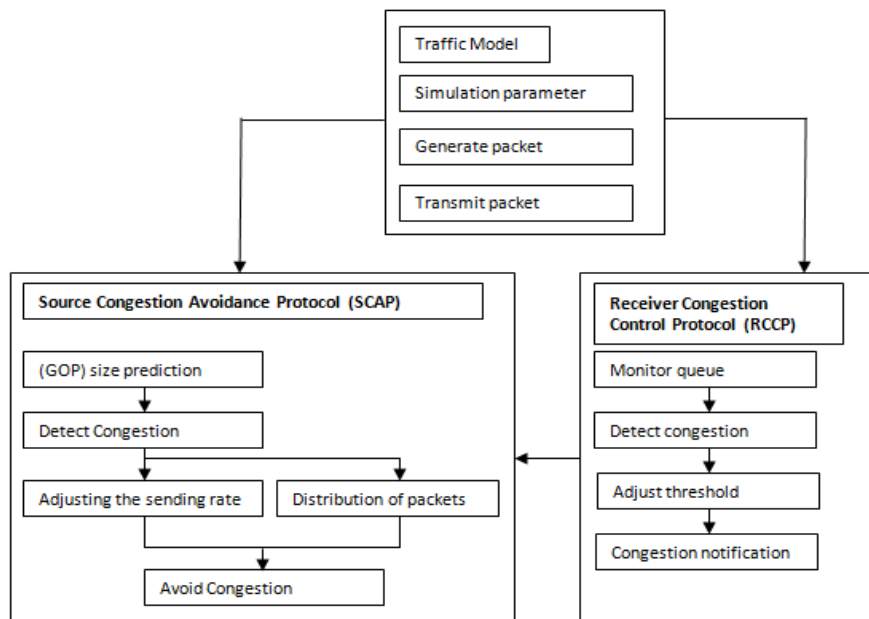


Figure 2: Proposed Architecture

4. Conclusion

In this paper, different congestion control protocols are discussed for WMSN. All these protocols are not content aware instead of importance of data they concentrate on congestion control strategies. A new content-aware cross layer protocol (EWCCP) is discussed in this paper to minimize the packet loss in WMSNs by considering the traffic characteristics, inter-arrival pattern of packets, and video packets priority. EWCCP employs intermediate nodes queuing, and source traffic model to detect and remedy the congestion. In the source part, it uses a GOP size prediction method to predict future sending rate and congestion occurrences. It, then adjusts the source traffic to avoid congestion. In the receiver part, it detects congestion in the network by using a queuing model and sends feedback to the source.

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