Resource Management Technique for QOS Support in Hybrid Wireless Network

M.Yohapriyaa[1] A.Lalitha[2]
[1]P.G Scholar [2]Assistant Professor
[1,2]Department of Computer Science & Engineering
[1,2]Valliammai Engineering College, Chennai, Tamilnadu, India

Abstract— Wireless hybrid network that integrates a mobile wireless ad hoc network (MANET) and a wireless infrastructure network has been proven to be a better alternative for the next generation wireless networks. The Hybrid wireless network has higher capacity than cellular networks. It increases flexibility and reliability in routing. It has better coverage and connectivity. Hybrids networks inherit invalid reservation and race condition problems in MANETs by directly adopting resource reservation-based Quality of Service (QoS) routing for MANETs. This affects the quality of service in hybrid network. Most of the current work in hybrid networks focus on enhancing quality of service but cannot reduce the transmission time and traffic between sender and receiver in the network. In this paper, an ADAPTIVE RESOURCE MANAGEMENT approach is proposed to enhance the QoS by reducing the transmission time and traffic in hybrid networks. Adaptive resource management incorporates six algorithms: 1) Admission controller to select qualified neighbor for packet forwarding, 2) Encryption algorithm to encrypt the content of the source node, 3) Channel assignment to reduce traffic in the network, 4) Packet scheduling algorithm to further reduce the transmission delay, 5) Packet resizing algorithm that adaptively adjusts segment size according to node mobility, 6) a redundancy elimination algorithm to eliminate the redundant data in the packet.

Key words: Hybrid wireless networks, mobile wireless ad hoc network (MANET), quality of service

I. INTRODUCTION

The rapid development of wireless networks has stimulated numerous wireless applications that have been used in wide areas such as commerce, emergency services, military, education, and entertainment. The number of Wi-Fi capable mobile devices including laptops and handheld devices (e.g., smartphone and tablet PC) has been increasing rapidly. For example, the number of wireless Internet users has tripled world-wide in the last three years, and the number of smartphone users in US has increased from 92.8 million in 2011 to 121.4 million in 2012, and will reach around 207 million by 2017 [1]. The widespread use of wireless and mobile devices and the increasing demand for mobile multimedia streaming services are leading to a promising near future where wireless multimedia services are widely deployed.

The emergence and the envisioned future of real time and multimedia applications have stimulated the need of high Quality of Service (QoS) support in wireless and mobile networking environments. The QoS support reduces end to-end transmission delay and enhances throughput to guarantee the seamless communication between mobile devices and wireless infrastructures. At the same time, hybrid wireless networks (i.e., multi hop cellular networks) have been proven to be a better network structure for the next generation wireless networks and can help to tackle the stringent end-to end QoS requirements of different applications. Hybrid networks synergistically combine infrastructure networks and MANETs to leverage each other.

Specifically, infrastructure networks improve the scalability of MANETs, while MANETs automatically establish self-organizing networks, extending the coverage of the infrastructure networks. In a vehicle opportunistic access network (an instance of hybrid networks), people in vehicles need to upload or download videos from remote Internet servers through access points (APs) (i.e., base stations) spreading out in a city. Since it is unlikely that the base stations cover the entire city to maintain sufficiently strong signal everywhere to support an application requiring high link rates, the vehicles themselves can form a MANET to extend the coverage of the base stations, providing continuous network connections. How to guarantee the QoS in hybrid wireless networks with high mobility and fluctuating bandwidth still remains an open question.

In the infrastructure wireless networks, QoS provision has been proposed for QoS routing, which often requires node negotiation, admission control, resource reservation, and priority scheduling of packets. However, it is more difficult to guarantee QoS in MANETs due to their unique features including user mobility, channel variance errors, and limited bandwidth. Thus, attempts to directly adapt the QoS solutions for infrastructure networks to MANETs generally do not have great success [2]. Numerous reservation-based QoS routing protocols have been proposed for MANETs [3] that create routes formed by nodes and links that reserve their resources to fulfill QoS requirements. Although these protocols can increase the QoS of the MANETs to a certain extent, they suffer from invalid reservation and race condition problems. Invalid reservation problem means that the reserved resources become useless if the data transmission path between a source node and a destination node breaks. Race condition problem means a double allocation of the same resource to two different QoS paths. However, little effort has been devoted to support QoS routing in hybrid networks.

Most of the current works in hybrid networks [4], [5], [6] focus on increasing network capacity or routing reliability but cannot provide QoS-guaranteed services. Direct adoption of the reservation-based QoS routing protocols of MANETs into hybrid networks inherits the invalid reservation and race condition problems. In order to enhance the QoS support capability of hybrid networks, in this paper, the Adaptive resource management algorithm makes five contributions,

A. Admission Controller:

The new connections are allowed to join the network, if the requested resources are feasible. If the requested resources are infeasible, then it is dropped.

B. Encryption:

RSA is used for digital signatures, key exchange, and encryption.

C. Channel Assignment:

The proposed algorithm allocates channels in a way that (a) self-interference is avoided and (b) co-channel interference levels among links that use the same channel are kept as low as possible.

D. Packet Scheduling Algorithm:

The packets are scheduled based on the type of packet.

E. Packet Resizing Algorithm:

Based on the mobility the larger size packets are assigned to lower mobility intermediate nodes and smaller sized packets are assigned to higher mobility intermediate nodes.

F. Redundancy Elimination Algorithm:

An end-to-end traffic redundancy elimination is used to eliminate the redundant data.

II. RELATED WORKS

A. Infrastructure Networks:

Existing approaches for providing guaranteed services in the infrastructure networks are based on two models: Integrated services and differentiated service [7]. IntServ is a state full model that uses resource reservation for individual flow, and uses admission control and a scheduler to maintain the QoS of traffic flows. In contrast, DiffServ is a stateless model which uses coarse grained class-based mechanism for traffic management. A number of queuing scheduling algorithms have been proposed for DiffServ to further minimize packet droppings and bandwidth consumption. Stoica et al proposed a dynamic packet service (DPS) model to provide unicast IntServ-guaranteed service and Diffserv like scalability.

B. MANETs:

A majority of QoS routing protocols are based on resource reservation, in which a source node sends probe messages to a destination to discover and reserve paths satisfying a given QoS requirement. Perkins et al extended the AODV routing protocol by adding information of the maximum delay and minimum available bandwidth of each neighbor in a node’s routing table. Jiang et al. proposed to reserve the resources from the nodes with higher link stability to reduce the effects of node mobility. Liao et al. proposed an extension of the DSR routing protocol by reserving resources based on time slots. However, these works focus on maximizing network capacity based on scheduling but fail to guarantee QoS delay performance. Conti et al proposed to use nodes’ local knowledge to estimate the reliability of routing paths and select reliable routes. Shen and Thomas proposed a unified mechanism to maximize both the QoS and security of the routing.

C. Hybrid Wireless Networks:

Very few methods have been proposed to provide QoS guaranteed routing for hybrid networks. Most of the routing protocols only try to improve the network capacity and reliability to indirectly provide QoS service but bypass the constraints in QoS routing that require the protocols to provide guaranteed service. Jiang et al. [8] proposed a resource provision method in hybrid networks modeled by IEEE802.16e and mobile Wi-Max to provide service with high reliability. Cai et al [9] proposed a semi distributed relaying algorithm to jointly optimize relay selection and power allocation of the system. Z. Li and H. Shen [10] proposed a two-hoppacket forwarding mechanism, in which the source node adaptively chooses direct transmission and forward transmission to base stations. Unlike the above work Adaptive resource management aims to provide guaranteed quality of service by reducing transmission time and traffic in the network.

III. AN OVERVIEW OF ADAPTIVE RESOURCE MANAGEMENT APPROACH

The source node will send the packet forwarding request to all the neighbor nodes in the network. The nodes that have space utility less than threshold will reply to source node. Fig 1 clearly shows the Adaptive resource management approach. The admission controller will choose guaranteed neighbor node for forwarding the packet. The Encryption algorithm will encrypt the content of the source node.

The channel assignment algorithm will assign channel in such a way that (a) self-interference is avoided and (b) co-channel interference levels among links that use the same channel are kept as low as possible. The priority scheduling algorithm will schedule the packets based on the type of the packet. The packet resizing algorithm will resize the packet based on the mobility of the nodes. The redundancy elimination eliminates the duplicate data in the packet.

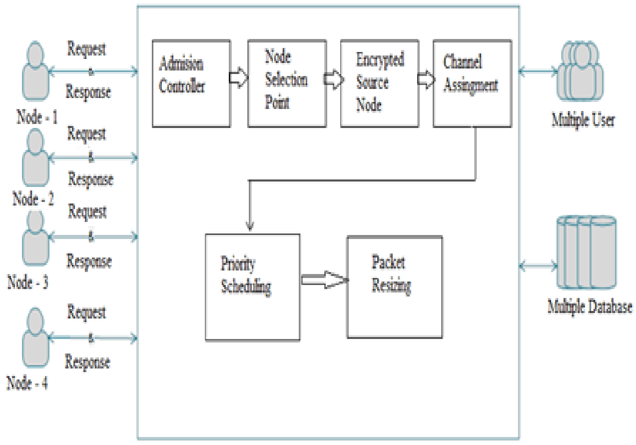

Fig. 1: Adaptive resource management

IV. WORKING PRINCIPLE

A. Admission Controller:

The function of admission control is to determine whether or not to grant permission to a new node based on information such as the current channel occupation, the bandwidth and QoS requirements of calls in service, and the characteristics of the call that requests admission.

An admission control strategy is essential to provide protection to the sources that are currently being serviced. The new connections are allowed to join the network, if the requested resources are feasible. If the requested resources are infeasible, then it is dropped. Admission control is a validation process where a check is performed before a connection is established to see if current resources are sufficient for proposed connection. The Admission controller will maintain a database that maintains information about the nodes that are currently being serviced. The Admission controller will select guaranteed neighbor using the neighbor selection algorithm.

The source node sends the packet the packet forwarding request to its neighbor nodes. After receiving a packet forward request from a source node, a neighbor node with space utility less than a threshold replies the source node. The reply message contain information about available resource for checking packet scheduling feasibility, packet arrival interval, transmission delay and the node's mobility speed for determining packet size. Based on this information, the source node chooses the neighbors that can guarantee the delay quality of packet transmission. The selected neighbor nodes periodically report their status to the source node, which ensures their scheduling feasibility and locally schedules the packet stream to them.

1) *Algorithm for Neighbor Node Selection:*

– Algorithm 1: Neighbor node selection executed by a source node

1) if receive a packet forwarding request from a source node then
2) if this.SpaceUtility < threshold then
3) Reply to the source node.
4) end if
5) end if
6) if receive forwarding request replies for neighbor nodes then
7) Determine the packet size Sp(i) to each neighbor i
8) Estimate the queuing delay Tw for the packet for each neighbor.
9) Determine the qualified neighbors that can satisfy the deadline requirements based on Tw
10) Sort the qualified nodes in descending order of Tw
11) Allocate workload rate Ai for each node
12) for each intermediate node ni in the sorted list do
13) Send packets to ni with transmission interval Sp(i)/Ai
14) end for
15) end if

B. *Encryption:*

The RSA algorithm involves three steps: key generation, encryption and decryption.

1) *Key Generation:*

– Step 1: Generate the key for the data in the source node.

RSA involves a *public key* and a *private key*. The public key can be known by everyone and is used for encrypting messages. Messages encrypted with the public key can only be decrypted in a reasonable amount of time using the private key.

2) *Encryption:*

– Step 2: Encrypt the data by converting the plain text in to cipher text.

A transmits public key (n, e) to B and keeps the private key d secret. B then wishes to send message M to A.B first turns M into an integer m, such that $0 \le m < n$ by using an agreed-upon reversible protocol known as a padding scheme. B then computes the cipher text C corresponding to

$$c \equiv m^e \pmod{n}$$

3) *Decryption:*

– Step 3: Decrypt the data by converting cipher text in to plain text.

Receiver can recover m from c by using her private key exponent d via computing.

$$m \equiv c^d \pmod{n}$$

Given m, she can recover the original message M by reversing the padding scheme.

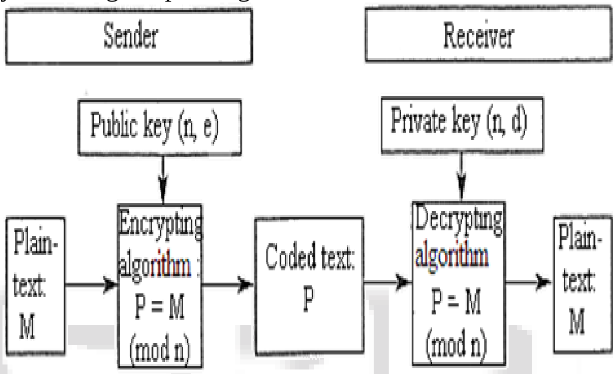

Fig. 2: Encryption

C. *Channel Assignment:*

Channel assignment deals with the allocation of channels to in a wireless network. Channel allocation schemes must not violate minimum frequency reuse conditions. Channel allocation schemes should adapt to changing traffic conditions. The proposed algorithm avoids self-interference by not assigning a channel to any link whose incident links have already been assigned channels and minimize co-channel interference. In co-channel interference, the channel that is assigned to a link is selected based on the sum of link. This sum is calculated for each of the channels and the channel with the least associated value is selected for the link. If the same link is reassigned then co-channel interference occurs. The proposed algorithm allocates channels in a way that (a) self-interference is avoided and (b) co-channel interference levels among links that use the same channel are kept as low as possible. The channel allocation in the proposed system reduces the computation and communication overhead.

D. *Packet Scheduling Algorithm:*

The source node selects intermediate nodes that can guarantee the QoS of the packet transmission. In order to further reduce the stream transmission time, a distributed packet scheduling algorithm is proposed for packet routing. This algorithm assigns real time packets to forwarders with lower queuing delays and scheduling feasibility, and assigns non real time packets to forwarders with higher queuing delay so that the transmission delay of an entire packet stream can be reduced. Sp denote size of the packet, p(r) denote the real time packets, p(n)denote the non- real time packets and TQoS denote the delay QoS requirement. Let WS and WI denote the bandwidth of a source node and an intermediate node respectively, we use TS-I=Sp/WS to denote the transmission delay between a source node and an intermediate node, and TI-D =Sp/WI to denote the transmission delay between an intermediate node and an destination. Let Tw denote the packet queuing time and Tw (i) denote the packet queuing time of ni. The source node needs to calculate Tw of each intermediate node to select intermediate nodes that can send its packets by the deadline, i.e., that can satisfy Tw < TQoS –TS-I – TI-D. Consider source node generates three packets p1, p2, and p3, p1 contain real time data, p2 contain non real time local data and p3 contain non real time remote data.

Packet scheduling algorithm assigns higher priority for p1, middle priority for p2 and lowest priority for p3. A packet p's total transmission delay equals: TS-I(i)+Tw(i)+TI-D(i). Since all these packets are generated from the same node, the transmission delay from the source node to each intermediate node TS-I(1),TS-I(2), and TS-I(3) are almost the same. If the queuing delay in each intermediate node satisfies Tw(3) <Tw(2) <Tw(1), then p1 should send to first intermediate node, p2 should send to second intermediate node and p3 should send to third intermediate delay. As a result, the final packet delivery time for the three packets from the intermediate nodes to the destination node can be reduced.

E. Packet Resizing Algorithm:

In a highly dynamic mobile wireless network, the transmission link between two nodes is frequently broken down. The delay generated in the packet retransmission degrades the QoS of the transmission of a packet flow. Reducing packet size can increase the scheduling feasibility of an intermediate node and reduces packet dropping probability. However, we cannot make the size of the packet too small because it generates more packets to be transmitted, producing higher packet overhead. Based on this rationale and taking advantage of the benefits of node mobility, a mobility-based packet resizing algorithm is proposed.

The larger size packets are assigned to lower mobility intermediate nodes and smaller size packets are assigned to higher mobility intermediate nodes, which increases the QoS-guaranteed packet transmissions. As the mobility of a node increases, the size of a packet Sp sent from a node to its neighbor nodes i decreases.

F. Redundancy Elimination Algorithm:

Due to the broadcasting feature of the wireless networks, in a hybrid network, the mobile nodes cache packets. An end-to-end traffic redundancy elimination (TRE) algorithm is proposed that eliminate the redundancy data to improve the QoS of the packet transmission. Traffic redundancy elimination (TRE) reduce network loads and costs and to speed up communication and applications. End to end, software based TRE should meet the following desirable properties:

1) Standard:

The TRE standard needs to work across all server and client platforms and operating systems. This will enable servers to reduce redundant traffic, regardless of the client nature and location.

2) Application Independent:

The TRE should support most applications that transmit redundant information. Similar data may be observed across different applications, e.g., mail attachments may repeat data transmitted by the file system, FTP or web browsing. This calls for the implementation of a standard TRE at the transport layer.

3) Stateless:

Servers should be able to perform equally well for both persistent and casual clients. Note that most middle box solutions assume that the server side middle box is aware of the state of the client side middle boxes.

4) High Server Performance:

The additional TRE computations should minimize the performance impair of servers. In particular, it should limit the size of a TRE specific buffering and the amount of processing overheads due to expensive lookups and data computations. For smooth integration of TRE standards, the TRE solution itself should not become the server side bottleneck.

5) Minimum Impact on End-To-End Latency:

TRE protocols introduce additional traffic latencies even when TRE is not in effect. The standard TRE should minimize additional latencies.

The source node caches the data it has sent out and the receiver also caches its received data. When a source node begins to send out packets, it scans the content for duplicated chunks in its cache. If the sender finds a duplicated chunk and it knows that the AP receiver has received this chunk before, it replaces this chunk with its signature (i.e., SHA-1 hash value). When the AP receives the signature, it searches the signature in its local cache. If the AP caches the chunk associated with the signature, it sends a confirmation message to the sender and replaces the signature with the matched data chunk. Otherwise, the AP requests the chunk of the signature from the sender. The reduction in the size of the message increases the scheduling feasibility of the mobile nodes, which further enhances the QoS performance of the system.

V. CONCLUSION

Hybrid wireless networks that integrate MANETs and infrastructure wireless networks have proven to be a better network structure for the next generation networks. However, little effort has been devoted to supporting QoS routing in hybrid networks. Direct adoption of the QoS routing techniques in MANETs into hybrid networks inherits their drawbacks. In this paper Adaptive resource management is proposed to support quality of service in hybrid wireless network. The Admission controller algorithm chooses guaranteed neighbors for packet forwarding. The Encryption algorithm will encrypt the source node before forwarding the packets to the neighbor nodes. The Channel assignment algorithm implements the self-interference and co-channel interference to avoid traffic in the network. The packet scheduling algorithm schedules the packet to further reduce the transmission time. The mobility-based packet resizing algorithm resizes packets and assigns smaller packets to nodes with faster mobility to guarantee the routing QoS in a highly mobile environment.

The redundancy elimination algorithm eliminates the redundant data in the packet.

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