A novel QoS frame work for MDSRAODV Routing Protocol in MANET

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Abstract
Mobile Ad Hoc network (MANET) is a multi-hop temporary autonomous system of mobile nodes with wireless transmitters and receivers without the aid of pre-established network infrastructure. With the development of network and demand of users, QoS has become one of the focus issues. Some of the routing protocols provide QoS performance; however, more work is required in developing scalable ad hoc routing protocols that support quality-of-service (QoS). Link stability (in term of link survival time) has great impact to QoS Performance of routing in ad hoc networks**.** By implementing link stability, the QoS performance of varieties of ad hoc routing protocols could be improved. The dynamics of Mobile Ad-hoc Networks (MANET), as a consequence of mobility of mobile hosts, propose the problem in finding stable multi-hop routes for effective communication between any pair of source and destination. In an ad hoc network, the topology varies as a result of the mobility of its mobile hosts. Consequently, the task of performing ad hoc network routing is more complex and less efficient. In this paper, a link stability model is proposed for Modified DSR- AODV routing protocol to improve the QoS performance. This protocol adopts dynamic source routing mechanism and extends the AODV protocol. The link stability model includes two major phases: routing discovery and routing maintenance. Routing discovery process is to find feasible paths between source and destination node. Routing maintenance process is to monitor and predict the future information about availability of link. Link stability factor and QOS performance are taken consideration in routing discovery and maintenance. The simulation results have demonstrated the significant advantages of the proposed routing protocol with link stability model over the existing routing protocol.

Index Terms
MANET, Link Stability Model, MDSR, AODV, QOS

Introduction:

In a MANET, the mobile nodes are the routers. They must cooperate in order to pass packets around and they must work efficiently, with lowest delay and smallest possible energy consumption. The routing al algorithms used in a MANET are therefore very different from wired networks. To begin with, in a MANET routers move. The meaning of geographic distance in mobile networks as it pertains to routing algorithms becomes questionable. When a source has a packet to send, it first checks to see if itself knows of a path. If so, then it goes ahead and sends out the packet hoping a neighbor would pick it up and forward it. If the source does not know of a route, it sends out a route request. The intermediate nodes help by forwarding the packets until the request eventually reaches its intended destination. (if it does not, then the source sends another request, and yet another until the packet lifetime expires in which case it is dropped). Once the intended destination receives a request, it answers with a reply packet.

Again the intermediate nodes cooperate to this time, deliver the reply to the source. The main purpose is to save the energy and to prolong the lifetime of the network. It cannot provide any service quality guarantee. It is an interesting and complex problem to combine them together to satisfy both the QoS and the energy requirements. Variable link conditions are intrinsic characteristics in most mobile ad hoc networks. Rerouting among mobile nodes causes network topology and traffic load conditions to change dynamically. Given the nature of MANET, it is difficult to support real-time applications with appropriate QoS. In some cases, it may be impossible to guarantee strict QoS requirements. However, at the same time, QoS is of great importance in MANETs since it can improve performance and allow critical information to flow even under difficult conditions. Unlike fixed networks such as the Internet, quality of service support in mobile ad hoc networks depends not only on the available resources in the network but also on the mobility rate of such resources. This is because mobility may result in link failure, which in turn may result in a broken path. Furthermore, mobile ad hoc networks potentially have fewer resources than fixed networks. Therefore, more criteria are required in order to capture the quality of the links between nodes.

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QoS-AODV:

The QoS-aware extensions, to AODV laid the foundations for the route request/reply based admission decision procedure that prevails in most of today's many protocols for multi-hop MANETs. These extensions specify that, if an application data session has constraints on the maximum end-to-end delay or delay jitter it can tolerate, or requires a minimum level of throughput, it must specify these Requirements in a route request (RREQ) header extension when seeking a route. An intermediate node receiving the RREQ may only rebroadcast it if it can satisfy the QoS requirements specified in the header extension. Since a node may not have up-to-date information about the QoS-related states at downstream nodes, it should rebroadcast the RREQ, even if it knows a route to the destination. Delay-constrained route discoveries are handled by having each node forwarding a RREQ subtracting its "node traversal time" from the maximum end-to-end delay bound, until the RREQ either reaches the destination or the difference between the delay bound and the accumulated node traversal times reaches zero. In the second case, the RREQ is dropped and the requesting session is not admitted. If the RREQ reaches the destination, that node replies to the source with a route reply (RREP). Throughput-constrained route discoveries proceed in a similar manner, except that the RREQ only reaches the destination if each forwarding node has sufficient available capacity to support the requesting session. In the RREP stage, the bottleneck residual capacity on the route is recorded in the RREP header. On receiving the RREP, the source admits the session if the bottleneck achievable throughput is adequate. A jitter constraint is handled in a similar manner again. Each intermediate node also stores the IP addresses of source nodes requesting various levels of QoS. If the node finds it can no longer support these requirements, an ICMP QOS_LOST message is sent to the sources of any affected sessions. Source nodes receiving such a message may attempt to re-admit the affected sessions by seeking an alternative route. In fact, QoS-AODV is not considered an AC protocol, only a QoS-aware routing method. Indeed, the methods of estimating the node traversal times and residual channel capacities are not specified in. However, QoS-AODV provides a framework for RREQ/RREP-based AC, since session admission is contingent upon finding a route that is able to satisfy its QoS requirements. The QoS-metric constrained Route discovery mechanism described above shall henceforth be referred to as QoS-AODV-style route discovery. The proposed protocol, the contention-aware admission control protocol (CACP) is combined with a source routing protocol similar to DSR. Admission control takes place in two stages. When a session requesting admission arrives at a source node, a QoS-AODV-style route discovery is triggered. Nodes monitor the CITR and only forward the RREQ if their capacity is sufficient, given the intra-route contention on the partially discovered route up to this point. On reaching the destination, the route in RREQ is cached for a short time. Thus, if multiple RREQs reach the destination on different routes, several routes are cached. One route is selected, such as the first one to be discovered, and a RREP is sent on this route back to the source. Each intermediate node receiving the RREP again tests its locally available capacity, but this time with full knowledge of the level of intra-route contention.

Common analysis in this type of Category:

As opposed to the previous two categories, these protocols explicitly query the residual capacity of nodes that would be impacted by a new session, thereby reducing the chance of false admissions. Compared to non-reactive resource discovery schemes, discovering the resources of neighbor's on demand has several advantages. Firstly, this avoids needless overhead (compared to proactive approaches) at times when nodes are not receiving any new session requests and therefore do not require any resource state information. Secondly, it aids in avoiding false admissions in networks with any users, where a session admission request packet has passed through a neighbor node and reserved resources there, but the session has not yet begun using them, since the rest of its route is still being tested. Explicit querying of such neighbor nodes allows the reservations to be subtracted from their residual capacity values. On the other hand, the disadvantages of these protocols are also obvious. Firstly, session or route request packets are delayed at each relay node while the resources of its neighbors are queried. This results in increased session admission times. Secondly, querying can produce an unexpected burst of overhead, temporarily increasing interference and collision rates in the region. Unless such effects are averaged out in residual capacity estimations, some nodes may falsely report a decrease in residual capacity.

Impact of Qos in MANET:

One of the main challenges in providing QoS in mobile ad hoc networks is the mobility of the nodes, which makes connectivity unpredictable. The movement of the nodes constantly invalidates old paths, causing the packets of the flow to wait until the routing protocol is able to get information about the new paths. This degrades the performance of the network, reducing the throughput and increasing the delay. This also intuitively implies that the performance of the network will be different under different mobility scenarios of the nodes. Arora et al have analyzed the variation in the throughput and delay experienced by the packets under different mobility scenarios, varying parameters such as node speed and movement patterns. It is therefore very important to have an estimate of the average speed of movement of the nodes to provide QoS assurances to the applications of a network. The detail of performance evaluation under various traffics is out of the scope of our paper. We have articulated the necessity of measurement of link stability in order to provide QoS while selecting route.

Link Mobility Model in MANET:

The statistical link stability distribution shows that in different movement patterns, the property of link stability varies. To better estimate and predict the link stability parameter, we further analyze links lifetime

Distribution and develop different models for different movement patterns. The objective of measuring link stability parameter is to give a prediction of residual link lifetime whenever this parameter is needed. By using this measurement, the routing protocols can have smart to avoid unstable links to achieve better QoS performance. When nodes move in random destination pattern, envelop of the link lifetime distribution is similar to Rayleigh distribution *P_Rayleigh(r)*. The mobile node, in this pattern, moves towards a pre-selected destination and does not change movement direction before arrival. Thus, this movement pattern has the least randomness and to measure the residual lifetime, the past link lifetime should be considered. The link stability measurement model is described as follows:

$$\Pr(\text{residual\_lifetime} > t = \int_{t+\text{past\_lifetime}}^{\infty} \text{p\_Rayleigh}(r)dr$$

The link stability property when node moves in random walk pattern is similar to random destination pattern. The Rayleigh distribution measurement models still applies to this pattern but needs some modification. The leftmost peak there exist quite a few links that are unstable. The reason of this is studied and explained as follows. The uncertainly of movement introduced will make the distance between some nodes changes around 250 meters frequently which causes more link breakage events. To avoid using these links, only those links having past lifetime greater than certain threshold will be considered in routing. The revised measurement model is described as:

$$\Pr(\text{residual\_lifetime} > t) = \begin{cases} \text{not\_defined} & \text{if past\_lifetime} < \text{threshold} \\ \int_{t+\text{past\_lifetime}}^{\infty} \text{p\_Rayleigh}(r)dr & \text{o.w.} \end{cases}$$

When node moves randomly, the network topology changes most frequently and there are many transient links. However, there also have some links with very long lifetime, e.g. when two nodes are close to each other, in this movement pattern, the probability that they will move out of communication range is quite low. To estimate the residual lifetime more precisely, discarding those transient links is very necessary. In this movement pattern, we use weighted window model to estimate the link residual lifetime. We define the current time slot to be slot 1 and the window size is n. We observe the past behavior of the current link by weighed average over past n time slots. The time slot can be defined by application. The Movement speed and signal transmission range determines the scalar. The model is described as follows:

$$\text{Stability Weight} = \begin{cases} \sum_{i=1}^{n} w_i E_i & \text{if } E_i = 1, \\ 0, & \text{o.w} \end{cases}$$

in which,

$$\sum_{i=1}^{n} w_i = 1 \text{ and } w_i \geq w_j \text{ if } i<j$$

$$\text{and } E_i = 1 \text{ (link exists in time slot i)}$$

$$E_i = 0 \text{ (link not exists in time slot i)}$$

$$\Pr(\text{residual\_lifetime}>t) = (\text{Stability Weight})^{t/\text{scalar}}$$

The links can be divided into two categories, i.e. intra-swarm links and inter-swarm links. They have different stability properties and should be measured in different ways. For intra-swarm links, we use the similar measurement model in random destination pattern except that we use Gaussian distribution *P_Gaussian(r)* instead of Rayleigh distribution. For inter-swarm links, the same measurement model used in random movement pattern is applied. To evaluate the effectiveness of measurement models, we compare the residual lifetime of the link when applying and not applying link stability measure. Expected link lifetime T, which could be one of QoS requirements, is fixed as 2/3 of the mean link lifetime. With link stability measurement, the link with the largest probability that the residual lifetime is longer than T is selected. In addition, a random selection of links is used as reference.

Stability Measurement Models with AODV:

AODV is one of the widely discussed ad hoc routing protocols. However, it does not support QoS. We extended by implementing link stability measure models. By measuring and predicting the link survival time distribution, the extended routing protocol selects the route, which is as short as possible while meeting the QoS requirements of the flow. To evaluate the performance improvement of implementing link stability measurement models, a simple extension of AODV.

RREQ Format:

The format of the routing request (RREQ) packet in the extended AODV is slightly different from the RREQ in AODV. The difference is described as follows: 1) In addition to the hop count, there will be another field *Pa*, which represents the accumulated survival probability of all the selected links from the source node to the current node. For example, if the RREQ goes from source *S*, to node *n1*, and then to node *n2*, when node *n2* receives this RREQ, the *Pa* is the product of the selected survival probability of links (*S, n1*) and (*n1, n2*).
2) Each RREQ has a new field called QoS Indicator, which specifies QoS parameters, i.e. {*Pr, Tr*} generated by the application.

Route Discovery:

The route discovery process is initiated whenever a source node wants to communicate with another node for which it has no routing information. Our protocol satisfies a pure on demand rule. We maintain neither any routing table nor exchange routing table information periodically. When a source node requires a communication, it starts to flood a QoS route request (QRREQ) packets to its neighboring nodes in a MANET until they arrive at their destination nodes. We assume a free space radio propagation model in which the signal strength solely depends on the distance to the transmitter. All nodes monitor signals from its neighboring nodes. Signal strength values can be obtained from radio device and strength regulator averages strength values. If the strength of signal received from the neighboring node is greater than or equal to the threshold, the link from the neighboring node is considered as stability link. Otherwise, the node will drop the packet. Each packet records the path history and all link-state information. The link-state Information is delivered from the source to the destination. The destination possibly collects link-state information from different QRREQ packets, each of which travels along different paths. For each bandwidth request, a number of QRREQ packets may be sent. Each QRREQ packet is responsible for searching a path from the source node to the destination node. However, final paths are eventually selected from all of the paths, which are received by the destination.

Routing Maintenance:

Because of the high mobility of nodes, links between nodes are likely to break. Routing maintenance is usually classified into full reconstruction and partial reconstruction. In full reconstruction, a node will break the path when it does not receive a reply packet. In this case, the node sends a route error (RERR) packet to the source node. When the source node receives the packet, it will reconstruct a new path to the destination node. In partial reconstruction, a node will break the path when it does not receive a reply packet. In this case, the node will find a replacement route, making it unnecessary for it to send anything back to the source node. Full reconstruction requires more overheads to send data. But the full reconstruction method will find the more reliable path for routing. Therefore, we use a full reconstruction method to maintain a routing path in this paper. When a node finds that a path is broken, the node starts the process of route maintenance.

Experimental Results:

To evaluate the performance of MDSR-AODV effectively, we compare it with the original DSR and AODV through simulations. We implemented the simulators within NS2 Simulator. The IEEE 802.11 MAC protocol is used in the simulation. Random way-point is selected as movement model. The source and destination node are randomly selected. Empirically, *a* is set to 0.8 and *b* is set to 1.2. The major parameters are shown in table 1.

Table 1.Experimental Parameters:

Parameter	**Value**
Number of nodes	50
Topology dimension	1000m * 800m
Radio Range	250m
Pause time	0 – 50s
Maximum node speed	20m/s
Length data packet	512 bytes
Transmit ratio	1packet/s
Data rate (total)	320Kbps

Figure 3 and 4 show that the packet delivery ratio and average end-to-end delay against the velocity variety of mobile node. With the velocity increasing, the delivery ratio becomes lower because frequently changing network topology leads to link failure and packets loss. Furthermore, as the source node needs to rediscover a new route, the delay will increase.

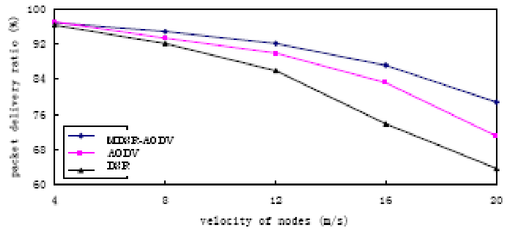

Fig3: Packet delivery ratio vs. velocity of nodes, 30 nodes

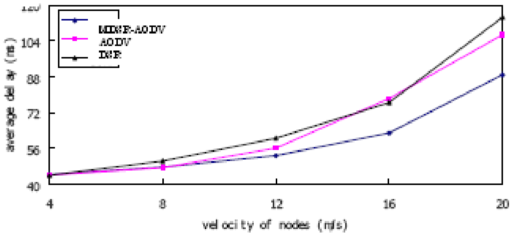

Fig4: Average delay vs. velocity of nodes, 30 nodes

Conclusions:

In this paper, we present a new QoS routing protocol (MDSR-AODV) for MANET with Link Stability Model. MDSR-AODV makes routing decisions according to link state and dynamic delay detection. In the route discovery phase, MDSR-AODV finds paths with great link stability factor. Thus, a feasible path that is more likely longer-lived is selected for data transfer. In the route maintenance phase, MDSR-AODV effectively keeps monitoring network topology changes by delay prediction and performs rerouting before the paths become unavailable. With these route discovery and maintenance mechanisms operating together, MDSR-AODV significantly improves routing performance and guarantee QoS request.

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