Bandwidth Reservation Based QoS Model For Multi Hop Ad Hoc Networks

M.SULLEMAN MEMON
Department of CSE/IT
QUEST, Nawabshah
PAKISTAN

MANZOOR HASHMANI
Department of CSE/IT
MUET, Jamshoro
PAKISTAN

NIAZ A.MEMON
Department of CSE/IT
QUEST, Nawabshah
PAKISTAN

Abstract: This paper proposes a model for providing assurances of QoS in multi hop ad hoc networks. Different applications have different requirements regarding QoS and their associated parameters are also different. Here we have concentrated upon one of those parameters, i.e., bandwidth reservation. Our model is designed not only on the basis of conceptualization but we have considered the basic functionalities available in networking equipments like routers etc. We also propose the design of a middleware and its components which are required for optimizing QoS. These elements are QoS aware application, admission control, resource reservation, policy control and a feedback module. Finally we discuss our future work to find the primary and alternative route to the destinations by keeping the bandwidth constraints in mind.

Keywords: Multi hop, Ad hoc Networks, Packet Classifier, Resource Reservation, Quality of Service, Real Time Applications

1. Introduction

From the two architectural designs given in [1], ad hoc networks are 2nd approach that does not rely on stationary infrastructure. Ad hoc networks are formed in situations where mobile computing devices require networking applications while a fixed network infrastructure is not available or not preferred to be used. In these situations mobile devices could setup possibly short-lived network for the communication needs of the moment, in other words ad hoc network. **Fig.No.1** gives conceptually the idea of Fixed and Multi hop ad hoc network.

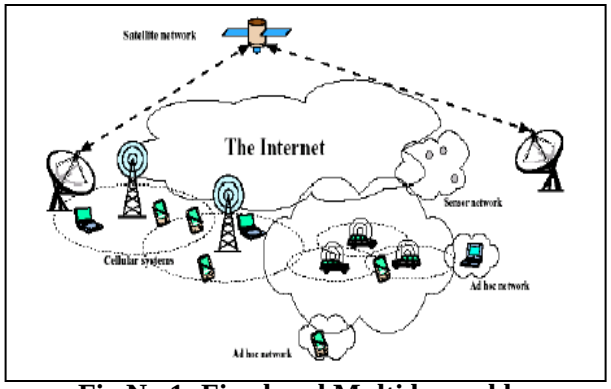

Fig.No.1: Fixed and Multi hop ad hoc Network Environments

Multi hop ad hoc network are formed by a group of mobile users or mobile devices spread over a certain geographical area. We call the users or devices forming network as nodes. The services area of ad hoc network is whole geographical area where nodes are distributed [2]. Each node is equipped with a radio transmitter and receiver, which allow it to communicate with other nodes [3]. As different nodes crates a multi hop ad hoc network among themselves without using any administrative support [4]. Ad hoc wireless networks are self-organized, self-creating and self administrating. They come into being solely by interactions among their constituent wireless mobile nodes, and it is only such interactions that are used to provide the necessary control and administration functions supporting such networks. Each node of ad hoc network can generate data for any other node in network [5]. A mobile ad hoc network may be connected through dedicated gateways or nodes functioning as gateways, to other fixed networks or the Internet. In this case the mobile ad hoc network expends the access to fixed network services [6].
Therefore, all nodes can function, if needed, as relay station for data packets, to be routed to their

destinations. Thus a node in ad hoc network operates both as host and router.

2. Problems and Issues

The absence of fixed infrastructure makes the nodes to communicate directly with one another in peer-to-peer fashion. The mobility of these nodes imposes limitations on their power capacity and on their transmission range [7]. As the nodes move in out of range with respect to other nodes, resulting that topology becomes dynamically changeable. In accommodating the communication needs of user applications, the limited bandwidth of wireless channels and their generally hostile transmission characteristics impose additional constraints with respect that how much administrative and control information may be exchanged and how often [8]. Effective routing is one of the great challenges of multi hop ad hoc network [9].

The frequent path breaks due to the mobility, difficulty of time synchronization that consumes bandwidth, bandwidth reservation that requires complex medium access protocol and cost of an elegant mobile host are major problems with multi hop ad hoc networks [10]. Where as medium access schemes, routing, multicasting, transport layer protocol, pricing schemes, self organization, security, energy management, addressing, service discovery, scalability, deployment consideration and above all Quality of Services (QoS) are major solvable issues to mobile ad hoc networks [11].

3. Motivation

Rapid adoption of wireless technology continues; coupled with the explosive growth of the Internet, it is clear that there will be increasing demand for wireless data services.

A user node in a multi hop network has to transmit both relayed and its own traffic. Also it has to maintain the routing information of the network. **Fig.No.2** shows a simple multi hop ad hoc network. In this network, node A is the source node (VoD Server) and node B is destination node (VoD Client/Player). If node A transmits data to node B, it has to get help of various intermediate nodes. So data has to move from multiple hops before reaching to destination and there can be congestion at any intermediate node. The topology is very much dynamic in such multi hop networks as any mobile node can vanish due to any reason and we have to ensure continuous connectivity for a mobile unit.

For this the routing algorithms and protocols should be capable of keeping up with drastically and unpredictably changing network topology, with minimized message exchanges, in a fully distributed way. Most proposed ad hoc routing protocols, such as destination-sequenced distance vector (DSDV), ad hoc on demand distance vector (AODV), and dynamic source routing (DSR), adopt the content of routing information from the Internet protocols and react to topology changes [12].

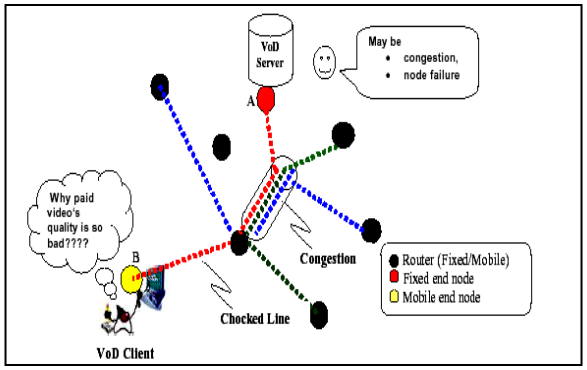

Fig.No.2: Multi hop Ad hoc Network

4. QoS

QoS is the performance level of service offered by the network to the user [13]. The goal of provisioning of QoS is to achieve a more deterministic network behavior, so that information can be better utilized. A network or service provider can offer different kinds of services to the user. A service can be characterized by a set of measurable and specified service requirements as here in our paper we are concentrating on bandwidth reservation [14].

After accepting a service request from user, the network has to ensure that service requirements of a user's flow are as per agreement throughout the duration of transmission of packets stream from source to destination.

4.1. Bandwidth Reservation for QoS

In multi hop ad hoc networks host's available bandwidth is not only decided by the raw channel bandwidth but also by its neighbor's bandwidth usage and interferences caused by other resources, each of which reduces a host's available bandwidth

for transmitting data [15]. Application can not properly optimize their coding rate without knowledge of the status of the entire network. Thus bandwidth estimation is a fundament function that is needed to provide QoS in multi hop ad hoc networks.

However bandwidth estimation is quietly difficult because each host has imprecise knowledge about network status and links change dynamically. Therefore an effective bandwidth estimation scheme is highly desirable. Bandwidth estimation / reservation can be done using various methods. We propose a QoS model and its tentative flow of control for bandwidth estimation and reservation to provide QoS to the user application.

5. Related Research Work

5.1 QoS Support

Previous work shows that research has been done in this field to support QoS in the areas of designing of QoS model, designing of QoS routing protocols, designing of signaling procedures and designing of QoS MAC protocols. In this paper we have covered the initial area of QoS support and we have proposed a QoS model based on certain constraints for providing QoS to application.

We believe that QoS support can be achieved by either finding a route to satisfy the application requirements or by offering network feedback to the application when requirements can not be met. Some applications require minimum bandwidth support. If the minimum bandwidth can not be met, all data will be useless. Thus, it is better not to transmit; this is done by an efficient admission control scheme. Our proposed QoS model supports both feedback and admission control scheme in a well managed way.

5.2 QoS Routing

QoS routing offers serious challenges for different service types, e.g., voice, live video and document transfer require different amount of bandwidth and all other different conditions. A lot of work has been done for the solution of best result oriented routing in ad hoc networks.

Ad hoc routing protocols may be categorized as *proactive* and *on-demand*. The proactive protocols from time to time spread routing information among all the nodes in the network, so that every node has the up-to-date information for all possible routes. On-demand routing protocols operate on a need basis, discover and maintain only active routes that are currently used for delivering data packets.

Many of routing protocols as DSDV, WRP, FSR, AODV, DSR and CBRP etc in unicast and AOMDV, SMR, AODVM, MSR etc in multi cast for the above said categories are proposed but they do not support QoS. At the same time a number of protocols such as TBP, PLBQR, and QoSAODV etc are available that support QoS, but we are considering only those which are related to bandwidth reservation based routing. CEDAR supports this issue. In Core-Extraction Distributed Ad hoc Routing (CEDAR) algorithm [16] bandwidth information is advertised by the core nodes along with their link-state updates, to identify and avoid congested parts of the network. A Multi-Path QoS Routing protocol based on the ticket-based probing technique proposed in [17] that also service this purpose. Tickets are used to limit the spreading of route-request messages. Many other protocols are also available which focuses the bandwidth reservation constraint Few of those are BR, OQR, OLMQR etc and a lot of work is still in progress by different researchers in this regard.

At this point of time when we are at the stage of model design and its validation, we can not say exactly about our future research dimensions for the specific routing protocol but with respect to our suggested QoS model we have evaluated few important ideas, those are discussed in section 7.

6. Proposed Architectural Model

As stated earlier, our objective is to enable an ad hoc network to provide assurances on Quality of Service (QoS). There could be many solutions to this problem. However, here we have proposed an architectural model that is on the basis of bandwidth reservation. The model is organized in two parts. First part handles the matters pertaining to the reservation of bandwidth and second part specifies the policy to achieve the results of first part by applying certain constraints.

6.1 Traffic Contract (Reserve Bandwidth)

Our idea is to discriminate traffic on the basis of their priority. The high priority traffic (paid accordingly) would have a contract with the network. This contract may consists of various parameters including but not limited to the amount

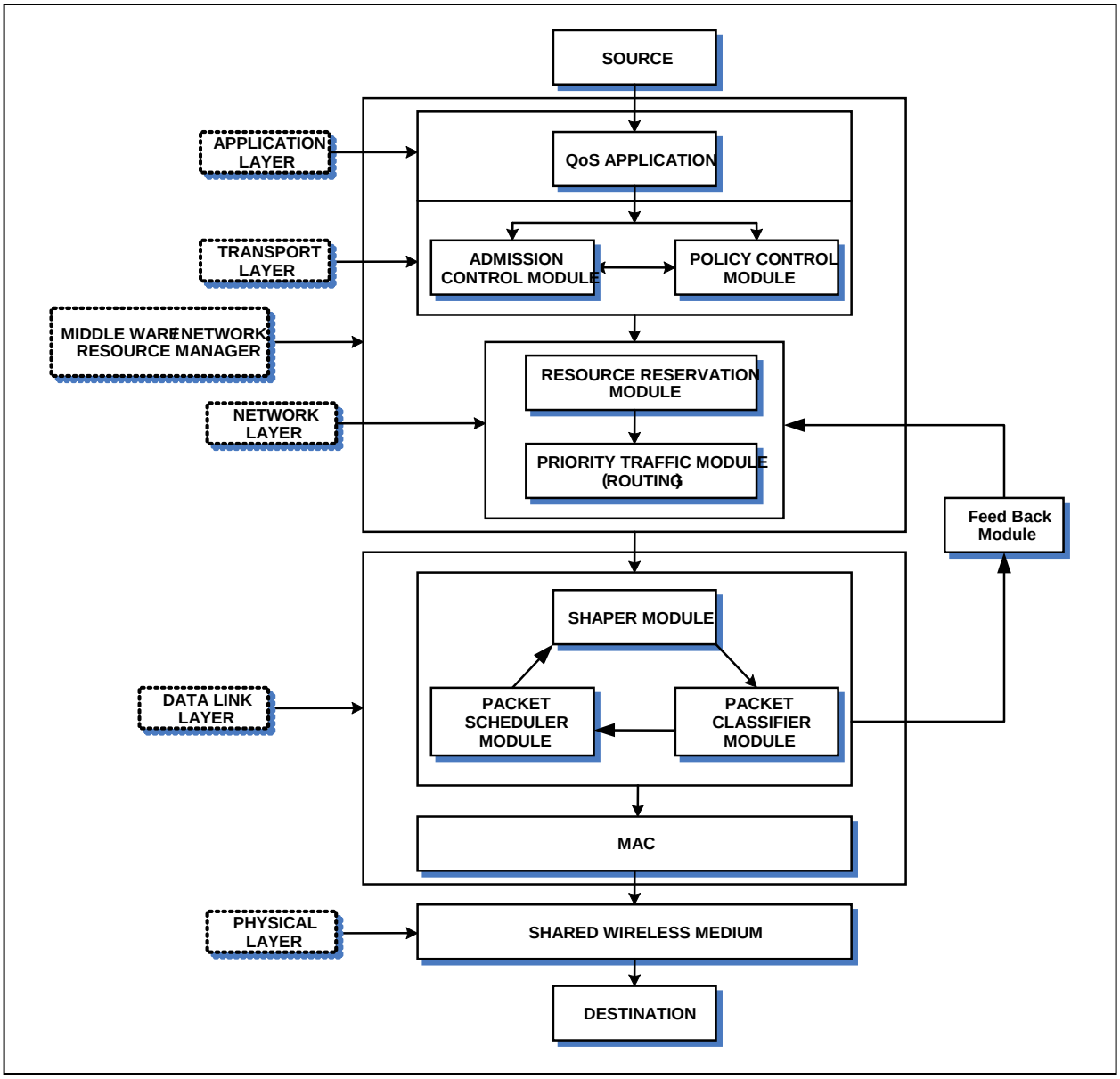

Fig.No.3: QoS Model

of bandwidth to be used and the duration of time for which it is to be used. These contracts would enable the network to determine the needs of the users and the available network capacity. The network resource manager (a middle that we have designed), would ensure that the contract do not go beyond the network capacity. In **Fig.No.3** the proposed design of model is given, which contains the QoS Application Module, Admission Control Module, Resource Reservation Module and Policy Control Module. We expect that the modules of design will perform the following functionalities:

i) QoS application: This is a real time application, demanding QoS. This includes Audio, Video or Voice applications.

ii) Admission Control Module: This module is responsible for accepting or rejecting a new QoS request. If the required resources are available, the request is accepted otherwise the request will be rejected.

iii) Resource Reservation Module: This module is responsible for reservation of resource for the real time application. Once resources reserved, these resources will be used by that application only.

iv) Policy Control Module: This module will be responsible for forcing the over all policy of the QoS architecture. This module includes the rules and regulations for resource reservation and other related issues.

6.2 Contract Enforcement (Policing, Shaping, Etc)

In order to ensure the assurances for the QoS of the network to the users, it is also necessary that the users give honor to their contract. However, one can not leave contract enforcement on the will of users, because it is likely that some of the users would not be able to fulfill their contract intentionally or unintentionally. If some users do not fulfill their contract and uses network resource more than allocated to them, the network would not be able to fulfill its guarantees to other users as well. Therefore, we need to make sure that all users behave according to their agreement made with the network. For implementing this behavior we have designed "**Contract Enforcer"** and we intend to implement this "**Contract Enforcer"** on the routers**.** This contract enforcer would enforce user contracts by ***policing*** (dropping packets which are not within the scope of the contract) and ***shaping*** (smoothing if out of the format of the traffic so as to make it compliant with the contract).Our proposed design contain three modules for implementation of this contract enforcement as Shaper Module, Packet Classifier Module and Packet Scheduler Module. The functionalities of the modules are expected as follows:

i) Shaper Module: The shaper module is responsible for making the packet into its agreed upon format. If the sender is violating the size and frequency of the packet, it re-shapes the packet accordingly.

ii) Packet Classifier Module: This module is responsible for classifying the incoming packets according to the agreement. After classification, the packets are put into the appropriate queue.

iii) Packet Scheduler Module: This component is responsible for sending the packets to the outgoing interface depending upon its priority. The high priority packets are sent to the outgoing interface before the low priority packets, this providing service differentiation.

iv) Feedback Module: This module is responsible to acquire data from the lower layer devices (routers etc), analyze that data to verify compliance of the contract for a particular communication. If that particular communication is found to be non-compliant, report it to the middleware for an appropriate decision. Feedback module may also verify if the allocated resources have, indeed been provided to that particular communication.

7. Future Work

Routes in ad hoc networks are very dynamic and may change frequently for an application during the session. Therefore an other route is required to be determined. We intend to handle this issue for our future work in a way that:

i) Normally found route for the transmission of QoS requiring application is **Primary Route,** now we wish to find an **Alternative Route** as the primary route becomes unavailable due to the dynamical topology change.

ii) Second approach is to find **Primary** and **Alternative Routes** before the communication begins so that the delay can be controlled which takes time to find an alternative route.

Currently we are in the process of doing simulations to evaluate these two approaches. Based on the analysis of the obtained results, it is also possible that a combination of the two may be more feasible.

8. Summary and Conclusion

In this paper, we propose a model for providing Quality of Service (QoS) on multi hop ad hoc networks using bandwidth reservation. This architecture provides assurance of a particular service level to the users of the network by;

1. Allocating and reserving the required bandwidth, and,
2. Making sure that no user uses more bandwidth than its due share (reserved) by using policing, shaping and dropping.

References:

[1] J. Jubin and J. D. Tornow. The DARPA Packet Radio Network Protocols. In Proceedings of the IEEE, volume 75, 1, pages 21--32, Jan. 1987.

[2] Hashmani.M "Network Management Ensuring QoS According to Contents Policies," Euromedia2002, April 15-17, Modena, Italy.

[3] B. M. Leiner, D. L. Nielson, and F. A. Tobagi. Issues in Packet Radio Network Design. Proceedings of the IEEE Special issue on ‘‘Packet Radio Networks", 75, 1:6--20, 1987.

[4] T. S. Rappaport et al., “Wireless Communications: Past Events and a Future Perspective,” IEEE Communication Magazine, vol. 40, May 2002, pp.

[5] Hashmani.M “Network Functionalities Necessary for QoS Service Provisioning,” International Workshop on Next Generation Internet and its Applications (IWS2001), February 21-23, 2001, Tokyo, Japan.

[6] C. E. Perkins and P. Bhagwat. Highly dynamic destination-sequenced distance-vector routing (DSDV) for mobile computers. In *Proceedings of the SIGCOMM 94 Conference on Communications Architectures, Protocols and Applications*, pages 234–244, August 1994.

[7] C. E. Perkins, E. M. Belding-Royer, and S. R. Das. Ad hoc on-demand distance vector (AODV) routing. *IETF Internet Draft.* http://www.ietf.org/internetdrafts/draft-ietf-anetaodv-13.txt,February 2003.

[8] D. B. Johnson and D. A. Maltz. Dynamic source routing in ad hoc wireless networks. *Mobile Computing*, pages 153–181, 1996.

[9] Hashmani. M “Design and Deployment of QoS Enabled Network for Contents Businesses,” International Conference on Computer Communications (ICCC’99), Sep 14-16, 1999, Tokyo, Japan.

[10] Bharghavan, Sinha, Sivakumar,”CEDAR: A Core- Extraction Distributed Ad hoc Routing Algorithm”, IEEE Journal on selected areas in communication, Vol. 14(1) pp.61-72, Jan 1999.

[11] Liao, Sheu, Tseng, Wang: ”A Multi-Path QoS Routing Protocol in a Wireless Mobile Ad hoc Network”, presented at International conference on Mobile computing and networking, Italy 2001.

[12] Chen, Nahrstedt: ”Distributed Quality-of-Service Routing in Ad hoc Networks”, ACM computer communication review (CCR), 27(5), 1999.

[13] I. D. Chakeres and E. M. Belding-Royer. AODV Implementation Design and Performance Evaluation. To appear in a special issue on Wireless Ad Hoc Networking of the International Journal of Wireless and Mobile Computing (IJWMC), 2005.

[14] Hashmani.M “Server-Based Inter-Domain QoS Routing: Cost Evaluation and Decision Enforcement,” International Conference on Advances in Infrastructure for Electronic Business, Science, and Education on the Internet, August 06-12, 2001, L’Aquila, Italy.

[15] C.-K. Toh. Associativity-based routing for ad hoc mobile networks. *Wireless Personal Communication Journal, 4(2) 103-139, Marc 1997.*

[16] Z. Wing and J. Crowcroft, Quality of service routing in ad hoc networks using a spine, IEEE Intl. Conf. on Communications ICC’97), Las Vegas, Sept. 1997.

[17] E. Crawley, R.Nair et al , A framework for QoS-based routing in the Internet, http://www.ietf.org/rfc/rfc2386.txt, Aug. 1998.