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MAC Protocol for Wireless Multimedia Sensor Network: A Survey

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Abstract – Wireless Multimedia Sensor Networks (WMSNs) are wireless connected sensor's with audio and video capabilities in addition to scalar sensing. Limited availability of bandwidth is a major constraint for multimedia data in WMSNs. The requirement of real time streaming poses another challenge in the network. Medium access control (MAC) protocols designed for traditional wireless sensor networks cannot be adopted for WMSNs. The overhead caused by multimedia data results in congestion and data losses. In this paper various MAC protocols for WMSNs are surveyed and open research issues are discussed in detail. Architecture of WMSNs is also explored along with different heterogeneous type of setups.

Keywords: WSNs, WMSNs, Video sensor network, multimedia communication, MAC protocols.

I. INTRODUCTION

Small sensor nodes capable of sensing scalar data are now days replaced with video and audio sensors that are capable of capturing still images, video and audio in addition to the scalar data as well. These sensors are also equipped with processing and communication capabilities and collaborate with each other in adhoc manner to form wireless multimedia sensor networks [1]. Due to MEMS technology the sensor hardware is equipped with CMOS camera and microphone.
WMSN is expanding the application scope of wireless sensor networks, such as tracking of objects. In scalar sensors networks only the availability or non availability of object can be recognized, but in the WMSNs we can have the images/video of the available object. This helps us to better recognize the object in the monitoring area. Other applications like environment monitoring and multimedia surveillance are also enhanced with WMSNs.

APPLICATIONS
Multimedia surveillance system
Object tracking system
Environment monitoring system
Automated assistance for elderly
Vehicular adhoc networks
Traffic avoidance system
Theft control system

Table1. Applications of WMSNs

The table 1 lists all the applications of wireless sensor networks that are enhanced by the WMSNs. Broadly the WMSNs are stretching the horizon of traditional WSNs system [2]. By using multiple video sensors at different locations will enlarge the view of that location. The enhancement of the view can be obtained as multiple redundant images can be obtained from different video sensors. Moreover the zooming capability of cameras provides a good view of region of interest. This paper is presented as: Section I represents the Introduction of WSNs. Section II represents the network architectures and challenges. Section III covers MAC protocol for WMSNs. Section IV represents open research issues in MAC layer design of WMSNs. The last section represents the conclusion and references

II. NETWORK ARCHITECTURE

This section will explain about the different network architectures that can be used to deploy the multimedia sensor nodes. The design of architecture in WMSNs affects the MAC protocol used for the architecture. The main issue is to

design scalable network architecture. Two different type network architectures are discussed in this section; they are homogeneous and heterogeneous architecture. The homogeneous network may not be suitable for WMSNs for the purpose of saving energy at each node.

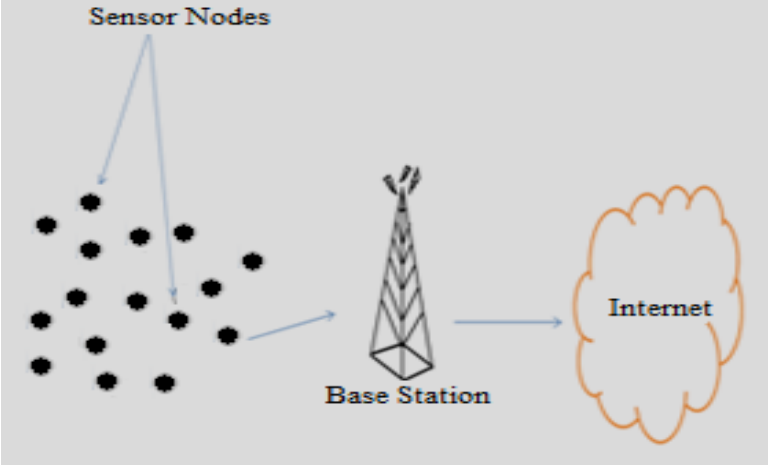

Figure 1. Wireless Sensor Network

Heterogeneous network architectures are classified into two categories as Single tier clustered topology and Multi tier heterogeneous topology. Single tier clustered approach use the concept of centralized processing and centralized storage. This topology requires data to be moved to a central location before processing. In multi tier heterogeneous topology the concept of distributed processing and distributed storage is used. This topology saves the communication bandwidth but require the storage and processing capabilities at each node. The figure 2 is drawn with reference to [1]. In the paper the author use three types of sensor nodes in the network i.e. scalar sensors, video sensors and audio sensors.

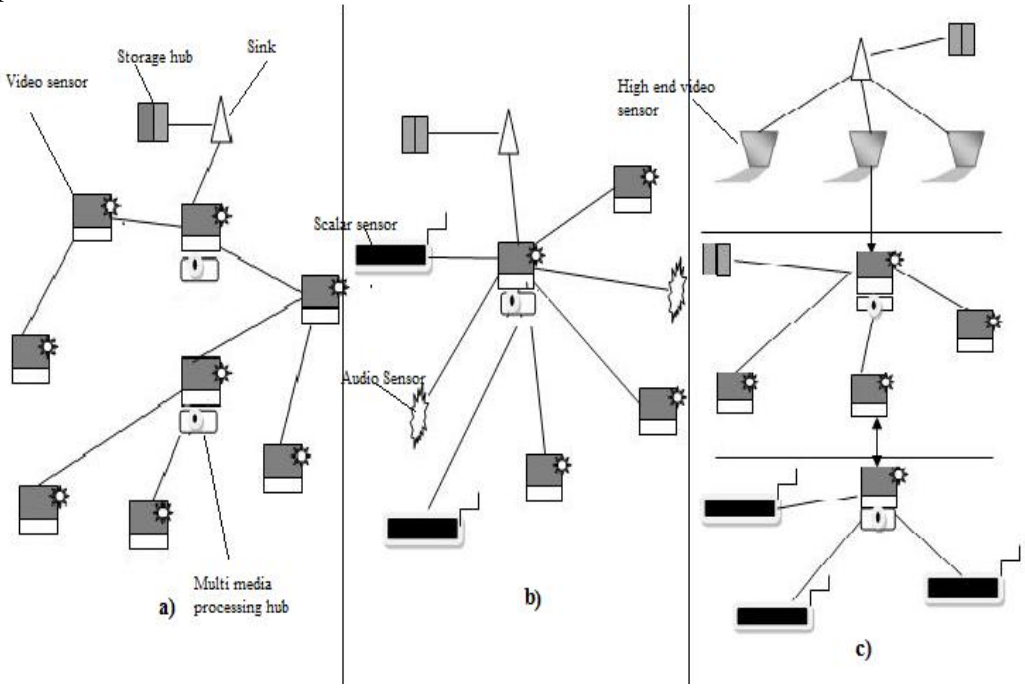

Figure 2. Network architecture for WMSNs

Challenges in WMSNs:-

Different challenges faced by WMSNs, which are not present in the WSNs are

1. High bandwidth requirement
2. Delivery of real time data
3. Delay tolerance
4. Rate of frame loss

There are several other resource constraints in WMSNs as energy, bandwidth availability, memory availability, buffer size and processing capabilities. Energy constraint is the major challenge during the development of any MAC protocol for WMSNs [2]. The more the energy is consumed less is the network lifetime. Therefore during the design of any new MAC protocol the energy constraint is the major issue. Due to real time delivery of data in WMSN the packets cannot be delayed and energy cannot be saved as is there in the case of WSN where the scalar data can be delayed and combined with other packets to save energy

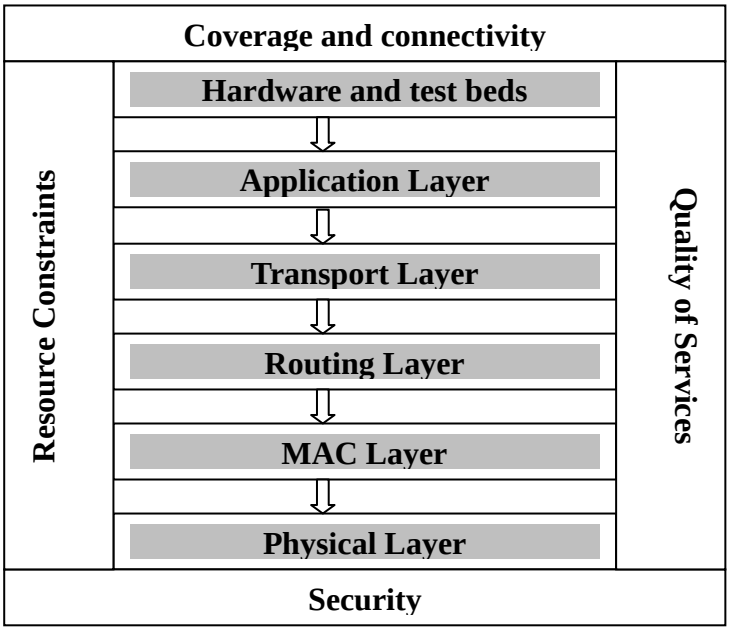

Figure 3. Research challenges in WMSNs

III. MAC Protocols for WMSN

WMSN consist of dense network which has very limited battery life. The communication medium in these sensors is energy expensive short-range radio communication. WMSN need energy-efficient MAC protocol for communication. There are many MAC protocols lie SMAC, TMAC, RMAC, QAMAC etc available for WSN but de to more energy saving requirement of MWSN, these protocols cannot be adopted in WMSN. In this section we study different MAC protocols for WMSN with their performance comparison for better understanding of the protocols. The protocols at MAC layers are categories in [1] as:

(a) Contention based protocols
(b) Contention free protocols
(c) Multichannel protocols

Contention based protocols assume a single radio architecture. The sensors are put on sleep to save energy. Most contention based protocols aim to reduce energy consumption at the cost of latency and throughput. The applicability of contention based protocols to multimedia contents is limited due to quality of service (QoS) requirement of multimedia traffic. Contention free protocols use reservation schemes such as slotted time frame. The real time streaming requirement of multimedia data demands priorities to the packets in the network. Time Division Multiple Access (TDMA) and Varying Time Division Multiple Access (VTDMA) schemes are preferred in multimedia contents of the network. The brusty nature of multimedia contents imposes additional challenges for the design of protocols in WMSN.
Multichannel protocols use multiple channels in overlapped manner. The utilization of available bandwidth can be increased for supporting multimedia applications. To develop a distributed channel assignment policy is the main challenge in designing multi channel protocols for WMSNs.

3.1 Frame sharing (FRASH) MAC protocol

MAC protocol in WMSN must support QOS requirement for different flows, therefore well defined scheduling becomes a major challenge. Another challenge in contention free protocol is the design of frame structure and the schedules of each node in the time frame. The FRASH MAC [3] protocol aims to address the challenges by implementing earliest Deadline First (EDC) scheduling scheme. The EDF scheduling algorithm exploits using TDMA-based medium access mechanism. The FRASH protocol is developed for periodic multimedia traffic. In which each node schedule its transmission according to the EDF scheme. The frame structure as described in figure 4 is taken with reference to []. The EDF mechanism in FRASH is used for QoS provision.

A Direction	Intra cell frame	B Direction	Intra cell frame	C Direction	Intra cell frame	D Direction	Intra cell frame	E Direction	Intra cell frame	F Direction

Figure 4. Frame structure of FRASH protocol

The drawback of FRASH is that it assumed a periodic traffic and the schedule are generated for periodic traffic only. The application where the traffic is event base cannot be well supported by this protocol. The requirement of time synchronization between nodes is another overhead of the protocol which implements TDMA structure.

3.2 Real Time Independent Channels (RICH) MAC protocols

RICH MAC [4] uses CDMA communication to provide Quos support to WMSNs. By using CDMA approach the requirement of time synchronization in TDMA-based schemes can be eliminated. Each sensor node is assigned a specific CDMA code to minimize the interference between neighbour nodes. RICH protocol performs localized optimization by exploiting the information between each neighbour for EDF scheduling. This protocol is based on cellular architecture and assumed that each node have seven different radio's. Each node follows a distributed EDF scheduling algorithm. The sampling rates of and transmission frequency of each nodes are optimized accordingly to available bandwidth of neighbour. Strict deadlines are provided for different traffic classes in WMSNs. The drawback of RICH is the complex transceiver architecture is required to support CDMA communication. The application that require simple and low cost components did not fit in this approach due to complex requirement at each node in this protocol

3.3 Dynamic duty cycle and adaptive contention window based MAC protocol

This protocol [5] is capable of achieving application specific QoS. It also attempts to save energy without compromising on QoS constraints. The protocol is based on a CSMA/CA approach and it adjusts the contention window as per the requirement of the application. The dynamic adjustment of contention window size is dependent on both the traffic and wireless channel characteristics. Duty cycle of the protocol is also adjustable which results in energy saving. The algorithm described in [5] explains the QoS and duty cycle use to implement the protocol. This protocol classifies the wireless traffic into different categories and adaptively provides better QoS than existing protocols.

3.4 QoS supported Energy efficient MAC (QEMAC)

QEMAC [6] cater the need of QoS for multimedia heterogeneous environment with fairness features. QEMAC is based on IEEE 802.11e standard and enhance it for the conservation of energy and fairness without violation QoS constraints.
The author's simulation results shows that QEMAC provide fairness and suffer low delay and jitter with efficient energy consumption as compares to other QoS aware MAC protocols for WMSN. The protocol works in two phases. In the first phase the innovating priority mechanism is introduced in Qos for IEEE 802.11e. Different priorities are assigned to different type of data. The hybrid coordination function combines both distributed contention based channel allocation and centralized polling based channel access mechanism. Figure 6 shows the EDFC proposed by the author in [6] EDCF is enhanced version of IEEE 802.11 Distributed Coordination function with extension to QoS support. In Second phase of the protocol dynamic duty cycling is involved to preserving the energy of the nodes in the network. This is achieved by using dynamic duty cycling on the base of priorities. CSMA/CA can optionally be supplemented by exchange of RTS (Request to send) and CTS (Clear to Send) packets, all the nodes within the range of sender and receiver keep quiet for the duration of packet [13]. This is known as IEEE 802.11 RTS/CTS exchange.

3.5 Cluster Based on Demand Multichannel MAC protocol for WMSN

COMAC [7] is energy efficient, high throughput and reliable data transmission protocol is WMSN. The operation of COMAC is done in three phases. Request phase, Scheduling phase and Data transmission phase.

***Request phase*: -**

During request phase two protocols are designed to send request to cluster head. The first protocol is contention based, in which the channel is allocated for each node to transmit the request message. All available channels can be used as control channel. After the assignment of control channel the request transmission phase starts. The nodes sends request to cluster head and on receiving back the ACK message the data is transmitted. In the second type of protocol control slot is assigned when the network is deployed. Each slot on each channel is assigned to a different node; this made any request to be send without interfering with transmission of other node.

Scheduling phase:-

Cluster head is responsible for generating scheduling phase for data transmission by each node and broadcast message through control channels. The schedule contains the assigned channels for the particular sensor nodes.

Data transmission phase:-

The sensor node will transmit its data as per the time slot and the channel assigned during schedule. Time slot is divided into data transmission section and acknowledgement section. Acknowledgement is use to support link layer error control.

IV. OPEN RESEARCH ISSUES

Access methods in WMSNs have experienced a lot of improvements that may be subject to other future studies in WMSNs. The QoS is a major challenge in WMSNs due to real time delivery requirement of the network, more specific QoS supported protocols can be developed. Energy conservation is another major challenge in WMSNs, while developing the QoS specific protocols the energy consumption should always be taken in consideration.
Exploitation of multi channel communication provides better energy efficiency, high throughput and data reliability support in wireless multimedia sensor networks. CO-MAC uses cluster based on demand multi channel communication but the overhead of scheduling and channel assignment, proved costlier in terms of energy. The more messages we share, more is the energy consumed [9] [10]. Another new protocol on multi channel communication can be designed which save the energy in comparison to CO-MAC or the extension to CO-MAC can be developed where the communication

overhead of schedule can be reduced or completely eliminated. In TDMA based schemes schedules, once created should also be able to account for dynamically changing topology due to the dynamic nature of sensor network [12]. On the basis of survey a new Hybrid type of method that can take the features of these protocols can be designed. The ideas presented here could also be fully or partially applied to improve the performance of existing protocols. Experimental performance evaluation and comparison with other existing protocol represents an open research issue.

V. CONCLUSION

A Wireless Multimedia Sensor network is a multi-hop ad hoc network of hundreds or thousands of sensor devices. The sensors collect useful information in the form of audio/video data. The sensors itself play the role of routers for communication under severe battery constraints. In this paper we have discussed and surveyed in detail the research carried out for MAC layer in wireless multimedia sensor networks. We have analyzed the major technical challenges and research issues related to design of algorithms of WMSNs. We also studied QoS-MAC protocols which classify the network traffic into different classes and adaptively assign channel to various traffics.

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