Review of Wireless Multimedia Sensor Networks: Its Technology, Architecture, Routing Protocols and Applications

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Abstract: From last few years there has been wide research in wireless sensor networks, its challenges, practical issues etc. In WSN, nodes are usually deployed to measure pressure, temperature, location of objects, humidity. The availability of microphones and CMOS cameras have led to the development of new networks called Wireless Multimedia Sensor Networks. In this paper architecture, network Structure, open research issues and applications are discussed further.

Keywords: wireless sensor networks; smart cameras, wireless multimedia sensor nodes, multimedia communications

I. INTRODUCTION

Advancement in low power digital and analog electronics, embedded microprocessors and radio communication have led to the development of low priced and small sensor nodes that made Wireless Sensor Networks. WSN's consists of battery powered nodes that are randomly scattered in a geographical area[1]. In WSN, sensor nodes first sense the data, then collects the data from nearby nodes and finally sends the aggregated data to the sinks. WSNs have wide areas of research including scientific areas, disaster relief, military, health care, environmental, industrial and household monitoring[2]. The recent challenges have realized the researchers and scientists that there should be some enhancements in sensor nodes so that they are capable of sensing the multimedia data. Thus the growing demand had made it possible to design such advanced sensors. By the availability of small size and low cost microphones and smart cameras these have been fitted with sensor nodes so that more descriptive information can be extracted. WMSN consists of video sensor, audio sensor, multimedia sensor and multimedia hub as shown in Fig. 1. It consists of large number of multimedia sensor nodes that are deployed in a network area and the base station. The sink or Base station acts as main coordinator or network controller. Its main function is to monitor and coordinate the function of these multimedia sensor nodes. Base station collects the gathered information from the nodes which is further stored and processed. The base station is located near to these nodes in order to avoid higher energy consumption as it determines the lifespan of network. During communication process, more energy is consumed than that during sensing[3,4].

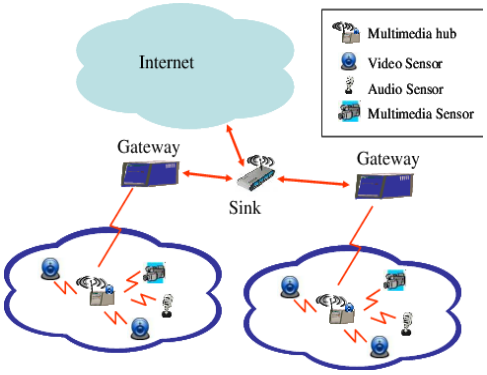


Fig1. Wireless Multimedia Sensor Network

II. DESIGN CHALLENGES AND RESOURCE CONSTRAINTS

In Wireless Multimedia Sensor Network, there are some main challenges and resource constraints that we need to deal with in order to improve the lifetime and communication efficiency[5].

A. QoS Requirements:

QoS parameters such as bandwidth, delay, jitter and reliability should be taken into account as there are many multimedia sensor network applications which are time critical and to be reported in a specific and limited time.

B. Energy Consumption

Multimedia Sensor based applications requires advanced processing capabilities and high transmission rate as they produce large volume of traffic which further leads to more energy consumption as compared to wireless sensor network. Thus network protocols for routing should be designed in such a way that the network lifetime is enhanced by less energy consumption.

C. Multimedia Coding Techniques

In wireless multimedia sensor network, huge traffic is generated because of use of multimedia sources such as audio sensors, video sensors or smart cameras. The information to be transmitted is generally decreased by the compression techniques but the quality of the data gets degraded. This is because that the multimedia coding techniques are not directly applicable to the wireless multimedia sensor networks. Two main goals in multimedia encoding techniques that are required for efficient multimedia data transmission. Firstly, compression techniques should be applied in a such a way that the quality

of data does not get degraded. Secondly, the compressed data should be sent reliably over the network.

D. High Compression Efficiency:

In order to limit the energy consumption and bandwidth, high compression ratio is to be achieved in wireless multimedia sensor network[5,6].

III. NETWORK STRUCTURE

The structure of wireless multimedia sensor network consists of multimedia node, cluster head, network node and base station as shown in Fig 2.

Fig.2 General Network Structure of WMSN[7]

A. Wireless Multimedia Sensor Node

Multimedia nodes are the end points in the network that consists of audio sensor or smart cameras(video sensors) which captures the data known as image frame, processing module to process the useful data and discard the other images, communication module which sends the compressed data to the other wireless multimedia sensor nodes and power unit.

B. Wireless Cluster Head

The data for WMN's is further sent to WCH which includes processing module, communication module and power unit.

C. Wireless Network Node

In wireless network, data is relayed from one sensor node to another till it reaches the Base station

D. Base Station/Sink

The data is gathered throughout in Wireless network and sent to the base station[7]

IV. ARCHITECTURE OF WIRELESS MULTIMEDIA SENSOR NETWORK

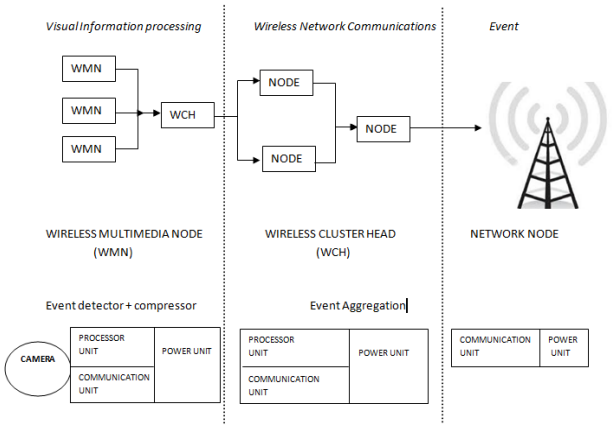
In this section, classification and architectures of wireless multimedia sensor network i.e. homogeneous or heterogeneous and tier architectures i.e. multi tier or single tier are discussed as shown in Fig 3.

A .Homogeneous and Heterogeneous Architectures

In homogeneous network, the nodes have same properties with respect to computation, energy and storage. In heterogeneous network, nodes have different properties for sensing the data, processing the data and communication process. Therefore, heterogeneous network have sensor nodes that have more memory, processing power, energy storage and better communication in comparison to other multimedia sensor nodes. Thus, this type of network can be used to enhance the life time of network and to improve the energy efficiency as more communication tasks and processing, can be assigned to the better nodes[8,9].

B. Single Tier and Multi Tier Architectures

In single tier architecture, the network may have heterogeneous or homogeneous components but in multi-tier architecture, end nodes have higher communication and processing capabilities and uses hierarchical network. In hierarchical type of network, the sensor nodes are divided into clusters. Nodes having different energy level are used for different process. Sensor nodes having low energy are used to perform sensing tasks and communication at shorter distance whereas sensor node having higher energy is made as cluster head to collect the data from other sensor nodes and send the processed data to the base station. When the network grows, scalability improves by this techniques and traffic load is balanced[10].



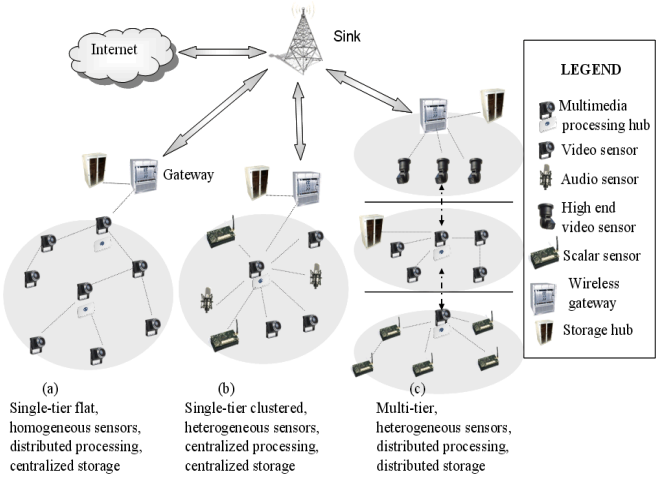


Fig 3. Architecture of Wireless Multimedia Sensor Network[8]

V. ROUTING PROTOCOLS IN WMSN

In the past few years, many routing protocols have been designed and proposed for Wireless Multimedia Network.

A. *Sequential Assignment Routing (SAR) Protocol*

It is first routing protocol in wireless multimedia sensor network that considers QoS and energy efficiency of multimedia sensors and thus improves the lifetime of the network. This protocol creates a table including the routing path from one node to the other and the base station. The disadvantage of this protocol is that it is difficult to maintain the tables as the number of sensor nodes is huge[11].

B. State-less Protocol for real time Communication (SPEED):

It is real time protocol that aims at providing uniform delivery of packets across the wireless multimedia sensor network. With this protocol end to end delay can be estimated in real time applications[12].

C. *Optimized energy-delay sub-network routing protocol (OEDSR)*

It is a cluster based routing protocol that find s the available energy, average latency values and the distance from the base station to the next best forwarding node.

D. Ant-based Swarm Intelligence Based Routing Protocol (ASIR):

It is a hierarchical protocol that choses different paths for different services, thus maximizing the network efficiency. Selection of routing path is based on packet loss rate, delay, energy consumption and bandwidth required by traffic[13].

VI. APPLICATIONS OF WIRELESS MULTIMEDIA SENSOR NETWORK

A. Storage of Relevant activities

Multimedia wireless sensors can record relevant activities such as car accidents, thefts, traffic violations. This recording can be saved or made available for any query in future.

B. Traffic avoidance and control system

With the advance research in wireless sensor network it is possible to control and monitor the traffic in highways or big cities. Advance smart parking system helps to find the parking space availabilities. Multimedia wireless sensors can also detect the information such as number of cars, average speed etc[14].

C. Advanced health care

Advanced health care services can be provided if 3G multimedia sensor networks are integrated with telemedicine sensor networks. In this advance technology patients body will carry medical sensors so that various parameters such as blood pressure, body temperature, pulse rate, breathing activity, ECG etc can be recorded[15].

D. Industrial applications

Still images or videos based data can be analyzed and extracted by wireless multimedia sensor network to support manufacturing process.

E. Person Locator Services

Multimedia content i.e. still images and video streams with signal processing technologies can be used to identify terrorists or criminals or to find missing persons.

F. Surveillance Multimedia Sensor Networks

It consists of battery powered inter connected smart cameras that are capable of sending, receiving and processing the data. Audio and video sensors are used to improve the present surveillance system against terrorists attacks and crime as shown in Fig 4. Wide Multimedia sensor networks are used to monitor public events, borders and private properties[16].

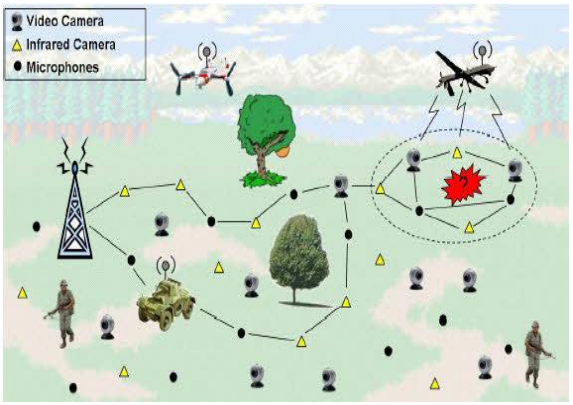


Fig.4 Surveillance Multimedia Sensor Network

VII. COMPARISON OF DIFFERENT HARDWARE PLATFORMS

The Comparison of features of the hardware platforms of wireless multimedia sensor networks is shown in the table 1.

Table 1: Hardware Platforms required

Device Name	Processor	Memory	Multimedia Support	Wireless
Stargate	Intel PXA-255 Xscale processor at 400 MHz	32 MByte Flash 64 MByte RAM	High computation power, embedded linus OX	802.11 Compact Flash, 802.15.4 through MICA2/z interface
Imote2	32 bit PXA271 Marvell Processor at 13-416 MHz	32Kbyte Flash 64Kbyte RAM	MMX co-processor for audio/video imaging acceleration	Integrated 802.15.4
CMUcam3	32-bit NXP LPC2106 microcontroller at 60 MHz	128 Kbyte Flash 64K Byte RAM	On-board cc3-open source image processing library	-
MeshEye	32-bit ARM7TDMI RISC processor at 55 MHz	128 Kbyte Flash 64Kbyte RAM	Multiple resolution support	-
WiCa	IC3D Xetal II processor at 84 MHz	10 Mbit RAM	Dedicated parallel processor, multiple camera modules	-
Cyclops	8-bit ATMEL ATmega 128L microcontroller	512 Kbyte Flash 512 Kbyte RAM	On-board image processing, low power, cost and size	-

VIII. CONCLUSION

WMSNs (Wireless Multimedia Sensor Networks) have shifted the research focus from scalar wireless sensor networks to the multimedia sensor networks which are capable of retrieving audio, video, images etc. In this paper research on Wireless Multimedia Sensor network is discussed and surveyed. The network structure and architectures of multimedia sensor networks have been described. Routing protocols such as SAR, SPEED, OEDSR and ASIR of WMSN have been discussed. Design Challenges and Applications have been surveyed and discussed.

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