QoS Guaranteed by Neighbor Node Selection Based on Packet Scheduling in Hybrid Wireless Networks

T. Parameswaran, Dr.C. Palanisamy, A. Varalakshmi

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 combination 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. In this paper, we propose the QoS-oriented Distributed routing protocol (QOD) to improve the QOS in Hybrid wireless networks. QOD Protocol, which converts the packet routing problem into the resource scheduling problem. QOD protocol integrates five 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. Soft Deadline based packet forwarding and scheduling used to increase the throughput 5. Eliminating data redundancy to purge the unwanted data further improves the QoS. By using the random waypoint model Ns-2 simulation results are produced.**

Index Terms— **Access Point, Admission control, Hybrid Networks, Mobility, Routing.**

I. INTRODUCTION

Most of the current work in hybrid wireless networks is concentrated on increasing the network capacity or routing reliability. It 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. 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 QOS-oriented distributed routing protocol (QOD). The QOD protocol transforms the packet routing problem into a dynamic resource scheduling problem. The main aim of QOD is to reduce transmission time and increase the network capacity 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. In QOD 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 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, 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 [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 [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 [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 [10] proposed a method to achieve efficiency in higher bandwidth by selecting the best relay. From the above works QOD protocol provides a better scalability, mobility-resilience and higher throughput.

III. OVERVIEW OF QOD PROTOCOL

The source node generates the packet periodically. 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 $U_c(i) = \frac{T_{NAV}(i)}{\overline{T}}$,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.

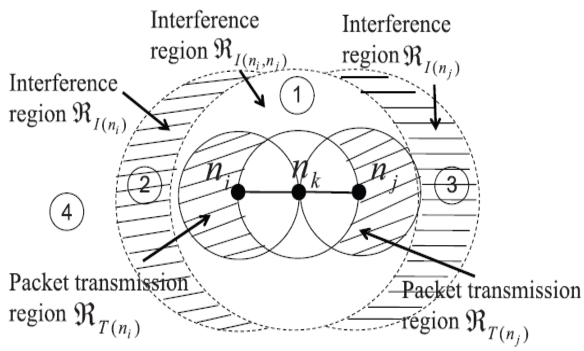

Fig 1 Interference between two neighboring nodes

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 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

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

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

$$U_s(i) \Rightarrow \frac{S_p(1)}{T_a(1)} + \frac{S_p(j)}{T_a(j)} + ... + \frac{S_p(m)}{T_a(m)} \leq W_i. \quad (2)$$

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 QOD, 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

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

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

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

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

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. $\left\lceil T_w^{(x)} / T_a^{(j)} \right\rceil$ 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. 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 $\frac{S_p}{W_i . T_a}$. 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 decrease as following

$$S_p(\text{new}) = \frac{\gamma}{v_i} S_p(\text{unit}). \qquad (5)$$

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.

E. 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, QOD chooses EDF or LSF algorithm.

F. 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 QOD. In this algorithm chunking scheme is used to determine the boundary of chunks in 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 QOD, Two-hop, E-AODV and S-Multihop.

A. Throughput vs Node Mobility

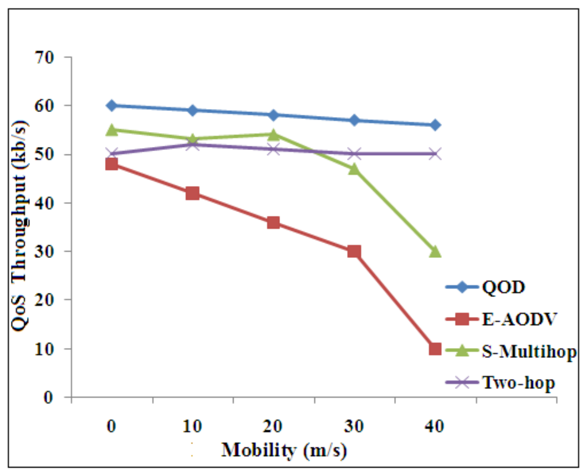

Fig 2 QoS Throughput versus Mobility

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. Comparing to QOD and Two-hop, E-AODV and S-Multihop have large number of hops in the routing paths from the source nodes to APs. But, QOD and Two-hop have only two hops in the routing paths. If there is any link breaks down occurs easily can choose another path.

Due to the intermediate nodes which periodically update its status to source node constant throughput can be produced in QOD.

B. Throughput vs Network size

The throughput of the system gets analyzed with the mobility, speed of 0 and 20 m/s.

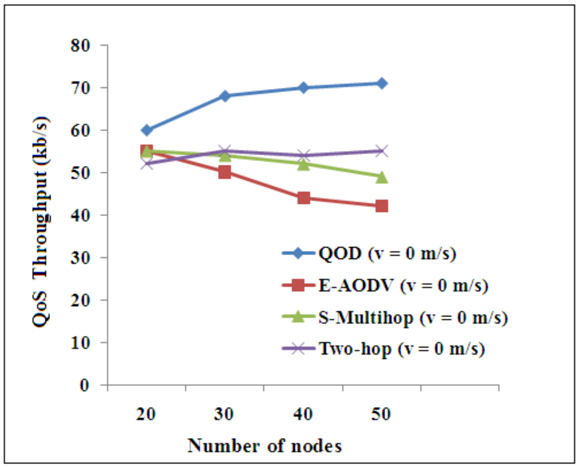

Fig 3 (a) QoS throughput versus network size and node mobility (Ave. node mobility = 0 m/s)

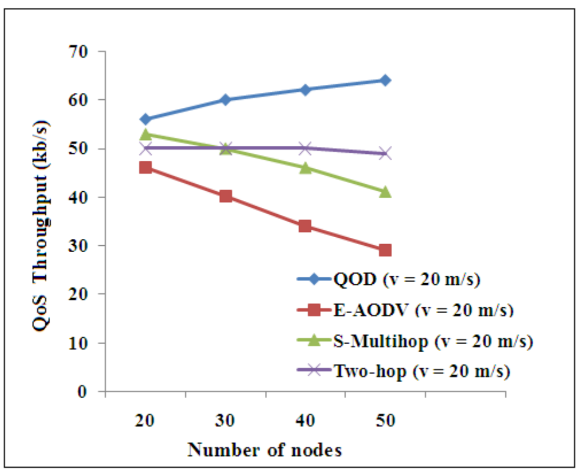

Fig 4 (b) QoS throughput versus network size and node mobility (Ave. node mobility = 20 m/s)

The figure (a) and (b) 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 in E-AODV and S-Multihop. Due to the mobility-resilient feature of QOD and Two-hop increase in mobility does not affect the QoS throughput. Two-hop also suffers from increasing in mobility because interference gets increased which leads to decrease in throughput. Comparing to all, QOD can produce higher throughput due to its workload digest ability.

C. Throughput vs Number of Access Points

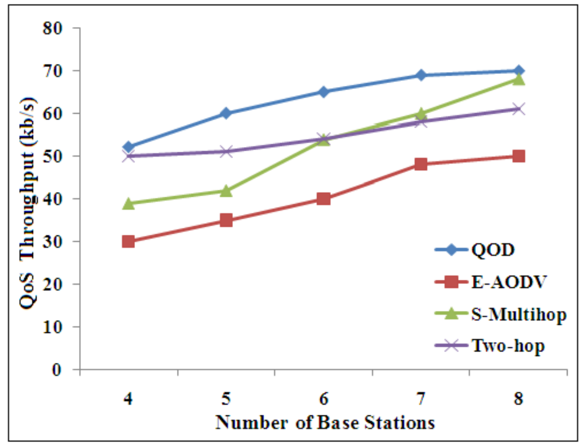

Fig 5 QoS throughput versus Number of Access Points

The above figure shows that, the physical distance between the source and destination node becomes reduced due to increase in the number of access points. In E-AODV and S-Multipath, there is a dramatic increase in QoS throughput. In Two-hop there is only two hops between the source and destination node. So, there is only small increase in QoS throughput. But in QOD there is a constant increase due to its effective use of resources.

D. Throughput vs Workloads

The below figures (a) and (b) shows that, how much throughput can be produced by each protocol, with the workload gets increased with the mobility speed 0 to 20 m/s. The throughput of E-AODV increases initially. Due to increase in number of source nodes, it has to reserve the resources which lead to race condition problem. So, the throughput decreases. In Two-hop packets are always forwarded where there is a higher transmission link rate. S-Multihop due to the less buffer usage schedule and forwards the packets. QOD uses packet scheduling scheme to manage even heavier workload. It produces higher throughput.

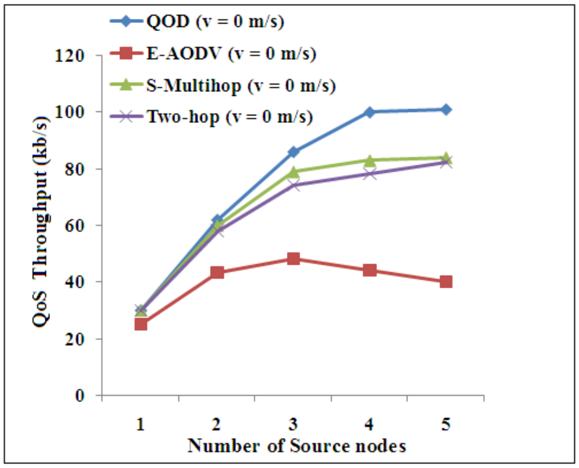

Fig 6 (a) QoS throughput versus Number of source nodes (Ave. node mobility = 0 m/s)

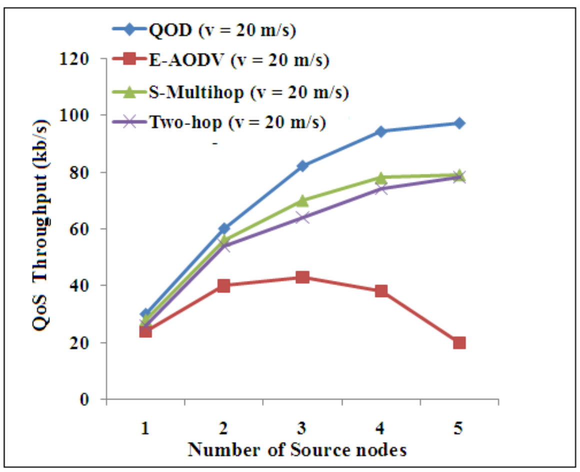

Fig 7 (b) QoS throughput versus Number of source nodes (Ave. node mobility = 20 m/s)

5. CONCLUSION AND FUTURE WORK

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. In this paper, we can guarantee QoS by using five techniques. By using neighbor node selection, feasible path is chosen. The packet delivery ratio can be increased through packet resizing based on the mobility of a node. And using effective packet scheduling, packet loss rate is reduced. The simulation results show that QOD protocol can achieve higher throughput, flexibility and scalability. In the future, we plan to improve the performance of QOD using dual channels.

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