Webology (ISSN: 1735-188X)
Volume 18, Number 6, 2021

Modified IOT-RTP Routing Protocol For Transmission Of Multi-Modal Biomedical Data

Shashidhar P K[1], Dr. Thanuja T C[2] , Rajashekar Kunabeva[3]

1.Research Schlor, RRC, VTU, Belagavi and Asst professor, Dept of ECE, SKSVMACET, Lakshmeshwara, Gadag.

2.Professor ,Dept of ECE, Centre of PG Studies, Muddenahalli, Bangalore, VTU
3.Assistant Professor, Dept of ECE GMIT, Davangere.

Abstract: With multimodal biomedical signals constituting complex multimedia messages to be transmitted from WBAN over WSN with IoT in e-health monitoring applications there is need for novel routing protocols. Transmission of medical signals and images over Internet of Multimedia Things (IoMT) predominantly face the challenges in ensuring quality sensory data. In this paper energy-efficient routing mechanism based on modified IoT versions of Real time Transport Protocol (RTP) and Real Time Control Protocol (RTCP). The proposed protocol achieves improvement in energy efficiency of 3.02%, reduction in end-end delay of 4ms and Packet loss of 19% respectively.

Keywords: WCE images, RTP, RTCP, Multimedia, IoT, WSN and WBAN.

1. INTRODUCTION

Raising health disorders requires interpretation of multimodal medical data for precision diagnosis of disease making and accurate identification of disease or disorders. So biomedical signals and images needs to be transmitted to remote locations where further processing and analysis is performed by the medical experts. This demands communication of multimedia data over IoT infrastructure and overcome different challenges like delay and loss. **Different data kinds (text, sound, graphics, picture, animations, video, etc.) are included in multimedia signals, which might be time-dependent (sound, video, and animation) or spatially-dependent (text, sound, graphics, picture, animations, video, and so on) (images, text and graphics).**Internet of Multimedia Things (IoMT) is a routing paradigm in which various multimedia objects can interact and coordinate over the Internet [24]. For accurate diagnostic decision different biomedical signals are applied. Significance of each of these signals are discussed in brief in following sections.

Electrocardiogram (ECG) signal is an electrical signal representing functionality of Heart and is used for analysis in identifying cardiac disorders. Cardiovascular Diseases (CVD) is the leading killer as per World Health Organization (WHO)[32]. The cardiac functionality is reflected in the ECG wave pattern and different types of associated abnormalities in rhythm are termed as Arrhythmias [25]. The graph of normal electrocardiogram waveform is shown in Figure 1.

Electroencephalographic (EEG) waves serve to the examination of a brain activity. EEG signals are the powerful tool that has the capability to reflect all the activities of the brain from all the various parts of the brain viz., Central Nervous System (CNS) which comprised of Spinal cord and Peripheral Nervous System (PNS). Depending on a human brain activity, several types of electroencephalographic (EEG) waves can be distinguished. Deviations of the normal EEG waves corresponding to alpha or beta activity, i.e. sharp spikes, can refer to pathologic patterns accompanying neurological illnesses. Based on a detection of pathologic patterns recurring with period of one or a few seconds in EEG signal, it has been used to diagnose diseases such as epilepsy or polio. Because of the important role of the EEG examination in neurological disease diagnostics it has been considered in this study.
It has been also been that seizures are frequently linked to changes in the circulatory and respiratory systems, such as tachycardia. [16, 18].

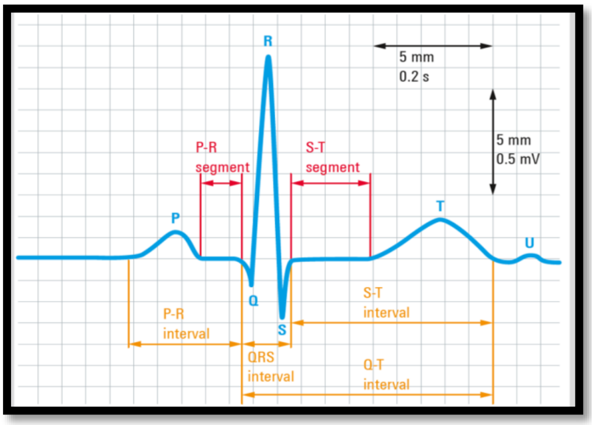

Figure 1: ECG sample waveform [6]

Simultaneous ECG recording and EEG testing is a clinical requirement for detecting and determining the clinical significance of co-existing ECG and EEG abnormalities [23]. In the literature it is mentioned that to improve the accuracy of disease detection it is preferable to use more than one modality. Hence with the combination of EEG & ECG signals it is possible to identify cardiac disorders. Therefore in this study ECG and EEG signals have been taken for transmission over IOT.

Wireless Capsule Endoscopy: Capsule endoscopy is used to record inward photos of the gastrointestinal tract to take biopsies and release remedy at unequivocal territories of the entire gastrointestinal tract. The main interest has been identified to be obscure gastrointestinal bleeding diagnosis. High data transfer speeds are required for wireless capsule endoscopes and biomedical image processing (nearly 10 Mbps).

It was discovered that there is association between acute upper gastrointestinal bleeding and ECG changes particularly Right Bundle Branch (RBBB) for around 30% cases. [FA Gamboa]. This clearly illustrates that ECG and WCE image data are related to each other and could be used for identification of cardiac disorders.

Audio signal

In the diagnosis of cardiovascular illness Heart Sound and ECG are two highly essential and widely utilised diagnostic aids.. Morphological similarity between ECG and Heart sounds is useful in detection of a Heart disease. One dimension audio signal extracted from, an open dataset HSCT-11 containing data can be used for performance evaluation of heart sounds biometric systems.

Thus multimodal data contains three 1-D signals and a WCE Image which are related to each other and contribute towards increase in the accuracy of Heart disease detection.

Remote health monitoring

Remote patient monitoring is a technology-based process that allows patients and healthcare providers to monitor their health outside of hospitals. Remote health monitoring has the potential to significantly improve the quality of life for long-term sufferers. It can assist patients with a variety of ailments, although the technology is most commonly used to monitor heart and diabetes conditions [31].

The remainder of the article is covered in following sections. Section 1 introduces biomedical signals and images. Critical review of the existing IOT routing protocols in literature is carried out in section 2. Section 3 presents block diagram of the proposed solution and section 4 contains detailed description of proposed method. Results analysis is performed in section 5 and related conclusions are drawn in the division 6.

2. LITERATURE REVIEW

In this section survey of recent IoMT routing protocols are analysed along with their limitations.

Overview of IoT, use-cases and opportunities for horizontal integration between IOT services were explored along with summary of the most important IEEE, IETF and EPC global routing protocols in [3]. The illustration of layered architecture of building blocks and technologies of IoT show the provision for IPv4 and IPv6 based routing of data. Classification of solutions in IOT for smart –cities was addressed and pointed out that energy-consumption and life time of IoT devices are key issues in delivery of solutions [6].

The core idea of the Sea Computing model was realized in CASCR (Context-Awareness in Sea Computing Routing Protocol) for Internet of Things [4]. CASCR has more energy efficiency, prolonged lifetime, and higher Throughput than the protocols like LEACH and SPT [4]. The limitation of CASCR protocol is that number of control packets required is more than others. Further clustering can be applied in IoT networks.

Delgalvis I. et al. proposed a technique for real-time transmission which demonstrated that the buffer size is determined based on multimedia packet dimension and traffic in network and contributes for the introduction of more delay and packet losses. The limitation of this approach is that requirements are stringent for transmission of the multimedia streams [7]. A real-time data model based on a web service was exhibited, and the model components were examined. The demerit of this method was its low energy efficiency [8].

IOMT network routing approach using UDP for real-time exchange over the IoT environment was proposed in [9]. The major drawback lies is its inappropriate representation of the IoT environment where performance parameters like delay jitter was not included in the study. Proposed adaptive version of UDP did not include application layer functions in the multimedia communication [9, 10].Also no information about end-to-end delay and packet loss was given.

Jingwu C. et al. proposed a energy constraint multimedia scheduling transmission mechanism over an IoT network [11, 12]. The significant limitation is the that heterogeneity was not considered in the IoT environment and thus quantification of energy consumption was not available.

Another approach for transmitting video streams over the Internet termed Using an MDC coder, the Adaptive Multiple Description Coding Protocol (AMDCP) was created [13].
Multi-flow At the session layer, the Real-time Transport Protocol (MRTP), which is developed for ad hoc networks, combines MDC and transport protocol techniques to partition multimedia streams into flows that are conveyed along a dedicated path. [14]. But it was for ad hoc networks only and is not for IoT systems because of scalability, diversity issues and No multimedia transmission over IOT was considered. Thus exact values for each performance metric have not been reported in many studies which focussed on individual metrics only.

The Adaptive Multi-flow Real-time Multimedia Transport Protocol (Adam RTP) for proposed for WSN to modify RTP and RTCP [15]. Adam RTP mitigates congestion and ensures good QoS, lesser energy consumption for multimedia transmission.

More significantly it can be noted that most of the studies concentrated on only 1 type of data and particularly multimodal data with 2-D and 1-D signals have not been reported in the literature. Hence the Objective of the work is to develop energy efficient low loss, and low-delay routing protocols for communication of Multimedia data over IOT networks.

3. Experimental setup and materials

Simulation based experiments are conducted using four sensory data taken from different datasets. ECG data is taken from MIT-BIH Arrhythmia dataset [26], Heart sound Audio signal [21], EEG [27] and Image from [29]. All the four data are fed to the routing module at a time where the priority is assigned for each data and the further transferred over the IOT network.

Thing speak software: It is an IoT assessment platform that facilitates aggregation, picturization and examines live data streams in the cloud. Performance of the modified IoT-RTP and RTCP protocols is carried out using MATLAB and later assessed using Thing Speak.

4. Proposed Solution

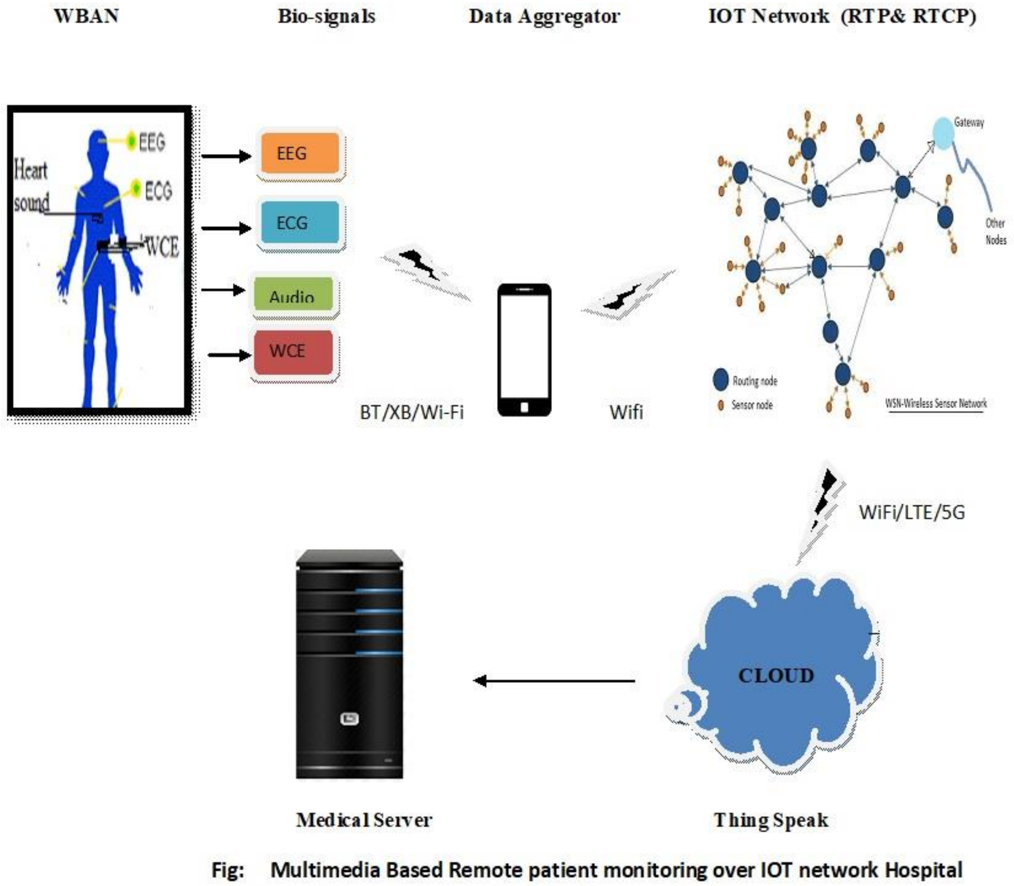

Figure 2: Block diagram of IoT –RTP based E-health Monitoring Network

For Cardiac disease detection four different signals EEG, ECG, audio sound (Heart sound) and WCE are acquired and transmitted to medical server via IoT infrastructure using IoT-RTP protocol as shown in Figure 2.

The challenge lies in routing data by assigning while simultaneously extending life time of the underlying entire WSN. For this purpose modified IoT versions of RTP and RTCP protocols are deployed. The work flow of modified IoT-RTP protocol is shown in Figure 3.

Flow Diagram

Deploy WSN network (Uniform Distribution) of ‘n’ sensor nodes

↓

Find similar characteristics among nodes

↓

Form Hierarchical and hold distance between sensor nodes

↓

Use K-means algorithms for clustering centriod of each cluster

↓

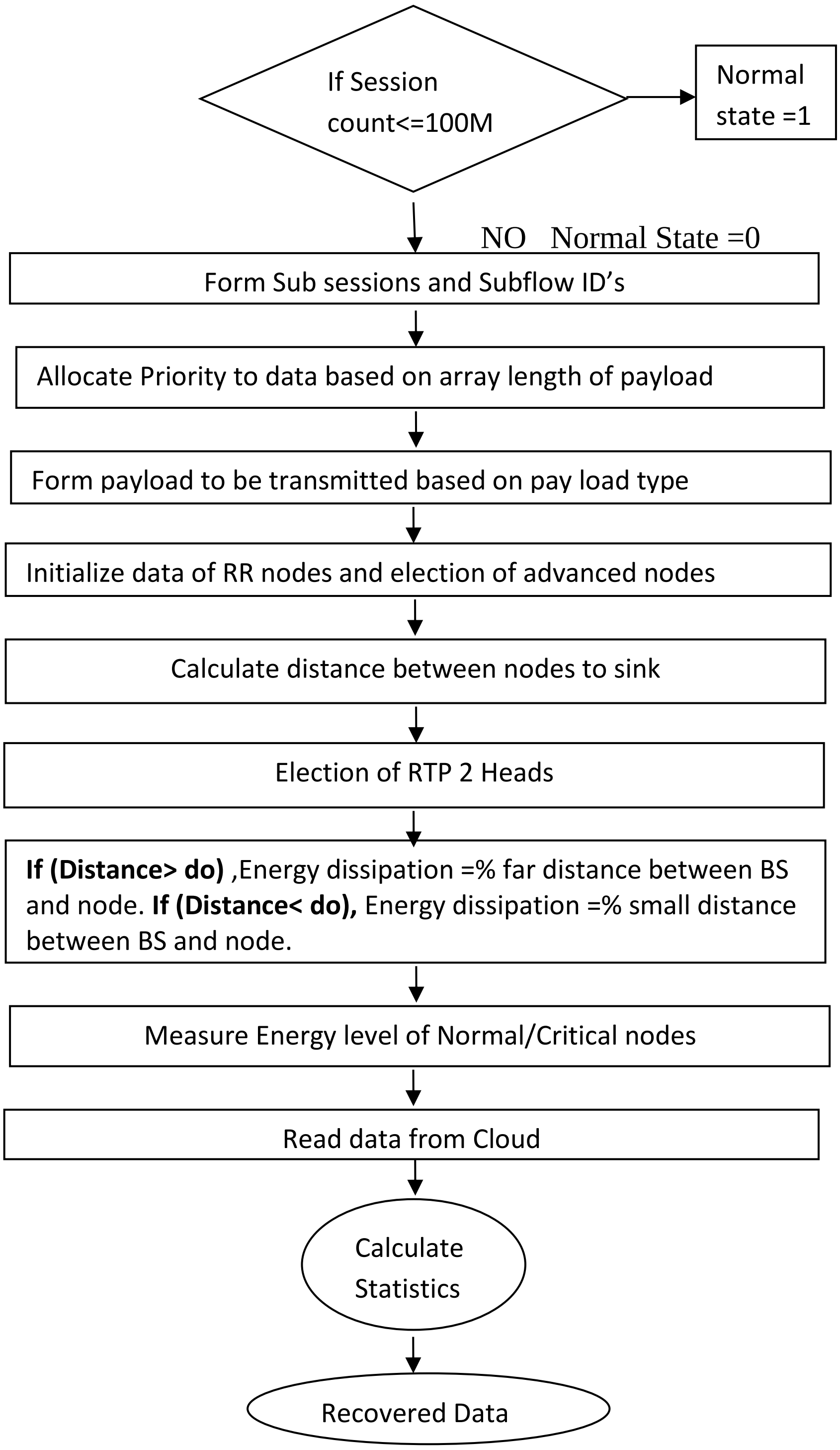

Fig 4.3: shows Flow diagram

FORMATION OF THE CLUSTERS IN WSN

The process of cluster formation, determination of cluster head and base station of each signal is discussed as follows. Let the clusters be represented as CL_1,CL_2,CL_3 and their base stations are b_1,b_2,b_3 respectively. Equation (1) states that k-means objective function with base station b_i, which can be applied to update the CL_i using equation (2).

$$F(b_i, CL_i) = \sum_{i=1}^{b} \sum_{q_i \in CL_i} ||q_i - b_i||^2 \qquad \text{-------------------------------------(1)}$$

$b_i = \frac{1}{CL_i} \sum_{q_i \in CL_i} q_i$ --------------------------------------(2)

For determination of distance between sensors and base stations Euclidean distance is used and is given by equation below.

$D(q_i, q_{j)})^2 = ||q_i - q_j||^2 = \sum_{1=i,j=i+1}^{d} (q_i, q_j)^2 = (q_i - q_j).(q_i - q_j)$ --------------------(3)

In this work, all datasets are converted into packets, these packets has session ID, sub-SID, sub-sub-SID, flow ID, sub-sub-FID, node counter and timing setup for counter of packets shown in Fig.4.

IOT-RTP Protocol

The measure of media session in the IoT frameworks may likewise be all of a sudden expanded or diminished because of quick joining or leaving of members. In this manner, the versatile condition of RTP ought to suit numerous adjustments in the conventional RTP variant so as to work regardless of the IoT condition challenges. The IoT-RTP manages the IoT interactive media session as little parts. Thus, the mixed media session ought to be partitioned into straightforward sessions. Each sub flow ought to be distinguished by whole number pursued by its unique stream identifier.

<table>
<tr><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>1
0</td><td>1
1</td><td>1
2</td><td>1
3</td><td>1
4</td><td>1
5</td><td>1
6</td><td>1
7</td><td>18</td><td>1
9</td><td>2
0</td><td>2
1</td><td>2
2</td></tr>
<tr><td>V</td><td colspan="5">PT</td><td colspan="3">Session ID</td><td colspan="3">Sub-SID</td><td colspan="3">Sub-Sub-SID</td><td colspan="2">Flow ID</td><td colspan="2">Sub-FID</td><td colspan="4">Sub-Sub-FID</td></tr>
<tr><td colspan="19">Counter for sensor node</td><td colspan="4">Thing type</td></tr>
<tr><td colspan="14">Level of Normal Energy for each node</td><td colspan="9">Critical level measurement of energy</td></tr>
<tr><td colspan="17">Extended Sequence number</td><td colspan="3">Thing state</td><td colspan="3">Priority</td></tr>
<tr><td colspan="23">Time stamp</td></tr>
</table>

Figure 4: IoT –RTP Header format [1]

E: Number of transmitter nodes
G: Total number of sub-sessions
Y: Subsequent session ids
R: Capacity of Network for all the sessions
R_{div} : The network's capacity after the division at sub sessions levels
W: Count of the sub-flows

IoT-RTP Algorithm:

1. if $\sum_{j=1}^{E}$ session Id $\leq$ R)
   Normal state
   else
2. for X=1 to G
3. begin

if $\sum_{j=1}^{E/G}$ session Id $\leq R_{div}$)
Normal state
4. else $pf_i = \frac{\text{session id}}{W}$
Normal state
else
5. for i=1 to 4
pf_i, RTP should be used for transmission and cloud storage.
6. End

IoT-RTCP Protocol

In the same way, the flexible form of RTCP analyses the condition of the IOT structure when it comes to the transmission of blended media streams. Furthermore, never-before-seen blended media coding should be considered for reducing RTCP reports while maintaining data transmission across IOT structures.

Prioritization of control reports should be related with this goal to achieve it. In IOT-RTCP, Sender reports (SR) and receiver reports (RR) should be refreshed by adding various fields to gather unequivocal information about the IOT structure.

IoT-RTP algorithm

BT: Time set aside for receiving packets, In the interval before the report is received (RR).
GL: Top level of entire multimedia session.
OL: Mid level of divided session.
NL: Bottom level of divided session.
DEE: End-end-delay.
SL: Packet loss.
U: Jitter with delay
RR: Report on the reception of the packet.

1. if(TP $<$ BT)
2. begin
3. for P=1 to GL
4. begin
5. for N=1 to ML
6. begin
7. for Q=1 to NL
8. begin
9. if (DEE, SL, U are normal values)
10. begin
11. IoT-RTCP stopped the additional fields
12. Report on the reception of the packet
13. $RR_P = RR_N + RR_Q$
14. end
15. else

16 increase BT

17. include additional fields of IOT-RTCP

18 . send $RR_P = RR_N + RR_Q$

19. end

20. $RR_{ML} = RR_{GL} + RR_N$

21. end

22. $RR_{GL} = RR_N + RR_{ML}$

23. end

5. RESULT ANALYSIS

This section presents results obtained from the simulation of the modified IoT-RTP protocol using MATLAB tool.

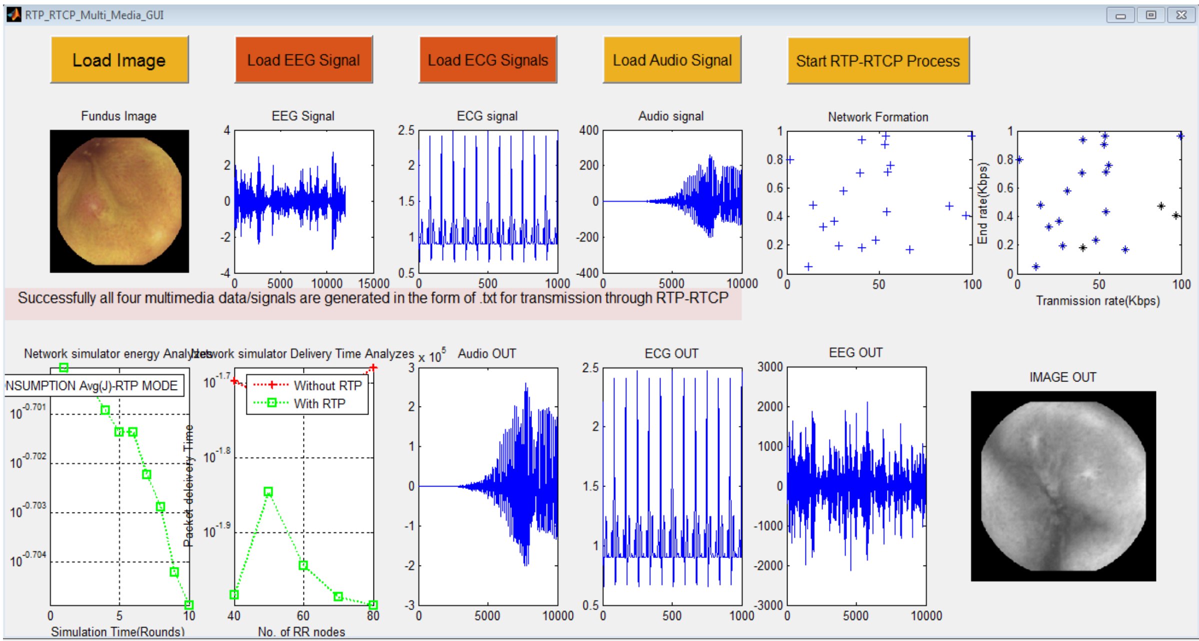

Figure 5. Multimedia data Transmission through IoT network

In this paper, performance evaluation of the IoT-RTP and IoT-TCP protocols has been carried out using 4 sensory data. The multi-modal data namely ECG, EEG , Audio signal and WCE image are transmitted via IoT network to the medical server. These data are prioritized and then transmitted over the WSN networks running RTP and RTCP protocol. The behavioural analysis of IoT-RTP and IoT-RTCP protocols has been studied when data with different dimensions are transmitted. The impact on network metrics indicate superior performance of the IoT versions of RTP protocols. All the data are written into IoT channel via Thingspeak and read at reception end. Figure 6 illustrates transmission and reception of Multimedia data over IoT network.

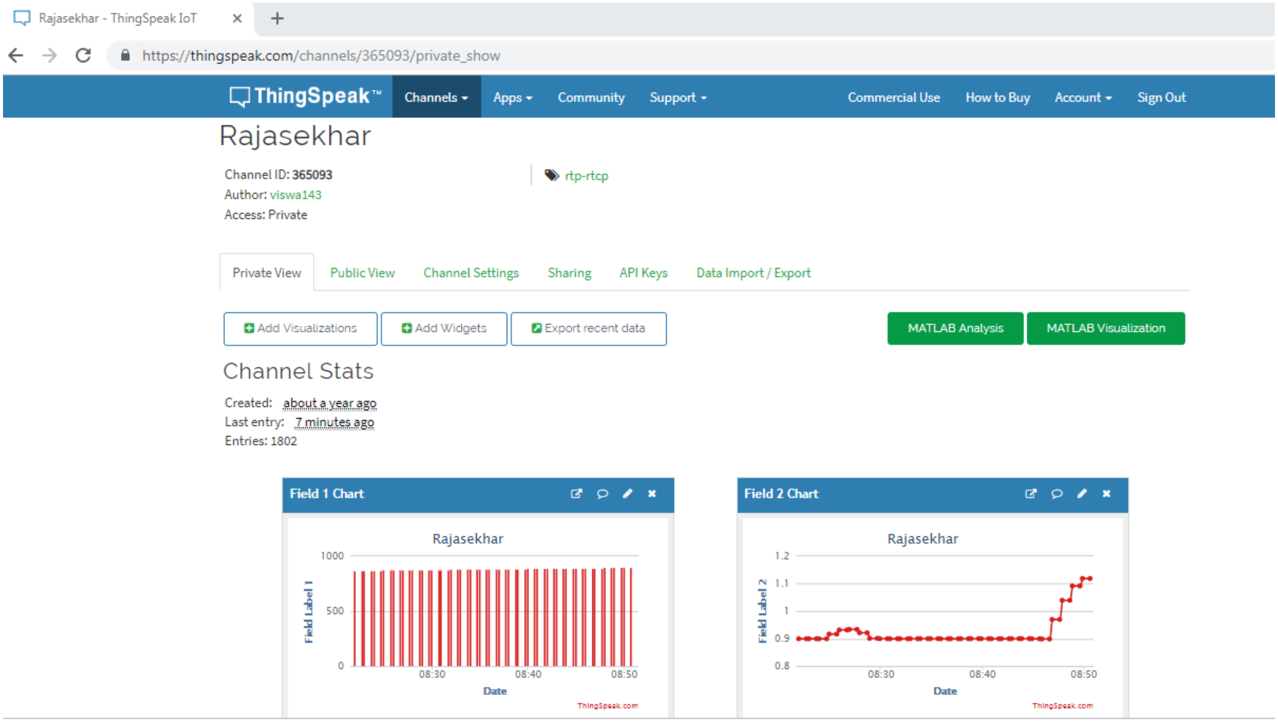

Figure 6. Statistics of RTP-RTCP protocol by using thingSpeak.com

Table 1: Comparative statement between previous work and proposed work

Parameter	Previous work [1]	Proposed work
Packet loss	37.42%	**19%**
End to End delay	200ms	**196ms**
Energy Efficiency	18.35%	**21.33%**

The performance comparison of the proposed modified IoT-RTP over IoMT network is shown in Table1. From the obtained results, it is concluded that there is reduction of packet loss by18.42%, energy efficiency increased by 3.02% and end to end delay is reduced by 4ms.

6. CONCLUSION

In this paper modified IoT versions of RTP and RTCP protocols were subjected to transmission of multimedia data comprising of three 1-D signals and one image. The multimodal data was chosen to increase the detection accuracy of the Heart diseases. The network performance improvement in energy efficiency by 3.02%, reduction in end-end delay by 4ms and Packet loss of 19% respectively is achieved has been attained because of the prioritization criterion introduced in IoT-RTP protocols. Further improvements of other
network performance metrics can be done by pursuing compression techniques along with novel data driven routing mechanisms

REFERENCS

[1].Omar Said, Yasser Albagory, Mostafa Nofal, and Fahad AL Raddady," IoT-RTP and IoT-RTCP: Adaptive Protocols for Multimedia Transmission over Internet of Things Environments", IEEE Access, vol. 5, pp. 16757_16773, 2017.

[2] Y. Sun, H. Song, A. J. Jara, and R. Bie, ``Internet of Things and big data analytics for smart and connected communities," IEEE Access, vol. 4, pp. 766_773, 2016.

[3] Al-Fuqaha, M. Guizani, M. Mohammadi, M. Aledhari, and M. Ayyash, ``Internet of Things: A survey on enabling technologies, protocols, and applications," IEEE Commun. Surveys Tuts., vol. 17, no. 4, pp. 2347_2376,4th Quart., 2015.

[4] Z. Chen, H. Wang, Y. Liu, F. Bu, and Z. Wei, ``A context-aware routing protocol on Internet of Things based on sea computing model," J. Comput., vol. 7, no. 1, pp. 96_105, Jan. 2012.

[5] S. Chen, H. Xu, D. Liu, B. Hu, and H. Wang, ``A vision of IoT: Applications, challenges, and opportunities with China perspective," IEEE J. Internet Things, vol. 1, no. 4, pp. 349_359, Aug. 2014.

[6] ECG Waveform for single channel , https://www.rohde-schwarz.com/in [online]

[7] Delgalvis, I.; and Davison, G. (1964). Storage requirements for a data exchange, IBM System Journal. 3: 2-13.

[[8]] Guan, H.; et.al. (2013). Cache isolation for virtualization of mixed general-purpose and real-time systems. Journal of Systems Architecture - Embedded Systems Design. 59 (10): 1405 – 1413.

[[9]] Jiang, W.; and Meng, L. (2012). Design of Real Time Multimedia Platform and Protocol to the Internet of Things. IEEE 11th International Conference on Trust, Security and Privacy in Computing and Communications (Trust Com), 2012. PP 1805–1810.

[10] Jiang, W.; and Meng, L. (2013). IOT Real Time Multimedia Transmission over Co UDP, International Journal of

[11] Jianxin, J.; and Baoyu Zheng, C. (2013). Energy-aware distributed scheduling for multimedia streaming over Internet of Things. Int. J. of Ad Hoc and Ubiquitous Computing, 13(4): 176 - 186.

[12] Chen, J., et al. (2013). Application-dependent frame design for the Internet of Things. IEEE International Conference on Communications (ICC), Budapest, Hungary, 9-13 June 2013. PP 3694 - 3698,

[13] Lotfallah, O., and Panchanuthan, S. (2003). Adaptive Multiple Description Coding for Internet Video. IEEE International Conference on Acoustics, Speech, and Signal Processing, 6-10 April 2003. PP 732-735.

[14] Mao, S.; Bushmitch, D., Narayanan, S., and Panwar, S. (2006). MRTP: a multiflow real-time transport protocol for ad hoc networks. Transactions on Multimedia. 8(2): 356 - 369.

[15] Zakaria, A., and El-Marakby, R. (2009). Adam RTP: Adaptive Multi-flows Real-time Multimedia delivery over WSNs. IEEE International Symposium on Signal Processing and Information Technology (ISSPIT), Ajman, UAE, 14-17 Dec. 2009. PP 440 – 445.

[16] M. Valderrama, C. Alvaradoa, S. Nikolopoulos, J. Martinerie, C. Adama,V. Navarroa, M. Le Van 11 Quyen (2012) Identifying an increased risk of epileptic seizures using a multi-feature EEG–ECG 12 classification, Biomedical Signal Processing and Control Volume 7, Issue 3, pp. 237–244.

[17] Mithin. R., Abubeker K.M., Thomas E. (2012) Detection of Epilepsy using Heart Rate Variability, 14 International Journal of Research in Antennas and Microwave Engineering – IJRAWE.

[18] Greene B.R., Boylan G.B., Reilly R.B., de Chazal P., Connolly S. (2007) Combination of EEG and 11 ECG for improved automatic neonatal seizure detection., Clin Neurophysiol. 118(6), 1348-59.

[19] Varon C., Jansen K., Lagae L., Van Huffel S. (2013) Detection of epileptic seizures by means of 21 morphological changes in the ECG. Computing in Cardiology, 40, 863-866.

[20] Yangzhe Liao 1,*, Mark S. Leeson 1, Matthew D. Higgins 2 and Chenyao Bai, "Analysis of In-to-Out Wireless Body Area Network Systems: Towards QoS-Aware Health Internet of Things Applications:, Electronics 2016, 5, 38; doi:10.3390/electronics5030038, MDPI Journal.

[21] F Wang, T Syeda-Mahmood, D Beymer, "Finding Disease Similarity by Combining ECG with Heart Auscultation Sound" , IEEE, Computers in Cardiology 2007;34:261−264.

[22] FA Gamboa oritz et.al., "Electro cardiographic changes related to acute upper gastro intestinal hemorrhage", May 2006, Anales DE Medicine Internas

[23] Mustafa Tansel Kendirli , Diagnostic Role of ECG Recording Simultaneously With EEG Testing", Clinical EEG and Neuroscience ,Sage publications, September 27, 2014

[24] Sheeraz, A.; et al., (2015) Internet of multimedia things: Vision and challenges. Elsevier Ad Hoc
Networks. 33: 87–111.

[25]. "Arrhythmias", Heart foundation, 2014.

[26]. MIT-BIH arrhythmia database [online],www.physionet.org/mitdb/- last accessed on 14/09/2017.

[27]. CHB-MIT Scalp EEG database[online], https://archive.physionet.org/physiobank/dat abase/chbmit/ -last accessed on 07/08/2019

[28] Silvio Barra et.al,"Physio Unica DB: A dataset of EEG and ECG simultaneously acquired ",Pattern Recognition Letters , (2017),Elsevier.

[29] KID Project: an internet-based digital video atlas of capsule endoscopy for research purposes
http://is-innovation.eu/ kid/ [online].

[30] "Accelerating Information Security in Cloud Computing using a Novel Holomorphic Scheme",
International Journal of Innovative Technology and Exploring Engineering, 2019

[31] https://www.medicaldevice-network.com/features/remote-health-monitoring- benefits, 28 August 2018 (Last Updated January 23rd, 2020 13:37)

[32] Non-communicable Diseases (NCD) Country Profiles-[online] www.who.int- World Health Organization accessed on 26.10.2018.

Professor
Dept. of Electronic & Communication Engineering(DECS)
Member BoS ECE board, VTU
Center for PG sstudies, Muddenahalli, Bangalore
Visvesvaraya Technological University