International Journal of Computer Applications (0975 – 8887)
Volume 46– No.7, May 2012

QoS Services Constrained Signal Stability based Adaptive Routing (SSQR) Protocol for MANETs

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ABSTRACT
Routing protocols for Mobile Ad Hoc Networks (MANETs) have been explored extensively in recent years. Much of this work is targeted at finding a feasible route from a source to a destination without considering current network traffic or application requirements. Therefore, the network may easily become overloaded with too much traffic and the application has no way to improve its performance under a given network traffic condition. While this may be acceptable for data transfer, many real-time applications require Quality-of-Service (QoS) support from the network. The main idea of the proposal is that QoS support can be achieved more efficiently by considering the link stability and signal strength of intermediate channels. We propose an on demand QoS routing scheme named signal Stability based QoS Routing (SSQR), that provides QoS support in terms of bandwidth and end to- end delay in mobile ad hoc networks (MANETs). SSQR is designed over Signal Stability based Adaptive Routing (SSA) and aims to find as well as maintain stable QoS routes in ad hoc network. The SSQR emphasizes on selecting QoS routes that can survive for longer period of time. This is accomplished with the help of signal stability which consists of signal strength and link stability. The performance of SSQR is extensively investigated by simulation in NS-2. Our results validate that SSQR represents an important improvement in QoS provisioning in MANET by selecting longer-lived QoS routes in mobile wireless networks.

General Terms
Signal stability, neighborhood alignment, route identification, admission control, bandwidth reservation

Keywords
SSQR, quality of services, Ad hoc network, path selection algorithm

1. INTRODUCTION
Ad-hoc network is an infrastructure less network which consists of a set of nodes, communicate over a transmission radio. It does not require any central administration [1]. The growth of interest and research on multihop wireless network[2] is exponential in recent years. In mobile ad hoc networks (MANET), the nodes play the role of routers to forward the packets of neighbor nodes as there is no fixed infrastructure available to do so. Data transmitted by a node is received by all the nodes within its communication range. We focus on the analysis of varying a range of the transmission in terms of distance. Mobility is becoming increasingly important for users of computing systems. Recent advances in technology has provided smaller, less expensive, and more powerful wireless devices. With the help of these advanced wireless devices, users gain ability to maintain connectivity to their primary computer while roaming through a large area. The growth of real time applications in such environments has drawn a lot of attention to wireless networks that support quality of service (QoS).Many different protocols [4], [12] have been proposed to support QoS in MANETs, each based on different assumptions and intuitions. Current proposals [14], [15] in the literature have attempted to provide QoS support in terms of delay and bandwidth. We propose an on demand QoS routing scheme named signal Stability based QoS Routing (SSQR), that provides QoS support in terms of bandwidth and end to- end delay in mobile ad hoc networks (MANETs). SSQR is designed over Signal Stability based Adaptive Routing (SSA) and aims to find as well as maintain stable QoS routes in ad hoc network. The SSQR emphasizes on selecting QoS routes that can survive for longer period of time. This is accomplished with the help of signal stability which consists of signal strength and link stability. The performance of SSQR is extensively investigated by simulation in NS-2. Our results validate that SSQR represents an important improvement in QoS provisioning in MANET by selecting longer-lived QoS routes in mobile wireless networks. The rest of the paper is organized as follows. Related work discussed in Part 2. In part 3, we introduce the proposed SSQR algorithm. We validate the proposal by means of performance evaluation and discussion in section 4 and Section 5 concludes the paper.

2. RELATED WORK
This part depicts some of the most prominent QoS aware routing protocols in MANET. *A. Ad Hoc QoS on demand Routing(AQOR)*AQOR [14] is a resource reservation based routing and signaling algorithm that provides end-to-end QoS support in terms of QoS metrics, i.e. bandwidth and end-to end delay which are used to make admission control and resource reservation. AQOR works in five phases (1) Neighborhood Alignment (2) Route Identification (3) Admission control (4) Bandwidth Reservation and (5) Adaptive Route Recovery. Neighborhood information is maintained using hello packets. Route discovery algorithm is accomplished by route exploration from source to destination and route registration in the reverse path. Detailed computation has been used for the accurate measurement of bandwidth availability in the shared wireless channel and accurate measurement of effective end-to-end delay. In AQOR, the bandwidth reservation will be activated for the flow only when the real data flow arrives at the registered nodes. AQOR proposes an adaptive route recovery model when aQoS violation is detected. This model makes the destination do a reverse route exploration. AQOR also includes efficient mechanism for QoS maintenance and destination initiated recovery process. Because of its instant QoS violation detection and recovery mechanisms, AQOR scales well with moderate node mobility with no significant performance degradation. In large mobile networks, AQOR

dynamically adjusts its admission policy with the offered load and node mobility while keeping high delivery ratio of the admitted flow. *QoS constrained Adaptive Routing protocol (AQR)*AQOR provides end-to-end QoS support in terms of bandwidth and end-to-end delay, which are used to make admission control and resource reservation. It has already been proved in the literature that the problem of finding a path with two independent constraints is a NP-complete problem. Therefore AQR [3] introduces one more constraint called cost and aims to find a bandwidth and delay constrained least cost path among all candidate paths from source to destination. AQR also incorporates admission control and bandwidth reservation schemes to satisfy the QoS constraints of the applications. Route is discovered on demand by propagating route request and route reply between source and destination. For the route discovered that obeys QoS requirements, the admission control policy should guarantee for each flow the requested minimum flow bandwidth B_{min} and the maximum end to end delay T_{Max}. Due to nodes mobility and shared unreliable physical medium, the communication in MANETs usually disconnects and experiences channel deterioration. AQR [3] introduces adaptive route recovery phase which includes local route repair, QoS violation detection and recovery phase. AQR can quickly re-route packets along the new path so minimizing their effect on QoS flows.

3. PROPOSSED WORK

The proposed signal stability based QoS Routing (SSQR) uses signal stability along with QoS parameters as route selection criterion. Signal stability consists of signal strength and link stability. The signal strength criterion allows the protocol to differentiate between strong and weak channels. The idea behind intermediate link stability is that the nodes which have been stationary for a threshold period are less likely to move. Therefore it allows the protocol to select a channel which has existed for a longer period of time. Selecting the most stable QoS links which exhibits stronger signals for maximum amount of time, leads to longer lived QoS routes and less route maintenance. Together these two concepts form the signal stability criterion that chooses strong channels which have been in existence for a longer time. QoS so the protocol signaling allows for both on demand route discovery and end-to-end QoS reservation in terms of minimum bandwidth (Bmin) and maximum delay (Tmax).

3.1Neighborhood Alignment

By the exchanging of HELLO messages, each node accumulates connectivity information and signal stability of one hop neighbors. Connectivity is determined by listening for packets from a node's set of neighbors. Each node maintains a neighbor list which contains an identifier for each neighbor, the bandwidth reserved, received signal strength and link stability information of the neighbors. Two new types of fields, signal strength and link stability, are also included in neighbor list to get the signal stability of the neighbor. To maintain the link stability, neighbor list has the fields Last, Clicks and Set value. Last is a binary field that indicates whether a Hello packet was received within the most recent interval. Clicks records for how long Hello packets have been continuously received and Set value indicates the strong channel with appropriate link stability.

3.2 Signal Stability Measurement

Signal Stability measurement [6] is based on signal strength (SSreceived) and link stability (Last and Clicks) metrics. Whenever a node gets a Hello packet from its neighbor, it checks its neighbor table. If it gets a Hello packet for the most recent time interval then last is marked as 1 and other updates are done as follows Received signal strength (SSreceived) is calculated based on isotropic radio model as follows:

SSreceived = Sending Power - Pathloss + Fading

```
/*Updating Neighbor Table*/
If (SS_received>= SS_threshold )
{
        Clicks++;
/* check link Stability */
    If (Clicks >= Clicks_threshold and
Last)
        Set value=1;
        else
        Set value=0;
        }
        else
        {
        Set value=0;
        Clicks=0;
        }
```

Where $SS_{threshold}$ and $Clicks_{threshold}$ are determined experimentally. The SSthreshold determines the extent ofthe host's coverage area within which the neighbor nodes have strong signals. The $Clicks_{threshold}$ determines threshold above which routes are considered stable and it should be determined based on known mobility patterns of hosts [4] in the ad hoc networks. It should be noticed that when $Clicks_{threshold}$ equals 1, link stability is not considered.

3.3 Admission Control

The radio channel of each node is shared with all its neighbors in wireless networks. So a node can successfully use the channel only when all its neighbors don't transmit and receive packets at the same time. This effect is called as aggregation effect and is used in the AQOR. SSQR adopt the bandwidth estimation model used in as it shows promising results at each node, the admission control is responsible for admitting or refusing requests to allocate resources to flows. For bandwidth estimation we adopt the the model used in [14] as it shows promising results.

3.3.1 Bandwidth Control

Due to the shared channels in the wireless networks, bandwidth of each node is affected by the interference of other node Real Bandwidth available at node I, BWavail(I) can be calculated as follows:

BWavail(I) = BW -P

J2N(I)BWself (J)

where BW is maximum transmitting bandwidth of the node and BWself (J) is the total reserved bandwidth of all the existing flows at node J. It is manipulated based on the flow information available in the flow table [14]. BWcons(I,j) is the bandwidth consumed by flow j at node I, and can be calculated

as follows:

BWcons(I,j) = BWuplink(I)(j) + BWdownlink(I)(j)

Where both BWuplink(I)(j) and BWdownlink(I)(j) can either equal Bmin or 2Bmin. By comparing BWavail(I) and BWcons(I,j), each node can now decide whether to accept the flow.

3.3.2 End-to-End Delay Control

One way end-to-end delay by round trip time method. T_{round} will be the delay from the source to the destination and back to source. The Average delay (Avg del) is calculated through the following

formula:

Avg del=_ * Avg del + (1-_) * measured del

where measured del = Tround /2 and _ is an experimentally decided quantity which lies between 0 and 1.

3.4 Route Identification

The SSQR protocol performs on demand route identification between the source and destination using limited broadcast. When a route to destination is not present or the existing route is not fresh enough, source initializes the route request (RREQ) packet to the requested QoS parameters (maximum delay T_{max} and minimum bandwidth B_{min}) and broadcasts It to all its one hop neighbors. Each node implementing SSQR maintains a route request buffer for caching the duplicate route requests.

3.4.1Forwarding Route Request

When a node receives the RREQ packet, it checks whether it can satisfy the QoS requirements. Necessary updations are done in the RREQ packets and forwarding decision is taken based on freshness of RREQ. If node wants to forward the request then it prefers to select the RREQ packet with Set value as 1. Path selection Algorithm (PSA) algorithm is as follows.

Path Selection Algorithm

/*Set value,current delay and Bmin
fields of RREQ are referred as
Rq Set value, Rq current delay and
RqBmin, respectively.*/
Step1: Calculate Bconsumed by using
Bmin and check
Check ***If*** Bavail> Bconsumed,
Then go to step 2.
Else Drop RREQ packet
Step2: ***If*** Rq current delay < Tmax,
Then go to step 3.
Else Drop RREQ packet
Step3:
(a) /* Update the Rq Set value */
If (Rq Set value==1 ***and***
Nb Set value==1)
/* Nb Set value is the
Set value
in neighbor list */
then Rq Set value =1
Else Rq Set value = 0
(b) Modify the Rq current delay
(c) ***If*** RREQ exists in Route Request
Buffer ***then***
Cache this request in route request buffer
and wait until RREP comes back
Else
(i)Add RREQ packet in
route request buffer and
set wait flag as 1
(ii)Re broadcast the
RREQ having Rq Set value as 1

As a node receives the RREQ packet and finds out that it is not the destination. It checks whether it can ensure the required delay and bandwidth. If so, it update the RREQ packet fields as discussed above and make sure that it is fresh request, then forward it. Otherwise RREQ packet is simply dropped.

3.4.2 *Propagating Route Reply*

The destination node receives a RREQ packet, it propagate RREP packet and uncast it back to source node. If it is getting duplicate requests then it selects one having Rq set value as 1. As RREP packet passes through its intermediate node, these node update their routing table so that QoS data can be routed through these nodes in the future. If an intermediate node receives a RREP packets before timeout. It will farward the packet downstream towards the source and purge RREQ packets cached in the route request buffer.

3.5. *Adaptive Route Maintenance*

The QoS mechanism needs to be adaptive, even when confronted with rapidly changing environments, in order to provide relatively stable QoS guarantees. The QoS route may frequently break due to change in topology and routing information. Because of this broken path, no QoS can be guaranteed for the flowTo quickly re-establish reservation on this path is a critical aspect when maintaining the QoS of real time flows in MANET. SSQR has a simple but efficient local route repair mechanism along with QoS violation detection and recovery phase. SSQR route maintenance is designed to avoid cumbersome tear-down and re-establishment process as it can severely affect the performance.

3.5.1 Local Route Repair

When a node detects neighbor lost, it degrades the route in its routing table by marking it as down. Node sends a RERR packet back to source and simultaneously starts the route discovery process for the same destination. If the node successfully discovers a route up to destination then QoS flow will now be shifted to this newly found route. Otherwise source will start a fresh route discovery process for new QoS route between source and destination.

3.5.2Violation Detection Phase

Delay violation of control packets can be detected by means of current delay parameter of RREQ. During the route discovery phase, if an intermediate node finds that the current delay has exceeded the T_{max}, then the RREQ packet will be simply dropped as described in the PSA algorithm. For detecting the delay violation of dataflow, destination has to monitor the one way delay of arriving data packets. If the destination observes that delay of data packets continually exceeds the T_{max}, the QoS recovery will be triggered.

3.5.3 *Recovery Phase*

Whenever QoS violation is detected, the destination will update route sequence number and broadcast route update (REDU) packet back to source. The REDUpacket is treated same as the RREQ packet with admission control and signal stability considerations. REDU packet is forwarded using PS algorithm but in reverse direction.

3.6Comparison of QoS aware routing Protocols

Table-I compares SSQR with two other prominent QoS constrained protocols based on the key characteristics and properties. AQOR uses bandwidth and end-to-end delay metrics as the route selection criterion. However it has been stated that the problem of finding path based on two independent metrics is NP complete. So AQR has incorporated one additional parameter cost and local route recovery to reduce the route maintenance. None of the above protocols has used the signal stability as the route selection criteria which can significantly increase the route longevity as will be shown in section [6].

Table-1 comparison of quality of services aware routing protocol.

	AQOR	AQR	SSQR
On- Demand	YES	YES	YES
Least Cost	NO	YES	NO
Signal Stability	NO	NO	YES
Local Route Repair	NO	YES	YES

4. PERFORMANCE EVALUATION

We performed simulations in NS-2 network simulator [7] to study SSQR's performance in different configuration and scenarios.

In this section, we discuss the performance evaluation of SSQR in greater detail.

4.1 Assumptions

Our simulation model is based on the following main principles:

• The network is represented by a random graph model, in which nodes are initially placed randomly in a given region.

• All the nodes independently decide its movement by using random waypoint model.

• The node can either receive or transmit at a time.

• There is no turn around time between transmitting and receiving: the nodes can switch between transmit and receive mode instantly.

4.2 Simulation Procedure

The simulation procedure is very close to a real Ad-Hoc network operations. The topology of the network is generated by randomly distributing the nodes in a given region of1000X500. Each of the 50 mobile nodes is randomly placed by selecting its x and y co-ordinates. SSQR routing model is built on the top of the IEEE 802.11 MAC model of NS-2 and node mobility is taken care by random waypoint model which has been implemented at each node. An Omni-directional antenna with Two-ray ground propagation model is used for communication. The HELLO packet interval is taken as 1sec and radio coverage range is 250 meters. The Location stability constant Click threshold should be slightly greater than the mean of short stay period. A Clicks threshold of 5 is chosen since the mean of the short-stay period is 3 [7].

The protocol has been tested for 10 different scenarios with maximum mobility speeds of nodes ranging from 1 m/s to 10m/s. Each scenario contains 10 different CBR flows in which10 source-destination pairs are randomly chosen among the 50 mobile nodes. Each traffic source sends packets of 512 bytes at a rate of 10 packets/sec. A QoS request is generated in the network with a predetermined bandwidth of 40 kb/second end-to-end delay of 0.1 sec. To buffer all the data packets waiting for a route, a send buffer of 64 packets is implemented at each node.

4.3 Performance Metrics

We use the following performance metrics to analyze the performance of SSQR.

• Normalized Control Overhead: This is defined as the ratio between the total number of control packets transmitted(except HELLO packets) by all the nodes and the total number of data packets delivered to the destinations.

• Traffic Admission Ratio: This is the ratio between the number of data packets sent by the sources and the number of data packets generated at the sources.

• End-to-End Delay: This is the delay, experienced by packets between their generation time and the arrival time at the destination.

• Packet Delivery Ratio: This is the ratio between the number of data packets received at the destination and the number of data packets sent from the sources.

4.4 Results Analysis

For analyzing the SSQR under different load conditions and mobility speeds, we performed the simulation for 10 flows as well as 15 flows with mobility ranging from 1 to 10 m/s.

Figure-1 and figure-2 depict normalized control overhead against the increasing node mobility speed for 10 and 15 flows respectively.

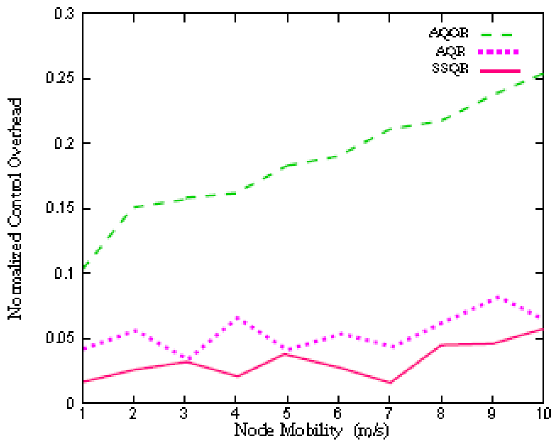

Fig. 1. Normalized Control Overhead vs Mobility for 10 flows

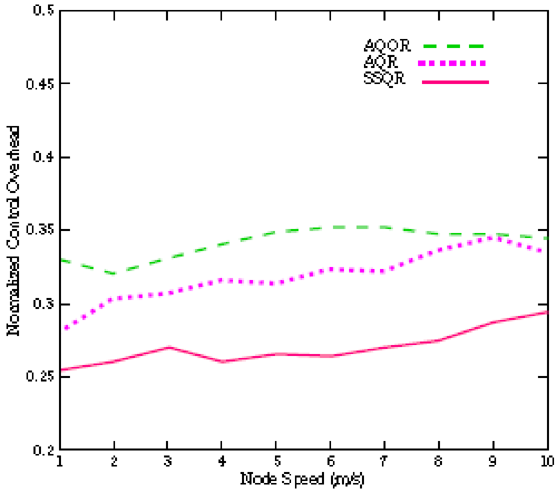

Fig. 2. Normalized Control Overhead vs Mobility for 15 flows

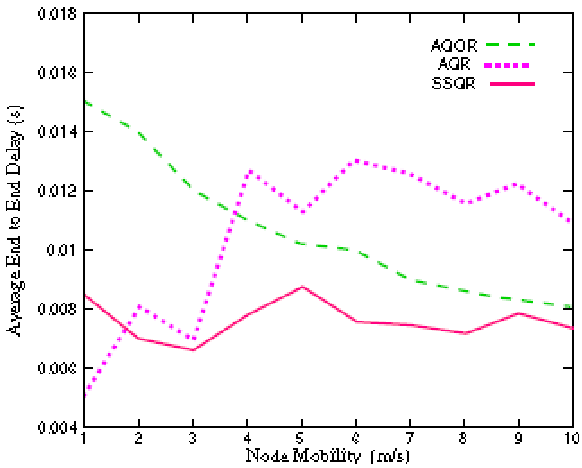

Fig. 3. Average End to End Delay vs Mobility for 10 flows

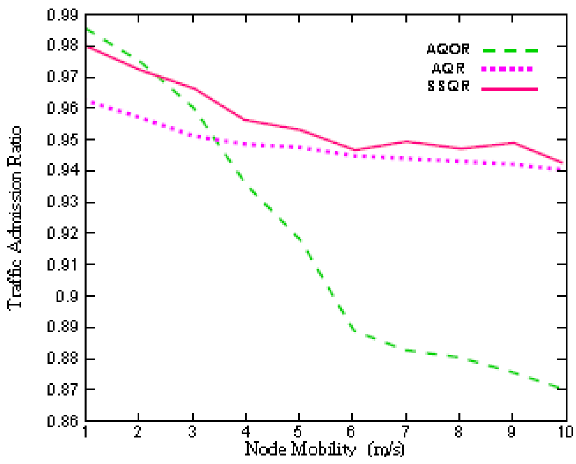

Fig. 4 Traffic Admission Ratio vs Mobility for 10 flows

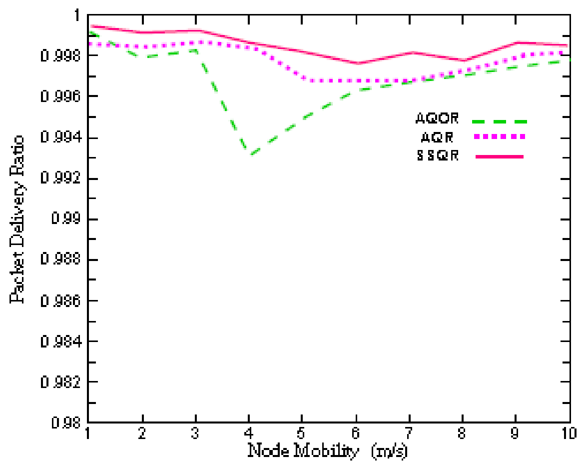

Fig. 5 Packet Delivery Ratio vs Mobility for 10 flows

5. CONCLUSION

We have proposed a QoS Aware Stable path Routing (SSQR) protocol, which finds out routes that satisfy bandwidth and delay constraints based on signal stability. The signal stability estimation is done with the help of signal strength and link stability.

Simulations have been conducted using NS-2.network simulator for performance analysis and compared the performance of SSQR with two prominent on demand QoS aware routing protocols for ad-hoc networks, AQOR and AQR.

6. ACKNOWLEDGMENT

I like to thank our Chairman Dr.V.K Agarwal, Executive Director Dr. Manju Agarwal and Director Mr.S.P.Garg for providing all the facilities and working environment in the institute. I also like to thank the entire institute faculty who helped me directly or indirectly to complete my research work.

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