A Framework for QoS Management and Contract Enforced Services in MANETs for Prioritized Traffic Environment

M. Sulleman Memon†, Manzoor Hashmani†† and Niaz A. Memon†††

†, ††† Department of CSE/IT, Quaid e Awam UEST, Nawabshah 67480, Pakistan
†† Department of CSE/SWE, Mehran UET, Jamshoro 76062, Pakistan

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Summary
In many performance oriented applications like cooperative information sharing, defense applications, disaster management, mission critical applications and commercial production applications End to end QoS is a very critical issue. They all require connectivity like leased lines of conventional networks that remain difficult in MANETs due to changing topology, minimum bandwidth and routing problems but all this can be managed by using an excellent QoS Management Control with the support of a Contract Enforced Agreements. In this paper we have addressed both issues and have proposed design, functions and even implementing mechanisms of Contract Enforced Agreement with its postulates and QoS Management Control with its mechanism to support QoS in MANETS.

Key words:
QoS Management, Contract Enforcement, Pricing Pitch, QoS Resource Reservation, Prioritized Traffic.

1. Introduction

MANETs have potential to provide mobile computing capacity in situations where an efficient, economical and rapid deployment of communication is required and where the use of wired / infrastructure based network is too expensive or impractical such as disaster and rural areas[1]. In these situations, mobile devices could set up possibly short-lived network for the communication needs split second [2]. Multi hop ad hoc networks may be connected through dedicated gateways or nodes to the other fixed networks. Fig No.1 sows the scenario for fixed and Ad hoc networks.

The nodes in ad hoc networks are mostly the PDA's, Laptops or sensors those have many constraints on them with respect to bandwidth, power, processing and other wireless capabilities. They share each other communication facilities in order to achieve overall system connectivity. One node by itself, with such limited characteristics, is not capable of large communication range, but when nodes collaborate helping each other in forwarding information from source to destination , the total value of network is much higher than the sum of communication span of each node [3].

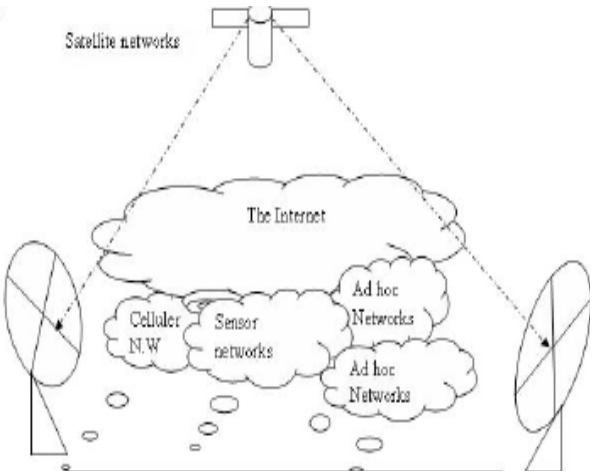

Fig No.1 Scenario for Fixed and Ad hoc networks.

There is a variety of fields where ad hoc networks are used such as cooperative information sharing, defense applications, disaster management but mission critical applications and commercial production applications are new, most demanding, attention appealing and market oriented fields of applications for these networks which mostly , contain real time audio and video streams and require absolute guarantee for QoS. QoS means minimum bandwidth; minimum delay and jitter guarantee and Contract based enforced service agreements. Different applications have different requirements regarding QoS and their associated parameters regarding routing and QoS management conditions remain also different. For example in mission critical and commercial applications the key attribute for guarantying for QoS is, they need routing path for connectivity like virtual leased line that is very difficult in the scenario of mobile ad hoc networks due to the mobility of nodes and changing topology conditions. Some of the prominent features that characterize MANETs are dynamic topology, Bandwidth constraints etc. in particular to provide QoS and manage it is quite difficult task. Therefore, it is a big challenge but it is very necessary to give affordable solution [4]. In MANETs Bandwidth, delay and jitter are commonly considered as the metrics for QoS enabled networks. From which again bandwidth reservation schemes can be categorized to work

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in two sections. One is about the bandwidth management and second is related to routing for suitable path [5].

On the other hand here the second issue is occurrence of different types of traffic in the presence of those different traffics how one can be assured to get best service from the network, even if ready to pay extra. The most common solution to this is to classify the traffic in different categories and give certain priority levels to each type of traffic according to their service level agreement for that they pay. According to those priorities network will provide a specific type of service to that particular traffic. Further more network provide advance resource reservation for traffic type that will pay extra and give priority routing facilities to those prioritized traffics according to their service agreements with network.

In hostile environment where MANETs are deployed with limited resources, service differentiations and dynamic bandwidth management can help to avoid graceful degradation of performance and enhance the overall survivability of the network. Various aspects of providing QoS in MANETs are studied like QoS architecture, QoS Resource reservation, QoS routing but QoS management[6]. The end to end QoS management is a very tricky task and support to QoS provisioning and QoS management in MANETs is not yet well understood and still is open area of research.

2. Literature Review

A lot of work has been performed on MANETs but to optimize QoS in ad hoc networks is still an open issue for research and QoS Management is burning and hot section of that. Therefore the study of network with its QoS Management issues is still lacking.

W. Chen in [7] propose ANMP protocol that addressed the problems like temporary deployment, limited survivability, heterogeneity, limited resources, low bandwidth and dynamic topology changes in MANETs. It gives two algorithms dealing with message overhead but still lacks to address QoS issues. Same work was extended by Yong in [8] by giving algorithm for finding relative mobility among nodes in unidirectional links.

In [9] D. Kidston performs well by addressing real life ad hoc environment as C-WAN. In C-WAN problems like heterogeneity, low bandwidth, scalability and interoperability were addressed. Frame work for security and QoS management was given but unfortunately no practical performance comes on this work. The authors also give CORBA to avoid some problems encountered in ANMP.

J. Brand in [10] gives a solution for QoS management in military environment MANETs which specially deals with low bandwidth. In this research C2 model was introduced for storing logical and tactical network information. In C2 issues like network planning, operations and reconfiguration of network were discussed.

I. Marshal in [11] gives a solution for adaptive and automatic manageable for ad hoc network by proposing two algorithms as bacterial colony and genetic algorithms. The model was designed to function on increased network load, load balancing, induction of new policies and services, price schemes for real traffic streams etc. As over all this was a brilliant piece of work.

3. Attributes for QoS in MANETS

3.1 QoS Architecture

In [12] authors, propose a framework for QoS model that was suppose to serve for different categories of traffic types according to specific condition of service contract. With many other features delay control, admission control, policy control, classification, shaping, feedback control, scheduling, traffic control and contract enforcement are distinguishing feature of the model.

The authors conclude in paper that a good strategic traffic management approach is needed to handle different categories of traffic on their priority and fine resource reservation policy for routing is required to acquire the required end to end QoS in multi hop ad hoc networks. The current paper discovers the tentative solution to these issues.

3.2 QoS Routing

The routing protocol is the element responsible for determining the best route from source to destination. After route is determined the forwarding mechanism processes the packets according to the information in the routing tables. Topology may change during session life time requiring the routing protocol to react and update routes between end points. Because the nature of ad hoc networks routing protocols should be highly dynamic and robust [13].

In [14] authors make a detailed review for proactive routing protocols and make a detailed study about very important protocols with respect to their design, rout finding process, advantages, disadvantages, their QoS support, their compatibility with simulators etc. Authors propose to use some cluster based, OSLR, CEDAR or DSDV/TDMA type of protocols with little modifications from the proactive category to support the route break predictions, bandwidth estimations, resource reservations and having the facility to maintain more than one path available in advance to destination.

3.3 QoS Resource Reservations

Real time audio and video streams and require absolute end to end guarantee for QoS. The key attribute these applications for guarantying for QoS is, they need routing path for connectivity like virtual leased line that is very difficult in the scenario of mobile ad hoc networks due to the mobility of nodes and changing topology conditions. With respect to transfer the contents, resources are required to be reserved along the selected path(s).Regardless of old load balancing and redundant path schemes in [15] authors introduced entirely a new approach in which authors find multiple paths and select best three from all those as primary, secondary and ternary on certain criteria of maximum bandwidth and minimum hopes and these paths must be loop free and node disjoined. Resources are reserved on both primary and secondary paths and allocate those reserved resources to different categories of traffic according to their priority on the basis of service agreement made with network. Authors designed the complete package of policies and their relevant algorithm for implementation mechanism for allocating the resources to different priority traffics and tried to avoid the route breaks.

3.4 QoS Management

QoS guarantee require some management and management is performed through some policy which address many matters regarding QoS issues as QoS measurement, price pitches [16], security etc. Therefore QoS management is a backbone foe any network to make it advantageous and more reliable about agreements.

Management System allows to discover the capabilities of the network, maintain up to date knowledge about network topology, collect information about application/user involved, keep track of network utilization. It discover problems such as failure of network elements etc. it also allows to configure the various network elements and determines relationship among them.

4. Contract Enforcement and QoS Management

4.1 Contract Enforcement

In a scenario, where network is providing different nature of services to different users on their priority (in accordance to the category of traffic and the order of payment linear to the mode of service and priority), it is necessary that require QoS must be provided to the legitimate customer/user. In order to ensure 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 network need a “Contract Enforcer” and that intend to implement this “Contract Enforcer” on the routers. Contract Enforcement can be sectioned as its design and agreement of services offered.

4.1.1 Proposed Design of Contract Enforce

When a customer wants to use a service offered by a service provider, an agreement is needed. That agreement is a though a formal negotiated agreement between a service provider and its customer. The contract involves functional and nonfunctional parameters related to service. The high level of interpretability offers intra domain and cross domain services. We suggest that 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:

1) 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.

2) 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.

3) 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.

4) 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. Fig No.2 shows the design of Contract Enforcer and its link with resource reservation Schemes module

4.1.2 Contract of Service

Contract of Service is commonly known as SLA (Service Level Agreement) is actually a mutually negotiated contract between client/user and network/service provider which contain some functional and nonfunctional parameters related to the service to be provided1[17].

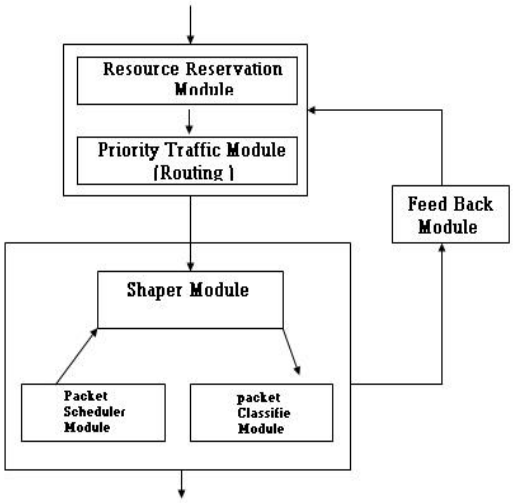

Fig No.2: Design of Contract Enforcer and its link with resource reservation Schemes module

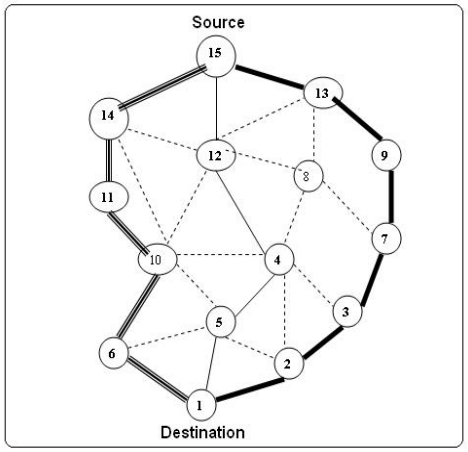

Fig. 3: Intra Domain Services to Resource Reservation

Normally Service Agreements are made in two modes:

1) User with its local network (Intra domain). Figure 3 shows the resource reservation on different paths [18] and concept of in Intra domain services.

2) Network to network (Inter Domain). Figure No 4 highlights the concept of Inter Domain services agreed by two different domains having user in one and client in other domain.

In Inter Domain Services the problem became complex because in that case service may be result of the composite of services deployed in many administrative domains, every domain autonomously manages resource reservation policies by means of some quantitative and qualitative measures diverse to each other in management. In figure 4 we have designed the explained scenario. The quality of final service delivery to customer is strongly affected by those services employed to composite it.

In MANETS where resources availability is very dynamic and topology is changing every time, promising and guaranteeing specific QoS levels to the customer is a big and real challenge. Authors have given the solution to this in [19] by introducing advance resource reservation schemes.

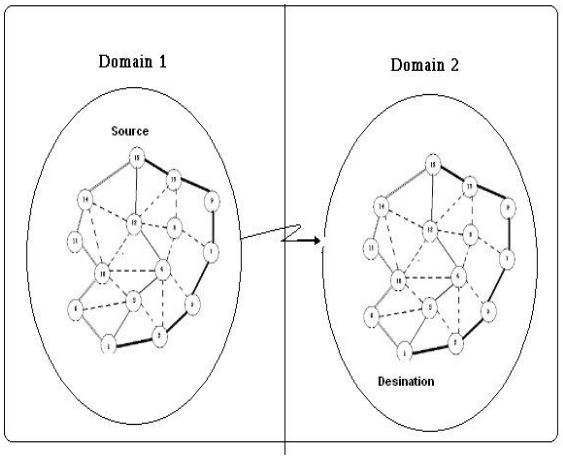

Fig. 4: Scenario of services offered in two different domains having source at one and destination in other.

4.2 QoS Management

The need for QoS Management in MANETS must be maintained at functional state and network Management control must be automated in the light of Contract agreement. As we have already assume that network supports different types of traffics with their respective contract to provide them QoS up to a required level i.e. network will provide different queuing and scheduling for

different traffics and this will combined with QoS management mechanisms that will distinguish and provide preferential treatment to high priority traffic. In all this scenario Admission Control Module and Policy control Module of [15] will play a vital role. The second issue to QoS management will to QoS Control Policy (QCP). The main function of QCP will be to adopt changes of network and modify the network flow, their admission and provide agreed guarantees to users according to contract. Since bandwidth is a core problem in our research and it always change randomly therefore network must be adoptable and provide agreed QoS. For this we have given a solution of Pre-emption not allowed in [20], but it can be turned ON depending on network load/situation.

4.2.1 Proposed Design

Fig No.5 describes the minimum basic set entities for QoS Management Control involved from source to destination according to functions performed by each module in accordance of flow of information.

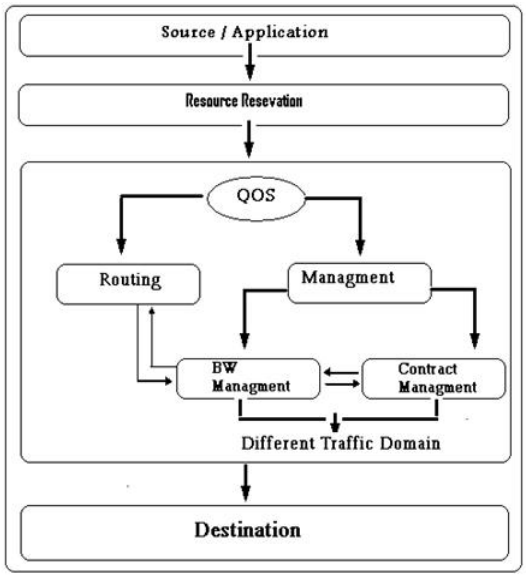

Fig. No 5: Proposed Design for QoS Management in MANETs

Above Figure shows that with respect to QoS matters, management is performed in two sections as Band Width Management and Contract Management. So as a matter of actions is needed, it is supposed that when ever an event in the shape of a request occurs from the use /client side for resource reservation the contract agreed conditions in the shape of policy will be applied by QoS management control as resource manager.

Figure 6 indicates the proposed place for implementing /placing for QoS Management Control (QMC). It clearly shows that each domain must have its own QMC so that terms and conditions with service supplier remain unchanged to user of specific domain. In the case of Inter domain conditions of service, only QMCs of each domain will contact for conditions of supply of service and user remain unaware of upper level situations.

4.2.2 SW Requirement of Design

1) Testbed: For the practical tesbest system, it is recommended that main API must be designed in JAVA or C. This design helps QMC to analyze and access the services performed by the resource reservation mechanism [15]. Resource reservation controller is also required to be developed in JDK. The depository System i.e. Dictionary, can be communicated through Light weight Directory Access Protocol. In this regard it is recommended to use JNDI (1.1.2) for communication. CORBA [21], web servers and protocols as COPS, ANMP etc are recommended to be used for communication between request/application and QMC or interpretability.

2) Simulation Experiments: Simulations can be performed by using common simulators available in market as NS2 or GUI based simulator OPNET. Both equally support ad hoc networks in a well manner.

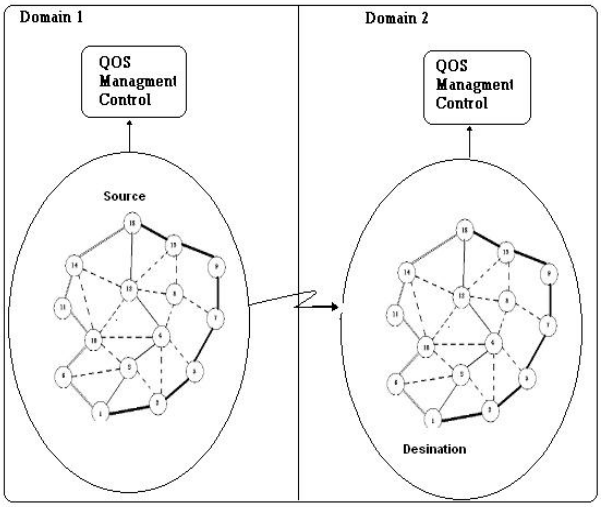

Fig. No: 6: QoS Management showing Control on networks in different domains

5. Example

For clear understanding, let us extend the example that we have given in [22]. Here a user/client of network request for VoD from a supplier but he is not getting required quality of video for which he pays to network due to the

congestion on line.

Now we extend it with respect to our new QoS Management frame work by supposing that supplier of VoD is in other domain that of user and user has given connectivity through different domains managed by his own domain's QoS Management Control. Now if we design the scenario then at its simplest state it will like Figure 7. Here there are two QoS Management domains and they must have service contract between them to specify terms and conditions if they use services of each other. Customer has to specify kind of service he desire and will bargain about his required QoS level. VoD supplier considers the QoS requirements of customer and either accept or reject by keeping in view his network position because he will need to use two types of services as Intra domain and Inter domain services those are not his control and he has to negotiate with other domain QoS Management Control about resources required by user i.e. path, bandwidth etc.

If we suppose that all dialogue for supply of service between all parties became successful then now Contract enforcement will be activated and an agreement between parties will be made about service.

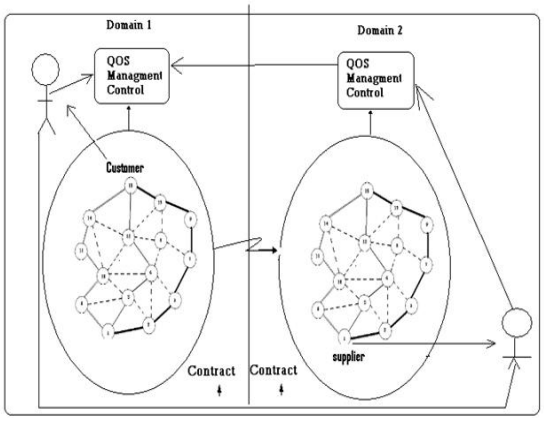

Fig. No: 7: A practical scenario for QoS Management for transferring VoD

6. Conclusion

In this paper authors have discussed very important issue of QoS management which is a backbone for the satisfaction of requirements of customer in the presence of different categories of traffics and their different terms and conditions with network. Authors have tried to give complete solution for QoS assurance in MANETs by giving proposal for the design of contract enforcer for implementing policies on network users according to agreement plus authors have given design of QoS management Control with all details of its model, SW requirements for its implementation etc.

7. Future Work

Authors have given an overall frame work scenario for general working conditions but still its design is an open issue and many thing like Delay Management, Future Reservation, Traffic analysis, Resource tracking, Bandwidth calculation, Heterogeneous router support, can be added to this design.

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M. Sulleman Memon received the B.E in Computer Engineering and M.E. in Software Engineering from Mehran University of Engineering & Technology, Jamshoro in 1990 and 2004, respectively. He is now a PhD scholar at Quaid e Awam University of Engineering and Technology, Nawabshah. He is expected to submit his thesis in September 2009. He is working as Assistant Professor in the Department of Computer Engineering and Information Technology, QUEST, Nawabshah. He is author of many International and national papers. He has presented his work at many countries of the word in International Conferences. His field of study is Wireless communications. He is Senior Member of IACSIT and member of Pakistan Engineering Council, ACM, and IEEE.

Professor Dr Manzoor Hashmani received his B.E. (Computer Systems Engineering) from Mehran University of Engineering & Technology, Jamshoro (Pakistan) in 1991, M.E in 1997 and Ph.D. in 1999 from Nara Institute of Science & Technology, Nara (Japan).He has authored and co-authored more than 30 research papers published in various journals and conferences of international repute. He is a member IEICE (Japan), IEEE Communications Society (USA), and Pakistan Engineering Council. His research areas of interest include: High Speed Communication Networks, Software Engineering and Alternative Energy.

Professor Dr Niaz Ahmed Memon received his B.E. degree from NED University, Karachi, Pakistan in 1986. He received his PhD in Computer Engineering from UK in 1994. He has a very vast field experience and presently working as Professor and Chairman of CSE/IT at QUEST, Nawabshah, Pakistan from last 5 years. He is author of many International and national papers. His work has been presented in many countries of the word in International Conferences. He is member of ACM, PEC, IEEE and many statutory bodies of university. His fields of interests are Mobile computing, Gird Computing and Software Engineering.