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Improve the quality of services to help congestion control flows to send a video in wireless multimedia sensor networks

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Abstract— **the quality of service in Wireless Multimedia Sensor Networks (WMSN) is related to packet loss rate. Recently different studies have been done on developing efficient protocols in the transport layer for controlling packet loss in WMSN. However, all of these protocols are independent of the characteristics of multimedia content. Transport layer for wireless sensor networks have many challenges. One of these challenges is the congestion. It leads to undesirable effects such as increased the packet delay, energy consumption and decrease quality of video. Considering these effects provide appropriate congestion control mechanisms can lead to improve the quality of service (QoS) requirements. This paper introduces a new congestion control method for transmitting the video stream. This method gives the faster congestion detection and congestion control based on the property of video information.**

The experimental results shows that our method provide performance improvement in terms of high video quality, packet loss, energy conservation and delay compared to other protocols.

Keywords- congestion control, video transmission, wireless multimedia sensor networks, queue length.

I. Introduction

Wireless Multimedia sensor networks are a set of sensor nodes that nodes are equipped with devices such as cameras and microphones. Multimedia Wireless sensor networks or WMSNs are able to transfer multimedia data such as photos, streaming video and audio. WMSNs as WSNs have many different resource constraints, such as: power, bandwidth, memory, buffer size and processing capability. Given the small size of the nodes and produce large amounts of data in multimedia applications, there require high transfer rate and large computation, one of the important issues is energy consumption. One of the important issues for these applications is the development of protocols, algorithms and architecture for increased network lifetime and improved QoS parameters. In WMSN and WSN traffic flow from the large number of nodes to the sink node. Consider these features are essential to achieve quality of service parameters, fair and efficient use of network resources. To support multimedia communications having a reliable and congestion control mechanism is important. In traditional communication networks, the transport layer is responsible for bridging the application and network layers using multiplexing and demultiplexing. The transport layer provides end-to-end reliability data delivery and congestion control by regulating the amount of traffic injected into the network. As it argued in [3], the traditional TCP/UDP transport protocol cannot be directly implemented for WMSN and WSN. Therefore, it is important to develop a reliable and congestion control protocol for WMSN to ensure that the often differing QoS requirements of various applications can be met [1, 2].

Congestion control is another important issue that should be considered in transport protocols. Congestion is an essential problem in WSN. It not only wastes the scarce energy due to a large number of retransmissions and packet drops, but also hampers the event detection reliability [3]. Congestion in WSNs and WMSNs has a direct impact on energy efficiency and application QoS. Two types of congestion could occur in sensor networks [4]. The first type is node-level congestion that is caused by buffer overflow in the node and can result in packet loss, and increased queuing delay. Not only can packet loss degrade reliability and application QoS, but it can also waste the limited node energy and degrade link utilization. In each sensor node, when the packet-arrival rate exceeds the packet-service rate, buffer overflow may occur. This is more likely to occur at sensor nodes close to the sink, as they usually carry more combined upstream traffic. The second type is link-level congestion that is related to the wireless channels which are shared by several nodes using protocols, such as CSMA/CD (carrier sense, multiple accesses with collision detection). In this case, collisions could occur when multiple active sensor nodes try to seize the channel at the same time. To avoid the negative aspects of congestion in WMSNs, congestion must be effectively controlled.

The reminder of this paper is organized as follows. In Section 2, we present a brief review of previous studies in congestion control in wireless sensor networks. In Section 3, the proposed method is described. In Section 4, using computer simulation, we evaluate the proposed method. Section 5 concludes the paper.

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II. Related Works

Different mechanism and protocols has been proposed for congestion control in wireless sensor networks. The congestion control mechanisms all have the same basic objective: they all try to detect congestion, notify the other nodes of the congestion status, and reduce the congestion and/or its impact using rate adjustment algorithms. They differ in the way that they detect congestion and the way in which they adjust the data rate when congestion occurs. In this section, we review some of them and their limitations for using in WMSNs are described in table1.

ESRT [8] Event-to-sink reliable transport protocol monitors the local buffer level in intermediate sensor nodes and sets a congestion notification bit in the packet when the buffer overflows. If a base station receives a packet whose congestion notification bit is set, it broadcasts a control signal to inform all source nodes to reduce the sending rate according to certain proportion. ESRT limits sending rate of all source nodes when congestion occurs regardless of where the hot spot happens in WSNs. The best way is to regulate Those source nodes that is responsible for this congestion.

CODA [7] Congestion detection and avoidance (proposes an open-loop, hop-by-hop backpressure mechanism and a closed-loop, multi-source regulation mechanism in event-driven WSNs. Sensor nodes detect congestion by monitoring the channel utilization and buffer-occupancy level. In response to congestion, the congested sensor nodes send backpressure messages to their neighbors which may drop packets, reduce their sending rate and further propagate backpressure messages. If the sending rate of a source node is greater than the preset threshold, the source node must receive a continuous stream of ACKs from the base station in order to maintain that rate. By this means, the base station may limit the sending rate of a source node based on deciding how many ACKs to broadcast. CODA employs the AIMD (Additive Increase Multiplicative Decrease) coarse rate adjustment. It only guarantees simple fairness of the congestion control.

RMST [9] (Reliable Multi-Segment Transport), protocol uses selective ACK (SACK) and designed to run in conjunction with directed diffusion. Although RMST offers high reliability with guaranteed delivery and fragmentation/reassembly however it lacks energy conservation mechanism and does not support the congestion control feature of transport protocol design.

STCP[6] is a generic, scalable and reliable transport layer protocol where a majority of the functionalities are implemented at the base station. However, STCP has some drawbacks like; i) it doesn't provide any explicit and detailed mechanism for controlling congestion in the network, ii) the ACK/NACK based reliability mechanism might not be feasible for wireless sensor networks in terms of delay and memory usage.

Table1- comparison of schemes at the transport layer [4]

Scheme	Approach Used	Drawbacks
Congestion Control Mechanisms		
FUSION[10]	Combination of hop-by-hop flow control, rate-limited traffic, and prioritized MAC	Does not support multiple packet priorities, implicit notification slow, assumes all sensor nodes have same amount of data
CODA[7]	Receiver based congestion and multi-source regulation with feedback	Detection Does not support multiple packet priorities; implicit notification provides slow congestion control.
CCF	Congestion control based on routing tree with a notion of fairness	Simplistic notion of fairness, cannot handle multiple data priorities
PCCP[11]	Congestion control based on sensor node priority and congestion	Congestion notification implicit, degree does not support packet priorities
Siphon	Virtual sinks to improve fidelity affected by packet dropping and rate control	Dependent on an effective congestion control algorithm as the base.
Reliable Transport Mechanisms		
RBC	Window-less block ACK scheme to handle moderately bursty traffic	Support for bustier and jitter prone multimedia traffic not studied
RMST[9]	Correct segmentation, reassembly and delivery guarantee for all packets	Provides reliability for all packets, hence is wasteful
Both Congestion Control and Reliable Transport Mechanisms		
STCP[6]	Based on sessions, congestion control using RED mechanism	Not scalable to large networks
ESRT[8]	Event-to-sink reliability and congestion control through the use of the reporting rate	Does not consider multiple priorities, or reliability in fragmented packets. Handling of large packets or jitter not studied

III. PROPOSED METHOD

As mentioned in the WMSN, multimedia information received from the environment and sent to the destination node [5]. We suppose that the video stream received from the source node and sends to the sink node. Thus, there is only video traffic in the network. The proposed method is described in next section.

Congestion control mechanism is described in three parts [5, 13]: congestion detection, congestion notification and rate adjustment.

A. Congestion detection

Accurate and efficient congestion detection plays an important role in congestion control of sensor networks. Several technologies have been proposed to detect congestion, but they are too energy consumed and complexity. There is a need for tradeoff between efficient and complexity. Recent work reports that, for traffic pattern in which multiple sources send to a single sink, queue length(occupancy) is a sufficiently accurate indicator of congestion. Therefore, we use the queue length (occupancy) as our congestion detection symptom. Due to high transmission rate of video stream's measure, the Intermediate nodes queue lengths are efficient for knowing congestion. In the proposed method, when the packets enter intermediate nodes queue; the queue length is measured, and a congestion degree is assigned. Congestion index is determined as follows:

If ($L_{CUR} \le \alpha L_H$) then *Index0*
If ($\alpha L_H \le L_{CUR} \le \beta L_H$) then *Index1*
If ($L_{CUR} \ge \beta L_H$) then *Index2*

L_H shows the maximum queue length of the intermediate nodes, and the LCUR shows the current queue length. Amount α and β is considered α =65% and β =75%. If the current queue length is less than the lower threshold, the index of congestion is set to Index0. In this case (Index0), the queue of intermediate nodes is in the good situation, and the congestion is not occurring. In this case does not need to rate adjustment. In the second case if the queue length be between the two thresholds, the probability of congestion is high and the congestion index is set (adjusted) to Index1. And appropriate rate is assigned to traffic source at the rate adjust the phase.

B. Congestion notification

After congestion detected in the network, congestion should be notified to other nodes. In the proposed method, intermediate nodes in the network are responsible for congestion notification. If the congestion degree is Index1, congestion of network is not high and the explicit congestion notification is announced. Thus, a small control packet sends to the source node to adjust its rates. If congestion is typed of Index2, implicit congestion notification to be done to prevent more traffic in the network. In this case, intermediate node's active CN bit in the packet header that sent to the sink node. The sink node after receiving packets that are active CN bit the NACK packet that sends for packets lost to the source, an active congestion bit. The source node after receiving NACK packet that congestion bit is active set its appropriate rate.

And Congestion notification is determined as follows:

If (*Index1*) then *(CN bit ==1)*
If (*Index2*) then send a notify packet in downstream node and source

C. rate adjustment

In MPEG standard, there are three types of the frame with different priority that called I, P and B frame. I frames has the highest priority; P frames have second and B frames have lowest priority. Each of these frames has different size and thus produces the different packet's number. The proposed method for rate adjustment is performed by the source node based on the congestion index (assigned by the intermediate nodes) and the priority of video frames. If the Index1congestion notified to the source node, rate adjustment1 is performed (is done) and B frame that has lowest priority is dropped. In this case, the source reduces its rate. This reduced rate will continue until the time is greater than a threshold1, and no congestion notified. In this case, the source rate returns to the initial rate. If network congestion Index2 notified to the source node, the second phase of rate adjustments will begin and in addition of the B frames, P frames (that is the second priority) is dropped. In this case, the source reduces its rate. This reduced rate will continue until the time is greater than a threshold2, and no congestion notified. In this case, the source rate returns to the initial rate.

Algorithm1: rate adjustment in the source node

```
Received (Index i) {
If (Index1 )    {
    While(no index & time<theresholdl){

Rate1= drop B frame
                }
     Stop drop B frame & set base rate }
                      if (Index2) {
     While(no index & time<thereshold2){
          Rate2= drop P and B frame }
     Stop drop B& P frame & set base rate }
```

IV. SIMULATION RESULT

The proposed method is simulated with NS2 [12] simulator and evalvid [14] tool. Simulation parameters are shown in Table 2. In the simulation, video streams are sent from the source node to destination node. To generate more traffic in the environment the number of CBR flows is sent with the video stream. After simulation to evaluate of proposed method, four parameters are calculated. The average packet delay, average remaining energy in the network, the percentage of lost frames in the sink node and the average PSNR. The proposed method is compared with STCP protocol. In this simulation, 50 nodes are spread in the area of simulation. Packets of 400 video frames are transmitted by the proposed mechanism. To generate more traffic video streams is sent with one, four, six, eight ,eleven and fifteen CBR over the network.

Table1- Simulation parameters

Area of Simulation	*670 × 670m²*
Routing Protocol	*AODV*
Propagation way	*TowRayGround*
Channel	*WirelessChannel*
MAC	*802.11*
Antenna	*Omni Antenna*
Packet size	*1000Byte*
Video file	*Foreman with MPEG format*
Queue length	*50 Packet*
Initial Energy	*10 J*
Receive Power	*%24*
Transmit Power	*%36*

Energy is one of the important criteria in WMSN. Hence, any mechanism or algorithm is introduced for this type of network should be considered these criteria. Figure 2 shows the energy consumption of nodes in the proposed method and STCP [6]. Faster congestion detection, effect congestion control and lead to reduce energy consumption. So increase average remaining energy in the network.

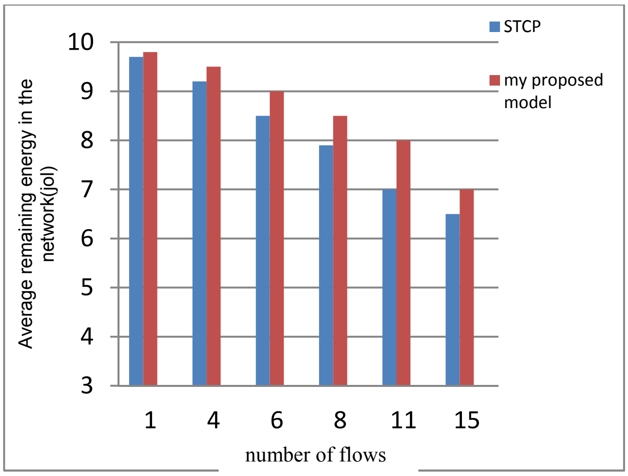

Figure2- Average remaining energy in the network

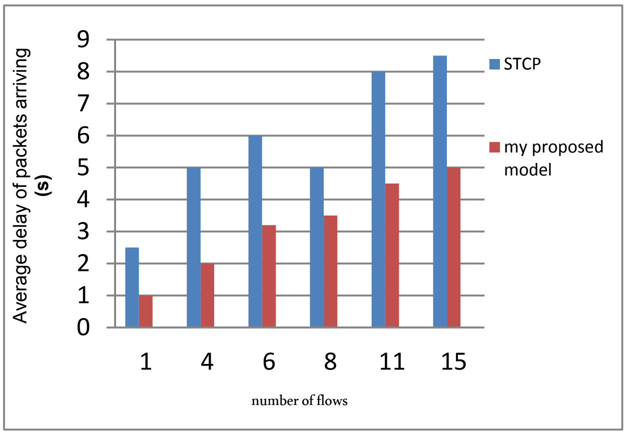

Figure3- Average delay of packets arriving

Figure3 is shown average packet delay arriving for the proposed method and other protocols. Delay is one of the most important criteria for video applications. In proposed method, quick congestion detection leads to appropriate congestion control. As the result with reduce congestion the network return to normal state. Congestion control in STCP does not perform until the queue length at intermediate nodes to reach the maximum. So traffic and average packet delay is increased in the network.

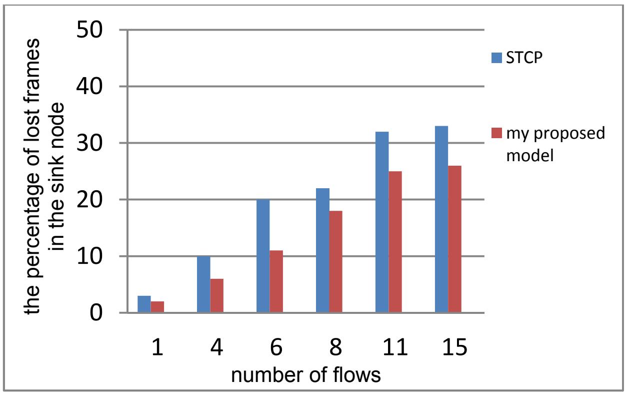

Figure 4- the percentage of lost frames in the sink node

By increasing congestion, more frames will be lost in the network. In the proposed method by quick congestion detection, frame loss is reduced at the destination node. In Figure 4, with the increasing number of CBR flows frames loss is less in the proposed method. In the STCP protocol, frames loss because it responded to the congestion later, the percentage loss of frames is high the destination node.

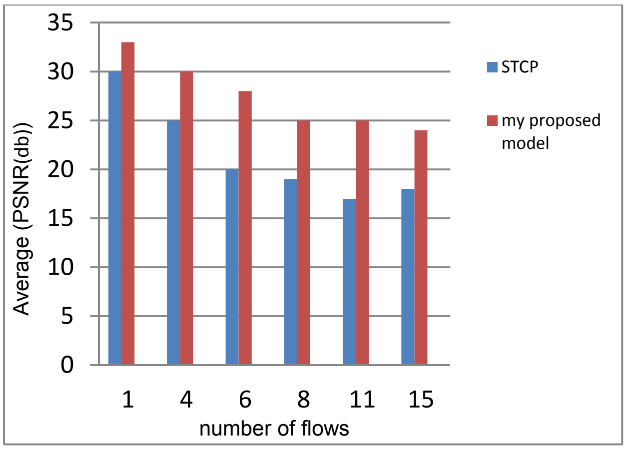

Figure 5- Average (PSNR)

Figure 5 is shown, PSNR of the received video by the destination node. As it is shown in the figure, the proposed method can maintain quality of video. In the congestion situation in the network, I frame at risk than other frames to be drop. As the result the video quality is decrease. In two reasons, the proposed method is guaranteed received of I frames to the destination. First I frame received is guaranteed with stored in the intermediate node buffer, and when this frames are lost retransmission to be done faster. The congestion quickly detected and adjusts the appropriate rates for sources.

V. Conclusion

This paper is presented a new congestion control mechanism based on queue length and property of video information for transmission of video in the wireless multimedia sensor networks. In this mechanism a congestion index will be assigned based on the intermediate nodes queue length. Sources of traffic in the network adjust the transmission rate according to this congestion index. The efficiency of the mechanism shows with Simulation results. These results show that the proposed mechanism detects and controls congestion quickly. so received video quality will be better. Furthermore, due to the fast congestion control, less energy is lost from the sensor nodes, and the network lifetime is increased.

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