A STUDY ON CONGESTION CONTROL TECHNIQUES in WIRELESS MULTIMEDIA SENSOR NETWORKS

A SURVEY

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Abstract- **In recent years, sensor nodes are capable of capturing multimedia content and this information is used for developing real time applications for wireless multimedia sensor networks. Congestion is one of the challenging problem of wireless multimedia sensor networks which reduces energy efficiency compared to traditional wireless sensor networks. While transmitting the high quantity of multimedia contents like audio, video etc, congestion occurs which degrades the performance of the network.This paper provides a survey on congestion problems that occurs during multimedia transmission over wireless multimedia sensor networks. The various routing strategies for congestion control are examined and the different techniques and strategies used for controlling congestion are also discussed.**

Keywords- **Wireless Multimedia Sensor Networks, Congestion control, Multipath routing protocols.**

I.INTRODUCTION

Wireless Multimedia Sensor Network is an emerging field of technology as it has been used in many applications like target monitoring systems, surveillance systems and health care monitoring systems. With the increased availability of CMOS cameras and microphones, as well as more powerful and energy-efficient WSN nodes, they can be equipped with multimedia sensor suites to collaboratively monitor a given area. The WMSN application domain is very broad. Among the many challenging tasks of WMSNs like transporting collected images through wireless channels while satisfying application, QoS criteria is one of the most critical issue. It is difficult to transfer a large amount of image data through low bandwidth and error-prone wireless channels. Moreover, WMSNs may have higher sampling rates and the application may require the samples being transferred to have correct temporal relationships so that these samples can be interpreted properly. While transmitting the huge volume of data, there is a probability of occurrence of congestion in the network. The heavy load and the unpredictable network conditions may lead to congestion. There are two types of congestion namely, node level and link-level. Node-level congestion is occurred at a particular node when the packet inter arrival rate is greater than the scheduling rate and it results in packet loss, increasing queuing. The other type of congestion called link-level congestion is occurred due to channel contention, interference, and packet collision due to accessing transmission medium simultaneously by multiple active sensor nodes. Wireless multimedia sensor networks have resource constraints in which embedded sensing devices are constrained in terms of battery, memory, processing capability, and achievable data rate.In addition to data-delivery modes of typical scalar sensor networks, multimedia data include snapshot and streaming multimedia content. Snapshottype multimedia data contain event triggered observations obtained in a short time period (e.g., a still image). Streaming multimedia content is generated over longer time periods, requires sustained information delivery, and typically needs to be delivered in real time. Therefore the problem of congestion occurs more likely in WMSN than in WSN due to the streaming of multimedia data.

II.DESIGN CONSTRAINTS IN WMSN

Wireless Multimedia Sensor Networks face with many design constraints and challenges. Multimedia contents, especially video streams, require higher data rates than that are supported by certain sensors. Hence, transmission techniques for high data rate and low power consumption need to be leveraged. Multimedia traffic demands for high bandwidth which requires new transmission techniques to provide the required bandwidth with acceptable energy consumption level. Multipath or multichannel can be used as a solution to support the required bandwidth.Capacity and delay attainable on each link are location dependent, vary continuously, and may be bursty in nature, thus making quality of service (QoS) as a challenging task. Because of the shared nature of the wireless communication channel, there is a strict interdependence among functions handled at all layers of the communication protocol stack. This has to be explicitly considered when designing communication protocols aimed at QoS provisioning on resource- constrained devices. Processing of multimedia content has mostly been approached as a problem isolated from the network-design problem. Similarly, research that addressed the content delivery aspects has typically not considered the characteristics of the source content and has primarily studied cross-layer interactions among lower layers of the protocol stack. However, processing and delivery of multimedia content are not independent, and their interaction has a major impact on the achievable QoS. The QoS required by the application will be provided by means of a combination of cross-layer optimization of the communication process and in-network processing of raw data streams that describe the phenomenon of interest from multiple views, with different media, and on multiple resolutions. Multimedia application produces high volume of traffic which requires high transmission rate and processing capabilities which leads to consume more energy than WSN. Routing protocols should be aware of energy consumption to prolong the network lifetime.QOS requirements differ according to different types of multimedia applications. QOS metrics such as delay, bandwidth, reliability and jitter must be disparately taken into account as needed. Most of the multimedia applications are time critical and need to be reported with a limited time.

III.CONGESTION IN WMSN

Congestion in wireless multimedia sensor network (WMSN) is one of the critical problems still from its evolution. The probability of congestion in WMSN is higher than in WSN due to the high volume of data arising from the multimedia streaming. Congestion in WMSN can be a severe problem, as it causes plethora of malfunctions such as packet loss, lower throughput, energy efficiency, increase in collisions, increase in queuing delay and decreases network lifetime. As a result, the performance of the whole network is subject to undesirable and unpredictable changes. Its performance control can be carried out by robust congestion control approaches that aim to keep the network operational under varying network conditions. Congestion is a challenging problem which is common in wireless networks occurs when offered load exceeds available capacity or the link bandwidth. Normally the problem of inefficient bandwidth is due to the fading channels. It leads to packets drop at the buffers, increased delays, wasted energy, and requires retransmissions. Moreover, traffic flow will be unfair for nodes whose data has to traverse a significant number of hops. Retransmission of packets leads to consumption of more energy. This considerably reduces the performance and lifetime of the network. Additionally, the networks have constraints imposed on energy, memory and bandwidth. Therefore, energy efficient and minimum delay data transmission protocols are required to mitigate congestion resulting from fading channels and excess load. In particular, a congestion control mechanism is needed in order to balance the load, to prevent packet drops, and to avoid network deadlock.

A. Effect of Congestion

The problem of congestion may lead to many effects. The traffic from various parts of the network leads to congestion which in turn degrades the radio channel quality. With a well-regulated traffic, the pitiable and time varying channel quality, asymmetric communication channels, and unseen terminals make the deliverance of the packets weaker. When a packet traverses a large number of hops under traffic load, it gets penalized leading to large degrees of unfairness. Buffer drop may occur due to degradation of overall channel quality. Delay can also be increased in the network due to this. The link-level congestion causes increase in packet service time and decrease in link utilization. Energy efficiency and QoS is affected by both these congestions this decreases the network lifetime.TCP congestion causes all segment losses. Due to this, window based flow control and congestion control are triggered. The diverse data rate from very low rate periodic data to very high rate event data are generated by nodes. Hence, the capacity of the network is lesser than the aggregate traffic rate causing the bottleneck. Timely delivery of information is very essential for wireless multimedia sensor networks and congestion in network may increases the delay and affects the network performance.

IV.OVERVIEW OF CONGESTION CONTROL TECHNIQUES IN WMSN

There are several causes of congestion and ways to mitigate them. All sensor nodes share a single communications channel using a multiple access protocol. The packet transmission may lead to a time overlap of two or more packet receptions, called collisions. The packet collision problem causes packet loss, packet retransmission, decreasing throughput, increased delay/latency and increased wasted energy consumption. Division Multiple Access (TDMA) is a solution to reduce the packet collision problem. Total transmission time is divided into frames and each frame is divided into time slots. After that each time slot will be assigned to a sensor node to guarantee that every node is granted permission to send a packet in its time slot guaranteeing collision avoidance. Latency directly varies with frame length. On other hand, throughput inversely varies with frame length. Rate controlling techniques can also be preferred for controlling congestion but it regulates the data sending rate by dropping some frames in case of congestion. In addition, sensor nodes are resource constrained having limited energy and low processing power. Therefore, the characteristics of the proposed algorithm for a sensor network should be competence and efficiency. So, a scheduling strategy based on the queue priority technique that is simple and easy to implement in resource constrained devices is proposed. QOS requirements differ according to different types of multimedia applications.QOS metrics such as delay, bandwidth, reliability and jitter must be disparately taken into account as needed. Most of the multimedia applications are time critical and need to be reported within a limited time. Priority to each packet will be assigned and those packets will be ordered in the queue according to their priority. Real time packets are considered as more important in wireless multimedia sensor networks. So the scheduling strategy which is energy efficient gives higher priority to real time data packets. The queue management is an efficient solution for controlling congestion.

The network layer is important to QoS support for multimedia application because it is responsible for providing energy efficient path that meets QoS requirements and it serves as intermediate for the exchange of performance parameters between application and MAC layer. In this section various approaches and routing protocols proposed for congestion control in WMSN are surveyed.

A. Fuzzy Logic Approach

Fuzzy logic methodology is a proactive approach to solve QoS related issues. Fuzzy logic is very effective to manage the performance, without requiring a mathematical model. Fuzzy control theory provides formal techniques to represent, manipulate and implement human expert's heuristic knowledge for controlling the network. Fuzzy logic implements human experiences and preferences via membership functions and fuzzy rules. Fuzzy logic uses certain parameters for predicting congestion. Based on the calculated value of the parameters, congestion level in the network is estimated. In [15], the indicators used for estimating congestion are number of contenders, buffer occupancy of the parent(next-hop) sensor node and the ratio of incoming to outgoing packets within a time window is given as output for finding out the congestion level. In [14], for controlling congestion, the three most important variables for predicting congestion are average node degree, average queue length and net data arrival rate. This fuzzy logic is mainly used for congestion estimation model with fuzzy set variables. QoS management and control module is essential for wireless networks. For congestion mitigation in [5], the buffer length of the sensor node is continuously monitored using the congestion headers br-stamp, delay-stamp and rate stamp fields in the packet header.

B. Rate Based Control Techniques

In rate based control methods, each node estimates the number of flows derived from upstream nodes and based on this it modulates the rate when congestion is detected. In [1], the rate regulation message includes node id and congestion level such as low or high. By receiving rate regulation notification message, each upstream node measures its congestion level using fuzzy logic system. If congestion level is low or high, then they estimate a new data sending rate considering existing data sending rate, node degree and queue length. Then feedback the new data sending rate to the sender node. By receiving new data sending rate, the sender node regulates its data sending rate. Thus congestion is controlled by rate adjustment technique.

C.Buffer Based Management

Buffer based protocols forward their packets to their upstream neighbours, only when buffer has enough space to hold the packets. It does not consider the data rate of upstream and downstream neighbours. It eliminates the complicated rate based signalling. These methods give faster detection and feedback action will be taken place at right time and they are best suited as reliable methods. This mechanism of buffer based congestion control prevents data packet from overflowing the buffer space of the intermediate sensors and automatically adapts the sensor forwarding rates to nearly optimal without causing congestion. Some buffer based approaches provides the highest priority for the node with maximum occupied buffers and makes an optimal choice of next hop forwarding.

D. Priority Based Methods

In WSNs, different packets may be of different importance in the serving of event detection. Since the precision of sensors decreases when the distance grows, the data collected by the nodes closer to the event are usually more precise than those collected by nodes farther away, and therefore when there is a critical situation and the network fails to transmit all packets to sink, it should try its best to transmit the packets which are more important. Priority can be utilized to describe the importance of the packet and node.Packets with priority will be assigned and those packets will be orderedin the queue according to their priority. Packets with higher priority will be serviced before those with lower priority. Queue Based Congestion Control Protocol (QCCP-PS) with Priority Support [5] uses the queue length as an indication of congestion degree. If the packets in the queue exceeds, then there is the probability of congestion. The rate assignment to each traffic source is based on its priority index as well as its current congestion degree.

E. Bandwidth Management

Jenn-Yue Teo [3] proposed a protocol for multipath environment but the parent node divides the bandwidth equally among its child nodes. Pump Slowly Fetch Quickly(PSFQ) protocol is to distribute data from a source node by sending data at a relatively slow speed (“pump slowly”) based on the available bandwidth but allowing nodes that experience data loss to fetch (i.e., recover) any missing segments from their local immediate neighbours aggressively(“fetch quickly”). It slowly injects packets into the network, but performing aggressive hop-by-hop recovery in case of packet losses. The pump operation in PSFQ simply performs controlled flooding and requires each intermediate node to create and maintain a data cache to be used for local loss recovery and in-sequence data delivery.

V.OVERVIEW OF MULIPATH ROUTING PROTOCOLS FOR CONGESTION CONTROL

Routing protocols are mainly used for forwarding the data from one node to the other. It chooses the best path for transmission and it provides the routing table in which path construction is updated. The traffic is transmitted using multiple paths to reach the destination and high priority packets are transmitted prior in the presence of congestion. Hence, these protocols achieve a high degree of reliability. Congestion aware routing mechanism enforces a differentiated routing approach to discover the congested zone of the network that exists between high priority data source and data sink and to dedicate this portion of network to forward primarily high priority traffic. Traffic aware dynamic routing mechanism is used to route packets around the congestion areas and scatter the excessive packets along multiple paths consisting of idle and under loaded nodes.

Guannan et al. [9] proposed a routing protocol for wireless multimedia sensor network using multipath and load balancing, aiming to increase the reliability, save more energy, and control the congestion situation. The proposed protocol is flat and event driven. No global topology is required, and the sensor node is only aware of its neighbour nodes which reduce the overhead. Three full disjointpaths are built from source node to sink called primary, alternate, and backup paths. The primary path is the least delay path, then the alternate and backup paths. By default the backup path will be used in case the primary or alternative paths fail. The transmission on these paths will be on stable rate and in round robin fashion but with specific time control called time slice control. Each sensor node will use two paths for transmission. As the primary path has less time delay it will get more time than the alternate path. The congestion control mechanism is designed for the major node (joint node) which is a node used by two paths as a relay node and is done by monitoring the queue of this node if the receiver queue reaches the threshold. A congestion notification is sent back to the source then it will stop transmitting in this path and switch to the another path. The simulation result shows that the protocol enhances the life time and throughput but under higher transmission rate, the receiving rate and the network life time drop fast. The redundancy is low which affects the reliability.

Mande and Yuanyan [6] proposed multipath routing protocol to support hole bypassing, load balancing, and congestion control. The proposed algorithm consists of two phases. The first one determines a set of multiple paths while the second selects a routing path from the found paths.During exploring the path, the node that belonged to FCS (set of nodes that is nearer to destination and farther from the source than the current node) with less DEF (Decisive Energy Factor) (energy consumption for transmitting data packet) value is selected as next forwarding node. This protocol uses amazing search algorithm which consists of wave front expansion and path back tracking. In wave front all valid nodes from source to destination are labeled in a decreasing tag number till reaching the destination. During path backtracking, the algorithm starts from destination to source and selects the node whose tag number is greater than the current node. When the source node is successfully reached, then the path is built. After multiple paths are determined, selecting paths randomly and independently from different sources increases the congestion and energy consumption in some nodes. To overcome these problems a path selection strategy is designed. To manage energy consumption, a Decisive Energy Ratio Change Request (DERCR) message is introduced which is sent by node to source to update the energy consumption value on the path. For congestion avoidance a control message is introduced which contains node and path ID;when the queue exceeds threshold specified by user the node sends this message to all nodes in routing tables; then two adjustment strategies are used, (1) gradual increase strategy based on the path and (2) gradual increase strategy based on flows.

Geographic routing protocol: Biased Geographic Routing (BGR) is a light weight stateless, geographical forwarding protocol which is a cost effective complement to greedy routing. BGR routes packets on curved trajectories by forwarding packets along curves, instead of shortest path.

In time-critical wireless sensor network (WSN) applications, a high degree of reliability is commonly required. In Dynamical jumping real-time fault-tolerant routing protocol (DMRF), each node utilizes the remaining transmission time of the data packets and the state of the forwarding candidate node set for dynamically choosing the next hop. Once node failure, network congestion or void region occurs, the transmission mode will switch to jumping transmission mode, which can reduce the transmission time delay, guaranteeing the data packets to be sent to the destination node within the specified time limit. By using feedback mechanism, each node dynamically adjusts the jumping probabilities to increase the ratio of successful transmission. This mechanism not only efficiently reduce the effects of failure nodes, congestion and void region, but also yield higher ratio of successful transmission, smaller transmission delay and reduced number of control packets. Stateless Protocol for Real-Time Communication in Sensor Networks (SPEED) is one of the most classical real-time routing protocols which estimates the transmission rate between the current node and the sink node and establishes the path according to the estimated rate to ensure the data can be sent to the sink node before the deadline of the event that is detected.

TABLE I.COMPARISON OF CONGESTION CONTROL TECHNIQUES FOR WMSN

Protocol	**Energy Efficiency**	**Congestion Control**	**QOS parameters considered**	**Performance analysis**	**Methodology**
Maciej Zawodniok[1]	No	Yes	Delay	High packet loss ratio	Rate control by rate regulation notification messge.
Jenn-Yue Teo[3]	Yes	Yes	Bandwidth	High reliability	Aggressive hop by hop packet loss recovery.
Mande and Yuanyan[6]	Yes	Yes	Reliability	Enhances lifetime of nodes.	Multipath topology.
Guannan et al[9]	Yes	Yes	Delay	Enhances throughput.	Congestion control by multipath environment.
Cagatay Sonmez et al.[15]	No	Yes	Delay	Minimized delay but experiences increased packet losses.	Fuzzy based approach for congestion detection.

Table 1 shows summary of comparison between mentionedrouting protocols for WMSN based on the energy efficiency, QoSparameters and their performance analysis. Each methodology has its own metrics of mitigating congestion but it cannot control congestion completely. Multiple queue arrangements for packet transmission can be used for balancing all the QOS parameters.

VI.CONCLUSION

The issues in Wireless Multimedia Sensor Networks (WMSNs) like energy constraint, addressing heterogeneity, designing of cross-layer solutions and cooperation of nodes in the networks are still being addressed as a problem. By considering about the congestion problem, the packets are dropped according to their weights when congestion occurs. But in real time applications, the information that is gathered is very important and has to be transmitted without any packet loss. So better techniques that provides queue scheduling that minimizes packet losses and transmits with minimum delay can be efficient for controlling congestion in wireless multimedia sensor networks.

VII. REFERENCES

[1] Maciej Zawodniok, and Sarangapani Jagannathan, "*Predictive Congestion Control Protocol for Wireless Sensor Networks"*, IEEE transactions on wireless communications, vol. 6, no. 11, November 2007.

[2] Ahmad, B. Al-Kazemi, and A. Shoba Das, "*An efficient algorithm to findbroadcast Schedule in adhoc tdma networks"*, Journal of Computer System, Networks, Communication, January 2008.

[3] Jenn-Yue Teo, Yajun Ha, and Chen-Khong Tham ,"*Interference-Minimized Multipath Routing with Congestion Control in Wireless SensorNetwork for High-Rate Streaming"*IEEE Transactions on Mobile Computing, Vol. 7, No. 9, september 2008

[4] I.Lee, W.Shaw, and X.Fan,"Wireless multimedia sensor networks,"*Guide to Wireless Sensor Networks"*, S.Misra, I.Woungang and S.C. Misra editors, Springer, 2009.

[5] Can Basaran, Kyoung-Don Kang, Mehmet H.Suzet,"*Hop-by-Hop Congestion Control and Load Balancing in Wireless Sensor Networks*"LCN'10 Proceedings of the 2010 IEEE 35th Conference on Local Computer Networks,IEEE Computer Society ,2010.

[6] X. Mande and G. Yuanyan, "Multipath routing algorithm for wireless multimedia sensor networks within expected network lifetime," in *Proceedings of the International Conference onCommunications and Mobile Computing (CMC '10)*, pp. 284–287, April 2010.

[7] Liang Zhou, Han-Chieh Chao, and Athanasios V.Vasilakos "*Joint Forensics-Scheduling Strategy For Delay-Sensitive Multimedia Applications over Heterogeneous Networks"*,IEEE Journal on Selected Areas in Communications,vol.29,No.7,August 2011.

[8] P.Guo, T.Jiang, Q.Zhang,"*Sleep scheduling for critical event monitoring in Wireless Sensor networks*, "IEEE Trans.ParallelDistrib.Syst.,vol.23,no.2,Feb 2012.

[9] S. Guannan, Q. Jiandong, Z. Zhe, and Q. Qiuhong, "A reliable multipath routing algorithm with related congestion control scheme in wirelessmultimedia sensor networks," in *Proceedingsof the 3rd International Conference on Computer Research andDevelopment (ICCRD '11)*, pp. 229–233, March 2011.

[10] Syed Mahfuzul Aziz and Duc Minh Pham, "*Energy Efficient Image Transmission in Wireless Multimedia Sensor Networks"*, IEEE Communication Letters,vol.17, No.6, June 2013.

[11] Hee-Sook Mo, Euisin Lee, Soochang Park, and Sang-Ha Kim, "*Virtual Line Based Data Dissemination for Mobile Sink Groups in WSN*", IEEE Communication Letters, vol.17. No.9,September 2013.

[12] Nidal Nasser, Lutful Karim, and Tarik Taleb, "*Dynamic Multilevel Priority Packet Scheduling Scheme for Wireless Sensor Network*", IEEE Transactions on Wireless Communications, vol. 12,No.4, April 2013.

[13] Harjot Bawa, Parminder Singh, Rakesh Kumar, "*An Efficient Novel Key Management Scheme for Enhancing User Authentication in a WSN*", IJCNIS,vol.5,no.1.2013.

[14] U. Urathal alias Sri Swathiga, Dr. C. Chandrasekar, " *Congestion Prediction and adaptive rate adjustment Technique for Wireless Sensor Networks"* International Journal of Research in Computer Science ISSN 2249-8265 Volume 3 Issue 4 ,2013.

[15] Cagatay Sonmez, OzlemDurmaz Incel, Sinan Isik, Mehmet Yunus Donmez , and Cem Ersoy "*Fuzzy-Based Congestion Control for Wireless Multimedia Sensor Networks",* Sonmez et

al.EURASIP Journal on Wireless Communications and Networking 2014 , a Springer open journal.

[16] Awais Ahmad, Sohail Jabbar, Anand Paul, and Seungmin Rho "*Mobility Aware Energy Efficient Congestion Control in Mobile Wireless Network" ,* Hindawi , 2014.

[17] Akbar Majidi, Hamid Mirvaziri "*A New Mechanism for Congestion Control in Wireless Multimedia Sensor Networks for Quality of Service and Network Lifetime"*,American Journal of Computing Research Repository,2014,vol.2,no.1.

[18] Dingwen Yuan, Matthias Hollick "*Let's talk together: UnderstandingConcurrent Transmission inWireless Sensor Networks",38th Annual IEEE Conference on LocalComputer Network*.

[19] I.Ahmad and A. Shoba Das "*Aheuristic algorithm for the minimization of incompletely specified finite state machines*"2001.

[20] R.Karthikeyan, R.Nandha Kumar, M.Ramesh*"Priority based Packet Scheduling Approach for Wireless Sensor Networks"* International Journal of Innovative Research in Science, Engineering and Technology volume 3, Special Issue 1 , Febrauary 2014.