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Performance Improvement in Hybrid Wireless Networks using Multi Channel Transmission

[1]T.Parameswaran, [2]Dr.C. Palanisamy, [3]A.Varalakshmi
[1]Assistant Professor, Dept. of CSE, Anna University Regional Centre, Coimbatore.
[2]H.O.D, Dept of IT, Bannari Amman Institute of technology, Sathyamangalam.
[3]PG Scholar, Dept. of CSE, Anna University Regional Centre, Coimbatore.

Abstract- The hybrid wireless network has proved a better network structure for the next generation of wireless networks and help to tackle the stringent end to end QoS (Quality of Service) requirement for different applications. The hybrid wireless network is a mixture of infrastructure based (Base Stations) and infrastructure less networks (Ad-Hoc Network). The current works in hybrid networks reserve the resources for QoS path which inherits the invalid reservation and race condition problems. And also it does not guarantee the QoS. The Multichannel QoS-oriented Distributed routing protocol (MQOD) is to improve the QoS in Hybrid wireless networks. MQOD Protocol, which converts the packet routing problem into the resource scheduling problem. MQOD protocol integrates six algorithms. 1. Neighbor node selection to reduce the transmission delay between the source node and the destination node 2. Packet scheduling is used to reduce the packet loss 3. Packet resizing based on mobility of nodes to reduce the transmission time and packet loss 4. Multi-channel medium access control is used to improve the network throughput by enabling parallel transmissions 5. Soft Deadline based packet forwarding and scheduling used to increase the throughput 6. Eliminating data redundancy to purge the unwanted data further improves the QoS. By using the random way point model Ns-2 simulation results are produced.

Index Terms – QOS, Hybrid Networks, Routing, Mobility, Admission control, Reliability, Access Point, Throughput.

I. INTRODUCTION

Most of the current work in hybrid wireless networks does not guarantee an end to end quality of service in hybrid networks. The major problem in the hybrid wireless network is to provide a QOS in high mobility, dynamic network and having limited bandwidth. For QOS routing, this requires negotiating a node, controlling the admission of nodes, reserving the resources for transmission. Due to the reserving resources there may be two problems arises like Invalid Reservation and Race Condition problem.

Race Condition problem means for two different QOS paths allocating the same resource as double times. Invalid reservation means there may be a link break down between the source and destination nodes so the reserved resources becomes useless. And also Hidden terminal problem occurs frequently due to access of same channel at the same time by two different nodes. The Existing system focused on increasing the network capacity or routing reliability, which does not guarantee the QOS. To provide a QOS in a highly dynamic network, we proposed the Multi channel QOS-oriented distributed routing protocol (MQOD). The MQOD protocol, which transforms the packet routing problem into a dynamic resource scheduling problem. The main aim of Multi channel QOD is to reduce transmission time and increase the network capacity and throughput based on queuing condition, Channel condition and user mobility. In a hybrid network have two features: the access point (AP) may be the source or the destination for a mobile node and also the number of hops between the mobile node and the access point is small.

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In MQOD if the source node is not within the transmission range of an access point, the source node has to choose the nearby neighbor nodes where the transmission path should guarantee the QOS. The best neighbor nodes would be chosen by control channels. The neighbor nodes have to further transmit the packet to nearby neighbor or corresponding destination. There may be an 'n' number of neighbor nodes between the source and the destination. The QoS service is achieved through the implementation of techniques such as the Neighbor Node selection, Packet scheduling for Packet Routing, Packet resizing based on mobility of nodes, Multi-channel medium access control is used to improve the network throughput by enabling parallel transmissions, Soft Deadline based packet forwarding and scheduling, Eliminating Data Redundancy.

II. RELATED WORK

A. QoS in Infrastructure Based Networks

The existing systems of the infrastructure based networks are based on two approaches. They are integrated services (IntServ) [2] and differential services (DiffServ) [2]. The IntServ model kept the flow-Specific states in every IntServ enabled Router. It provides guaranteed service for fixed delay and controlled Load service for reliability. By keeping the flow state information will costs high and processing overhead due to the scarcity of resources. And also, it does not guarantee QoS. The DiffServ affords a limited number of aggregated classes. It uses fine-grained mechanism to manage traffic in the network [3]. But the packet dropping ratio and bandwidth cannot be reduced. So it fails to meet QoS.

B. QoS in Infrastructure Less wireless Networks

In MANETs majority of the routing protocols reserve the resources [7] and send a probe message to the destination for reserving the resources which satisfy the QoS requirement. Perkins et al. [6] proposed the AODV protocol. AODV maintains time-based states to update routing tables. In AODV, there is a frequent link break down between the source node the Destination node. So, it will degrade the network performance. DSR routing protocol [4] is an on-demand routing protocol, which composed of route discovery and route maintenance phases. It uses request to control packet to determine the acceptance level of available bandwidth. But it does not consider the transmission delay. Conti et al. [5] proposed an approach to select the reliable path by estimating the reliability of routing paths.

C. QoS in Hybrid Networks

Most of the methods used for routing focus on increasing network capacity or routing reliability. Jiang et al. [8] proposed the method, QoS guarantees for multimedia services by selecting a node and satisfying the time delay requirement in WiMAX network. Wei [9] proposed a stochastic decision making approach which selects the available relays according to the states which is an optimal relay. The quality of service (QoS) optimizes goals of mitigating error propagation and increasing spectral efficiency. Aggelos Bletsas et al. [10] proposed a method to achieve efficiency in higher bandwidth by selecting the best relay. From the above works MQOD protocol provides a better scalability, mobility-resilience and higher throughput.

III. NETWORK MODEL OF HYBRID NETWORKS

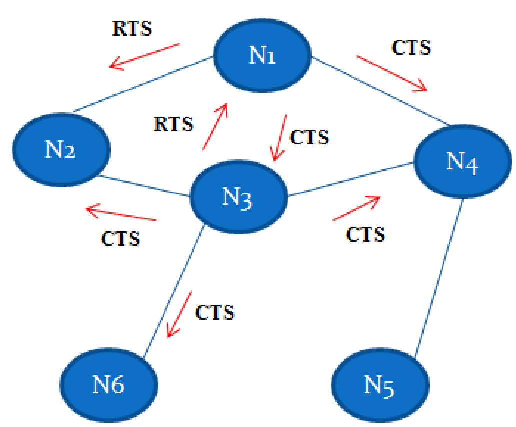

Fig 1 Network Model

The above figure 5.3 shows the network model of a hybrid network. For example, when a source node n_1 wants to upload files to an Internet server through APs, it can choose to send packets through the APs directly by itself or require its neighbor nodes n_2, n_3, n_4 or n_5 to assist the packet transmission. Assume that queuing occurs only at the output ports of the mobile nodes. Using the dedicated control channels the RTS to send control packets and CTS would be exchanged through control channels to select the best available data channel.

IV. OVERVIEW OF MQOD PROTOCOL

The source node generates the packet from time to time. It sends the packet directly to the destination node if it is within the coverage of access points. Otherwise the source node has to send the request to nearby neighbor nodes to reach the destination. The neighbor node compares the space utility (U_s) with the threshold and reply to the source node. Based on the replies from the neighbor nodes the source node calculates the queuing delay (T_w) and packet size (S_p (i)) and then determines the qualified neighbor nodes. The neighbor nodes get sorted in the descending order based on the queuing delay (T_w). Depending upon the workload of neighbor nodes the source node chooses the best neighbor.The neighbor node which having a lower queuing delay, a workload rate A_i gets allocated and for each sorted intermediate neighbor node, send packets to n_i with the transmission interval $\frac{S_p(i)}{A_i}$ from the source node.

A. Analysis of channel utility and workload differences

IEEE 802.11 uses CSMA/CA protocol to access the medium. In order to avoid a hidden terminal problem during accessing the medium, before a node sending a packet Request To Send (RTS) message will be sent to the adjacent hop indicating the duration of time subsequent transmission going to take place. The source node receives the reply from destination node and establishes a connection between them. The neighbor nodes overhearing RTS or CTS set their Virtual Carrier Sense indicator to avoid transmission of data into the channel within the packet transmission time duration. Channel utility means the fraction of time a channel is busy over a unit time. Let us consider $\bar{T}$ is a constant time interval used for channel utility updating, by referring NAV update time interval $\bar{T}$, each node calculate the channel Utility by $U_c(i) = \frac{T_{NAV}(i)}{\bar{T}}$,where $T_{NAV}(i)$ is the number of time units that n_i is interfered which is recorded in NAV. The available bandwidth can be calculated by $W_i = (1-U_c(i)).C_i$, where C_i is the transmission link capacity of node n_i.

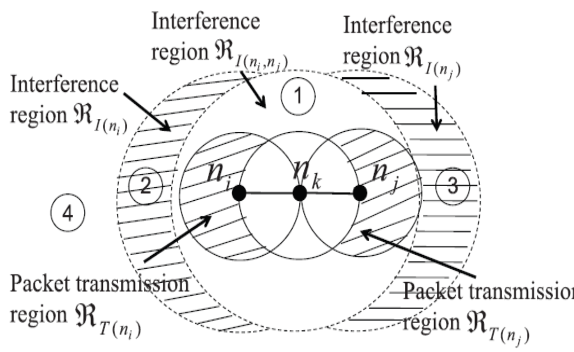

Fig 2 Interference between two neighboring nodes

The above figure shows that the interference between the two neighboring nodes n_i and n_j. The solid circles denote the packet transmission ranges of node n_i, n_j and the dotted circles denotes their interference ranges. The $R_{I(n_i)}$ is used to represent the interference regions of n_i that is not overlapped with node n_j and $R_{I(n_j)}$ is used to represent the interference regions of n_j that is not overlapped with node n_i. Then $R_{I(n_i,n_j)}$ is used to denote the overlapped region in the n_i and n_j. Before transmitting the packet, we have to analyze whether the nodes in $R_{I(n_i)}$, $R_{I(n_j)}$ and $R_{I(n_i,n_j)}$ have different channel utilities. When n_j is communicating with n_k the signal will not be received by other nodes in $R_{I(n_i)}$ and also other nodes can send and receive packets with no interference from the node n_j concurrently. Likewise, when n_i is communicating with n_k the signal will not be received by other nodes in $R_{I(n_j)}$ and also other nodes can send and receive packets with no interference from the node n_i concurrently. Hence, the nodes in $R_{I(n_i)}$ is independent from n_j and the nodes in $R_{I(n_j)}$ is independent from n_i. Therefore, the difference between the time durations of transmitting packets of node n_i and node n_j leads to different channel utilities of the nodes in $R_{I(n_i)}$, $R_{I(n_j)}$, and $R_{I(n_i,n_j)}$. We have to calculate the workload difference between the neighbor nodes n_i and n_j. The workload of a node is defined as the accumulated number of packets received by the node through the entire simulation period. The workloads in n_i and n_j are find out by the packets received by n_i and n_j from the nodes in $R_{T(n_i)}$ and $R_{T(n_j)}$, respectively, Where $R_{T(n_i)}$ denotes the packet transmission region of node n_i and $R_{T(n_j)}$ denotes the packet transmission region of node n_j.

B. Neighbor node selection

The source node generates the packet periodically. The source node sends the packet directly to the destination node if the access point is within the coverage. If the QOS of direct transmission between the source node and destination node is not within the coverage of access point, the source node selects the nearby neighbor nodes which guarantee the QOS path.

The Multi-channel QOD protocol uses the Earliest Deadline First Scheduling algorithm (EDF) which is the deadline driven scheduling algorithm to schedule the data traffic in intermediate nodes. In this algorithm the highest priority is assigned for the packet which would be closest to the deadline. In job scheduling model, each task has m number of jobs to complete. The deadline driven job scheduling is feasible iff, the $\bar{m}$ number of jobs can be computed by

$$\frac{T_{cp}(1)}{T_g(1)}+\frac{T_{cp}(2)}{T_g(2)}+\frac{T_{cp}(j)}{T_g(j)}+\ldots\ldots.+\frac{T_{cp}(\bar{m})}{T_g(\bar{m})}\le 1 \quad (1)$$

where $T_g(j)$ is the job arrival interval time period, $T_{cp}(j)$ is the job computing time of task j and 1 is the CPU utility(It means CPU is busy over the unit time). In network communication the transmission time of a packet in packet stream from node n_j can be considered to be the computing time $T_{cp}(j)$ of a job from task j. And the packet arrival interval T_a can be viewed as T_g. So, the CPU utility can be regarded as node space utility. Therefore, the job scheduling model can be formulated to

$$U_S(i)\Rightarrow\frac{S_p(1)}{T_a(1)}+\frac{S_p(j)}{T_a(j)}+\ldots\ldots.+\frac{S_p(m)}{T_a(m)}\le W_i \quad (2)$$

W_i is the available bandwidth of node n_i, S_p (j) is the size of the packet steam from node n_j. Here, that the scheduling feasibility of a node can be affected by packet size S_p, the number of packet streams from m neighbors, and its bandwidth W_i.

In order to avoid the queuing congestion and to make the scheduling feasibility for queue, for each node we set up a space utility threshold $\tilde{T}U_S$. The available space utility can be determined by $U_{as}(i)=\tilde{T}U_S-U_S(i)$. In MQOD, after receiving forward a request from the source node, the neighbor node verifies if enough resources are available or not. Before replying to the source node the intermediate node n_i compares if space utilization is less than the threshold and calculate its available workload rate $U_{as}(i)*W_i$. Then, send a reply with necessary information needed for source node.

The source node calculates queuing delay based on replies from neighbor node and makes confirm if the path satisfies QOS deadline. Otherwise, the source node rejects the neighbor node and chooses another path. The work load allocation can be made for QOS deadline satisfied nodes. The work allocation set can be calculated by

$$A=\begin{cases} W_g=\sum_{i=1}^{N_q}A_i \\ A_i\le U_{as}(i)*W_i \end{cases} \quad (3)$$

where $A_i=\frac{S_p(i)}{T_a(i)}$, N_q denotes the nodes, W_g kb/s is the packet generating rate of source node.

C. Packet scheduling for packet routing

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The distributed packet scheduling algorithm assigns former generated packets to forwarders with higher queuing delay and assigns recently generated packets to lower queuing delays, so that the transmission delay of the entire packet stream gets reduced.An intermediate node determines the priorities of its packets based on their deadlines D_p.

A packet with smaller priority value of x has a highest priority. Therefore, the queuing time $T_w^{(x)}$ can be estimated with priority x by

$$T_w^{(x)} = \sum_{j=1}^{x-1}\left(T_{I\to D}^{(j)} \cdot \left\lceil T_w^{(x)} / T_a^{(j)} \right\rceil \right) \; (0 < j < x) \qquad (4)$$

where x denotes the packet with the x^{th} priority in the queue. $T_{I\to D}^{(j)}$ is the transmission delay between the intermediate node and the Access point. $T_a^{(j)}$ denotes the arrival interval of a packet with j^{th} priority. $\left| T_w^{(x)} / T_a^{(j)} \right|$ denotes the number of packets arriving during the packet's queuing time $T_w^{(x)}$, which are sent out from the packet before this packet.

The source node receives the reply from the neighbor nodes which includes the scheduling information of all flows in their queues. The source node calculate the T_w of each packet in the neighbor nodes n_i which satisfies $T_w < T_{QoS} - T_{S\to I} - T_{I\to D}$, where T_{QoS} denotes the QoS requirement delay.

D. Transmission through Multi-channel

In multi-channel transmission hidden terminal problem occurs when a node is busy transmitting or receiving on a data channel, when a neighboring node initiates a channel reservation handshake on the control channel. To avoid congestion problem channel hopping approaches is used, where dedicated control channel schemes allocate common control channel to send control messages and data channels for data transmissions.

The control packets would be exchanged over the control channel before transmitting the data packets through the data channel and random back off timer would be sets by the sender before transmission. The back off counter would be decremented by the sender, if at least one data channel is available and the control channel is idle for the DCF interframe spacing (DIFS). After that the back off counter is decreased by 1 if the CC is sensed idle in a back off slot.

The sender freezes its back off counter, if the CC is sensed busy. If the back off counter reaches zero, the sender transmits an RTS packet, containing the sender's available data channel list. Packet periodically arrives at MAC queue.

When receiving the RTS, the receiver selects one of the commonly available DC and replies with a CTS packet. For DC selection, including channel quality and link capacity is considered. When the sender receiving the CTS from receiver, it transmits a decide-to-send (DTS) packet which announcing the DC will be used and the duration of usage. This DTS should inform the neighbors of the sender about the DC that will be reserved for the upcoming transmission.

E. Packet resizing based on mobility of nodes

The transmission link between the two nodes gets broken down due to the highly dynamic mobile wireless network. So, the packet has to be retransmitted. And the delay generated due to retransmission of packets reduces the QOS of the transmission of a packet flow.The space utility of an intermediate node forwards the packet by $\frac{S_p}{W_i \cdot T_a}$. If we reduce the packet size, the scheduling feasibility can be increased at the same time packet dropping probability gets reduced. The problem is that, we cannot reduce the packet size too small, because number of packets gets increased leads to higher packet overhead.

In this algorithm, the large size packets are assigned to lower mobility intermediate nodes and the smaller size packets are assigned o higher mobility intermediate nodes.So, we can increase the QoS-guaranteed packet transmissions.When the mobility of a node increases, the size of a packet S_p send to its neighbor nodes i decreases as following

$$S_p(new) = \frac{\gamma}{\nu_i} S_p(unit) \quad (5)$$

Where γ is a scaling parameter, v_i denotes the relative mobility speed of the source node and neighbor node and S_p (unit) = 1kb.

F. Soft Deadline based packet forwarding and scheduling

In the EDF algorithm, the closest deadline packets get chosen and forwarded by the intermediate node. If there are too many packets to transmit then the packet delay gets increased. Thus, EDF is only suitable for hard-dead line driven applications. The Least slack first scheduling (LSF) algorithm is used for soft-dead line driven applications. The slack time of a packet can be calculated by D_p– t – c’, where D_p is the packet delay, t is the current time of the packet. c’ is the remaining packet transmission time of a packet.

An intermediate node calculates the slack time periodically for each node and forwards the least slack time packet. The packet would be randomly chosen if all packets have the same slack time. The LSF does not transmit the packet before deadlines are met. It aims to make delays and the sizes of delay almost the same. In this algorithm fairness in packet forwarding and scheduling can be achieved. Based upon the applications, MQOD chooses EDF or LSF algorithm.

G. Eliminating Data Redundancy

During message transmission the mobile nodes overhear the messages and set their NAV values. If the NAV value is large the available bandwidth would be less and scheduling feasibility of a mobile node becomes small. So, we have to increase the scheduling feasibility of reducing the NAV value and we can increase the QoS of the packet transmission. In the hybrid network due to broadcasting feature of wireless network, the access points and mobile nodes overhear the packet transmission and cache packets. In order to eliminate the redundancy of data, we use end-end traffic redundancy elimination algorithm. It is used to improve the QoS of packet transmission in MQOD. In this algorithm chunking scheme is used to determine the boundary of chunksin a data stream. Generally, the access points and mobile nodes overhear the sent and received data and cache the packets. Due to this the nodes know who have received the packets. The source node scans the content for duplicated chunks in its cache, before starting the transmission of the packets. It replaces the chunk with its chunk signature, if it finds any duplicate chunk. Because it knows that access points and the intermediate node receives the packet already. The access point receives the chunk signature and search in its local cache. If match found for its chunk and the corresponding chunk signature, it sends an acknowledgement to the sender or else Access point request the source to send the data chunk for the chunk signature.

IV. RESULTS

Let us compare the performance of Single channel MQOD with Multichannel MQOD.

A. Throughput vs Node Mobility

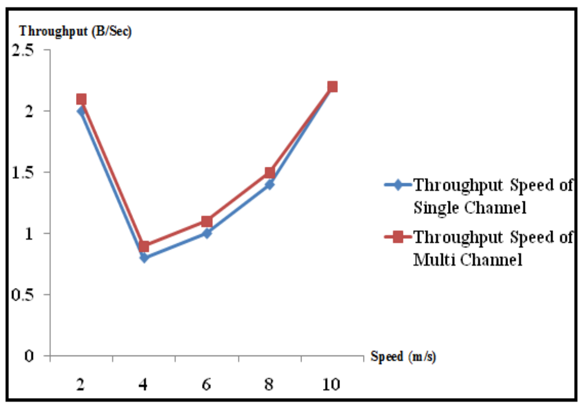

Fig 3 QoS Throughput versus Mobility

The above figure clearly shows that, when the mobility of a node gets increases there is a link break down between the two nodes which lead to packet drop. In Hybrid Network, rather than reserving the resources in each transmission link, the intermediate nodes periodically report their queuing status to the source node. High mobility nature suggests that rather looking for a shorter path in routing, we must stress on more stable path to reduce overheads. In single channel network if the mobility is high the packet loss will be more, so the QoS throughput decreases. But in multi channel network mobility of

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the packet does not cause any packet loss it provide higher throughput.

B. Throughput vs. Network size

The figure shows that, when the mobility of a node increases from 0 to 20 m/s, network size gets increased but there is a dramatic decrease in QoS throughput.

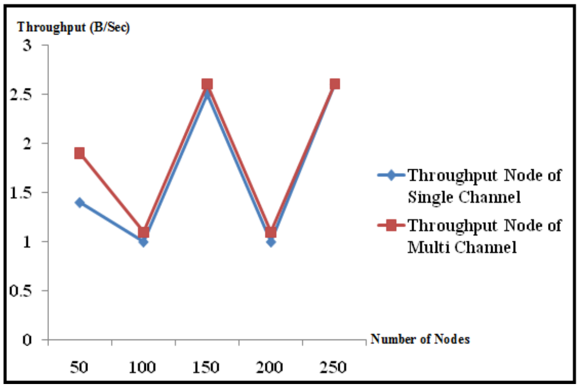

Fig 4 QoS Throughput versus Network size

Hybrid network provides a QoS-guaranteed neighbor selection algorithm to ensure that the selected next hop node can guarantee QoS routing. It also uses admission control mechanism to prevent source nodes from generating packets if no neighbor nodes can satisfy the QoS requirement. In single channel no of nodes increase causes congestion in network but in multichannel network congestion problem is reduced by setting back off timer.

C. Throughput vs. Number of Access Points

The figure shows that, the physical distance between the source and destination node becomes reduced due to increase in the number of access points. Hybrid Network effectively schedules the channel resources around the source node for packet forwarding, so its QoS Throughput remains constantly the highest. But in single channel throughput is not effectively increase when compare to multichannel. In multichannel if no of base station increase then the throughput also increase according to the coverage of base station.

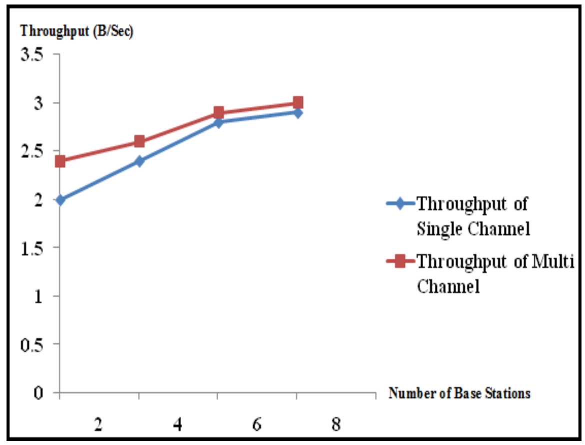

Fig 5 QoS throughput versus Number of Access Points

D. Throughput vs. Workloads

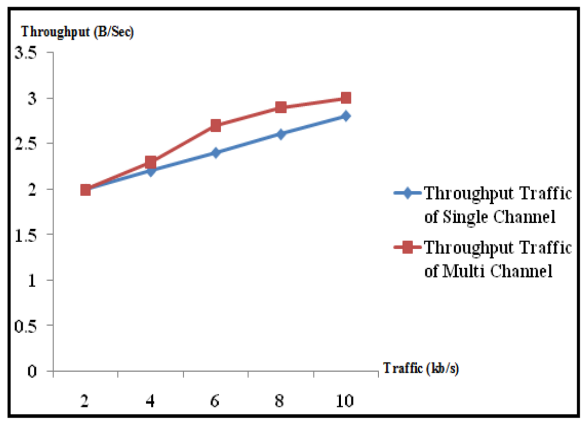

Fig 6 QoS throughput versus Workloads

The above figure 6 shows that, generating more packets into the networks may further decrease the QoS performance of other source nodes. Hybrid Network is much more mobility resilient which increases Hybrid Network's QoS throughput. But in multi channel network workload is splitter by sending and receiving the signal through multi channel without any overlapping. So, QoS throughput gets increase.

5. CONCLUSION AND FUTURE WORK

In this paper, we can guarantee QoS by using six techniques. By using neighbor node selection, possible path is chosen. The packet delivery ratio can be improved through packet resizing based on the mobility of a node. And using effectual packet scheduling, packet loss rate is reduced. Using dedicated control channels 0 to 7 multiple transmissions of packets without any interference is performed to increase the throughput. The simulation results show that Multi-channel QOD protocol can achieve higher throughput, flexibility and scalability. In the future, we plan to improve the performance of MQOD by further reducing the congestion in the network.

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AUTHOR'S PROFILE

T. Parameswaran. T has received his B.E degree in Electronics and Communication Engineering from Velalar College of Engineering and Technology, Erode, and M.E degree in Software Engineering from College of Engineering Guindy, Anna University Chennai in 2005 and 2008 respectively. He is currently pursuing his Ph.D from Anna University, Regional Centre Coimbatore. He is currently working as Assistant Professor in the Department of Computer Science and Engineering, Regional Centre, Anna University, Coimbatore, India. He has published more than 10 research papers in various journals and conferences. He has organized 3 national level workshops.

Dr. Palanisamy. C has received his B.E degree in Electronics and Communication Engineering from University of Madras, Chennai, and M.E degree (Gold Medalist) in Communication Systems from Thiagarajar College of Engineering, Madurai, Madurai Kamaraj University in 1998 and 2000 respectively.He has received his Ph.D from the faculty of Information and Communication Engineering, Anna University, Chennai in 2009. He has more than 13 years of

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academic and research experience and currently he holds the post of Professor and Head of the Department of Information Technology, Bannari Amman Institute of technology, Sathyamangalam and Tamilnadu, India. He has published more than 30 research papers in various journals and conferences.He has organized more than 10 workshops and holds 2 funded projects. He is a lifetime member of ISTE. He won Best M.E thesis award at Thiagarajar College of Engineering, Madurai and best paper award titled, "A Neural Network Based Classification Model Using Fourier and Wavelet Features," Proceedings of the 2nd Int. Conf. on Cognition and Recognition 2008, (ICCR 2008), Organized by P. E. S College of Engineering, Mandaya, Kastrnataka, India, pp. 664-670, 2008. His research interests include Data mining, image processing and mobile networks.

A. Varalakshmi. A is pursing M.E Computer Science and Engineering in the Department of Computer Science and Engineering, Anna University Regional Centre, Coimbatore. She received her B.E Degree in Computer Science and Engineering from R.V.S. College of Engineering and Technology, Sulur, AnnaUniversity, Coimbatore in 2007 to 2011. Her research interests are Ad-Hoc networking and Mobile networks.