Optimizing the Wireless Multimedia Sensor Network Applications

Milos Kosanovic[1] and Mirko Kosanovic[2]
[1]College of Applied Technical Science Nis
Aleksandra Medvedeva 20, 18000 Nis, Serbia
milos.kosanovic@vtsnis.edu.rs
[2]College of Applied Technical Science Nis
Aleksandra Medvedeva 20, 18000 Nis, Serbia
mirko.kosanovic@vtsnis.edu.rs

ABSTRACT: *In the current world, the Wireless Sensor Networks is inevitable and help many issues in mankind. The progress such as the creation of Micro Electro- Mechanical Systems (MEMS) and the introduction of CMOS cameras and micro-phones, have led to the creation of one aspect of WSN, which is termed as the Wireless Multimedia Sensor Networks. In the present Wireless Multimedia Sensor Networks. the transfer of more volume of data in the sensor nodes to the basic station with less bandwidth and less power use in the wireless communication is a major issue. We need to address the issue so that the multimedia applications like real-time multimedia streaming, video conferencing, conversational services (videoconferencing), surveillance, overhear reality become a reality. In this work we offer an explanation of the issue, principles and standards which are essential for multimedia based data. We studied how the storage and preservation of the data has impact on the life of wireless sensor networks and offer solutions.*

Keywords: Wireless Sensor Node, Multimedia Data, Efficient Transmission, Packets

Received: 26 October 2021, Revised 5 January 2022, Accepted 19 January 2022

DOI: 10.6025/jitr/2022/13/2/38-43

1. Introduction

Wireless Sensor Networks (WSNs) has become a big challenging issue for researcher community in the last few years. They represents one kind of wireless network composed of small sensor nodes (SNs) with limited computer resources, which are capable for gathering, data processing and communicating among each other completely independently [1]. WSNs are cost effective and distributed solutions implemented in various environments where conventional networks are impractical. WSNs have currently deployed in a wide range of applications as a sensor is becoming smaller and production cost is smaller. On the other side, the increasing development of Micro Electro-Mechanical Systems (MEMS), the availability of low-cost hardware, such as CMOS cameras and microphones, has fostered the development the other kind of WSN, named Wireless Multimedia Sensor Networks (WMSNs). They are capable to sample the physical environments at unprecedented spatiotemporal resolutions. Because of that, they can recorded many multimedia information such as images, video and audio streams from the environment, which allows their applicability into many data-intensive applications. All of this information requires an enormous amount of data to be sent through the network. Unlike traditional wired networks, the reliability of data transfer in WSNs is not a critical parameter. Namely, for most WSNs (monitoring environment, object tracking, etc.) some occasional amount of data losses is acceptable. However, as WSNs become ubiquitously deployed, such as multimedia and process control WSNs, reliable data transfer, RDT, is required. In this kind of applications every byte of the data packet has to be, reliable delivered to the destination. On the other side, the need to transport the massive amount of data generated by sensor nodes to base stations poses a fundamental challenge due to the limited node bandwidth and high power consumption of multi-hop wireless topologies. This implies that more conflict in traffic, more congestion in accesses, and more packet retransmissions among SNs are needed. As a result, the SN's power consumption increases, while its lifetime period becomes shorter.

In this paper, we look at the problem of efficient and reliable data transport in WMSN. We propose a new solution for information delivery in both directions upstream (from sensor node to master node sink) and downstream (form master node to sensor node). Our solution ensures reliable data transport in both directions with much better relation between payload data and header (reduced header) in spite of well known current solutions [2]. In the remainder of this paper, in section 2 we explain some important features that characterize data transmission in WMSM. The third section gives a suggestion for new solution intended for reducing the number of bytes in the header of the transport protocol. Analysis of its success from the standpoint of increased lifetime of WSN is given in the fourth section. The fifth section concludes this paper.

2. Characteristics of Multimedia Data Transmission

Due to the large differences in data transmission, a large number of network protocols developed for the classical WSN are not usable or require specific changes in WMSN [3]. The main difference lies in the fact that the majority of protocols developed for WSN focused on reducing energy consumption (low power) of SN in the network, because the flow of data in such networks is very low. Unlike them, WMSN protocols, in addition to the conditions (energy-efficiency), are faced with two new additional problems to solve: significantly increased the intensity of traffic and the need for greater communication quality (QoS). Usually wireless environment is error prone environment, what means that is an environment with a large percentage of errors in transmission (40%-70%) [4]. Therefore a reliable and efficient transmission of such data is a very complex problem [5]. Hereafter, we will point to some important features in the transmission of data in WMSN, which are representing the basic things on which we must pay attention, and that require the efficient solutions.

2.1. The Increased Number of Packets

In addition to significantly increased amount of data that the network needs to transmit, there is a problem in the speed with which data is sent. Thus, while the data rate in WSN is usually about 40 kb/s, in WMSN we must have min. 64 kb/s to send audio data, and min. 500 kb/s to send the video signal [6]. Bearing in mind that the delivered packets are with the length of payload data limited around of 30 bytes, it is clear that here we have a very large amount of packages. On the other side, the amount of packets further increases because we have many redundant packets coming from other neighboring SNs, due to multi-hop communication. The traffic intensity increases with in-sink approach, because it collected all the data coming from the peripheral SNs. Another problem is the different intensity of traffic, that can be classified as periodic or event triggered (event driven).

2.2. The Degree of Reliable Packet

In most cases in WSN, the degree of reliable (reliability) data was not great. This has arisen from the fact that most applications are not required that each packet is received. It is sufficient to receive only one correct package from SNs froma region, not all, because in most case, they have the same or similar information. It gives us more freedom in the development of network protocols for WSN. But in the WMSN it is not the some case, because the nature of the information transmission through network must be provided with completely reliable transmission. This fact making them very closely to standard wired networks. On the other hand, however, all multimedia data, images, video or audio information consists of data that have different standards for ecure data transmission. To achieve a data rate of multimedia information that had previously been described, SNs can not send all data from which this information is made. They sent only some relevant frames that contain some parts of this information, while the rest of the information will be obtained through different methods of interpolation at the destination, i.e. at sink. For example, it is critical to lose during transmission the packet with ROI (Region Of Interest) data if it is coding with JPEG 2000, or I-frame with MPEG compression [7]. If this happens, we irretrievably loss the transmitted information, and interpolation method is not possible. In WSN's two methods to solve this problem are used: HtH (Hop-to-Hop) and EtE (End-to-End). HtH method is demonstrated better results than the traditional EtE mechanism, because it reduces the density of traffic and thereby saving power consumption of SNs, which means long lifetime of WSN. Due to the large number of packages making up the information in WMSN better results have shown when a combination of both methods is used [7].

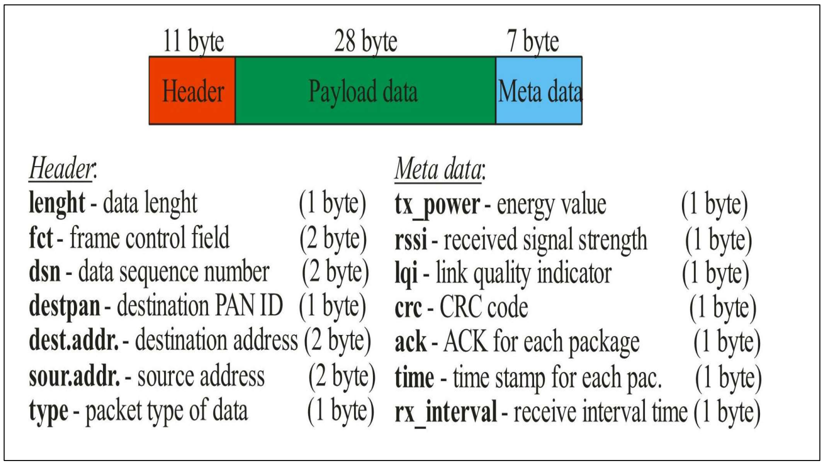

Figure 1. Structure of message_t package in TinyOS

2.3. Packet size

In most applications, communications in WMSN consists of a large number of packets which must be sent to only one frame. The size of these packages is limited to the applied operating system and the size of the transmitter buffer in SNs. Thus, TinyOS, which has become almost standard operating system for WSN, use program structure message_t for communication between the SN's (see Fig. 1) [8]. It consists of the standard size of 28 bytes for useful data size and a 11 byte for header. On the other hand, the standard communication chip CC2420, standard IEEE 802.15.4, use 128 bytes for packet length. In both cases this size can be changed by program operation [9]. Bearing in mind that the standard package, that is sent, have 28-110 byte useful (payload) data (message_t in TinyOS), it turns out that the number of packets which must be sent for only one picture are very large and exceeds the number of over a thousand packages. As in these packages we have great part of ''useless" data header and meta data (28/18), is of great importance that these ''useless" data reduce to a minimum. Primary role in it should be played by the development of new transport protocols designed for multimedia transmission of information, which should reduce the amount of data that is sent for header and metadata [9].

2.4. Control of traffic density

Eeffect of increased traffic in these networks should be emphasized. Due to large amounts of data required to send a multimedia information, and taking into account that the packets are sent from these data are limited to 28-110 byte useful (payload) data, it is clear that the number of packets are very large. On the other hand, the number of packets is further increase with many redundant packets arriving from other SN. The traffic intensity increases with the approach of the main sensor node - sink, because it collected all the data coming from the peripheral SNs. A special problem to solving this problem is the different intensity of traffic that can be classified as periodic or event triggered (event driven). This is that the traffic becomes very intensive only when there are changes in the monitored region. For any other time, the intensity is very small, i.e. it is almost nonexistent. Due to the nature WMSN, the detection of changes in time, there is a large number of redundant data. It follows from the fact that a large number of SNs can detect the same event. To effectively solve this problem we need to develop more algorithms that will contribute to: the effective selection of the observed events and the elimination of redundant data, detection and elimination of traffic congestion, congestion avoidance and control traffic flow in WMSN. Most of these algorithms base their decisions on the utilization of the buffer control in the SNs, as well as to control the frequency/speed of sending data (ACC-Active Congestion Control) [4].

3. Proposed Solution

During development of the new transport protocol we were aware that the protocol must primarily meet the requirements of energy-aware protocol type, and is simple enough to be implemented in hardware and software of a large number of WMSN applications. In addition we were aware that in the future, because of the increased need to carry more multimedia data will need a protocol that will enable reliable transmission in both directions. Therefore, the proposed solution is treated equally and provides reliable data transfer (reliable transport of data) in both directions, up-streams and down-streams. In most applications that need to transmit multimedia information, communication consists of a large number of packets to be sent for only one frame. Such as, for sending of a typical video images, we need about 25-30 MB (28 888 bytes in JPEG or 319 254 BMP-byte code) [6].

Having in mind that the standard package that is sent take from 28-110 bytes of useful (payload) data it turns out that the number of packets to be sent to only one picture is about 263- 1032 packets. As in these packages is usually a very small number of useful data, in relation to information relating to the header and metadata (28/18), if we succeed to reduce the size of ‘’useless’’ data, we will save a considerable amount of energy. In this way, we will increase the useful data and the total packet length would stay the same, which would lead to a significant reduction in the number of sent packets. As for the specific topology of these networks, communication mechanism is multi-hop (hop-by-hop), every SN’s in addition to basic functions, detection of an event, should meet the function of the router, i.e. to redirects the large number of packets passing through it. This means that if we have multihop communication we have much more packets between SNs. Saving only one byte in packets which are transmitted, we can save a large amount of power energy due multiplies number of skips between SNs. On the other hand, reducing the number of packets reduces the intensity of traffic, and thereby reducing the percentage of errors. All this contributes to saving large amounts of power energy in the SN’s, which is the main goal of any protocol in WSN [10].

The basic idea of our solution consists in reducing the header, and increases the space for transmits useful information. This is done in header in which we dropped 2B which are used to denote the unique data sequence number of packets being sent (field dsn on Fig.1). To maintain unique identification of packets sent, it is compensated by multiple different addresses that are dynamically allocated to SNs. All addresses within a segment of the WMSN dispose the main (master) node. From the standpoint of IP addressing this node acts as a DHCP server. It dynamically assigned addresses to SNs, depending on the traffic intensity, quality, quantity and direction data. One node in the sensor network can have one, two, four or more addresses (2n address), which are awarded based on traffic load, the number of SN’s that have data to sent, and the amount of data being sent. If exists only downstream communication, master SN all available addressesassigned to SN’s. In the case of up-stream communication each SNs has only one base address, while all the remaining addresses are assigned to the master SN. Each message can be divided into multiple packets; each of them becomes a unique packet that can be sent independently. The number of packets depends on the number of addresses assigned to the SN.

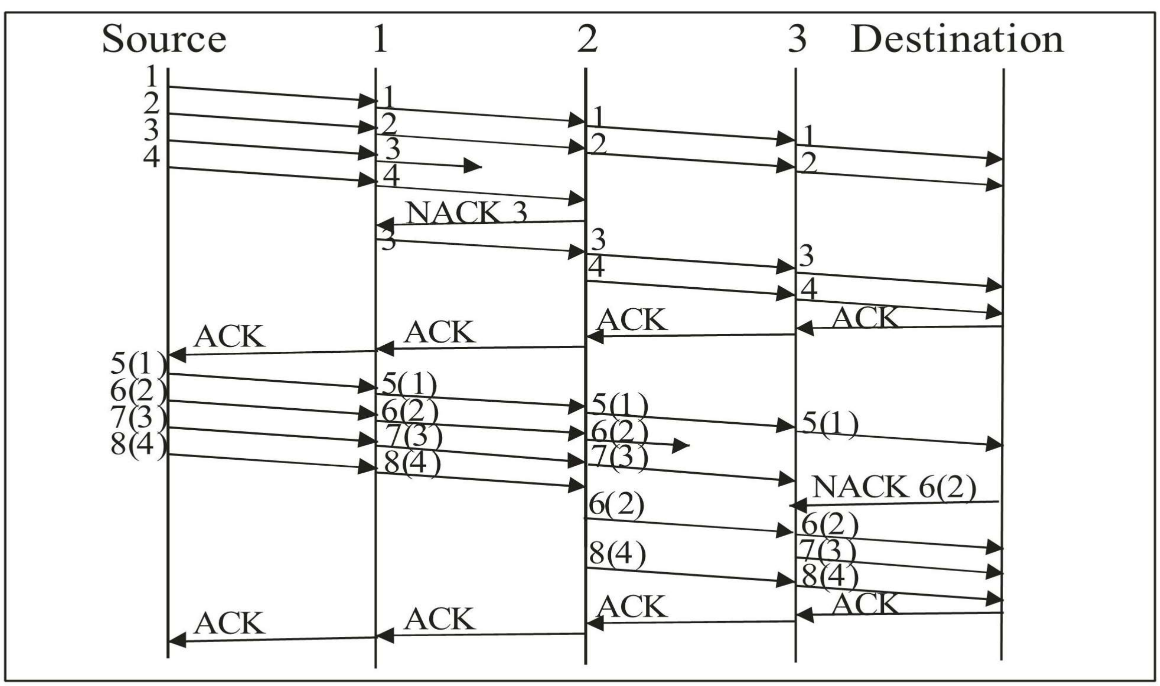

Figure 2. Transport sequence of frames among SNs in WSN

Destination SN collects all the packages and create message that is sent. The order of packets arrival at the destination is not important, because all packets is with different addresses and actual reconstruction of the message can be done. If the size of message that is sent is greater than the number of packets, i.e. address range assigned to the SN's, then a message is divided into blocks where each block has as many packets as the addresses assigned to SN's.

The Figure 2 shows the process of sending one message which consists of two blocks of 4 packets (SN destination addresses have been assigned to 4), as well as the procedure is carried out with the bad reception of a frame. The Figure 2 shows that the transient SN uses technique NACK, meaning that the transient SN can accept packets in any order.

If you accept a framework that is in the order, NACK message is sent only after the expiration of a timer that will later be explained. Each node accepts the framework is its buffering and passes it to the next node. Preferably the buffer size in each node is the same for all SN's. After the final destination SN receives all packets from the first block (in our case, all 4 packets), it sends an ACK message to the original SN who started this sending. On this basis, each SNs can reset its buffer in preparation for receiving new data block. Due to the nature of WMSN, primarily due to the large number of errors in communication, it is possible that many transient SNs do not receive the correct packets. In order to still allow each SNs that can accommodate all packets sent and to reset its buffer and receives a new frame with the same address, our solution introduced the three delay counters on each SNs. The role of the first counter is to disable the receipt of the frame currently sending NACK messages, unless it receives a frame in the sequence, because it assumes that it can also be delayed by multiple pathways. The second counter is introduced to allow sufficient time to each SNs that can be requested to resend the frame. It has a role to control the speed of sending the frame and thus the intensity of traffic in the WMSN. Each detection NACK message causes increase the value of the delay counter SN who received the message. In the initial state of the state of the counter is set to 0, and its value increases depending on the number of NACK messages that have reached him. The greater the number of received NACK message, the greater the value of the counter because it is assumed that there was deterioration in a relationship: higher traffic density, or communication problems. The third counter is reset to enable the role of the receiving buffer if the connection is asymmetric and difficult conditions, has not received a return ACK message. The timer is activated upon receipt of all necessary frameworks from one block (4 packets in our case). Now, if it receives a new data set with the same addresses and the value of the counter has expired, it is possible to reset the receive buffer and a new block of data regardless of whether we have received confirmation ACK from the destination node. When the ACK message arrives to the source, SN continues sending the next block of data that are stored in boxes that have the same address as the previous one, but with other information (now the packets 5, 6, 7 and 8 have addresses 1, 2, 3 and 4 respectively). The procedure is repeated until the entire message is sent.

4. Analysis of Protocol Success

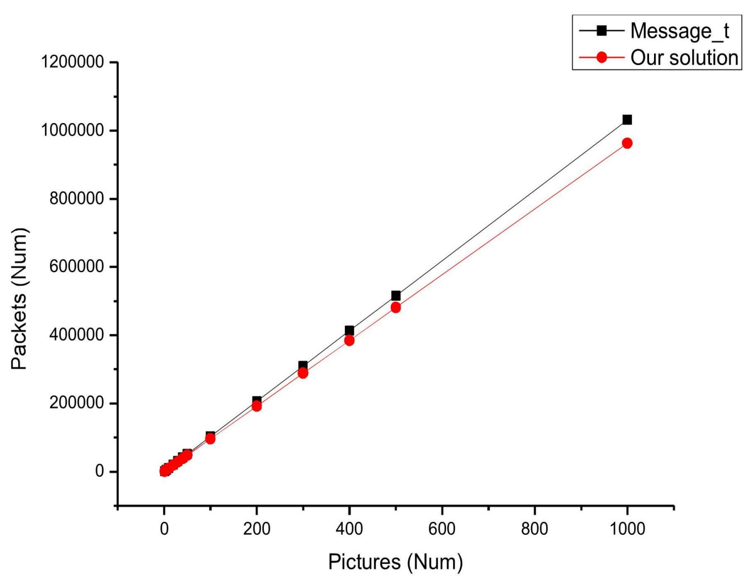

Figure 3. Number of packets in function of transmitted pictures

In order to evaluated our solution and the main savings for assigning multiple addresses to each SN wictc gets the required reduction in the header bytes in the frame to be sent. Now there is no need to send the data sequence number of the packet because it is uniquely determined by the address of SN. We will assume that the sensor network operating in ideal conditions, i.e. that no additional retransmissions and analyze the total number of packets are sent in function of number of pictures. We will study the case when the packet size is standard length of 46 bytes (11 byte header, 28 bytes of payload data bytes and 7 meta data) for standard message_t and compare with our solution.

According to the graphics presented in Figure 3. it can conclude that our solution always give better results. As the number of transmitted image increases, the difference in the transferred messages in favor of our proposed solutions, increase.

5. Conclusion

Transmission of multimedia data in environments that are subject to a number of errors is a very complex problem. When you add very poor resources of SNs, complex nature and unpredictable conditions in which they work problem is even more complicated. Just because of this, issue is very interested many researchers and currently represents one of the most researched areas in the WMSN. This paper has attempted to group together all the issues and parameters that should be taken into account for this transfer, to assist in the further development of an efficient protocol for transmission of multimedia data. We propose a simple solution, with reduction of the header for the only two bytes. Our calculation show us that can be achieve to savings about 1.8-6.66 % per packets (depends of packet length: 128 or 46 bytes) and thus extend the life of the entire WMSN. It should be noted that in the paper we shows the example when it comes to single-hop data transmission. If it is applying multi-hop transmission, that is standard for the WMSN, these will be obtained even better results because the number of packets transmitted increases even more.

References

[1] Akyildiz, I.F., Melodia, T., Chowdhury, K.R. (2008). Wireless Multimedia Sensor Networks: Applications and Testbeds, *In*: Proceeding of the IEEE. 96 (10).

[2] Taner Cevik., Alex Gunagwera., Nazife Cevik. (2015). A Survey of Multimedia Streaming in Wireless Sensor Networks: Progress, Issuse and Design Challenges, *International Journal of Computer Networks & Communications*, 7 (5) 2015.

[3] Costa, Daniel G., Guedes, Luiz Affonso. (2016). A Survey on Transport Protocols for Wireless Multimedia Sensor Networks, http://www. itiis . or g/digital-library/manuscipt/286, 20.03.2016.

[4] Rosberg, Z., Liu, R.P., Dong, A.Y., Tuan, L.D., Jha, S. (2016). ARQ with Implicit and Explicit ACKs in WSN. http ://www. ict.csiro.au/staffren.liu/publications/2008-rosberg¬Fdob.pdf , acc. 20.01.2016

[5] Misra, S., Reisslein, M., Xue, G. (2016). A Survey of Multimedia Streaming in WSN, http://www.public.asu.edu/'-ssatyaja / papers/ieee survey.pdf, acc. 20.01.

[6] Oztarak, H., Yazici, A., Aksoz, R. George. (2007). Multimedia Processing in WSN, WEE 4th International Conference Innovations in Information Technology, page78-82.

[7] Lee, Joa-Hyoung., Jung, In-Bum. (2010). Reliable Asynchronous Image Transfer Protocol in Wireless Multimedia Sensor Networks, Sensors, 10, 1486-1510

[8] Levis, P. (2012). TEP 111, message t, http://www.tinyos.net /tinyos-2.x/doc/html/ten111.html, acc. 20.01.2012

[9] Kosanovie, M., Stojeev, M. (2010). Reliable Transport Protocol with multi address sensor nodes, INFOTEH 2010, Jahorina.

[10] Soro, S., Heinzelman, W. (2009). A survey on Visual Sensor Networks, Advances in Multimedia.