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QoS Satisfaction in MANET Based Real Time Applications

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ABSTRACT

With the growing natural disasters and several emergency situations, the world is looking for interchangeable reliable medium of communication. MANET is the feasible answer towards maintaining connection in a pure infrastructure less scenario. Providing appropriate Quality of Services (QOS) in MANET for applications like voice, video and multimedia data is a challenging task. Due to dynamic network topology changes and also for the delay sensitive nature, services like voice and video demands specialized treatment compared to their counterpart data service. In this paper, we present Real Time AODV(RT-AODV), a novel AODV based routing mechanism that improves the quality of service for real time packets in a MANET. In order to build RT-AODV, first we developed another routing protocol, Power & Delay Optimized AODV (PDO-AODV), which introduces the concept of load balancing over MANET in a best effort manner. Simulation results reveal that the proposed RT-AODV accomplishes enhanced performance than best effort PDO-AODV routing protocol in terms of delay, data dropped and network throughput.

Index Terms: Real Time, MANET, QOS, AODV

1. INTRODUCTION

The great technological innovations of wireless communication have brought a boon in the form of Mobile Ad Hoc Networks (MANET), for today's global communication market. These types of network are capable of operating without any fixed foundation unlike cellular system. Because of their autonomous, distributed and multi hop relaying potential, MANETs are on huge demand for disaster recovery, vehicle tracking and battlefield management. The network topology changes dynamically due to unpredictable node movements. This creates a serious level of difficulties to maintain network connectivity with neighboring entities. At the end of the day, there is no guarantee of reliable data delivery with acceptable Quality of Services. Routing protocols play a vital role in establishing end to end path, as nodes are not always directly reachable to each other. The power hungry entities over such bandwidth limited network demand robust and efficient routing strategies for network longevity. So, routing mechanism needs to be designed judiciously to optimize network operation. Conventionally, there are two main types of routing techniques which are table driven and on demand basis. Table based approaches like OLSR, needlessly floods the network even without the presence of actual traffic and thus generates huge overhead. The MANET having inadequate bandwidth can't always afford the luxury of such additional payload. On the contrary, any on demand protocol such as AODV starts occupying the network resources whenever there is a need from the users to convey any info to their peers. AODV protocol keeps silent until such appeal comes from any network entity. Once the existence of aforesaid task is sensed, AODV starts route discovery procedure by broadcasting a route

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request (RREQ) packet. This route request message travels through the network and reaches to actual destination and forms a reverse route table. The recipient then responds back by generating a route reply (RREP) packet which is carried by the reverse route created earlier. This process helps to create the forward route for data packets. Here, the route discovery scheme induces delay and also some intermediate nodes get overloaded [11] due to carrying out the data handling frequently. So, traditional routing methods cannot be utilized for mobile ad hoc networks straight away because of their inherent impediments.In this paper, we concentrated on tweaking the primary AODV routing protocol to cater the aggressive QOS demand of real time network services in a MANET.The rest of the paper is organized as follows: all the previous works related to quality of services in ad hoc network are presented in section 2, section 3 depicts the encouragement behind this research; Then our main contribution of the proposed approach and design building blocks are illustrated over section 4. Thereafter, results out of extensive simulations and comparison with PDO-AODV protocol are shown in section 5 and finally Section 6 concludes the research.

2. RELATED WORKS

Several researches have been conducted in the past on MANET routing protocols. Agbaria et al.[1] devised extrapolation based technique that considered dynamic scheduling, resource management, velocity, multipath search to provide real-time and QOS need of a MANET. Sivakumar and Duraiswamy [4] presented efficient algorithm to support Quality of Service (QoS), by the use of load-distributing and congestion avoidance routing method. Their proposed algorithm computes the cost metric based on link loads. The links having lighter loads were preferred for sending traffic to avoid congestion. Srivastava and Daniel [9] advised an energy-efficient routing to improve the link utilization by equalizing the energy consumption between already exploited and underutilized entities .Their protocol deals with few key factors like Residual Energy, Bandwidth, Load and Hop Count for route discovery. In [16], Ze Li and Haiying Shen introduced a QOS oriented distributed routing protocol for a hybrid network having Infrastructure and ad-hoc MANET. They analyzed routing by linking it with resource scheduling problem. Their algorithm adaptively adjusts segment size based on node mobility and minimizes the transmission time. Maleki and Kargahi [17] recommended a load balancing algorithm based on DSR that can manage QOS for real time information. They speculated a node’s neighbour count as centrality metric for route selection. They considered link cost among set of nodes, to forward packets through load optimized path. Danilo and Demenico [18] proposed a real time protocol for MANET with the help of cross layer design. They combined MAC and routing layer in their protocol and tested with small Robot systems, which were exchanging kinematics or laser data. Real time protocols are discussed and their comparative analysis has been carried with network parameters to validate the network life time[6].Energy and Delay based Routing protocol has been designed in [8] named as PDOAODV that uses a new approach of selecting the next suitable node during routing in MANET. Detailed survey on MANET Routing protocols and real time applications are presented in [10] by M.Rath *et al*.To prevent the MANET security measures are important. Keeping this in view an IDS(Intrusion Detection System) proposal has been presented in [13] based on Mobile agent. Delay and Power based routing protocols in MANET are studied in order to classify them according to their techniques of power efficiency mechanism[14].A Cross Layer Approach of Protocol Design has been offered and implemented in [15]. In [19] Shanrma and Dimri suggested a improved AODV protocol, that enhances the packet delivery ratio for mobile ad-hoc network. However, they were transmitting more routing packets for real time scenario, which is adding overhead to the resource limited network.

3. MOTIVATION

With our detailed study from literature and analysis of existing AODV based protocols, it is observed that such protocols are not effective to tackle heavy network payload. This is mainly because shortest hop count based routing is prioritized, without considering network load and nodes’ energy, while selecting the suitable path among nodes. Moreover, the nodes, who take part in forwarding the traffic over same route, gets exhausted losing their precious energy. In addition to that, we felt, there needs to be acceptable QOS while users are moving independently. When the idea of QOS was just knocking into our mind, we further realized that there are different requirements of QOS for data and real time services. The data packets over a wireless link can be retransmitted with some permissible delay, if they are lost. Few deferred data packets won't jeopardise much to the network users, but same thing is not applicable for voice and video packets. The real time multimedia services are extremely delay sensitive, and are useless, if they fail to meet the delivery deadline by missing series of frames or packets. All the above mentioned bottlenecks inspired us to ponder in depth, and to design a decisive routing scheme for real time MANET network, such that (i) It divides the network load on equal fashion among all possible entities.(ii). It minimizes irrelevant transmission saving significant network bandwidth and node energy and (iii) It caters the need of real time multimedia services by providing acceptable QOS.Therefore, we came up designing a PDO-AODV routing mechanism, which would balance the uneven load distribution over a burdened MANET. This approach is accepting neighbouring nodes' power and delay as routing metrics for route selection. However, PDO-AODV was not having any intelligence for QOS scheduling, and works on a best effort mode. This was not fulfilling our earlier requirement to address the real time packets. Hence, we further brainstormed and developed RT-AODV, on the top of PDO-AODV framework. We verified through simulation that this proposed approach can help real time traffic to meet the legitimate timeline and improve the overall network performance.

4. CONTRIBUTION

We modified the standardized AODV protocols in incremental way of development phases. At first, we aimed to provide load balancing over a dense MANET by implementing PDO-AODV routing method, which was assigning equal priorities among various network services, i.e. they were scheduled on a first come first serve basis. This was conceptualized by taking nodes' power and delay as important metrics for optimized route selection. When this scheme was deployed over the network nodes, the packet loss and congestion issues were improved significantly. This achievement set up the foundation stone for us to venture into the second phase of development, which grants quality of services towards real time packets. Each of these phases is elaborated in the following.NS2 simulation environment was used for development and simulation in our experiment.

4.1. PDO-AODV Implementation

Our routing engine core modules were constituted of three sub modules that enable to take routing decision based on power and delay. They are explained as following.

4.1.1. Network Sensing

The primary objective of this sub-module is to sense all the one hop neighboring nodes' status. Here every node broadcasts its health status over the network. Here the innovative part is, we embedded any node's status message with the periodic control information, rather than sending a special purpose message. This is not going to put any additional overhead on network. Fig.1 containing the code snippet of status message, shows the parameters such as node energy, hello packets, timestamp, which were adopted for sending a node's health status.

4.1.2. Database Handler

This sub module stores the status message received over the air of all neighboring entities. After the reception of the status message, delay from a neighbor is calculated from the packet generation timestamp. The members of the database are defined to store various status related parameters like energy, hello message, delay etc.

4.1.3. Routing Decision

This part of our design aims to select suitable balanced route through which packets can travel with minimal loss. It's time to decide here, which all intermediate nodes will actually play the role of forwarding the

```
rh->rp_type = AODVTYPE_HELLO;
rh->rp_hop_count = 1;
rh->rp_dst = index;
rh->rp_dst_seqno = seqno;
rh->rp_lifetime = (1 + ALLOWED_HELLO_LOSS) * HELLO_INTERVAL;
rh->rp_timestamp = CURRENT_TIME;
iEnergy= iNode->energy_model()->energy();
rh->Node_Energy = iEnergy;
ch->ptype() = PT_AODV;
ch->size() = IP_HDR_LEN + rh->size();
ch->iface() = -2;
ch->error() = 0;
ch->addr_type() = NS_AF_NONE;
ch->prev_hop_ = index;
ih->saddr() = index;
ih->daddr() = IP_BROADCAST;
ih->sport() = RT_PORT;
ih->dport() = RT_PORT;
ih->ttl_ = 1;
```

Figure 1: Status message components

```
for(Sensor_id=0;Sensor_id<61;Sensor_id++)
 {
   if(Sensor_id==rp->rp_dst)
   {
    if(NbrTbl[index].Neighbour_Alive[Sensor_id]==0)
    {
     NbrTbl[index].NO_OF_NBR++;
     NbrTbl[index].Neighbour_Alive[Sensor_id]=1;
    }
     /* processing Delay from a neighbour as
      a load balancing factor */
     TMdb[index][Sensor_id].End_to_End_Delay =
          (CURRENT_TIME - rp->rp_timestamp);
     /* processing a neighbour node's power as
     a load balancing metric */
     TMdb[index][Sensor_id].Node_Energy=rp->Node_Energy;
     /*Claculate load balancing metric value of the
     neighbour by adding up all the trust meterics*/
     TMdb[index][Sensor_id].Direct_Trust_MetricVal=
     (TMdb[index][Sensor_id].End_to_End_Delay+
     TMdb[index][Sensor_id].Node_Energy);
     break;
   }
}
```

Figure 2: Capturing node's power and delay into database

traffic towards destination. For this purpose, we consulted the database handler sub module, which records power and delay information of any peer as an integrated load balancing metric as represented in Fig. 2. This load balancing metric is regarded as link cost between a set of nodes in our design. The higher cost links indicate better route, and routing decision is taken accordingly.

4.2. RT-AODV Development

Now, we are going to extend the already built load balanced framework for real time AODV procedure. The provision to entertain good QOS was achieved by two phases, namely packet filtering and route determination.

4.2.1. Packet Filtering

We envisaged the existence of diversified packet types in our target network. So, it was essential to refine delay sensitive packets from their generic counterparts for further processing. The filter was materialized by defining a flag variable. This filter was set in following cases:

i. If a real time packet was originated by the source node.

ii. If any other node receives information from a RREQ packet, that route request is for real time traffic.

iii. If any intermediate node receives RREP containing route reply for managing a real time data.

This flag is declared as a global static variable inside NS2-aodv.cc file.Fig.3 reveals the piece of code which sets the flag, if any real time voice packet is generated by a source node. Now, the presence of such delay sensitive data in the network, needs to be intimated to all other intermediate nodes towards destination. This information will help in between relay nodes to take special care of real time traffic. That’s why real-time flag info is also sent with the sendRequest () function as shown in Fig. 3.

4.2.2. Route Determination

This portion of our algorithm acts as a path selector for all type of packets. The value of the real time flag is checked to segregate real time packets from any normal data packets.

This concept is manifested in Fig. 4 code fragment. As, any real time packet should not miss their hard deadlines in our design, so they are relayed through shortest possible hop count. On the other hand, generic data packets have comparatively flexible timeline for delivery, and they are dispatched via load balanced route. This logic is implemented inside recvReply(Packet *p)function of aodv.cc NS2 soure file. Under this function, a node actually receives Route Reply(RREP) message and establishes the forward path for route determination.Fig.6 demonstrates the fundamental operation of how the basic PDO-AODV routing engine works to make the network operations optimized. Fig. 5 exposes the think tank of our proposed recipe for RT-AODV algorithm.

```
//For realtime voice packets
if(ch->ptype()==2)
 RealTimeFlag=1;
sendRequest(rt->rt_dst,RealTimeFlag);
```

Figure 3: Realtime packet Identification

```
if (rp->RealTimeFlag ==1)
   Trustvalue_Table[index][rp->rp_src]= INFINITY2;// REAL TIME PACKET
if ( (rt->rt_seqno < rp->rp_dst_seqno) ||   // Load Balanced route
     ((Trustvalue_Table[index][rp->rp_src] > Trustvalue_Table[index][rt->rt_nexthop])&&
      (rt->rt_seqno == rp->rp_dst_seqno) &&
      (rt->rt_hops > rp->rp_hop_count))
       ) { // shorter or better route

  #ifdef DEBUG
      printf("Load Balanced route  \n");
  #endif
 // Update the rt entry
  rt_update(rt, rp->rp_dst_seqno, rp->rp_hop_count,
  rp->rp_src, CURRENT_TIME + rp->rp_lifetime);
```

Figure 4: Route selection

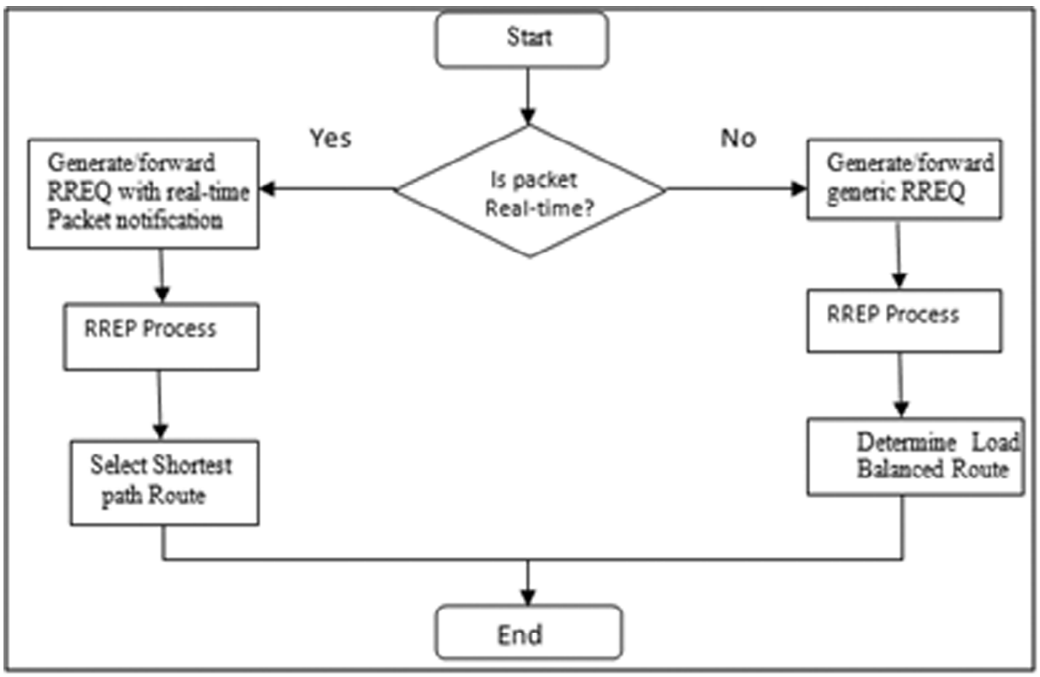

Figure 5: RT-AODV at a glance

5. COMPARATIVE ANALYSIS

After design of Real Time Protocol we have compared our protocol performance with other three important protocols which are based on different concept but efficient real time protocols and their concept is described in this section. A motivating proposal is given in [2], called Real Time Multi-hop protocol (RT-WMP) [2] along with its expansion version for Qos management which is executed over many nodal devices with hardware of specific configuration. It allows proficient end-to-end voice communication during the Qos extended module and the projected system works better for specific situation for definite topology. This application was tested and validated successfully in a real submission at Somport tunnel of Canfranc, Spain.

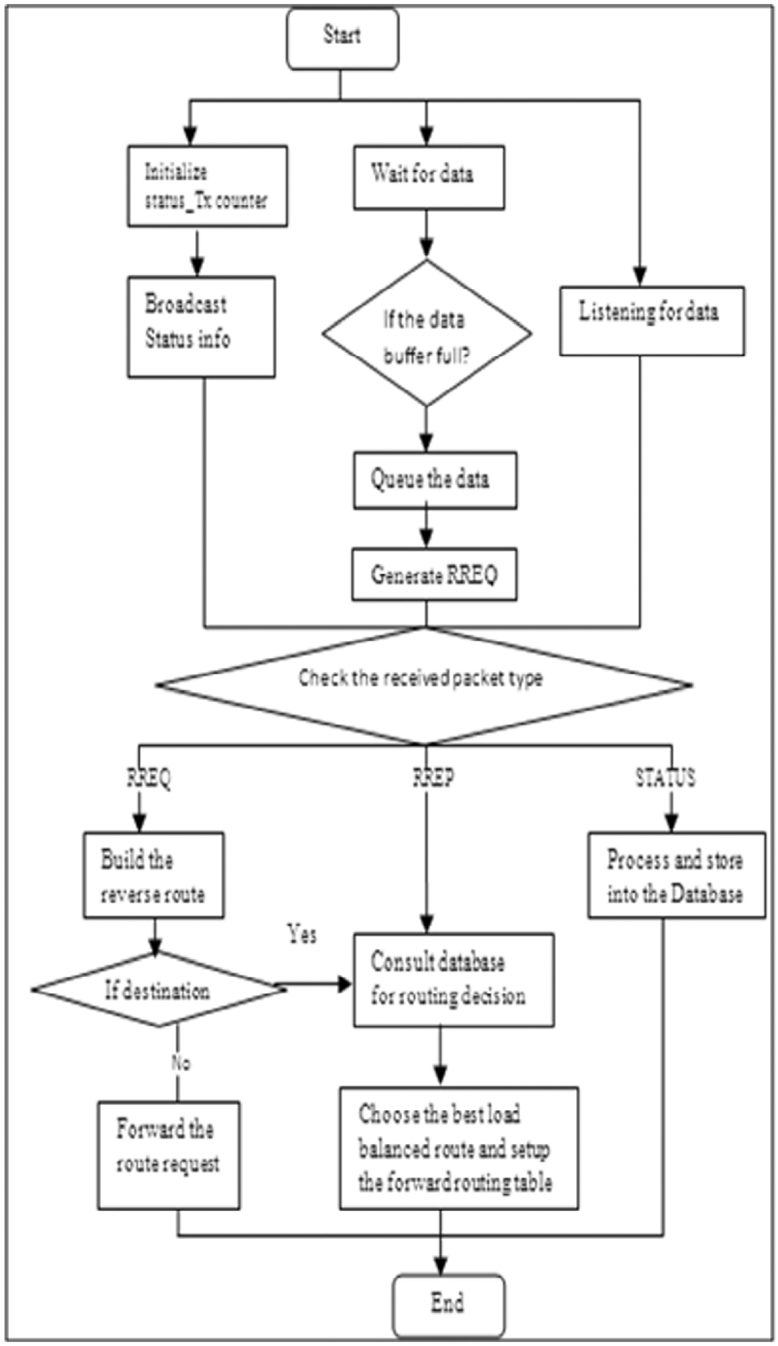

Figure 6: Basic PDO-AODV flowchart

In [3] a suitable proposal has been offered as per suitability of multimedia communication in Mobile Adhoc Networks. It proposes an innovative strategy of using Multicast-Tree Structure Protocol for Mobile Adhoc Networks. The methodology implements the MCT (Multicast-Tree) format for MANETS and assesses the performance with other two protocols Serial MDTMR and Parallel MNTMR.In [5], a methodology is adopted for better distribution of spectrum in MANETs which is called MRFM(MANET Real Time Frequency Management). This scheme uses a centralized control mechanism to stay away from confliction with Electromagnetic Environment. This function runs as an external application to the system that gathers the radio state information in real time case, relates rules about the spectrum allocation and controls the frequency levels received by MANETs. Use of the proposed system helps to trigger Capacity of DSA (Dynamic Spectrum Access) to radio signals of MANET which is not directly existing. Verification of MRFM was done in a prototype system where numerous tests were carried out with stimulating results.

6. SIMULATION AND RESULTS

This section elaborates the simulation scenarios deployed through NS2 simulator to proof our concept of providing decent QOS for multimedia packets. Further analysis was done to compare the performance of the proposed routing protocol with best effort PDO-AODV technique. Our network model speculated the total area of simulation as 1000m x 1000m. Numbers of mobile nodes that roam around this area were 60. We used Random Waypoint mobility model for users' movement. The underlying MAC and wirelessphy protocol was 802_11.

Fig. 7 reveals a part of simulation snapshot over NS2.The black circles represent exchange of control information among nodes or route discovery and reply packet types. It can be noticed here, two parallel

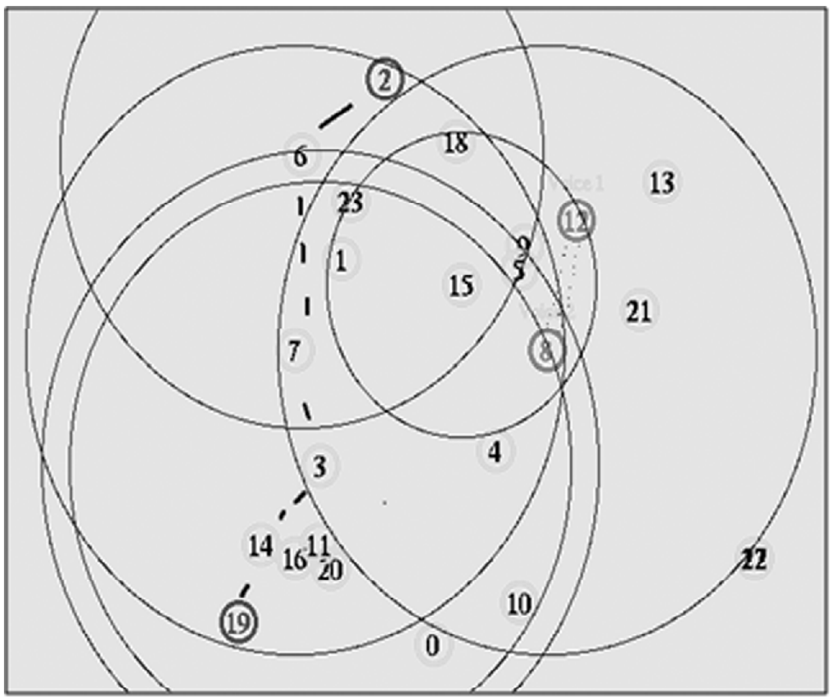

Figure 7: Simulation deployment scenario

Table 1
Simulation Parameters

Parameter Name	*Parameter Value*
Channel Type	Wireless Channel
Radio Propagation Model	Two Ray Ground
Network Interface Type	Wireless Phy
Type of Traffic	V B R
Simulation Time	10 Minutes
MAC Type	Mac/802_11
Max Speed	Maximum Speed 20 m/s
Network Size	1600 × 1600
Mobile Nodes	120
Packet Size	512 Kb
Interface queue Type	Queue/Droptail
Protocol	PDOAODV, RTAODV
Simulator	Ns2.35

streams of traffic are going on, between 8 and 12 bidirectional voip call and ftp between node 19 and 2. Table 1. shows the simulation parameters used during simulation of our proposed protocol

The following section describes the results of performance evaluated during our protocol design and simulation.

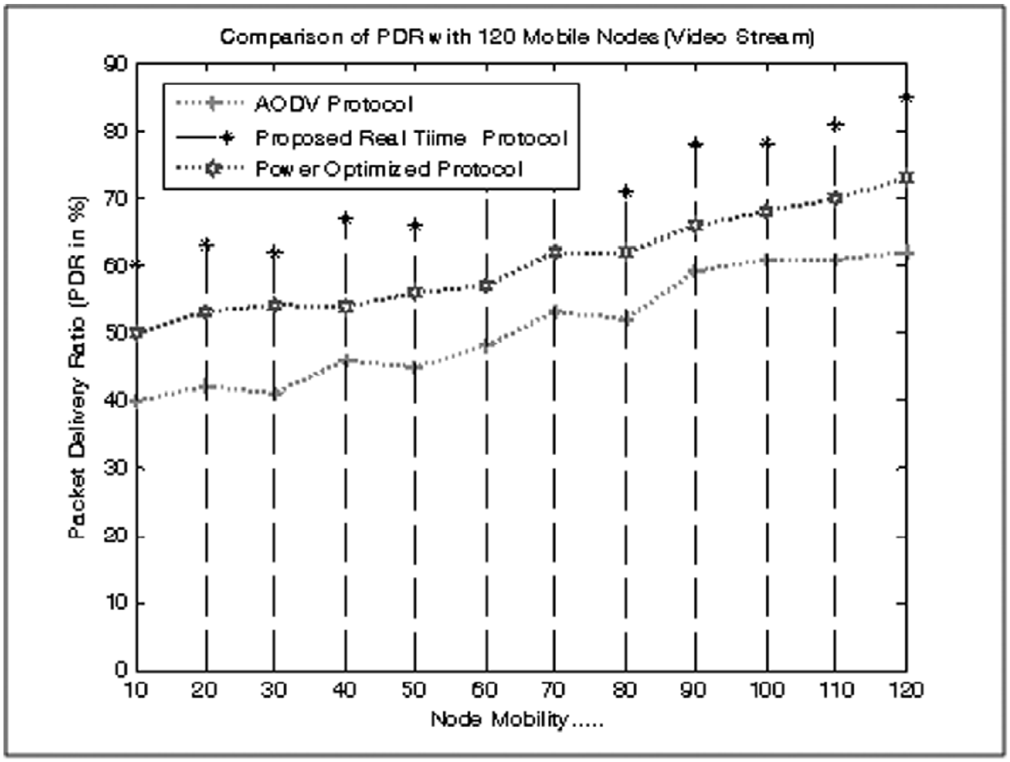

Figure 8: PDR Comparison with 120 nodes(video)

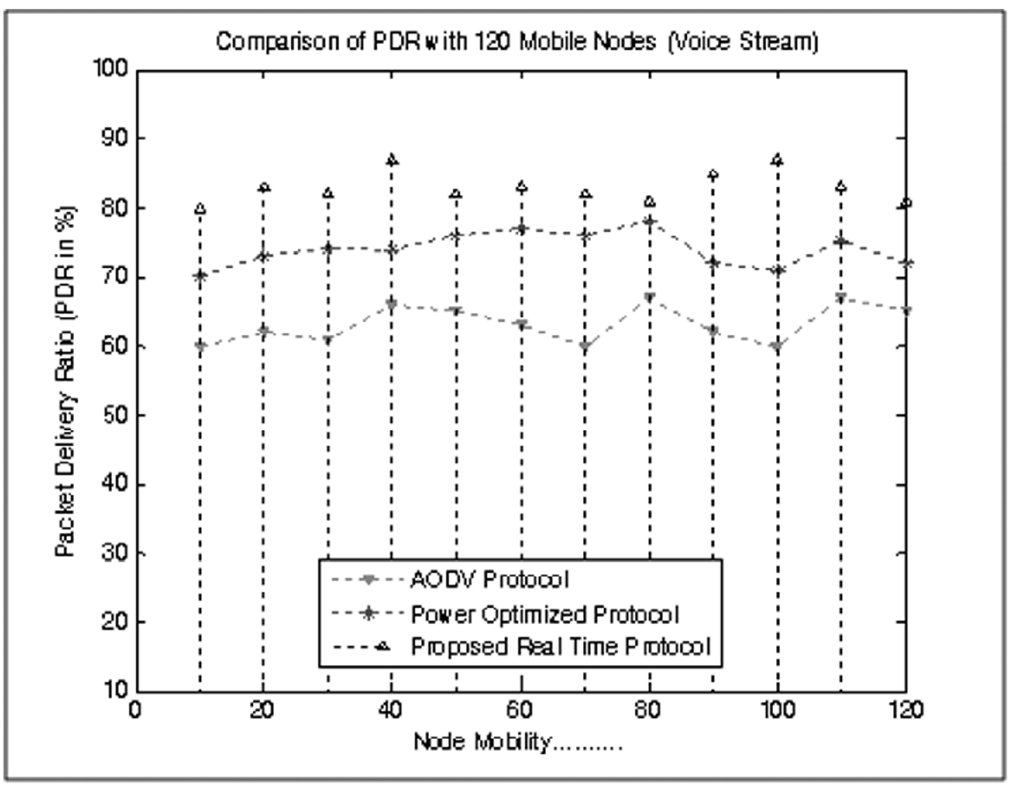

Figure 9: PDR Comparison with 120 nodes(voice)

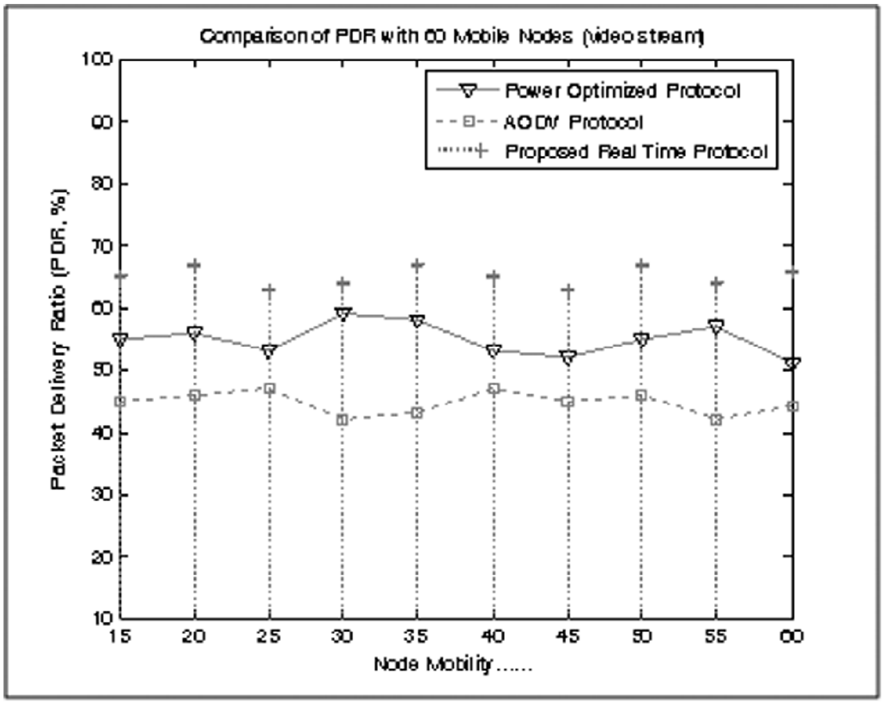

Figure 10: PDR Comparison with 60 nodes(video)

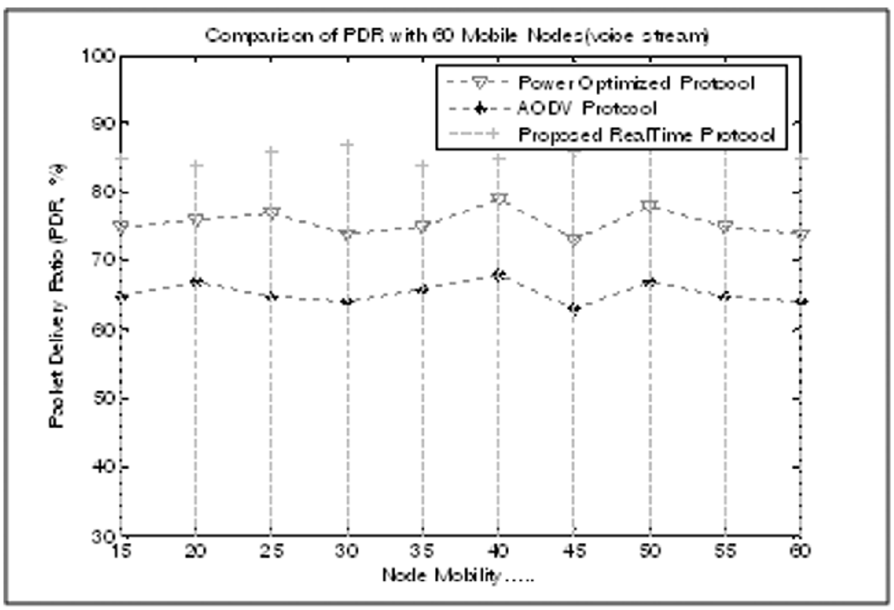

Figure 11: PDR Comparison with 60 nodes (voice)

7. ANALYSIS OF VOICE AND VIDEO IN RTAODV

Characteristics of real-time traffic is very critical than norml traffic. Because this traffic is generated through a code that carries out sampling of a continuous real world environment (image, voice etc.) and transmission of constant renew of these data to regenerate a visually diagrammatic or audio type outcome. Therefore it is the demand of the application to utilize constant bandwidth till the entire transmission period. Sensitivity to delay is another important characteristics of real time applications due to the fact that sampling and regenerating a continuous incident is regularly done by a real time stream such in a voice stream every piece of packet segment should reach at the destination end to be executed or played at the same and correct time. In case a single packet segment arrives late, then there will be a interval and gap in between two consecutive segments to be played.

So the continuous flow of the speech or audio (may be a music) will be disturbed resulting degradation of audio quality. The level of degradation of quality is important in real time applications depending on packet delay time and packet loss rate. Due to the importance of packet arrival time it is difficult for the transport level protocol to frequently retransmit a lost packet and wait for significant period of time. The reverse trip to source and to wait for re-transmission is much lengthy and by the time it reaches its already too late with missing its play window. Because TCP does not considers the issue, these are carried out with

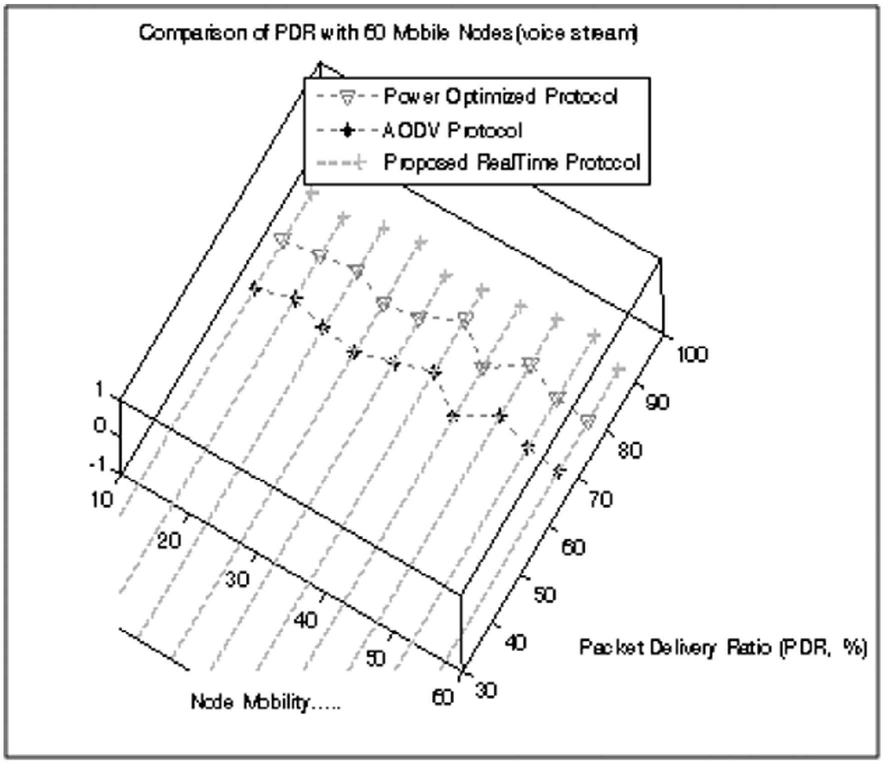

Figure 12: PDR Analysis in voice

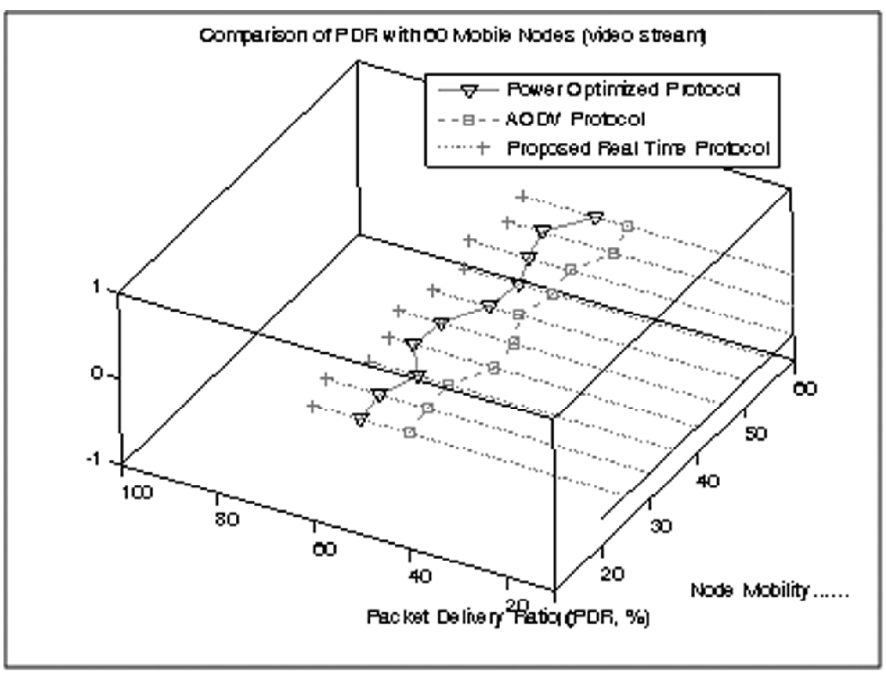

Figure 13: PDR Analysis in video

the UDP Protocol, which does not employ any recovery mechanism for lost packets. So the normal routing flow starts with packet sent by the sender to the network and they are delivered to the destonation in time or with delay due to congestion or sometimes lost during transition.

Fig. 12 and Fig. 13 shows the Packet Delivery Ratio of voice and video packets. It can be observed that in voice the PDR is approximately 92% in RTAODV with a better performance than PDOAODv and AODV, whereas in video stream the PDR is approximately 70% in RTAODV which is better performance than PDOAODV and AODV. Due to high density of image and multimedia stuff in video traffic there is reduction of PDR in video in comparison to audio traffic.

Fig.14 shows the end to end delay comparison between different proposed real time protocols as described above. It can be observed that our proposed RTAODV exhibits comparatively less delay than the other real time protocols proposed.

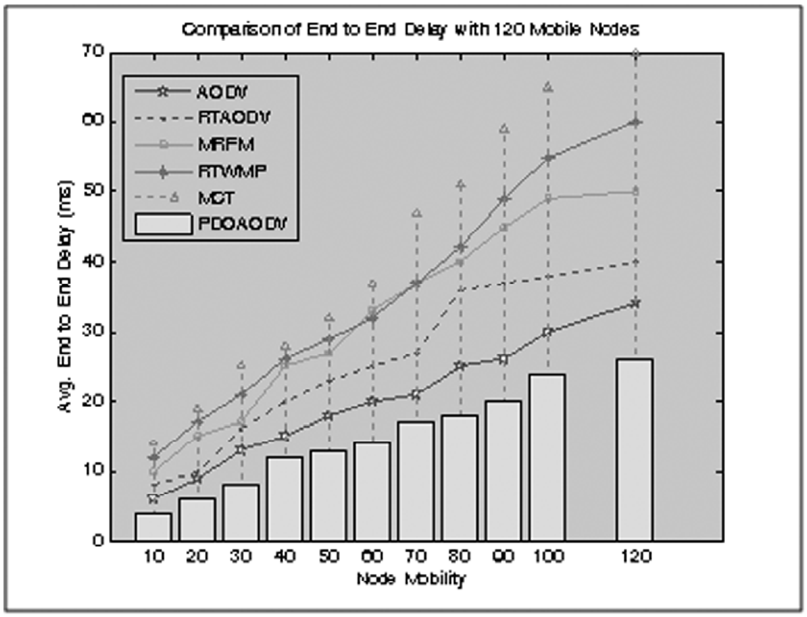

Figure 14: Delay Comparison(video)

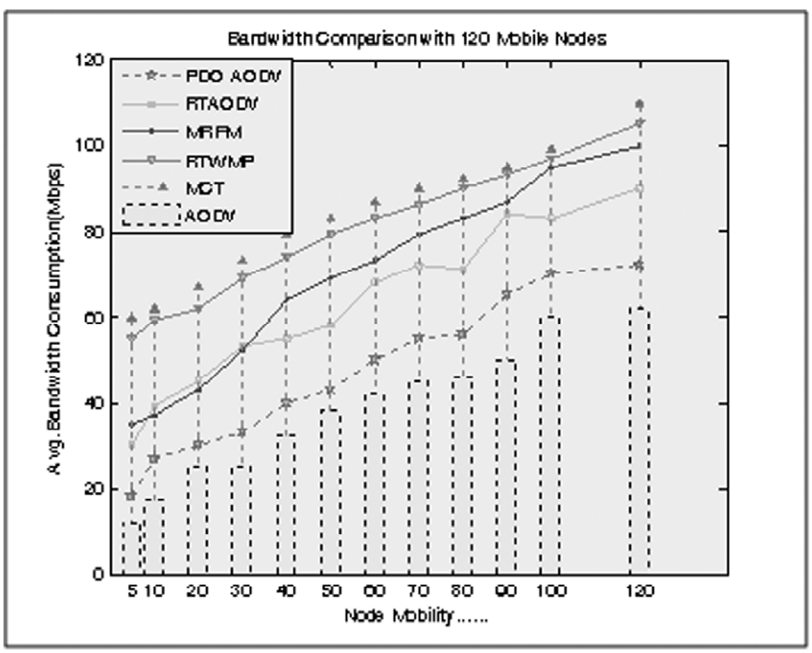

Figure 15: Bandwidth Comparison(video)

Fig.15 shows the comparison of average bandwidth consumption between various real time protocols and PDOAODV. It can be observed that our proposed RTAODV consumes comparatively lesser bandwidth than the other real time protocols proposed. PDOAODV consumes less bandwidth than RTAODV due to the fact that in RTAODV real time data such as multimedia rich applications are given priority which consumes higher bandwidth, whereas normal PDO AODV Protocol uses a power optimized path for sending packets in a load balanced way.

Fig. 16 depicts the data drop analysis between the discussed protocols. It can be seen that there is minimum data drop of packets in our proposed real time protocol.

Fig. 17 shows the throughput analysis between AODV, PDOAODV and RTAODV. It can be seen that there is maximum throughput approximately 70000 Mbps/sec in average in our proposed real time protocol which is a better figure than throughput of AODV and Power Delay Optimized AODV Protocol[8].

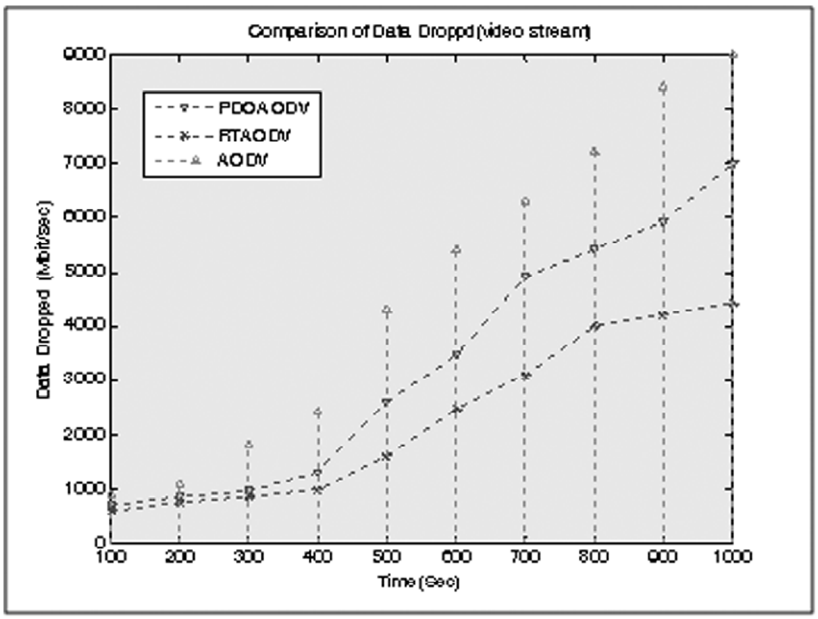

Figure 16: Data Drop Analysis(video)

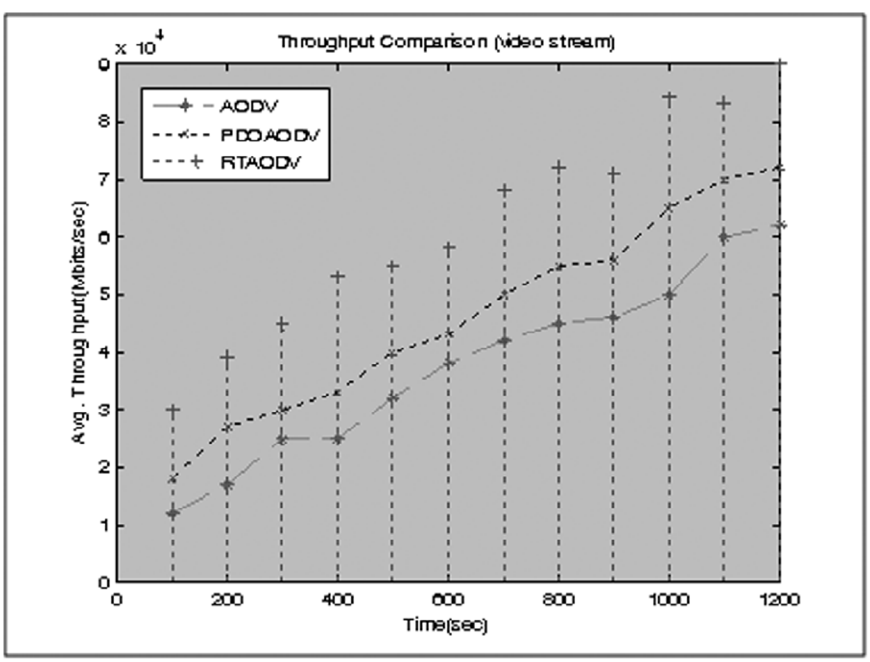

Figure 17: Throughput Analysis(video)

8. CONCLUSION AND FUTURE WORK

In this investigation we explored the difficulty of uneven load scheduling and QOS management for delay sensitive traffic. We devised two different formulas for route selection to deal with normal data and real time packets. Our experiment eventually achieved two milestones, optimizing network load and nourishing the need of realistic data. Our simulation manifested the superior network function of RT-AODV method compared to just load balanced PDO-AODV protocol. However, we could not test multimedia applications with few factors, such as varying node density and speed, more than two to three hops of voice call. Maintaining good QOS in those cases can be further challenging and be taken up as an activity of future research.

REFERENCES

[1] Agbaria, A.; Gershinsky, G.; Naaman, N.; Shagin, K., "Extrapolation-based and QoS-aware real-time communication in wireless mobile ad hoc networks," *Ad Hoc Networking Workshop, 2009. Med-Hoc-Net 2009. 8th IFIP Annual Mediterranean* , vol., no., pp. 21, 26, June 29 2009-July 1, 2009.

[2] D. Sicignano, D. Tardioli, S. Cabrero, J.L. Villarroel," Real-time wireless multi hop protocol in underground voice communication," *Ad Hoc Networks* Vol. 11, Issue 4, pp. 1484-1496, 2013.

[3] P.D.R. Vijaya Kumar and T. Ravichandran " A Real Time Multimedia Streaming in Mobile Ad Hoc Networks using Multicast Tree Structure" *Research Journal of Information Technology,* Vol. 5, Issue 1, pp. 24-34, 2013.

[4] Siva Kumar, P.; Duraiswamy, K., "A QoS routing protocol for mobile ad hoc networks based on the load distribution," *Computational Intelligence and Computing Research (ICCIC), 2010 IEEE International Conference on* , vol., no., pp. 1, 6, 28-29 Dec. 2010

[5] Boksiner, J., Posherstnik, Y., May, B., Saltzman, M., Kamal, S., "Centrally Controlled Dynamic Spectrum Access for MANETs,", *Military Communications Conference, MILCOM 2013-2013 IEEE* , pp. 641-646, 18-20 Nov. 2013.

[6] M. Rath, B.K. Pattanayak, B. Pati, "MANET Routing Protocols on Network Layer in Real Time Scenario", International Journal on Cybernetics & Informatics (IJCI) Vol. 5, No. 1, February 2016.

[7] Lal, C.; Laxmi, V.; Gaur, M.S., "Performance analysis of MANET routing protocols for multimedia traffic," *Computer and Communication Technology (ICCCT), 2011 2nd International Conference on* , vol., no., pp. 595, 600, 15-17 Sept. 2011.

[8] Mamata Rath, Binod Kumar Pattanayak, "Energy Competent Routing Protocol Design in MANET with Real time Application Provision", International Journal of Business Data Communications and Networking, 11(1), 50-60, January-March 2015.

[9] Srivastava, S.; Daniel, A.K.; Singh, R.; Saini, J.P., "Energy-efficient position based routing protocol for mobile ad hoc networks," *Radar, Communication and Computing (ICRCC), 2012 International Conference on* , vol., no., pp. 18,23, 21-22 Dec. 2012

[10] Rath M., Pattanayak B. "A methodical survey on real time applications in MANETS: Focussing on key issues. High Performance Computing and Applications (ICHPCA), 2014 International Conference on , pp. 1-5, 22-24 Dec. 2014.

[11] R. Vinod Kumar, R.S.D. Wahida Banu, "E2AODV Protocol for Load Balancing in Ad-Hoc Networks,"*Journal of Computer Science* 8 (7): 1198-1204, 2012.

[12] Rath M., Pattanayak, B., Rout U. Study of Challenges and Survey on Protocols Based on Multiple Issues in Mobile Adhoc Network, International Journal of Applied Engineering Research.2015, Volume 10, pp. 36042-36045, 2015.

[13] Pattanayak B., Rath M.A Mobile Agent Based Intrusion Detection System Architecture For Mobile Ad Hoc Networks. Journal of Computer Science, Vol. 10, pp. 970-975, 2014.

[14] Rath M., Pattanayak B., Pati B. A. Contemporary Survey and Analysis of Delay and Power Based Routing Protocols in MANET. ARPN Journal of Engineering and Applied Sciences, 2016, Vol. 11, No. 1, Jan., 2016.

[15] M. Rath, B.K. Pattanayak, B. Pati, "Energy Efficient MANET Protocol Using Cross Layer Design for Military Applications", Defence Science Journal Vol. 66, No. 2, March 2016.

[16] Ze Li; Haiying Shen "A QoS-Oriented Distributed Routing Protocol for Hybrid Wireless Networks", *Mobile Computing, IEEE Transactions on,* On page(s): 693-708 Volume: 13, Issue: 3, March 2014.

[17] Maleki, H.; Kargahi, M.; Jabbehdari, S., "RTLB-DSR: A load-balancing DSR based QoS routing protocol in MANETs," *Computer and Knowledge Engineering (ICCKE), 2014 4th International eConference on* , vol., no., pp. 728, 735, 29-30 Oct. 2014.

[18] Danilo Tardioli; Domenico Sicignano; José Luis Villarroel, "A wireless multi-hop protocol for real-time applications", Computer Communications 55 (2015) 4-21.

[19] Sharma, Lavanya; Dimri, Priti, "An improved AODV with QoS support in mobile ad-hoc network," *Computing for Sustainable Global Development (INDIACom), 2015 2nd International Conference on* , vol., no., pp. 2052, 2056, 11-13 March 2015.

[20] "*Design and Implementation of the Extended Routing Information Protocol for Mobile Ad-Hoc Networks in Linux*" www.grin.com