IJCSN - International Journal of Computer Science and Network, Volume 7, Issue 1, February 2018
ISSN (Online) : 2277-5420
www.IJCSN.org

QoE Aware Routing Protocols in Wireless Multimedia Sensor Networks: A Survey

[1] Harsh Bhatt; [2] Malaram Kumhar

[1] Computer Science and Engineering Department, Institute of Technology, Nirma University, hmedabad, Gujarat 382481, India

[2] Computer Science and Engineering Department, Institute of Technology, Nirma University, Ahmedabad, Gujarat 382481, India

Abstract – Wireless Multimedia Sensor Network (WMSN) has a grown as an area of interest in the recent years due to availability of various CMOS devices like camera and microphones. With this advent multimedia transmission is possible which can be enhanced by providing the transmission with various QoS (Quality of Service) parameters. QoE (Quality of Experience) plays a vital role in WMSN Multimedia Transmission as it is related to user perception for the application quality. Various QoE matrices like Mean Opinion Score(MOS), Peak-signal-to-noise ratio(PSNR), Structure Similarity Metric(SSIM), Video Quality Metric(VQM) are there for video quality measurement. The multimedia transmission contains audio, video, images and scalar data each which has a different metric for QoE. To provide a high-data rate transmission we need an efficient QoE aware routing protocol for multimedia Transmission in WMSN. Various Challenges and research issues are discussed in this paper.

Keywords - *WMSN, WSN, video transmission, QoE, multimedia*

1. Introduction

A wireless sensor network (WSN) is a wireless network composed of independent devices using sensors to monitor physical or environmental conditions. As WSN has many applications it became a growing area of research. Wireless Multimedia Sensor Network (WMSN) are extension of WSN equipped with various CMOS devices like camera and microphone. With the addition of these devices the WMSN are capable to retrieve audio-video streams as well as scalar data. [1]

The Figure 1 describe the sample architecture for WMSN. It can be categorized into 3 sections based upon the type of target application as follows:

1.The first section is single-tier flat architecture where the WMSN is homogeneous i.e. all the network in the nodes will have same type of sensors, computational ability, processing power. [2] This type of WMSN can serve only one application at a time.
2. Second section is single-tier clustered architecture, with heterogeneous sensor nodes. Here a single WMSN can have multiple type of sensors, processing power and Computational ability. It can also consist of various homogeneous clusters interconnected to one another to address a wide range of applications.

3. Third Section shows the multi-tier architecture which consists 3 tiers.

1) Scalar Nodes

2) Medium Resolution Video Sensor Nodes

3) Visual Sensor nodes for recognizing and tracking the object

The sink collects the relevant data and then the data is further processed as per the target application. [3]

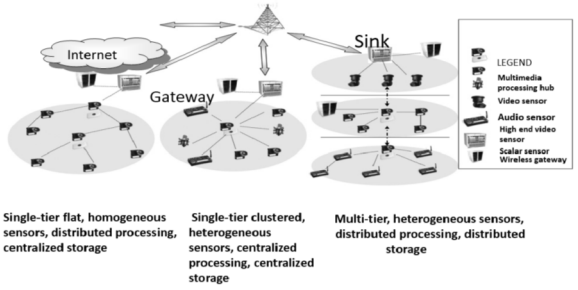


Figure 1 WMSN Architecture

2. Challenges associated in the design of WMSNs

- Application Specific QoS requirements
  Wide variety of applications are possible with WMSN. Each application demands different Quality of service. For most real-time applications timely delivery of the contents is very crucial for the success of the applications. Reliability of content delivery is also a parameter of interest or many applications. It is challenging to design solutions to full fill the diverse Quality of service requirements of different applications. [4]
- High bandwidth demands
  Multimedia contents usually require higher transmission bandwidth. Typical sensor platforms are based on widely used IEEE 802.15.04, which offers data rate of 250Kbps.Higher bandwidth can be offered by transceivers based on IEEE 802.11 but at the cost of higher power consumption. Controlling the bandwidth required by nodes is an active area of research.
- Multimedia encoding
  Captured multimedia contents need to be encoded as row data transmission is costly for transmission over a low bandwidth network. Traditional motion compensation based video encoding is too complex to be implemented on resource constrained sensor nodes. The encoding complexity can be swapped with the decoder using Distributed Video Coding(DVC). Proper choice of the encoder can have a significant impact on the network performance due to processing and energy constraints.
- Multimedia in network process
  Data aggregation helps in reducing the amount of information flowing in the sensor network. In WSN, aggregation is normally applied on numeric scalar quantity. In WMSN aggregation or fusion can be challenging as the information type can be video from multiple views. Depending upon the applications need irrelevant scenes can be converted to the scalar quantity or not transmitted at all. Multimedia in network processing plays significant role in optimizing the performance. [3]
- Field coverage
  Most scalar sensor nodes such as temperature, pressure, sound, humidity etc. have omnidirectional disk coverage model. A camera has directional coverage known as a field of view. As the objective is to cover maximum field area, directional coverage poses new challenges in deployment strategy and scheduling node activity.

3. WMSN Applications

With the availability of low power consuming devices like audio sensors, camera at a cheaper rate many new applications can be addressed such as:

- Tracking-

This is a military application where in the WMSN is used to track the movement of the enemy and help our army plan the attack accordingly. [5]

- Home Automation

- Multimedia Surveillance Sensor Networks

Multimedia Surveillance sensor systems will enhance the existing solutions to monitor the network. Interactive media content, for example, video streams and still pictures, and PC vision methods, can be utilized to find missing people, distinguish hoodlums or fear mongers, or induce and record other conceivably applicable exercises (thefts, car accidents, traffic violations)

- Environmental monitoring

Varieties of video sensors as of now are utilized by oceanographers to decide the development of sandbars utilizing picture preparing techniques. Video and imaging sensors likewise are utilized to screen the auxiliary strength of scaffolds or other common structures.

- Advanced Health Care Delivery

Telemedicine sensor systems can be coordinated with third and fourth era (3G/4G) cell systems to give universal medicinal services administrations. Patients will convey medicinal sensors to screen parameters, for example,

  - body temperature
  - circulatory strain
  - ECG
  - breathing movement
  - beat oximetry

Remote medicinal focuses will screen the state of them patients to deduce crisis circumstances.

- Traffic Avoidance, Enforcement and Control Systems

It will be convincing to screen auto movement in huge modern communities or on parkways and send admins that offer activity steering counsel to evade clog or on the other hand distinguish infringement. Likewise, smart parking counsel frameworks in view of WMSNs will recognize accessible parking spots and give drivers with computerized stopping exhortation.

- Storage of Activities
  - Accidents, thefts, Violations
  - The availability of audio/video streams for reporting and querying purpose.

- Industrial Monitoring

Wireless sensor nodes can be used in monitoring industrial processes specifically in nuclear and chemical plants where human monitoring and wired system may not be possible. Sensor nodes can be placed in hard to access areas to monitor wear and tear in the machine parts by measuring various parameters like vibrations, temperature etc.

- Military Applications

Wireless sensor network has proved its worth in all aspects of military operations like distribution of commands, logistic information and battlefield monitoring.

4. QoE Aware Routing Protocols for WMSN

4.1 LEACH (Low Energy Adaptive Clustering Hierarchy)

The main objective of this hierarchical routing protocol is to control the node energy consumption of the WMSN. However, LEACH is only used for Cluster Head selection and for the Data aggregation. It is also used for data fusion which lessens the number of messages forwards to the destination node. LEACH is a hierarchical protocol which forms clusters of nodes. Members of cluster are permitted to transmit the information to the Cluster Head(CH) only. The CHs are assumed to be in direct communication range of the base station. It is responsibility of the CH to transmit data to the base station. The CH is good candidate for data aggregation. Proper choice of CH can be useful in WMSN for multimedia transmission. Hierarchical routing protocols can be a reasonable choice for WMSN as data aggregation is also an important aspect of WMSN.

The node progresses toward becoming cluster set out toward the current round if the number is not as much as edge T(n). [6]

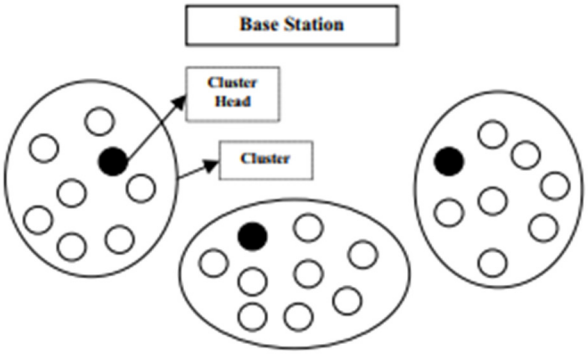


Figure 2 LEACH Protocol

Once the node is chosen as a cluster head it can't progress toward becoming group head again until the point that every one of the nodes of the cluster have move toward becoming bunch head once. These aides in adjusting the energy utilization. the non-cluster head nodes get the cluster head notice and afterwards send join demand to the cluster head educating that they are the individuals from the cluster under that cluster head as appeared in Figure. These non-cluster head nodes spare a considerable measure of energy by killing their transmitter constantly and turn it ON just when they have a comment to the cluster head. [7]

4.2 SPEED (Stateless Protocol for real-time communication)

The main aim of SPEED is to maintain end to end delay to the distance between the source and destination. SPEED uses back pressure and re-routing technique with the use of back pressure beacon it reduces the congestion. SPEED uses Stateless Non- deterministic Geographic Forwarding (SNGF), which provides soft, real-time, end to- end delivery. SNGF does load balancing over wide area, which helps to reduce congestion. The only drawback is no priority is considered for packets and packet's speed cannot be increased. As appeared in Figure, SNGF is the directing module capable for picking the following bounce competitor that can bolster the coveted conveyance speed. NFL and Backpressure Rerouting are two modules to lessen or occupy movement when clog happens, with the goal that SNGF has accessible possibility to browse. The last mile process is given to help the three-correspondence semantics said some time recently. Postponement estimation is the component by which a hub decides

regardless of whether blockage has happened. Also, signal trade gives geographic area of the neighbors so that SNGF can do geographic based steering. The points of interest of these parts are examined in the resulting areas, individually. [8]

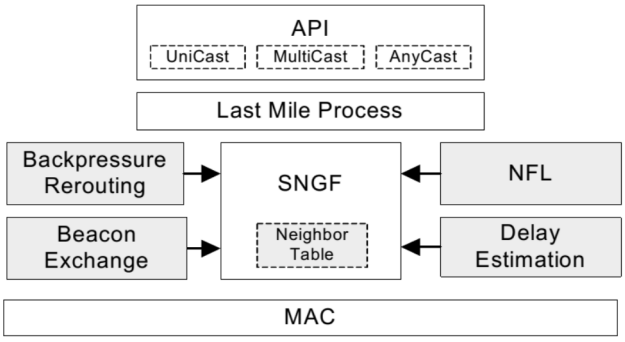


Figure 3 SPEED Protocol

4.3 MMSPEED

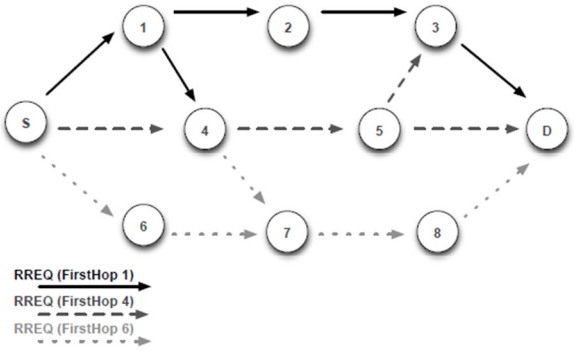
An extension to the SPEED protocol is proposed in Probabilistic QoS guarantee in reliability and timeliness domains in wireless sensor networks namely Multi-Path and Multi-SPEED routing protocol. MMSPEED is cross-layer protocol that intends to provide priority based services to packets. With QoS provisioning it also provides reliable packet delivery using the concept of multipath routing. The packets are classified into two parts reliability and timeliness. Based on the above two ratings packets are assigned priority and processed accordingly. Unique Services provided by MMSPEED:

- Local Packet delivery without network topology information.
- Minimizing less reliable and unbounded transmissions over wireless links.
- Service differentiation and guarantee in both reliability and timeliness domains.

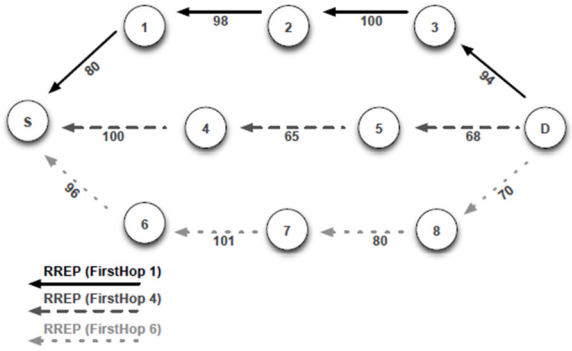
MMSPEED works powerfully by giving difference in speed what's more, way according to benefit necessities. It offers different speed levels. Distinctive parcels will require diverse velocities to meet the conclusion to-end due date. Considering the speed prerequisite, MMSPEED doles out parcels to various speed layers. It too guarantees unwavering quality to the parcel by assessing the dependability of the way through a hub in view of the present mistake rate. Since the unwavering quality of a way is assessed in view of 1-jump neighbor data just, it may not be sufficiently exact. The estimation can be enhanced if n-jump data is accessible. The nonattendance of vitality thought is yet an issue with MMSPEED.

4.4 MEVI (Multi-hop hierarchical routing protocol)

The main aim of MEVI is to send the real-time video transmission. It creates cluster and support cross layer design. The routes selection is based on network's condition. Link quality indicator is used to define the condition. Path selection is depending upon remaining energy(RE) and hope count(HC) and LQI. It transmits the packets to the path which have a highest path conditions. However, considering the LQI in the CH decision and in the way development requires intermittent updates, since the connections state change after some time, which produces higher overhead.



(a) Route request



(b) Route reply

Figure 4 MEVI Protocol

When the RREQ messages achieve the goal hub, it makes new way sections to the source hub for every approaching solicitation, notwithstanding when RREQs have an alternate to begin with jump. The goal hub transmits a relating RREP message for each approaching RREQ

message, with the plan to setting up a full bidirectional different way, as indicated Figure. The RREP message flies out back to achieve the source hub, which makes new way sections for each approaching RREP. [9]

4.5 GPSR (Greedy Perimeter Stateless Routing)

The main aim of GPSR is to uses the location and information as well as link quality to measure the path. It has two methods for forwarding the packets. First is greedy forwarding and second is parameter forwarding which is only used when greedy forwarding is failed. However, packet breakdown during the transmission because the destination node is moving its information in the packet header of intermediate node is never updated. [10]

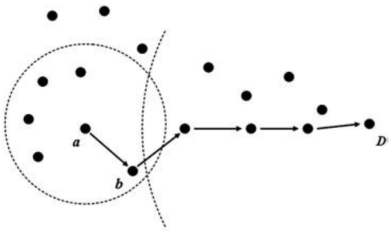


Figure 5 Greedy Forwarding

The figure 5 shows a sample WSN which nodes represented as dots. it also explains the greedy technique of the GPSR Protocol. The source and the destination nodes are known prior to the transmission in this technique. The routing starts with the source nodes following the below steps:

- Find neighbors who are nearest to the destination
- The packet is forwarded to the neighbor closest to the destination
- A node only needs to remember the location information of one-hop neighbor

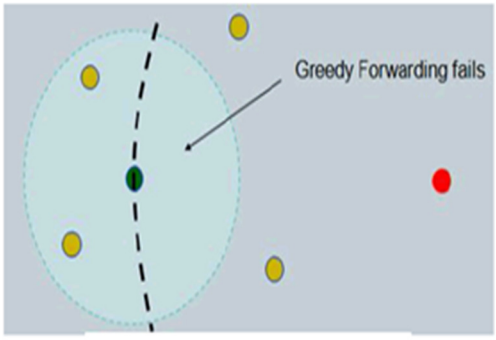


Figure 6 Failure of Greedy Forwarding

These steps are repeated until the destination node is reached.

Figure 6 represents a scenario where the Greedy Forwarding Technique fails to find the route in the WMSN.

It explains a situation where the node is unable to find it's one-hop neighbor nearest to the destination node as the intermediate node are out of the communication range of the finding node. Thus, in scenarios like this GPSR routing fails and is unable to find the route in the WMSN.

When greedy forwarding algorithm fails, then after Perimeter forwarding algorithm is used. It uses right hand rule to find the path. However, it does not work with the cross edges.

4.6 DGR (Directional Geographical Routing)

DGR is multi path routing protocol which constructed multiple disjoint path for parallel transmission of video streams. It implied that all the paths may not be optimal. Packets transferred along sub optimal paths are likely to be forwarded through the neighbors farther from the sink than the node itself. The paths were selected to ensure that they do not interfere to each other. DGR relied on an assumption that all video nodes do not transmit the video stream simultaneously rather they take turns to send video streams. The assumption is somewhat unrealistic as it is difficult to synchronize and enforce transmission schedule on all video nodes. Hence it becomes difficult to use DGR in large scale sensor networks.

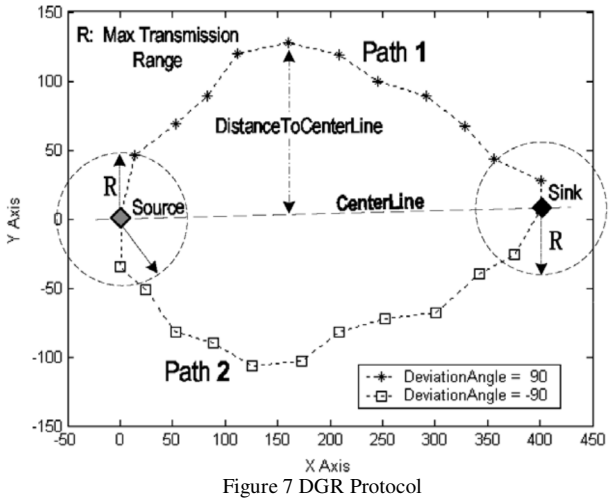


Figure 7 DGR Protocol

Utilizing simultaneous various ways in DGR additionally

has an essential impediment; i.e., DGR does not function admirably when various node send video to the sink all the while, as numerous converging ways meddle with each other extremely. Be that as it may, because of the restricted data transmission of a WSN, it is sensible to expect that whenever case just a single node sends video to the sink. Truth be told, due to the unpredictability and higher power utilization of node, we expect that among the huge number of sensor hubs in a WSN, just few them are, while the rest are less able minimal effort sensor hubs that capacity as transfers, which additionally have brought down power utilization than the VNs. A couple of (at least one) further developed sensors are furnished with camcorder and coding capacity, which fill in as video sources checking a couple of delicate areas. [12]

5. QoE Metrices

5.1 Mean opinion Score

The minimum threshold for acceptable quality is application dependent. The client QoE is regularly communicated on a Mean Opinion Score (MOS) scale. The MOS is expressed on a five-point scale, where

5 = excellent
4=good
3 = fair
2 = poor
1=bad

5.2 Peak Signal to Noise Ratio (PSNR)

PSNR is mostly used to measure the quality of reconstructions during compressions. The original video is the input signal and the compression through codecs introduces error to the video. [13] PSNR represents the perception approximation about the reconstructed video according to human.

The quality of reconstruction is high when the PSNR is high and vice versa.

$$PSNR = 10\ log_{10}\ \frac{MAX^2}{MSE}$$

MSE = Mean Squared Error
MAX=Maximum Input power

5.3 Structural Similarity (SSIM)

The similarity between two images id measured by the SSIM. SSIM measures prediction of image quality using a reference image which is distortion-free initial image. The SSIM is an estimation of the auxiliary contortion of the video, which endeavoring to get a superior relationship with the client's sub- jective impression, where the qualities differ near 0 and 1. The nearer the metric gets to 1, the better the video quality.

5.4 Video Quality Metric (VQM)

The Institute for Telecommunication Science (ITS) developed software to measure perceived video quality. The video impairments effects like blurring, noise, distortion of color, jerky motion is measured. Linear combinations of all these parameters are combined into a single metric VQM. Quality of video is analyzed using the number of packets sent to that of number of packets received. [14]

6. Conclusions

WMSN has grown as an area of interest in the recent times with this many of real time applications of WMSN have come to light. These applications demand the video should be as per the QoE and the energy consumption should be minimal. This paper presents the definition of WMSN, reference architecture and various applications of WMSN. This paper also discusses about the existing technical challenges faced and the existing protocols used in WMSN for multimedia transmission along with comparison of protocols and various QoE metrices for WMSN.

References

[1] I. F. Akyildiz, T. Melodia, and K. R. Chowdhury, "A survey on wireless multimedia sensor networks," Computer networks, vol. 51, no. 4, pp. 921–960, 2007.
[2] I. F. Akyildiz, T. Melodia, and K. R. Chowdury, "Wireless multimedia sensor networks: A survey," IEEE Wireless Communications, vol. 14, no. 6, 2007.
[3] [3] S. Aswale and V. R. Ghorpade, "Wireless multimedia sensor network: A survey on multimedia sensors," 2013.
[4] S. Misra, M. Reisslein, and G. Xue, "A survey of multimedia streaming in wireless sensor networks," IEEE communications surveys & tutorials, vol. 10, no. 4, 2008.
[5] B. Tavli, K. Bicakci, R. Zilan, and J. M. Barcelo-Ordinas, "A survey of visual sensor network platforms," Multimedia Tools and Applications, vol. 60, no. 3, pp. 689–726, 2012.
[6] R. K. Gill, P. Chawla, and M. Sachdeva, "Study of leach routing protocol for wireless sensor networks," in International Conference on Communication, Computing and Systems (ICCCS–2014), pp. 1–3, 2014.
[7] A. Hnini, A. Mohcin, A. Ezzati, and A. Hajami, "Evaluation of leach qos subject to multimedia traffic types," in Next Generation Networks and Services (NGNS), 2012, pp. 181–184, IEEE, 2012.

[8] T. He, J. A. Stankovic, C. Lu, and T. Abdelzaher, "Speed: A stateless protocol for real-time communication in sensor networks," in Dis-tributed Computing Systems, 2003. Proceedings. 23rd International Conference on, pp. 46–55, IEEE, 2003.

[9] I. Bennis, H. Fouchal, K. Piamrat, O. Zytoune, and D. Aboutajdine, "A realistic multipath routing for ad hoc networks," in Global Communi-cations Conference (GLOBECOM), 2015 IEEE, pp. 1–6, IEEE, 2015.

[10] B. Karp and H.-T. Kung, "Gpsr: Greedy perimeter stateless routing for wireless networks," in Proceedings of the 6th annual international conference on Mobile computing and networking, pp. 243–254, ACM, 2000.

[11] O. Chipara, Z. He, G. Xing, Q. Chen, X. Wang, C. Lu, J. Stankovic, and T. Abdelzaher, "Real-time power-aware routing in sensor networks," in Quality of Service, 2006. IWQoS 2006. 14th IEEE International Workshop on, pp. 83–92, IEEE, 2006.

[12] M. Chen, V. C. Leung, S. Mao, and Y. Yuan, "Directional geographical routing for real-time video communications in wireless sensor net-works," Computer Communications, vol. 30, no. 17, pp. 3368–3383, 2007.

[13] D. Rosario,´ R. Costa, A. Santos, T. Braun, and E. Cerqueira, "Qoe-aware multiple path video transmission for wireless multimedia sensor networks," Simposio´ Brasileiro de Redes de Computadores e Sistemas Distribu´ıdosSBRC, pp. 31–44, 2013.

[14] P. Juluri, V. Tamarapalli, and D. Medhi, "Measurement of quality of experience of video-on-demand services: A survey," IEEE Communications Surveys & Tutorials, vol. 18, no. 1, pp. 401–418, 2016.