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A Survey on Congestion in Wireless Multimedia Sensor Networks

Panchaxari Mamadapur[1] and Shiva Prasad K.H[2]

[1,2]*ACS College of Engineering, VTU, India*

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***Abstract*—** Wireless Multimedia Sensor Networks (WMSNs) have emerged and shifted the focus from the typical scalar wireless sensor networks to networks with multimedia devices that are capable to retrieve video, audio, images, as well as scalar sensor data. WMSNs are able to deliver multimedia content due to the availability of inexpensive CMOS cameras and microphones coupled with the significant progress in distributed signal processing and multimedia source coding techniques. In this paper, we outline the congestion, types of congestion, congestion control. As congestion has a significant impact on Quality of Services (QoS).

***Keywords*—** Congestion, QoS, WMSN,Congestion Control, CH

I. Introduction

The Wireless sensor network is collection of sensor nodes which senses the network for any change or any event to occur. It consists of one or more sinks which gathers the sensed information from sensor nodes and large number of sensor nodes scattered in an area. A wireless multimedia sensor network (WMSN) is a set of sensor nodes which are equipped with multimedia devices such as cameras and microphones. They have capability to transmit pictures, videos, sounds etc. Multimedia sensor devices are capable of storing, processing, and retrieving multimedia data such as video, audio, and images. They must cope with various challenges such as high bandwidth demand, high energy consumption, quality of service (QoS) provisioning, data processing, and compressing techniques, and cross-layer design. Also WMSN can sense, store, process, communicate and fuse multimedia data from different heterogeneous sensor devices in real time environment as shown in Fig 1.

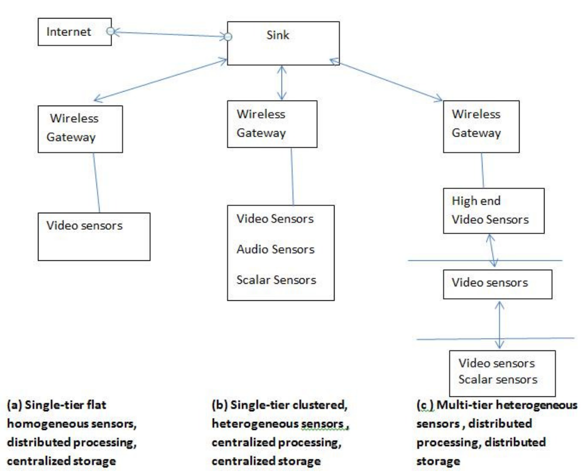

Figure 1: Reference Architecture of a WMSN

Section 2, describes the WMSN protocol stack viewed as different planes. Section 3 deals with the structure of WMSN network, and efficient multimedia support. In section 4, we highlighted potential applications of WMSN. Section 5 discusses congestion, possible outcomes to deal with congestion control and also suggests the QOS support to WMSN. Section 6 deals with Visual sensors. In Section 7 we conclude the paper.

II. WMSN Protocol stack

The sensor nodes are scattered in a sensor filed. Each sensor node has a functionality to collect and send data to the sink node and end users. The sink node may communicate with end user via internet. The protocol stack of WMSN consists of Physical layer, MAC layer, Network Layer, Transport layer and Application layer.

The protocol stack shown in fig. 2 can be viewed as set of management planes across each layer. Each layer includes power, connection and task management planes The power management plane is responsible for managing the power level of sensor node for processing, sensing , transmission and reception, which can be applied by employing efficient power management schemes at different protocol layers The connection management plane handles configuration and reconfiguration of sensor node to establish and maintain connectivity of a network in the case of node deployment and topology change due to node addition , node failure and node movement .

The task management plane is in charge of assigning tasks among sensor nodes in a sensing area to improve energy efficiency and extended network failure.

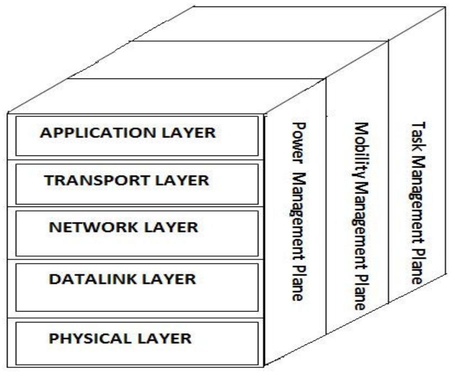

Figure 2: Protocol Stack

The first step in creating a WMSN is equipping a single sensor device with audio and visual information collection modules. As an example, the Cyclops image capturing and inference module, is designed for extremely light-weight imaging and can be interfaced with a host mote such as Crossbow's MICA2 or MICAz. In addition to the ability to retrieve multimedia data, WMSNs will also be able to store, process in real time, correlate and fuse multimedia data originated from heterogeneous sources

III. Structure of a WMSN Network

A general structure of a WMSN consisting of four main components: wireless multimedia node, wireless cluster head, wireless network node and base station.

Wireless Multimedia Node (WMN): The WMNs form the end points of the network. Each WMN consists of a camera or audio sensor, processing unit, communication unit and power unit. A captured scene is called an image frame. The processing unit performs the visual processing to reduce the high amount of scene data. Two approaches can be used. The first approach uses event detectors to identify useful events in the scene data. If an event is not detected, then the image frame is discarded and there is no need to transmit the frame through the network. The second approach uses event compressors to reduce the data for image frames that have to be transmitted through the network.

Wireless Cluster Head (WCH): The WCHs receive data from several WMNs. Each WCH consist of a processing unit, communication unit and power unit. Each WCH receives data from several WMNs. The image frames from different WMNs may be stitched into a single frame to remove the overlapping data.

Wireless Network Node (WNN): The WNN performs the same role as for a traditional wireless sensor network and consists of a communication unit and power unit. The communication unit relays the data from node to node until it arrives at the base station.

Base Station: The base station is the destination of all the data gathered throughout the network. This is likely to be a conventional computer capable of powerful processing and connected to a main power supply. Thus, energy efficiency and power issues are not important here [1].

Efficient multimedia support

CHs are responsible for gathering the information collected by WMSNs and processing them with suitable multimedia data fusion techniques. Gate-ways (GWs) that provide connections of the multimedia wireless sensor networks (MWSNs) through the appropriate CHs (first tier) with the content delivery network and hence with remote users and applications. Since MWSNs are usually densely deployed in an environment, the information flows generated by CHs of adjacent clusters can present spatial correlation. Hence, the efficiency of the multimedia content delivery network can be improved by removing the resulting redundancy as early as possible in the communication paths toward users and applications. This goal can be achieved by resorting to suitable in-network distributed data compression and coding techniques that lower the amount of data to be delivered without losing information contents [2].

IV. Applications of WMSN

Wireless multimedia sensor networks have the potential to enable many new applications such as,

Multimedia Surveillance Sensor Networks: Video and audio sensors will be used to enhance and complement existing surveillance systems against crime and terrorist attacks. Large scale networks of video sensors can extend the ability of law enforcement agencies to monitor areas, public events, private properties and borders.

Traffic Congestion Avoidance Systems: It will be possible to monitor car traffic in big cities or highways and deploy services that offer traffic routing advice to avoid congestion. Automated parking assistance is another possible related application.

Advanced Health Care Delivery: *Telemedicine* sensor networks can be integrated with 3G multimedia networks to provide ubiquitous health care services. Patients will carry medical sensors to monitor parameters such as body temperature, blood pressure, pulse oximetry, ECG, breathing activity. Similarly, elderly and family monitors will help in providing timely and essential support to the less able sections of society.

Industrial Process Control: Multimedia content such as imaging, temperature, or pressure amongst others, may be used for time-critical industrial process control. The integration of *machine vision systems* with WMSNs can simplify and add flexibility to systems for visual inspections and automated actions that require high-speed, high-magnification, and continuous operation.

V. Congestion in WMSN

For WMSNs where wireless channels are shared by several motes using carrier sense multiple access (CSMA-like) protocols, collisions could occur when multiple active sensor motes try to seize the channel at the same time. This can be referred to as link-level congestion. Link-level congestion increases packet service time, and decreases both link utilization and overall throughput, and wastes energy of the sensor motes. There is another type of congestion called node-level congestion which is common in conventional networks. It is caused by buffer overflow in the mote and can result in packet loss, and increase latency. Packet loss in turn can lead to retransmission and therefore wastes more energy. Both link-level and node-level congestions have direct impact on energy efficiency and QoS. Fig. 3 shows the types of congestion

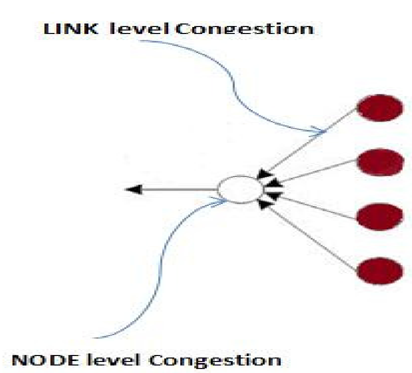

Figure 3: Types of Congestion

Congestion Control in WMSN

As multimedia applications produce high volumes of data which require high transmission rates, multimedia traffic is usually high speed. This may cause congestion in the sensor nodes [3].

Congestion Control is achieved by means of

QCCP-PS: New applications made possible by the rapid improvements and miniaturization in hardware has motivated recent developments in Wireless Multimedia

Sensor Networks (WMSNs). As multimedia applications produce high volumes of data which require high transmission rates, multimedia traffic is usually high speed. This may cause congestion in the sensor nodes, leading to impairments in the quality of service (QoS) of multimedia applications. Thus, to meet the QoS requirements of multimedia applications, a reliable and fair transport protocol is mandatory. An important function of the transport layer in WMSNs is congestion control. Congestion control protocol named QCCP-PS uses a queue based congestion indicator and can adjust the sources traffic rate based on current congestion in the upstream nodes and the priority of each traffic source. The buffer occupancy is used as a congestion indicator, and considered varying priorities for each sensor node [3].

SUIT: a new cross-layer progressive image transport protocol provides a fuzzy logic based congestion estimation and a novel congestion mitigation technique which decreases image quality on-the-fly at an acceptable level. In case of congestion, SUIT drops some packets of the frames in a smart way and thus transmits frames to the sink with lower, but acceptable quality [4].

DPCC: A dynamic priority based congestion control (DPCC) approach employs dynamic priority to represent packet importance and prioritizes the local traffic of motes near the base station when WMSN is highly congested. The dynamic priority based rate control with the aim to provide QoS for particular multimedia applications in WMSNs divides the congestion into three stages and presents corresponding algorithms for rate adjustment. And distinguish urgent traffic from normal traffic, and service different traffic according to corresponding priority. The idea of dynamic priority is to improve or maintain the high priority traffics' performance gains at the cost of sacrificing low priority traffics' benefits [5].

D3: In high speed wireless multimedia sensor networks (WMSNs) sensor nodes have different types of sensor node which gather different types of data. In such high speed event driven network, it is critical to report the detected immediately which results in bursts of traffic that causes congestion and packet loses in such networks. An energy efficient grid based D3 (Dynamic Data Dissemination) technique which avoids/controls congestion to occur in network. It uses queue buffer length to estimate congestion and then dynamically disseminates data to multiple forwarders. To make the technique energy efficient, deploy the sensor node in grid based strategy that improves energy efficiency, packet delivery ratio and throughput [6].

WCCP: The growing interest in applications of Wireless Multimedia Sensor Networks (WMSNs) imposes new challenges on congestion control protocols in such networks. Content-aware cross layer WMSN Congestion Control Protocol (WCCP) employs a Source Congestion Avoidance Protocol (SCAP) in the source nodes, and a Receiver Congestion Control Protocol (RCCP) in the intermediate nodes. SCAP uses Group of Picture (GOP) size prediction to detect congestion in the network, and avoids congestion by adjusting the sending rate of source nodes and distribution of the departing packets from the source nodes. In addition, RCCP monitors the queue length of the intermediate nodes to detect congestion in both monitoring and event-driven traffics. Moreover, to improve the received video quality in base stations, WCCP keeps the I-frames and ignores the other less important frame types of compressed video, in the congestion situations [7].

Hierarchical QoS framework: hierarchical QoS framework for wireless multimedia network combines adaptive FEC (Forward Error Correction), ARQ-SR (Automatic Repeat Request Selective Repeat) and TCP Friendly rate control scheme in different layers. The adaptive FEC schemes tune the number of packet transmission according to the wireless link error condition obtained from the ARQ feedback. TCP-Friendly rate control schemes tune the sending rate according to the wireless link congestion condition.

The hierarchical QoS framework decrease the transmission rate when detecting packet loss due to congestion occurs and increase redundant FEC packets when detecting packet loss due to wireless link error occurs, In addition the QoS framework regulates the UDP streams' transmission rate near TCP-Friendly streams' transmission rate. Hierarchical QoS framework combining adaptive FEC schemes that overcome wireless link error and TCP Friendly rate control schemes that alleviate wireless congestion [8].

QOS Support

The emergence of wireless multimedia sensor networks (WMSNs) has made it possible to realize multimedia delivery on tiny sensing devices. Cross-layer framework for QoS support in WMSN is to maximize the capacity of the deployed network to enhance the number of video sources given that the QoS constraint of each individual source is also preserved. This is achieved by implementing Wyner-Ziv lossy distributed source coding at the sensor node with variable group of pictures (GOP) size, exploiting multipath routing for real-time delivery and link adaptation to enhance the bandwidth under the given bit error rate. Hence, application requirements are mapped on joint operations of application, network, link and MAC layers to achieve the desired QoS [9].

VI. Visual Sensors

With the recent advances in imaging technologies and micro-electro-mechanical systems, producing small, low-power, and low-cost image/video capture devices at a large scale may be within reach in the foreseeable future. An obvious example of the advances in building small and cheap camera sensors is that almost all mobile phones in the market today incorporate tiny cameras with increasing quality over time.

With sensor nodes operate on limited energy resource, computational power and network bandwidth; energy efficient coding and transmission are of extreme important. As opposed to normal video system, video sensor network (VSN) system needs to provide high quality information only when situation calls for it. However, a certain degree of quality has to be guaranteed, especially for the region of interest (ROI) part. A simple technique based on multiple description coding (MDC) to reduce the amount of information transmitted while maintaining a higher quality standard for the ROI part of the frame and by conserving energy [23].

VII. Conclusion

We discussed the various aspects on Wireless Multimedia Sensor Networks (WMSNs).Congestion control in Wireless Multimedia Sensor Networks were surveyed and discussed.

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AUTHORS PROFILE

Panchaxari Mamadapur is an Assistant professor in Computer science and engineering at ACS College of Engineering Bangalore, Karnataka. He received M.Tech degree in Information and Communication systems and B.E in E&C. His area of interest includes Wireless Multimedia Sensor Networks, Ad Hoc Networks.

Shiva Prasad K.H. is an Assistant professor in Computer science and engineering at ACS College of Engineering, Bangalore, Karnataka. He received M.Tech degree in Computer Science and Engineering.