JOURNAL OF COMPUTING TECHNOLOGIES

ISSN 2278 – 3814

Available online at www.jctjournals.com

Volume 1 , Issue 2 , June 2012

Survey on QoS Routing protocols challenges and recent advances in MANETs

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Abstract

Mobile Ad hoc networks are self configuring, there is no central management system with configuration responsibilities. All the mobile nodes can communicate with each other directly, if they are in each others wireless range. In order to enable data transfer they either communicate through single hop or through multiple hops with the help of intermediate nodes. Research for the introduction of the quality of service (QoS) has received much attention by the emergence of multimedia in mobile ad hoc networks. However, when designing a QoS solution, the estimation of the available resources still represents one of the main issues.

This article presents an ample review of MANET characteristics, QoS routing, QoS parameters, QoS Models, resources and factors affecting performance of QoS routing protocols. The relative strength, weakness and applicability of existing QoS routing protocols are also considered and compared.

Keywords: MANETs, Quality of Service, Routing protocol, mobile node.

I Introduction

A MANET can be seen as an autonomous system or a multi-hop wireless extension to the Internet. As an autonomous system, it has its own routing protocols and network management mechanisms. As a multi-hop wireless extension to the Internet, it should provide a flexible and flawless access to the Internet. Recently because of the increasing recognition of multimedia applications and potential profitable usage of MANETs QoS support in MANETs has become an inevitable task [1].

The organization of the rest of the paper is as follows. Section II describes the characteristics of MANETs. Section III briefs the QoS, QoS parameters, classification of QoS metrics,QoS at different layers,QoS models. Section IV deals with some QoS routing protocols. Finally, the paper is summarized in section V.

II. Mobile Ad hoc network characteristics

MANETs are characterized by limited resource, dynamically varying network topology, lack of precise state information, shared radio channel, hidden terminal problem and insecure medium. Insecure medium makes it more challenging for providing QoS in Ad hoc networks. The major challenges that a routing protocol designed for Ad hoc wireless networks faces are mobility of nodes, resource constraints, and error-prone channel state, hidden and exposed terminal problems. Due to these issues wired network routing protocols cannot be used in Ad hoc wireless networks. Hence an Ad hoc wireless network requires specialized routing protocols [2]. A routing protocol for Ad hoc wireless networks should have the following characteristics:

1. It must be fully distributed.
2. It must be adaptive to frequent topology changes caused by the mobility of nodes.

3. Route computation and maintenance must involve a minimum number of nodes.
4. It must be loop-free and free from stale routes.
5. The number of packet collision must be kept to a minimum by limiting the number of broadcasts made by each node.
6. It must optimally use scarce resources such as bandwidth, computing power, memory and battery power.
7. It should be able to provide a certain level of QoS as demanded by the applications, and should also offer support for time-sensitive traffic.

III. Quality of Service (QoS)

QoS is the performance level of a service offered by the network to the user. The goal of QoS provisioning is to achieve a more deterministic network behavior so that information carried by the network can be better delivered and network resources can be better utilized [2]. The network is expected to guarantee a set of measurable pre-specified service attributes to the users in terms of end-to-end performance such as delay, bandwidth, probability of packet loss, delay variance (jitter), processing power, buffer space etc. Power consumption is another QoS attribute which is more specific to MANETs.

Technically there are two ways in which QoS can be achieved (1) over-provisioning and (2) traffic engineering. Over provisioning utilizes the best effort approach and simply increases the available resources. Traffic engineering tries to utilize resources efficiently and to make the network QoS aware.

Research on QoS in MANETs includes QoS models. QoS resources reservation signaling, QoS routing and QoS Medium Access Control (MAC) as shown in figure 1 below.

QoS model specifies an architecture in which some kind of services could be provided in MANETs. It is the system goal that should be implemented. All other QoS mechanism such as QoS signaling, QoS routing and QoS MAC must work together to achieve the goal

QoS signaling acts as the control center in QoS support. It co-ordinates the behaviors of QoS routing, QoS MAC, and other components such as admission control, resource reservation and scheduling. The functionality of QoS signaling is determined by the QoS model.

QoS routing searches for a path with enough resources but does not reserve any resources. It is the QoS signaling to reserve resources along the path determined by the QoS routing. So QOS routing enhances the chance that enough resources can be guaranteed when QoS signaling wants to reserve resources. Without QoS routing, QoS signaling can still work but the resource reservation may fail because the selected path may not have enough resources. QoS signaling will work better if coordinating with QoS routing.

QoS MAC protocol is an essential component in QoS support in MANETs. All upper layer QoS components are dependent on and coordinate with the QoS MAC protocol[1].

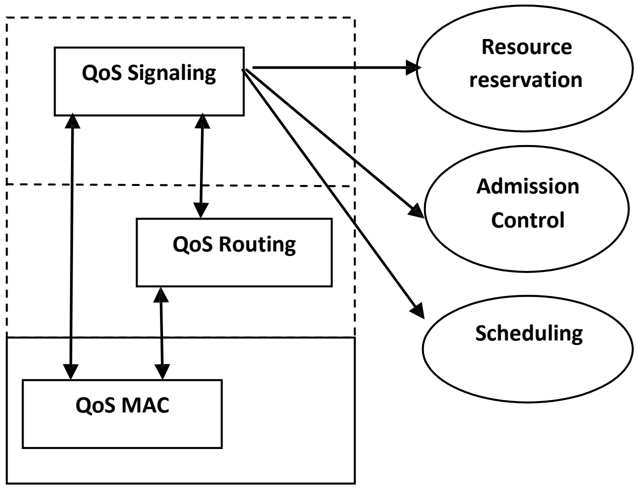

Fig 1: QoS Model

QoS parameters

QoS parameters differ from application to application. For example, in multimedia applications, the data rate and delay are the key factors, in military use security and reliability become more important. In emergency cases such as rescue, the key factor should be the availability. In sensor networks, battery life and energy conservation would be the prime QoS parameters.

B Classification of generally used metrics

The QoS metrics can be classified into three categories. They are additive metrics, concave metrics, and multiplicative metrics. Additive metrics is defined as sum of the value of the metric on all links along the path. Delay and jitter are additive metrics. A concave metric means the minimum metric value over a path. Metric value on every link along the path is taken into account. The minimum metric value stands for the metric value of the whole path. Data rate is a concave metric. A multiplicative metric represents the product of the metric values on all links over a path. The criteria of reliability or availability of one link, e.g. link outage probability is a multiplicative metric [3].

C QoS in different layers

QoS of a network can be considered at different layers. In physical layer, QoS means the quality in terms of transmission performance. QoS implemented in MAC layer could provide high probability of access with low delay when stations with higher user priority want to access the wireless medium. In routing layer QoS implementation aims to find a route which provides the required quality [3].

D QoS Models

The QoS model specifies the architecture in which some kind of services could be provided in the network. A QoS model for MANETs should consider the existing QoS architecture in the Internet, the different challenges of MANETs, the potential commercial applications of MANETs that require flawless connection to the Internet. The existing QoS models can be classified into two types based on their fundamental operations. The QoS models are Integrated Service (IntServ) and Differentiated Services (DiffServ) [22].

IntServ is a fine grained approach which provides QoS to individual flows. It uses Resource Reservation Protocol (RSVP) to provide a circuit switched service in packet switched network. IntServ provides Admission control. One of the main responsibilities of admission control is that the interference caused by adding a new flow should not make QoS of old flows get poorer than required. The drawback of IntServ is the scalability problem caused by the need of storing every flow state in the routes.

DiffServ provides QoS to large class of data or aggregated traffic. It is a coarse grained approach. It maps flows into a set of service levels. In DiffServ, routers are divided into two types: edge routers and core routers. Edge routers are at the boundary of the networks. In edge routers, traffic will be classified, conditioned and assigned to different behavior aggregate when it traverse between different networks. Core routers forward packets based on the Type of Service field and they also need to follow the Per-Hop-Behavior (PHB) which takes charge of scheduling of packets [3].

A Flexible QoS Model for MANETs (FQMM) considers the characteristics of MANETs and combines the high quality QoS of IntServ and service differentiation of Diff_Serv. Salient features of FQMM include: dynamic roles of nodes, hybrid provisioning and adaptive conditioning [4].

E Classification of Routing Protocols for MANETs

MANET routing protocols could be broadly classified into two major categories: Proactive and Reactive.

Proactive protocols continuously learn the topology of the network by exchanging topological information among the network nodes. Thus, when there is a need for a route to a destination, such route information is available immediately. If the network topology changes too frequently, the cost of maintaining the network might be very high. If the network activity is low, the information about actual topology might even not be used. The reactive routing protocols are based on some sort of query-reply dialog. Reactive protocols proceed for establishing route to the destination only when the need arises. They do not need periodic transmission of topological information of the network.

Often reactive or proactive feature of a particular routing protocol might not be enough; instead a mixture might yield better solution. Hence, in the recent days, several hybrid protocols are also proposed. Based on the method of delivery of data packets from the source to destination, classification of MANET routing protocols could be done as follows:

Unicast Routing Protocols: The routing protocols that consider sending information packets to a single destination from a single source.

Multicast Routing Protocols: Multicast is the delivery of information to a group of destinations simultaneously, using the most efficient strategy to deliver the messages over each link of the network only once, creating copies only when the links to the destinations split.

Multicast routing protocols for MANET can be classified again into two categories: Mesh-based multicast protocol and Tree-based multicast protocol. Mesh-based routing protocols use several routes to reach a destination while the tree-based protocols maintain only one path [5].

IV. Literature Survey

In this section some of the well-known QoS routing protocols have been briefed:

Ticket Based QoS Routing Protocol [TBP] is a alternative QoS aware routing protocol proposed by Chen & Nahrstedt [6], Donghak Pyo, Sunggu Lee, Min Gu Lee[7]. This scheme achieves a balance between the single path routing algorithm and the flooding algorithm. It does multipath routing without flooding. But the presence of backup paths has an adverse affect on the other message streams. Since valuable network resources have to remain reserved for the backup paths.

In [8] the results show that QAODV protocol works well when traffic on the network is relatively high. But problems arise when the node density of the network is high. The reason is that QAODV routing protocol uses Hello Message to exchange information between neighbors. When the node density is too high, the sending of Hello messages will cost much available data rate. As a result the network will be ruined and traffic will be delayed more since Hello messages have higher priority than data packets. To conclude, it is predicted that the QAODV will not work well in high density Ad hoc-networks.

Location information can also be used to reduce the routing overhead in Ad hoc networks as compared to the algorithm that does not use location information. However in reality there may be some error in the estimated location. When the estimated location error is very large such schemes would not be very effective [9].

AQOR method is poorly scalable. The admissible delay for a large network is to be set too high to get a valid route [10]. It assumes a contention-based medium access mechanism such as the IEEE 802.11 DCF. However, since DCF does not differentiate between flows, best effort traffic (which does not use AQOR) can interfere and cause QoS violations. In this case it uses route recovery to bypass the resulting QoS violations. Future deployment of QoS-aware MAC protocols e.g. IEEE 802.11e will reduce the number of such violations.

To further reduce the control overhead caused by flooding of route request packets AQOR can work with some location aided routing protocols. With increased mobility, the end-to-end delivery ability of the network decreases gracefully accompanied by reduced traffic admission ratio. Because of the nodes mobility the probability of collisions and route breaks increases. Thus both the late packet ratio and its standard deviation increase. The traffic load has more influence on AQOR's performance than nodes speed.

The evaluation of performance by combining Network Layer and MAC layer protocols with transport layer congestion control mechanism operating in mobile Ad hoc network has been discussed in [11].

In [12] further evaluation of the performance evaluation by combining IEEE 802.11 MAC Layer protocol with selective retransmission of Transport layer congestion control mechanism operating in mobile Ad hoc network.

In Geographical Ad hoc routing each node has to be equipped with Global Positioning System. This requirement is quite realistic today as such devices are inexpensive and can provide reasonable precision. LAR is an on-demand routing protocol using geographical location information to limit the area for discovering a new route to a smaller "request zone". Instead of flooding the route requests into the whole network, only the nodes in the request zone will forward them. Thus the routing overhead is widely reduced [9].

LACBER protocol is location aided and also energy efficient [13]. This approach is applicable in GPS scarce network. It is a better location aided routing protocol in terms of lower hop-count, improved energy & bandwidth utilization & low cost.

LAPAR protocol in mobile Ad hoc network is fully distributed while only location information of neighboring hosts is exploited to make routing decisions. The results show that the protocol is power-efficient [14].

EELAR protocol makes an improvement in control packet overhead and delivery ratio compared to AODV, LAR and DSR protocols. It makes significant reduction in energy consumption of mobile node batteries through limiting the area of discovering a new route to a smaller zone. Thus the control packet overhead is significantly reduced and the mobile nodes lifetime is increased [15].

ALARM protocol uses nodes current location to construct a secure MANET map. Based on the current map, each node can decide which other nodes it wants to communicate with. It also takes the advantage of some advanced cryptographic primitives to achieve node authentication, data integrity, anonymity and intractability. It also offers resistance to some insider attack. Results show that privacy is preserved even if a portion of nodes are stationary or if the speed of movement is not very high [16].

High Performance Scalable QoS Routing protocol (HPSQR) for MANETs constructs most reliable route path from a source node to a destination node. It is an enhancement over AODV. It selects a routing path based on following two parameters: (I) Stability of paths that found from the source node to the destination node. For calculating stability of a path, HPSQR uses the route life time (RLT) between two connected mobile nodes by using global positioning system (GPS). (ii) Residue energy of paths that from the source node to the destination node. For determining residue energy of a path, we find node with minimum residue energy along that path [17].

In [18], authors have presented multi-path routing protocol that considered the two issues of reliability and security for QoS support and quantified the security of the protocol in terms of the number of eavesdropping nodes.

In [19], authors have proposed a solution based on the swarm intelligence paradigm for QoS support.

In [20], authors have proposed a reliable multi-path QoS routing protocol with a slot assignment scheme. In this scheme, the QoS routing protocol is associated with searching for a reliable multi-path (or uni-path) QoS rote from a source node to a destination node in a MANET. In the protocol two parameters, the route life time between two connected mobile node and the number of hops, use to select a routing path with low latency and high stability. QOLSR [21] is an enhancement of the standard OLSR. QOLSR adds extensions to the messages of control during the discovery of the neighbors. It is appropriate to insert parameters such as the delay, the band passer-by, the expense of link, loss of packet.

V. Conclusion & Future work

More and more efficient routing protocols for MANET will be developed in the future, which might take security and QoS as the major concern. Until now, the routing protocols mainly focused on the methods of routing, but in future a secured but QoS-aware routing protocol could be worked on. Recently some multicast routing protocols have been proposed. The reason for the increasing importance of multicast is that this strategy could be used as a means to reduce bandwidth utilization for mass distribution of data. Ad hoc wireless networks find applications in civilian operations (collaborative and distributed computing) emergency search and- rescue, law enforcement, and warfare situations, where setting up and maintaining a communication infrastructure is very difficult. In all these applications, communication and coordination among a given set of nodes are necessary. Considering all these, in future the routing protocols might especially emphasize the support for multicasting in the network. The existing QoS aware routing protocol traffic is assumed to be all real time traffic and having the same priority, where as in reality traffic should be differentiated to have different priorities. Traffic differentiation is also an issue to be taken care. Much of the work needs to be done in providing QoS Performance.

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