Current Status and Design Challenges in Wireless Multimedia Sensor Networks

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Abstract

Wireless Multimedia Sensor Networks (WMSNs) will boost the capabilities of current wireless sensor networks, and will serve some novel applications, like multimedia surveillance. Today's world is of automation and WMSN plays a very vital role in today's world. WMSNs introduce several new research challenges, mainly related to mechanisms of deliver application level Quality-of-Service (e.g., latency minimization). The main research going on today in WMSN are on Video Streaming and on its Security area. The main focus of this research paper is on the problem related to video streaming of WMSN. This research paper introduces some of the solutions/suggestions with the help of which some of the problems like video streaming of wireless multimedia sensor network can be sorted.

Keywords

Wireless Multimedia Sensor Network, Quality of Service, Design Challenges, Video Streaming.

I. INTRODUCTION

WMSN is a new emerging type of WSN that contains sensor nodes attached with cameras, microphones, and other sensors gathering and providing multimedia content; hence, measurement of multimedia management is required. Multimedia management faces many new challenges in WSNs concerned with the supply of scalable quality of service (QoS) through the management of metrics, such as coverage (Tian & Georganas, 2002) [1], exposure (Megerian et al., 2002) [2] energy consumption (Zhao, Govindan, & Estrin, 2002) [3] and application specific metrics (e.g., for target detection, possible metrics are miss detection and false detection ratios). WMSNs have additional characteristics and challenges, in addition to those with WSN, because of the nature of the real time multimedia data such as high bandwidth demand, real-time delivery, bearable proper jitter, end-to-end delay, frame loss rate. Moreover, there are many resource constraints in WMNSs including energy, bandwidth, data rate, memory, buffer size and processing capability because of the physically small size of the sensors and the nature of the multimedia application that is typically producing a huge amount of data. Therefore, the challenge is that to meet the quality of service (QoS) requirements and to use the network constraint resources in a fair and efficient manner.

WMSNs have the potential to enable many new applications some of them are under the following heads:

- Used to Monitor the Traffic.
- Used in Advanced Health Care solutions.
- Used in Gaming.
- Used in Structural and Environmental Monitoring.
- Used to control industrial process.

II. CHALLENGES ASSOCIATED IN THE DESIGN OF WMSNS

Based on the result of various research contributions [4] some of the challenges associated in the design of WMSN are as follows:

QoS Requirements

System snapshots, streaming media, audio/video store as well as play-back applications have different necessity with respect to jitter, delay, and loss tolerance that necessitate a fresh look at providing essential QoS services.

Bandwidth

The available bandwidth is hardly limited as WMSNs require transmission bandwidth that is orders of magnitude higher than that supported by currently available sensors.

Power

Power consumption is of larger concern than in traditional WSN as multimedia applications produce high volumes of data, which needs high transmission rates, and widespread processing.

User Monitoring Facility

Integration with Internet (IP) architecture is of fundamental importance for the commercial development of sensor networks to provide services that allow querying the network to retrieve useful information.

Leveraging of In-Network Support

Distributed databases of multimedia data also including distributed storage and indexing of data within the network itself, in-network processing

techniques need to be developed to efficiently extract relevant information from received data.

III. Design Challenges For Security Schemes in WMSNs

The objective of this section is to focus on security design challenge for WMSNs. Sensor nodes are mostly deployed in unattended and even rough environments. They suffer from many kinds of attacks. Wireless channels are low-cost and unreliable. The transmission of data packets may delay or it is also possible that it may not reach its destination. Indeed, security challenges and opportunities in WMSNs stem from these characteristics. Based on various research contributions, some of security design challenges are examined here:

Unattended Deployment Environments

Sensor nodes mostly deployed in a large rough area. An attacker may adjust one or more than a number of sensor nodes without being observed. As a consequence, no solution is explicitly deployed for WMSNs. Hence, new approaches to take advantage of the characteristics of multimedia nodes should be developed [5]. There are many papers that explain how to deploy sensor node. Such as designing multimedia sensor networks to support volcanic studies requires addressing the high data rates and high data fidelity and sparse array with high spatial separation between nodes , however in this paper [6] is not described the security of the sensor node. In a research paper author [7] explains network. It is addressed to guide users to complete the deployment tasks systematically and also in the research paper of authors [8] surveys on the current state of the research on optimized node positioning in WSNs. Both of them are useful to deploy WSN and is not concerned to security of the sensor node.

Data Privacy

Privacy issues are one of the important concern in WSNs, if the collected data is private and sensitive. Video, image and audio data are typically more sensitive data than the scalar data like temperature. Hence the privacy improvement techniques, such as source location hiding and distributed visual secret-sharing [9], [10] may be essential for WMSNs. Privacy versus Attacks which exploit these vulnerabilities can be divided into distinct macro-types of techniques: Eavesdropping and Masquerading. The design of privacy protecting mechanisms is a big problem for the inseparable characteristic of WMSN. In a research paper authors [11], Gruteser et al proposed a methodology for identifying, assessing and comparing location privacy risk in mobile computing technologies. However, this method cannot be used for design security in WMSNs. The source location privacy problem is studied in [12] under the assumption of one single source under a specific period. This method is not specifically defined for WMSNs. Authors of a research paper [13],Yi et al proposed a Proxy based Filtering Scheme (PFS) and a Tree-based Filtering Scheme (TFS), which are simple but efficient event source unobservability preserving solutions for sensor networks. However these methods are not suitable for securing in WMSNs.

Data Authentication

Wireless communications make security and privacy requirements critical because they increase the vulnerabilities and the threats on the integrity and confidentiality of the transmitted data. For these reasons, authentication mechanisms [14] are required to guarantee the correctness and the confidentiality of data. Moreover, due to the high number of sensor nodes, this system could contain control units which broadcast data and commands to the nodes. Hence, the authenticity of these data and commands is a critical requirement for the correct behaviour of WMSNs. Data authentication guarantees and ensures that raw data are received at the aggregators at the same time as they are being sensed. In a research paper [15] authors Zhang et al proposed a watermark statistical approach for data authentication in WSN which provides inherent support for in-network processing. The data authentication is only work from sensor nodes to sink the data. The secure data authentication is not explained from the sink to the sensor node. In the literature [16][17] provide authentication algorithm for data authentication however this algorithm is not adequately satisfy the quality of service requirements of multimedia signals.

Multimedia In-Network Processing

Multimedia in networks processing is one of the factors that influence the design of WMSNs. WMSNs allow algorithm of processing, of multimedia content from the environment. A new architecture for distributed, collaborative, and resource-constrained procedure is required. This architecture allows for filtering and extraction of semantically relevant information at the edge of the sensor network. Authors of the research paper [18] Nath et al introduces IrisNet which uses application specific filtering of sensor feeds at the source and reduces the bandwidth consumed, since instead of transferring raw data, IrisNet sends only a potentially small amount of the processed data. Authors of a research paper [19], Stockdon et al introduces the technique of distributed filtering that can create a time-elapsed image in video security application. Both of them are concerned to specific filtering of sensor. However they do not concerned for securing in networks processing in WMSNs.

IV. Factors Affecting Multimedia Communication In WMSNs

Design of a sensor network for a certain application is influenced by several factors such as fault tolerance; scalability; production costs; operating environment; sensor network topology; hardware constraints; transmission media; and consumption of power [20]. These factors are addressed by many researchers as comprehensively surveyed in research paper[21][22].These research papers discusses some of the basic design constraints considering the incomparable requirements and challenges for multimedia communication in WSN.

On the other hand, there exist additional factors which affect the effectiveness of multimedia communication in WSN such as multimedia coding techniques, demand of high bandwidth, the application-specific, requirements of QoS and delay bounds, which will be expanded in this section as well. These factors are of great importance as they serve as a guideline to design communication protocols and multimedia applications/algorithms for efficient multimedia communications in sensor networks.

High Bandwidth Demand

In the design of multimedia WSN, high bandwidth requirements of multimedia traffic should be taken into account. For example, the size of a typical uncompressed video sample, i.e., frame, in QCIF (*Quarter Common Intermediate Format*) format (144x176) is approximately 25 KBytes. In addition to the transmission of their own data, sensor nodes also relay the packets coming from other nodes due to the essential low range, multi hop communication strategy of WSN. Therefore, for multimedia capable WSNs, data transmission rates of sensor nodes need to be sufficiently high to accommodate the high bandwidth demand of multimedia information. Consequently, the Ultra Wide Band (UWB) or impulse radio technologies may be considered as a promising communication technology to provide high bandwidth capacity for multimedia applications in WSN, especially in indoor applications [23].

Multimedia Coding Techniques

Since sensor nodes in a multimedia WSN compress and capture signals of multimedia, processing and efficiency of communication the compression algorithms are clearly a design constraint, which need to be carefully addressed.

Processing Efficiency

Predictive encoding is known to be an effective way of obtaining good rate-distortion performance for signals with temporal correlation which is inherent to multimedia. However, computational complexity of these algorithms is unacceptably high for power constrained sensor nodes. On the other hand, using all intra frame coding is efficient in terms of energy spent on processing. However, it is inefficient in terms of communication cost due to its low rate-distortion performance.

Communication Efficiency

Predictive coding can reach high compression ratios and dramatically reduce the bit rate of a source signal. It is error sensitive and should be properly handled while transmission over the channels which are lossy. Many new techniques are introduced in order to tackle with this problem, all of them which are based on adding some repetition with the cost of increased bandwidth demand reducing the efficiency of communication. Using channel codes is inefficient for the cases where losses exceed the correction and its capacity of the code, for example the burst losses, and cause a cliff effect. Unequal protection solves this cliff effect problem; however, layered presentation has a serious-rate-distortion penalty that results in communication inefficiency. Many or Multiple Description Coding (MDC)[35] is another approach which removes the cliff effect and has acceptable rate-distortion performance (except MD-FEC [24].

Since all of these solutions are based on predictive coding and they are inherently inefficient in terms of dissipated processing power. On the other hand, a new family of Wyner-Ziv encoders, multimedia encoders, is proposed which may be acceptably efficient in terms of both process and communication power, and should be considered as a promising coding technology for multimedia WSN.

Power Consumption

The severe power constraints of sensor nodes require sensor design with low-complexity and high compression efficiency in order to prolong the full lime of a wireless sensor node. In this way, both processing and communication power consumption can be reduced to acceptable levels which make the multimedia transport over WSN feasible. Power consumption due to communication in WSN has been widely researched or investigated [25][26]. Hence main focus is on the energy efficiency issues related to the multimedia processing at sensor nodes. The state of the art video encoders have very good rate distortion characteristics by following the classical complex encoder and simple decoder balance. However, such complex encoders are not implementable on resource constrained sensor nodes. On the other hand, intraframe coding is a low complexity compression scheme that can provide a low rate of distortion performance. For example, an unoptimized [27] interframe encoder can reach at very high compression rate, however even on today's powerful systems at a frame rate of 2-3 frames/second can be obtained, where intraframe coding of the same encoder can work at rate of (20-25) frames/sec. The techniques of new source coding which is distributed may find a good trade-off

between processing and communication cost by reverting the traditional balance of complex encoder and simple decoder in order to fit to the power constraints of sensor nodes. An application-specific approach for energy conservation is introduced in which can be used in state change detection of a hot spot. The buffering of previous gathered image is performed according to the current one to find out the changes in the hot spot which results in considerable amount of energy saving. However, this brings a challenging tradeoff between energy-efficiency and required memory capacity. In a research [28], communication and processing power and its consumption are considered simultaneously by incorporating an adaptive sender buffer in order to decrease both the CPU idle time and transmit radio idle time. In this approach, when the video sensor firstly it captures the event and then the processor encodes a frame as the transmitter waits for it in the idle mode. The finished frame transmitted by the radio while the processor is in idle mode. Then, it generates the next frame and continues this cycle until no data is available. However, the efficiency of this approach in sensor networks must be thoroughly investigated considering both energy and processing constraints of sensor nodes. On the other hand, distributed coding of the multimedia source is another promising approach which may also contribute to significant energy savings in WSN. In fact, it is shown in [29] that there exist an optimal number of nodes involved in the distributed coding process, which minimizes the total energy consumption.

V. Problem Formation of Video Streaming

Mostly WMSN is used in surveillance but continuous surveillance is not possible it is very difficult task to complete, because we don't have sufficient storage capacity to save and record everything which is recorded with the help of wireless nodes, and also the infrastructures and lack of services is also a major problem. Since the sensor nodes detects the information and sends it to the base station or the sink and the problem starts from here itself. Because of lack of infrastructure and services the problem occurs in transfer of the data like loss of data, quality degrade, low rate of transfer of data etc. Battery Consumption is also one of the major issues in the Wireless Multimedia Sensor Network because of continuous working of the wireless devices their battery does not support them for too long.

VI. Solution to the Problem

The problem of video streaming will overcome if WMSN use some tricks like if any movement or some change in the surrounding take place then only the sensor nodes record or take the snap and generate some type of alert like alarm or something else and then sends the information to the base station, so that the person sitting in the base station can recognize the alert and tells to the related authority. For example if some cameras are installed for surveillance of any object then instead of recording it continuously the camera's works only when there is any movement happens near that object, it is possible with the help of some algorithms or coding techniques. With the help of this theory WMSN can overcome with many problems like slow rate of video transmission etc. The problem related to the battery can also be sorted by this.

VII. Network Security

Security in WMSNs has recently caught the attention of the research community with increasing applications of sensors in military use. While the use of stronger codes, watermarking techniques, encryption algorithms, amongst others, has given resulted in secured wireless communication, there are altogether different considerations in WMSN. As explained in [30], a video sensor surveillance system may require in-network processing techniques to reduce the amount of information flowing in the network. At the aggregation point of incoming streams, the packets would have to be fully decoded and thus the computational complexity of the security algorithms must be low enough to allow real-time processing. There is hence a trade-off between providing enhanced security to the data flow by adopting a higher order code at the source video sensor and permissible multimedia delay requirements. Apart from devising effective light-weight coding techniques, we believe that efforts in this area must be directed to leverage physical layer strategies, as processing power on the battery-powered nodes is likely to be limited.

The delta–sigma (DR) modulator for high-speed speech processing is modified in [31] for simultaneously digitizing and authenticating sensor readings. By exchanging simple keys, filter parameters can be decided that are used to encode the generated stream, thus proving to be an computationally inexpensive scheme. However, this technique has several practical difficulties including modulator matching between the sender and receiver and precision tracking of the signal for accurate demodulation. Other areas that need to be more research are watermarking for heterogeneous streams of voice and video applications. Scalar or voice data may be rendered invisible by embedding it in frames of video images thus making eavesdropping difficult.
Based on the result of various research contributions [34]

VIII. Conclusion

The recent advances in WSN, the invention of low-power circuits, and the development of cheap CMOS microphones and cameras, which capture rich multimedia content, had given the birth to WMSNs. This paper is based on the detail study on Wireless Multimedia Sensor Networks (WMSNs). Due to centre of attraction next analysed the major

challenges and issues on designing challenges for WMSN. As well as, this paper introduces some of the new suggestions related to the existing problem of video streaming in WMSN.

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