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QoS providence and Management in Mobile Ad-hoc networks

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Abstract. Mobile Ad-hoc networks are Multihop networks, because the nodes participating in MANET are considered as end hosts and routers. At present one of the main issues related to mobile Ad-hoc networks is the provisioning and management of Quality of Service (QoS).The basic theme of this paper is to review the literature and critically evaluate the issues of how QoS should be provided to the Mobile nodes in Mobile Ad-hoc networks, keeping in view the bandwidth constraints. It will also show some protocols for the management of QoS in the Mobile Ad-hoc networks, which is a key issue to be coped with. This study will discuss some problems that may occur in providing QoS to Mobile nodes in Mobile Ad-hoc networks and solution for managing those problems, like dynamic topologies, that change continuously and unpredictable at any time. Currently researchers are working on certain aspects of the QoS in MANET including QoS Routing, QoS MAC and resource reservation. Even the proposed protocols are sufficient to meet the QoS need under certain assumptions; none of them proposes a QoS model for MANETs. A QoS model for MANET should also consider features of MANET like dynamic Topology, time varying link capacity, and limited power. This study will evaluate certain QoS models that can cope with these issues related to the QoS Provisioning and management in MANETs.

Keywords: QoS, MANET, SWAN, CEQMM, FQMM, IntServ, DiffServ

1. Introduction

Mobile Ad-hoc networks (MANETs) are going to be a great evolution in wireless networks. They provide a great way of constructing networks without the need for a specific infrastructure. It is because the nodes in the MANETs are free to move at any time to any place, causes the topology to change continuously. Also there is no need of specialized router's that manages the communication between these nodes. In MANETs each node act as a end-hosts and as a router to relay information among end-nodes making communication possible. QoS is a collection of rules and/or characteristics that a connection must guarantee in order to meet the requirements of a particular application [1]. QoS mechanisms are of great concern in case of mobile Ad-hoc networks, where the bandwidth is limited and its efficient usage is very much needed. This paper is divided into different sections: The literature review section describes different models for providing QoS and protocols for managing QoS in mobile Ad-hoc networks. The latter section provides a critical evaluation of the issues described in literature review section and will further provide conclusion and future work that summarize the work done in this paper plus future directions in this area.

2. Literature Review

Mobile Ad-hoc networks are a refined version of the traditional wireless networks. Its structure is different as compared to the already in use wireless networks. It's a wireless network having no specific infrastructure, more dynamic topology that changes over time, less battery power of the nodes, less bandwidth and transmission quality enhancement. These attributes makes it difficulty in deploying them, particularly when the network size become very large and the mobility increases. The purpose of this literature review is to study various QoS models that can provide efficiency in providing QoS in mobile Ad-hoc networks. Further this review will look at different QOS aware routing protocols that can be used for proper management of QoS in mobile Ad-hoc networks. This section is thus divided into two parts. The first part provides a review of the QoS models already implemented for QoS providence in mobile Ad-hoc networks.The latter section describes various routing protocols for managing the QoS in the underlying mobile Ad-hoc networks.

3. QoS Providence in MANETs

Mobile Ad-hoc networks are self-organized in nature [2]. Mobile Ad-hoc networks are considered as dominating networks in the upcoming future. Today with the advent of new technologies and multimedia data, such as Video on Demand, VoIP, voice communication requires real time access. The multimedia data require some form of speed, more bandwidth and other resources to transfer it across the network. QoS is a collection of characteristics or constraints that a connection has to meet in order to guarantee the requirements of an application [1]. According to [1], connection is characterized by a set of measurable requirements like bandwidth, delay, and delay variance (jitter). Once a connection is accepted from the user, the network has to ensure that the requirements of the user's flow are met throughout the duration of the connection.

In 2004, [3] QoS architecture was proposed to support real time multimedia traffic across mobile Ad-hoc networks, include a QoS transport layer, QoS routing, Queue management, and a priority MAC protocol. The application layer categorizes the applications as real-time and best-effort on the basis of their requirement and sensitivity. The real-time applications are given high priority as compared to the best-effort packets. In the transport layer packets are transported to the application layer either using UDP or TCP based on their requirements. In the network layer the packets are routed using different QoS aware-protocols based on their sensitivity. The QoS adaptation provides an interface to the application that they can use to submit their requirements [4]. There are three adaptation strategies discussed: Greedy strategy, Bottleneck strategy, and fair strategy [4]. The strength of this study is that it provides a flexible approach of maintaining the reservations as the network conditions are changes rather than allowing the network to force a binary decision of admit/fail. The limitation of this work is that none of the adaptation strategy provides no guarantee of reacting to the QoS changing conditions, that is main issue to be tackled in case of dynamic networks like mobile Ad-hoc networks.

In order to support QoS in MANETs some level of service differentiation is needed to guarantee applications requirements. One challenge in supporting QOS for real-time applications is associated with the design of the medium access control (MAC) protocol. SWAN [5] is a simple, distributed, and stateless network model that uses feedback-based control mechanisms to support soft real-time services and service differentiation in wireless ad hoc networks. The strength of this work is that SWAN is independent of the underlying MAC layer, and can be potentially suited to a class of physical/data link wireless standards. Another aspect is that the total rate of SWAN performs Explicit Congestion Control (EFC) for coping with the congestion experienced in the network due to mobility or traffic overloaded conditions. The limitation of SWAN is that it does not require the support of a QoS capable MAC. Instead, soft real-time services are built using existing best effort wireless MAC technology.

According to [6], a network model is studied that provides service differentiation in mobile Ad-hoc networks that combines a full distributed admission control approach with DIFS based differentiation approach of IEEE 802.11. It provides different kinds of QoS for various applications. The Admission controllers determine a committed bandwidth based on the reserved bandwidth of flows and the source utilization of networks. Packets are marked when entering into networks by markers according to the committed rate. By the mark in the packet header, intermediate nodes handle the received packets in different manners to provide applications with the QoS corresponding to the pre-negotiated profile. The strength of this paper is that the proposed mechanism can provide QoS guarantee to assured service traffic. Additionally it increases the channel utilization of networks. However the major weakness in this work is that its throughput is less than other methods.

The IntServ and DiffServ models were mainly proposed for providing QOS across wire networks. In 2000, [7] a flexible QoS model for mobile Ad-hoc networks (FQMM) was proposed for providing QoS across mobile Ad-hoc networks. In FQMM the mobile nodes have dynamic roles, a hybrid provisioning scheme that combines the per-flow granularity of the IntServ and per-class granularity of the DiffServ, and a relative and adaptive profile for maintaining the service differentiation among the flows keeping up with the network dynamics. FQMM defines The main points of concerns of FQMM are: dynamic roles of the nodes, hybrid provisioning and adaptive conditioning. The limitation of this work is that it can only be used for small to medium size MANETs, with less than 50 nodes using a flat non-hierarchical topology.

TABLE 1
SUMMARY OF QOS MODELS FOR MANETs

Authors	Summary	Problem defined	Applicability	Limitation
Lei Chen and Wendi Heinzelman June 2004	QoS architecture support real time multimedia traffic across mobile Adhoc networks, include a QoS transport layer, QoS routing, Queue management, and a priority MAC protocol.	To support real time multimedia traffic across mobile Adhoc networks	QoS architecture can be used across a small to medium mobile adhoc networks having upto 50 nodes	The performance of multiple different priority streams has not been presented.
Gahng-Seop Ahn, Andrew T. Campbell 2002	Provides service differentiation in mobile Adhoc networks that combines a full distributed admission control approach with DIFS based differentiation approach of IEEE 802.11.	provides Service differentiation across mobile Adhoc networks .	More suitable for multi-hope MANETs having strong mobility across the wireless nodes.	The major weakness in this work is that its throughput is less than other methods.
Hannan XIAO1, Winston K.G 2000	FQMM combines the per-flow granularity of the IntServ and per-class granularity of the DiffServ, and a relative and adaptive profile for maintaining the service differentiation among the flows keeping up with the network dynamics	QoS providence and Service Differentiation in mobile adhoc networks.	More suitable for MANETs with small to medium size i.e 50 nodes having dynamic roles.	The problem is that it can only be used for small to medium size MANETs, with less than 50 nodes using a flat non-hierarchical topology.
Hakim Badis, and Khaldoun October 2006	Quality of service model for MANETs that uses the positive features of the IntServ and DiffServ making its best to provide the QoS according to the needs of the underling network.	To offer the application with different levels of priorities based on their needs and create traffic classes.	The proposed model is one of the best ever proposed model for MANETs environment and can be used in dynamically changing environment.	In case of continues movement of nodes, the average delay is around 400 ms [8], which is the maximum delay allowed for most of the real-time applications that leads to more packets being dropped.

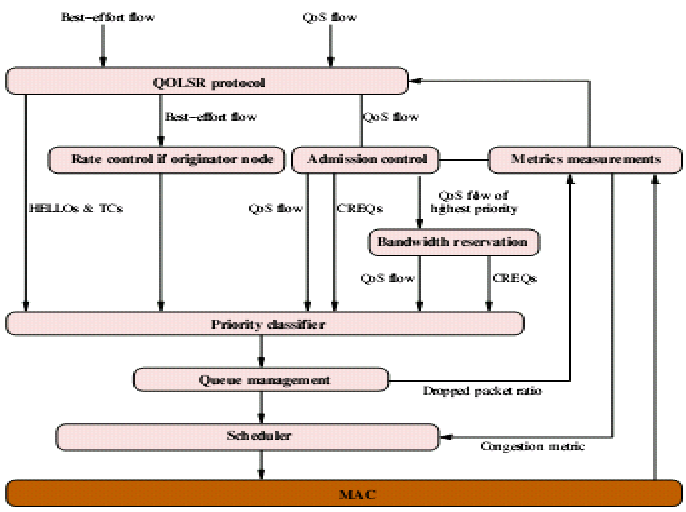

Figure 2 [8] CEQMM Architecture

CEQMM (Complete and efficient Quality of service model for MANET), is a Quality of service model for MANET, that uses the positive It uses a hybrid scheme by allowing both per-flow and per-class provisioning of services to the mobile nodes in the mobile Ad-hoc network. The strength of CEQMM uses the QOLSR protocol for supporting multiple-metric routing criteria and at to respond quickly in case of topological change. The CEQMM also provides a mechanism for congestion avoidance to avert the network from entering into a congested state. For this mechanism to work the CEQMM [8] three types of nodes: Ingress, Interior and Egress nodes. The Ingress node is outer/sender node, interior nodes are intermediate nodes that routes/forward the date as it receives from its destination node. The CEQMM integrates priority classifier, active queue management and packet scheduler to ensure that certain packets get high priority transmission than other packets. One limitation of implementing CEQMM for mobile Ad-hoc networks is that in case of continues movement of nodes, the average delay is around 400 ms [7], which is the maximum delay allowed for most of the real-time applications that leads to more packets being dropped. This shows that real-time applications suffer significant transmission delays under the intense movement situations.

4. QoS Management in MANETs

The characteristics of the MANETs have also led to the management problems, particularly related to the QoS management. The management solutions must be lightweight and easy to adopt in various situations, which requires less management overhead. There are several protocols developed that are used at several layers of the OSI model, that can improve the QoS performance in MANETs. The introduction of real-time audio, video and data services into mobile ad hoc mobile networks has created a number of potential problems that are due to the time-varying nature of the network topology, node connectivity and end-to-end quality of service (QoS). INSIGNA is a new in-band signaling system that supports QoS in mobile Ad-hoc networks [9]. In this case the term "in-band signaling" means that the control information is carried along with the actual data in the IP packets. The in-band signaling is more appropriate than that of explicit out-of-band approaches for supporting end-to-end quality of service in highly dynamic environments such as mobile Ad-hoc networks. According to [9], INSIGNIA is designed to support the delivery of the adaptive real-time services. The strength of this works is that it allows fast flow establishment, restoration and adaptation algorithms. It is very lightweight and responsive to the changing topological environment, node connectivity and changing QoS conditions. One limitation of this work is that Mobility often caused substantial link congestion and network partitioning. Also Adaptive real-time flows would be degraded to best-effort service due to lack of resources across the congested link.

Routing is used to set up and maintain paths between nodes to support data transmission between those nodes. In order to support QoS [10], the main problem is to find a route with sufficient available resources to meet the QoS constraints, and if possible add some additional optimization factors such as finding the lowest cost or more stable among the routes. AQOR is an on-demand QoS-aware routing protocol. In case a route is needed, the source host initiates a route request packets that contain bandwidth and end-to-end delay requirements. The intermediate nodes check their available bandwidth and perform bandwidth admission hop-by-hop. If the intermediate nodes have sufficient bandwidth to fulfill the requested needs, an entry will be created in the routing table in which expiration time is also mentioned. In case, where the reply packet does not arrive in the mentioned time, the entry will be deleted. According to [10] AQOR has the following features: available bandwidth estimation and end-to-end delay measurement, bandwidth reservation, and adaptive route recovery. The strength of this protocol is that if the reply packet does not arrive in the allotted time, the entry will be deleted reduce overhead. The problem in implementing this approach is the overhead in calculating the bandwidth of the neighbor nodes to fulfill needs of the real-time flow.

5. Critical Evaluation

QoS providence is one of the major issues related to the deployment of mobile Ad-hoc networks. In this section the existing work described regarding the issue of QoS providence and management across MANETs is critically evaluated. In previous section the QoS providence and management is discussed separately. Different QoS models were proposed to govern the QoS providence across MANETs. In Table 1 the summary of different QoS models for MANETs is given. Each QoS models has solved some problems like coping with the dynamic topology, bandwidth estimation, varying link capacities but none of them solved the issue completely. The SWAN was discussed that is independent of the underlying MAC layer, and can be potentially suited to a class of physical/data link wireless standards. Another aspect is that the total rate of SWAN performs Explicit Congestion Control (EFC) for coping with the congestion experienced in the network due to mobility or traffic overloaded conditions. But problem with SWAN is that it does not require the support of a QoS capable MAC. The FQMM model for MANETs was discussed that has features like: dynamic roles of the nodes, hybrid provisioning and adaptive conditioning. However this model can only be used for small to medium size MANETs, with less than 50 nodes using a flat non-hierarchical topology. Later on in 2006 another model CEQMM was proposed that also used the best features of the IntServ and

DiffServ. The problem in implementing CEQMM for mobile Ad-hoc networks is that in case of continues movement of nodes, the average delay is around 400 ms [7], which is the maximum delay allowed for most of the real-time applications that leads to more packets being dropped. This shows that real-time applications suffer significant transmission delays under the intense movement situations. Thus still work needs to be done in areas like dynamic topology, coping with mobility. The management of QoS across MANETs is almost very challenging.

Different QoS-aware protocols were proposed. The INSIGNA is an in-band signaling protocol, designed for MANETs. It allows fast flow establishment, restoration and adaptation algorithms. It is very lightweight and responsive to the changing topological environment, node connectivity and changing QoS conditions. However one problem is that Mobility often caused substantial link congestion and network partitioning. Also Adaptive real-time flows would be degraded to best-effort service due to lack of resources across the congested link. AQOR is an on-demand QoS-aware routing protocol. This protocol reduces the overhead by deleting the entry if the reply packet does not arrive in the allotted time. The problem in implementing this approach is the overhead in calculating the bandwidth of the neighbor nodes to fulfill needs of the real-time flow. The Ticket-based QoS protocol was proposed that uses tickets for finding bandwidth-constrained and delay-constrained paths. The major focus of this approach was that it incorporates the imprecision of each node's estimate of their neighbor's available resources for delay-aware and bandwidth-aware routing by using an imprecision model. The imprecision model uses a weight function with the variables of old bandwidth/delay state and new bandwidth/delay state to estimate the current bandwidth/delay within some precision tolerance. Additionally tickets are forwarded to provide multi-path searching for paths that satisfy the QoS constraints. The problem with this approach was that it does not perform bandwidth estimation. It is proactive in nature, thus not efficient in using it across MANETs. Different protocols were discussed that highlighted some problems and solved some of the problem, but none of them full solve the management of QoS across MANETs.

6. Conclusion And Future Work

In this study we have mainly focused on the QoS providence and management in mobile Ad-hoc networks. We have studied certain QoS models that provide architecture for providing QoS to the mobile nodes in the MANETs. One such model that we discussed is CEQMM (Complete and Efficient QoS model for MANETs) combines the quality attributes of IntServ and DiffServ and keeping in view the characteristics of the mobile Ad-hoc networks like dynamic topology and varying link of mobile nodes. Then we studied another model, FQMM (Flexible QoS model for mobile Ad-hoc network), that combines the attributes of the IntServ and DiffServ. We have reviewed certain protocols used for managing QoS in MANET like INSIGNA, QB-MAC and some QoS aware routing protocols consider the characteristics of the mobile Ad-hoc networks in this literature. INSIGNA uses in-band signaling in which control traffic is transmitted along with the data packets.

After studying various attributes of the MANETs and the requirements of various applications, still work need to be done to provide a stable and secure support for QoS in MANETs. Future work in this area can be divided into two parts QoS models for supporting QoS and QoS aware protocol to manage QoS providence in MANETs regarding routing, efficiency in managing the security.

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