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VIRTUAL NETWORKS THROUGH MANETS, A STUDY ON QOS ENABLED NDMR

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ABSTRACT

Ad hoc network (MANET) is a group of mobile nodes that can communicate with each other without using any fixed infrastructure. To sustain multimedia applications such as video and voice MANETs need a proficient routing protocol and quality of service (QoS) mechanism. Node-Disjoint Multipath Routing Protocol (NDMR) is a practical protocol in MANETs: it reduces routing overhead radically and achieves multiple node-disjoint routing paths. QoS support in MANETs is a significant issue as best-effort routing is not able for supporting multimedia applications. This paper presents a novel version of NDMR; QoS enabled NDMR, which brings out agent-based SLA management. This augmentation allows for the intelligent selection of node-disjoint routes depending on network circumstances, thus fulfilling the QoS requirements of Service Level Agreements (SLAs).

Keywords: MANET, Node-Disjoint, Multipath, Agent-based SLA Management

I. INTRODUCTION

Ad hoc networks are infrastructure less networks as the nodes are movable and can be quickly deployed. They are characterized by multi hop wireless connectivity, commonly changing network topology and the necessity for proficient dynamic routing protocols [1]. There are no fixed nodes such as base stations in the network. Each mobile node performs not only as a host but also as a router, transmitting packets to other mobile nodes in the network that may not be within direct wireless broadcast range of each other. The design of proficient and reliable routing protocols in such a network is a demanding issue. On-demand routing protocols are broadly used because they use much lesser routing load than proactive protocols [2]. Ad Hoc on-demand Distance Vector (AODV) [3] and Dynamic Source Routing (DSR) [4] are the two most broadly considered on-demand ad hoc routing protocols. The restriction over both of them is they build and depend on a single path route for each data transmission. Whenever there is a link shatter on the route, both of the two protocols require to initiate a new route detection process. This results in elevated routing load. On-demand multipath routing protocols can ease these problems by establishing multiple routes amid the source node and destination node during one route detection process. A new route detection is initiated only when all the paths fall short or only one path is available. This paper presents a move toward built on the Node-Disjoint Multipath Routing Protocol (NDMR) [5]. NDMR has two novel aspects compared to the other on-demand multipath protocols: it minimizes the routing overhead radically and achieves multiple node-disjoint routing paths [5].

Because of the growing attractiveness of multimedia applications in the saleable environment and the ever rising requirements of mission-critical applications in the military arena, a best-effort service cannot assemble all requirements in most situations. QoS support in mobile ad hoc networks has turn into an important area of research. Compared to the demands of conventional data only applications, these new necessities usually include high bandwidth availability, high packet delivery ratio and low delay rate.

Software agents have been illustrated to provide effective QoS uphold in networks [6, 7]. The main origin for using intelligent agents in ad hoc networks is to offer better independence to the mobile nodes (since they act as router as well as host). That independence, plus the flexibility associate with agents [8] allows the system to meet up different QoS requirements as network circumstances, eg traffic load [9], transform.

II. NODE-DISJOINT MULTIPATH ROUTING PROTOCOL (NDMR)

Node-disjoint multipath routing protocol (NDMR) is a new protocol developed by Xuefei Li [5], modifying and extending AODV to allow the path buildup feature of DSR in route request packets. It can capably detect multiple paths between source and destination nodes with low broadcast redundancy and least routing latency.

In the route detection process, the source creates aroute request packet (RREQ) containing message type, source address, current sequence number of source, destination address, the broadcast ID and route path. Then the source node transmits the packet to its neighboring nodes. The broadcast ID is incremented every time that the source node initiates a RREQ, forming a unique identifier with the source node address for the RREQ.

Finding node-disjoint multiple paths with low overhead is not straightforward when the network topology changes animatedly. NDMR routing computation has three key features that help it to achieve low broadcast redundancy and keep away from introducing a broadcast flood in MANETs: Path accumulation, decreasing multipath broadcast routing packets (by shortest routing hops), and selecting node-disjoint paths.

In NDMR, AODV is customized to include path accretion in RREQ packets. When the packets are transmit in the network, each intermediate node appends its own address to the RREQ packet. When a RREQ packet lastly reaches at its destination, the destination is responsible for judging whether or not the route lane is a node-disjoint path. If it is a node-disjoint path, the destination will generate a route reply packet (RREP) which contains the node list of entire route path and unicasts it back to the source that generated the RREQ packet beside the reverse route path. When an intermediate node gets a RREP packet, it updates the routing table and reverse routing table by the node list of the complete route path contained in the RREP packet.

When getting a duplicate RREQ, the chance of discovering node-disjoint multiple paths is zero if it is dropped, for it may approach from a different path. But if all of the duplicate RREQ packets are broadcast, this will generate a broadcast tempest and radically decline the performance. In order to avoid this problem, a new approach is introduced in NDMR recording the shortest routing hops to keep loop-free paths and reduce routing transmit overhead. When a node gets a RREQ packet for the first time, it checks the node list of the route path, computes the number of hops from the source node to itself and account the number as the shortest number of hops in its reverse routing table. If the node gets a copy RREQ packet again, it calculates the number of hops and compares it with the shortest number of hops in its reverse routing table. If the number of hops is bigger than the shortest number of hops in the reverse routing table, the RREQ packet is dropped. Only when it is less than or equal to the shortest number of hops, the node adds its own address to the node list of the route path in a RREQ packet and broadcasts it to neighboring nodes another time.

The destination node is accountable for selecting and recording several node-disjoint paths. When receiving the first RREQ packet, the destination stores the list of node IDs of the complete route path in its reverse route table and sends a RREP packet along the reverse route path. When the destination gets a duplicate RREQ, it compares the whole node IDs of the complete route path in the RREQ to all of the obtainable node-disjoint paths in its reverse routing table. If there is no general node (excepting the source and destination node) between the node IDs from the RREQ and node IDs of any node disjoint path in the destination's reverse table, the route path in existing RREQ is a node-disjoint path and is stored in the reverse routing table of the destination. Otherwise, the current RREQ is discarded.

III. QUALITY OF SERVICE (QOS) IN NDMR

Differentiated Services (DiffServ) is a standard Procedure to achieve QoS in any IP network and could effectively be used to provide QoS in MANETs. DiffServ provides QoS by isolating traffic into a small number of classes and assigning network resources on a per-class basis. The class is marked directly on the packet, in the 6 bit DiffServ Code Point (DSCP) field. The DSCP field is part of the novel type of service (ToS) field in the IP header. The IETF redefine the significance of the little-used ToS field, splitting it into the 6-bit DSCP field and a 2- bit unused field. The unused field is being allocated to the Explicit Congestion Notification (ECN) mechanisms, as shown in Figure 1.

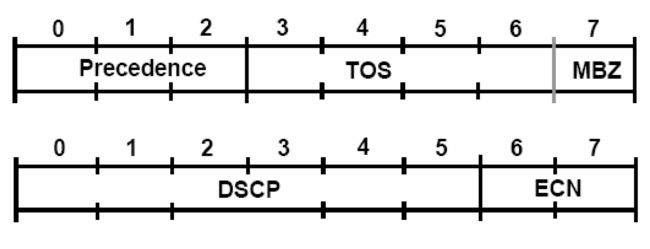

Figure 1. DSCP and ECN

The vital objective of the Differentiated Services architecture is to convene the performance rations of the users. It classifies traffic into diverse priority levels and applies priority scheduling and queuing management mechanisms to attain QoS support.

DiffServ is entirely distributed and stateless model. No state information is requisite to be maintained at any node. The model aims at pushing the complexity to the boundary nodes of the network so that the process in intermediate nodes can be as easy and fast as possible. Instead of providing QoS at per flow granularity, DiffServ distinguishes the traffic into a fixed number of classes.

The notion of QoS is an assurance by the network to gratify some fixed service performance constraints for the users in terms of the end-to-end delay, available bandwidth, probability of packet loss, and so on [10]. Future ad hoc mobile networks will bear increasing levels of varied multimedia applications such as voice, video and data.

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This has resulted in an increasing spotlight on guaranteeing the QoS for such delay sensitive applications such as voice, as specified to the customer in a Service Level Agreement (SLA). This section introduces a narrative approach to QoS in MANETS: QoS enhanced NDMR, which brings together the advantages of NDMR and DiffServ and makes it appropriate for the environment of MANETs to sustain end-to-end QoS solutions.

In NDMR, after deciding a path as a node-disjoint path, the destination will make a route reply packet (RREP) which holds the node list of entire route path and unicasts it back to the source. However, since an RREP only currently contains the route path, it cannot offer effective QoS support for MANETs. It is proposed that RREP packets should bear more information such as delay time (queue length) in order to meet certain SLA requirements. When each intermediate node gets a RREP packet, it adds the queue length of this node to the "queue_length" field in RREP packet. Thus, when the source node gets the RREP from the destination node it knows the precise queue length along the path.

Each source keeps three node-disjoint paths for a meticulous destination. With the "queue_length" field in RREP packet, it go for the path with the minimum queue length. This allows it to diminish the delay time thus giving higher QoS.

Figure 2 shows queue length along the multiple paths. Assume source node ***S*** first gets the RREP from route 2 (**R2**) (***s-a-b-d***). In standard NDMR, ***S*** will always broadcast data on that route so long as no link break occurs, even though route 3 (**R3**) (***s-g-h-i-d***) has a slighter queue length and hence a lesser rate of delay. With the introduction of the "queue_length" field in RREP, ***S*** will initially opt route 2 (**R2**) (***s-a-b-d***) to broadcast data as it gets an RREP from that route first. But after receiving the RREP from route 3 (**R3**) (***s-g-h-i-d***), it will compare the queue length of the offered routes, then change to route 3 (**R3**) (***s-g-h-i-d***) to go on transmitting data. Using this approach, it can decrease the transmission delay rate and meet the SLA requirements.

As an RREP is generated only in the route discovery process, the protocol currently cannot often refresh the queue length of every path. As part of the improvement to NDMR, the need for a similar packet, RUP, route update packet, containing the "queue_length" field used in an RREP packet that performs more recurrent updates has been identified. The destination node will at times unicast RUP packet containing up-to-date queue length to the source node. The source will be capable to choose the best path according to the variation of queue length in real time.

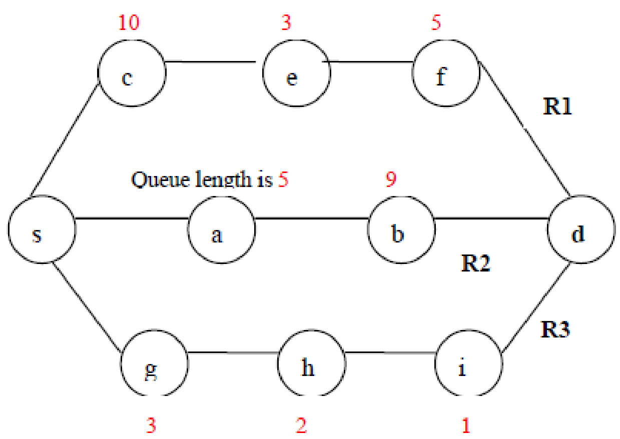

Figure 2. Queue Length in Multiple Node-Disjoint Paths

Figure 3 shows that the simulation results by OPNET of packet average delay for QoS enabled NDMR provide better presentation than that of NDMR. The delay time for all mobile velocities tends to be equal. The reason is that with RREP packets shipping real-time delay time back and RUP, the data packets will always be transmitted along the lowest congestion path.

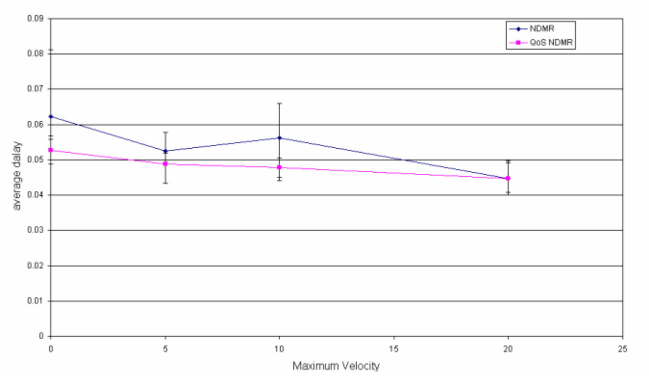

Figure 3. Average delay – CBR

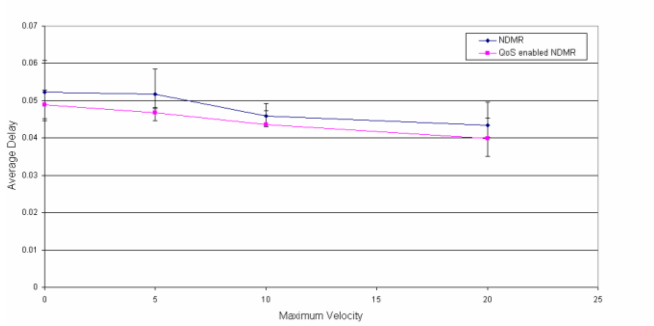

Figure 4. Average delay - exponential source

It can be seen from Figure 4 that QoS enabled NDMR gives enhanced performance when the source generates packets exponentially as well as in constant bit rate (CBR).

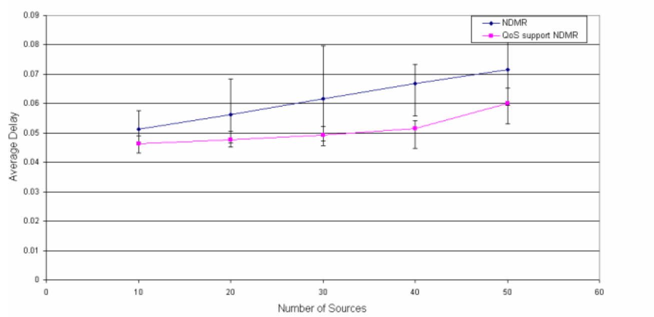

Figure 5. Average delay -different source, CBR

Figure 5 shows the average delay of dissimilar number of sources that produce packets. QoS enabled NDMR maintain the packet delay time lower as well.

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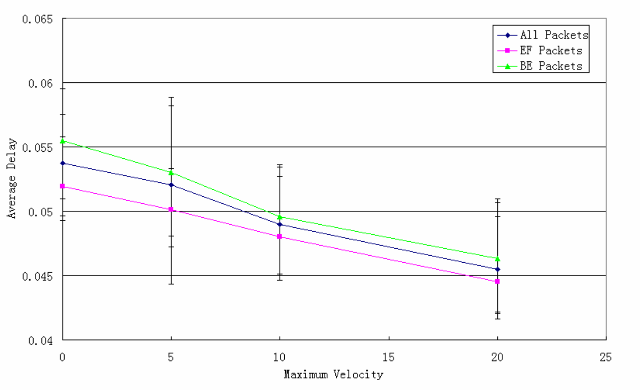

Figure 6. Average delay - dissimilar priority

It is necessary to let the Expedited forwarding (EF) traffic which frequently needs low packet delay time transmit on lower delay time path and Best effort (BE) traffic transmit on other node-disjoint paths. With QoS enabled NDMR, source is able to choose the best path for EF traffic. Figure 6 shows the average delay time of different priority traffic. EF traffic gets the inferior delay than BE traffic.

IV. AGENT-BASED SLA MANAGEMENT

An agent is a computational unit, such as a software program or a robot [11]. It acts upon its environment and is self-directed in that the behavior is based on its own experience.

There are four main properties according to [12]:autonomy, reactiveness, proactiveness and social ability.

Autonomous means an agent must be able to work without direct command from a programmer or user. *Reactiveness* means agents are able to control the environment and can proficiently move from current situation to the goals. *Proactiveness* means agents can initiate actions to move towards the goals. *Social ability* means agents can communicate with other agents directly and act on information from other agents to craft their own decision.

The main reason to use intelligent agents is to provide greater independence to the mobile nodes. The autonomy increases the suppleness to deal with new situations to obtain QoS to meet different SLAs.

A major feature of the QoS enabled NDMR proposed in this paper is the application of intelligent software agents for SLA management. Employing intelligent agents provides superior autonomy to the mobile nodes, considering for the essential flexibility to respond to the dynamic nature MANETs. This litheness will allow the system to meet the QoS requirements agreed in SLAs.

The delay time for each path is calculated from queue length or buffer length. These two parameters are very significant in queue management and should be taken into consideration to meet the necessities of any SLAs. A technique to maintain the queue length short in a long buffer is essential. It is proposed that this technique be under the control of an intelligent agent.

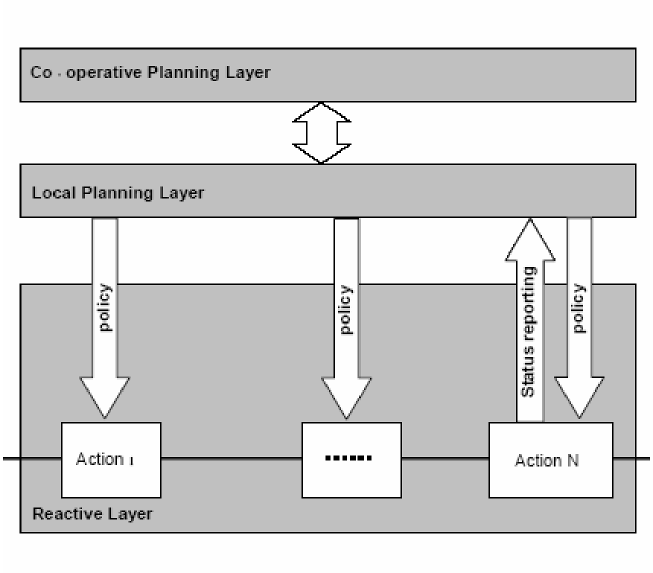

Figure 7. General Agent Structure [6]

The general agent structure is shown in Figure 7. It uses three layers – reactive, local planning and cooperative allowing it to take action and make decisions in different timescales. The reactive layer is intended for quick response in real-time. More complex and slower performing functions are implemented in the two planning layers. Generally the local planning layer is concerned with long-term actions within its own node and the cooperative planning layer is concerned with long-term actions with other agents. Future work will develop the communication and support with agents in other nodes.

In QoS enhanced NDMR, the co-operative planning layer is used for deciding whether to change path or not (according to the queue length of this node and other nodes); the local planning layer is for opting which path to transmit data (according to the queue length of this node). As illustrated in Figure 8, the packet is broadcasted on the reactive layer and the parameters critical to decision making (such as queue length) are passed up to the planning layers. After calculating delay and selecting the appropriate path, the packet will be routed out along this path.

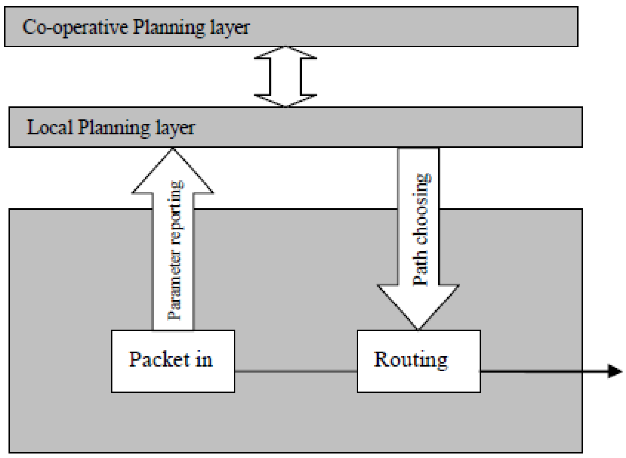

Figure 8. NDMR Agent Structure

V. CONCLUSION

This paper has presented architecture for guaranteeing QoS based on Node-Disjoint Multipath Routing Protocol (NDMR) in mobile ad hoc networks. The issue of QoS provision is highly challenging for MANETs and essentially different from conventional fixed networks. Due to the expansion in demand for varied multimedia applications, satisfying the QoS guarantees in SLAs requires solutions that are responsive to network state. The use of multiple node-disjoint paths gives the opportunity for allocating packets to paths in a finest way to meet instantaneous constraints. This paper has compared performance in different situation of NDMR and originates a means of developing NDMR – through the queue length field and additional route update packets to allow for QoS extent along such node-disjoint paths. By using intelligent agents it will be possible to distribute this optimization at the planning layer, thus allowing very fast processing to take place at the reactive layer while still taking into account the needs of all nodes.

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