RPRT: Energy Efficient Reserved Path Routing Topology for Mobile Ad Hoc Networks

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Abstract

Providing Quality of Service (QoS) support in Mobile Ad Hoc Networks (MANETs) is a mainly active research area with a number of proposals being made to support real-time applications that are based upon the communication between the routing scheme and a QoS provisioning mechanism. This paper construct upon such ideas and presents Energy Efficient Reserved Path Routing Topology (RPRT), a routing scheme that have been shown to offer important network development when compared to earlier proposed schemes. RPRT fundamentally modifies the previously proposed energy efficient scheme Mtrace to clearly provide QoS assurance. The new proposed scheme permit nodes to obtain and then use estimation of the energy levels to make appropriate channel admission control decisions. The performance discrepancy are investigated by developing simulation models. Results demonstrate the merits of the proposed scheme with a 16% increase in energy competence while end-to-end delay is reduced by 37% when compared with Mtrace and the necessity of Energy Efficient Reserved Path routing schemes in MANETs becomes more apparent.

Keywords: Mobile Ad Hoc Networks, Reserved Path routing, Quality of Service, Shortest Reserved Path Routing Topology.

1. INTRODUCTION

Routing schemes have prompted a great deal of interest from the starting of Mobile Ad Hoc Network (MANET) [1] research until the current time. Early work [2–4] focused on finding possible routes without considering information about the network status. In addition, without significant the bottleneck transmission competence or throughput, the source may send more data than the bottleneck node on the route can contain. The overloaded node eventually drops data which wastes transmission competence and unnecessarily use energy. Also, time is expended in transmitting such data. Therefore, data that lastly reaches its destination would have had to wait longer in packet queues, resulting in a considerably increased delay. Although this may be satisfactory for data only applications, many real-time applications need Quality of Service (QoS) support from the network. Possible QoS support can be accomplish by finding a route to suit the application requirements.

Energy Efficient routing takes into consideration multiple QoS requirements, link dynamics, as well as the inference of the chosen routes on network usage, rendering QoS routing a mainly challenging problem. However, the distinctive features of MANETs, namely dynamically varying network topology, imprecise state information, need of central coordination, error-prone shared radio channel, hidden terminal problem and time-varying transmission capability exacerbate the already complex routing problem [4]. More significantly, node mobility causes common failure and reactivation of links, completing a reaction to the changes in topology from the network's routing, thus increasing network control traffic and saturating the already congested links. Hence, all these aspects need a cost-effective Energy Efficient routing scheme.

The majority of the routing schemes proposed in the literature have focused on providing QoS based on two metrics: transmission competence (throughput) and delay [5–22]. Of these metrics, the most usually used is transmission competence. This is possibly because most real-time applications need some degree of guaranteed throughput in addition to other constraints. A number of schemes have been earlier proposed that estimate energy levels derived from window-based measurements of channel estimation. However, to enhance the user's perceived QoS, Reserved Path routing methods can be used to develop the previously proposed unipath solutions.

In this paper, a new Energy Efficient routing scheme is proposed. The novel part of the proposed scheme is a simple additional mechanism to estimate energy levels in IEEE 802.11-based ad hoc networks that provides enhanced than best-effort service. It is exposed through simulation-based evaluation to provide improved usage estimation and thus better available transmission competence based channel admission control.

The remainder of the paper is organized as follows. Section 2 presents an overview of the M-Trace routing scheme. Section 3 presents the proposed Energy Efficient routing scheme for MANETs. In section 4, simulation surroundings based on NS-2 [24] is proposed. Section 5 discusses the simulation results and concluding remarks are made in Section 6.

2. OVERVIEW OF THE MTRACE[23] ROUTING SCHEME

The Energy-Efficient Real-Time Multicast Routing in Mobile Ad Hoc Networks [23] is an energy-efficient real-time data multicasting architecture for mobile ad hoc networks. Mtrace is dropping the restrictions on the route selection scheme to raise the number of Reserved Paths possible. Rather than selecting routes that are node disjoint throughout. Mtrace increases the number of routes possible between a source and destination by requiring that the alternative routes be partially disjoint only, i.e. that they bypass at least one midway node on the primary path [23]. The primary path here is simply the first path to be acknowledged, i.e. the path for which the source receives the first route reply message. Rising the number of paths possible between a source and a destination makes the scheme more resistant to faults, and helps speed up recovery when a link along the path breaks. In [23], a mathematical analysis is used to prove that using a bigger number of partially disjoint paths enlarge the network's acceptance to faults, compared to link or node disjoint multiple paths. The operation of M-Trace is also divided into route discovery and route maintenance phases.

In M-Trace not all duplicate RREQs are discarded, in its place an intermediate node only forwards a RREQ if the number of hops the RREQ has traversed from the source to itself is less than or equivalent to the number of hops traversed by the first RREQ it established. On deciding whether to forward a duplicate RREQ, M-Trace nodes do not consider the incoming link on which the RREQ was received (as in SMR), since the scheme aims to build in part disjoint paths. in its place, it compares the number of hops from the source to itself in the route of the previous RREQ to the number of hops of the new RREQ, and only forwards the RREQ if the latter is less than or equal to the former. During the route discovery, only the destination is allowed to reply to a RREQ. Again, this limits the role of intermediate nodes in determining whether to forward a RREQ or not, and in fact forwarding the control messages. However, it is the source node that choose the paths, not the destination node. The destination node simply replies to the first few RREQs it receives. The route reply message (RREP) have the path the RREQ has traversed to arrive at the destination, including the destination address. The destination node also saves the route path for every RREP it sends in its cache, and lastly unicasts the RREP to source. When the source receives the RREP, it adds the new route to its cache and can then be used to send the data. In Route maintanace, if any intermediate node along a route is not capable to send data to the node on the other end of the link, then it declares the link broken and generates a ERR message destined to the source node. The intermediate node does not try to use an alternative to the broken link. When the source receives the ERR message, it eliminate the broken link from its routing cache, even if it is used to route data to one more destination. It then arbitrarily choose another route from the remaining alternative routes and uses it to send data.

3. ENERGY EFFICIENT RESERVED PATH ROUTING TOPOLOGY FOR MOBILE AD HOC NETWORKS

A novel and practical Energy Efficient Reserved Path routing scheme referred to as the Reserved Path Routing Topology (RPRT) is proposed. The proposed scheme adapt and extends the route detection and preservation of Mtrace [23] to provide QoS declaration by congestion and contention avaoidance. The RPRT allows nodes to use their estimation of the energy levels to make enhanced channel admission control decisions. The RPRT routing scheme achieves high energy competence, low delays and overheads in the presence of mobility and traffic load and enables natural combination with the local Energy Levels estimation. This section describes the energy levels estimation, route detection with channel admission control, QoS route reply phase, QoS route maintenance phase and path selection of the proposed scheme.

3.1 Energy Levels Estimation

Energy Levels estimation is a basic component in the provision of QoS in MANETs. The Energy Levels of a link relates to the idle transmission competence of the link during a meticulous predetermined time period. So, even though the transmission capability of a link depends on the fundamental transmission technology and propagation medium, the Energy Levels of a link additionally depends on the traffic load at that link and is, usually, a time-varying metric.

However, precise transmission capability view can be difficult; because every host has only vague knowledge of the network status; thus an efficient estimation scheme is extremely attractive. Many earlier proposed schemes [17–20] adopt 'Listen'-based estimation methods derived from IEEE 802.11 MAC/PHY specification [25]. The 'Listen' scheme need every node to listen to the channel and estimate the local Energy Levels based on the measurement of the local channel usage. Given the local channel usage $ch_u < (u(t)) >$ and the most achievable transmission transmission competence $\text{mtc}(\text{ch}_u) < c_{\max} >$. the local energy levels $ch_{el} < c_{res} >$ is estimated using the following equation:

$\text{ch}_{el} = (1\text{-ch}_u)\text{*mtc}(\text{ch}_u) < c_{res} = (1-u(t)).c_{\max}$ >………………….(1)

where $0 \le ch_u \le 1$is a measure of the channel usage. A easy and direct method for determining channel usage is to measure channel demanding time at nodes within its transporter sensing range [26]. At any given point in time, the channel can be inactive since no transporter found and channel allocation table unset(ntca). If transporter found or/and channel allocation table is set then the channel is full of activity. The states can be defined as ntcna(No transporter found and the channel allotment table is unset), ntca (No transporter found, but the channel allotment table is set), tfcna (transporter found and the channel allotment table is unset) and tfca (transporter found and the channel allotment table is set). If state of a channel is ntcna then channel is available, but in all other three states ntca, tfcna, tfc, achannel is not obtainable to allocate.

An additional state referred as fiew (frame interval expiration wait) that point to the channel busy state due to the waiting period for frme interval expiration.

All states apart from the ntcna, prohibit a node from transmitting in the channel and hence, in these states, the channel is considered as full of activity. At any precise instant in time, a link is either transmitting a packet or it is inactive, so the channel activity of a link can only be either 0 or 1. Thus, some meaningful measurement of the channel activity requires a node to keep track of the demanding channel periods over a time window which is the time interval of interest.As a result, the channel usage (u(t)) for a time period $(t\text{-}w,t)(w))$is given by the area under the channel activity function (f(t)) curve [27]:

$ch_u = \frac{1}{w}\int_{t-w}^{t} f(t).dt$ ………..(2)

The transmission transmission capability that observed is not most possible, this is due to the packet transmission overheads. The most transmission transmission capability can be identified as

$$mtc = \frac{ads}{ths + ihs + ads} * mtc(802.11) \quad <$$

$$(C_{\max}) = \frac{L_{Appl}}{L_{T.Hdr} + L_{I.Hdr} + L_{Appl}} \times C_{\max-802.11}$$

>………(3)

In the given equation (3) to measure most transmission transmission capability referred as mtc, data gram size at application layer referred as ads is divisioned by the sum of header size of transport layer ths, header size of IP layer ihs and ads, and lastly that result will be multiplied by most transmission transmission competence mtc of 802.11 MAC layer[28].

3.2 Route Discovery with Admission Control

RPRT is an on-demand Energy Efficient routing scheme that utilizes a cross-layer design. Therefore, the routing scheme depends on the application requirements. RPRT finds a route to the destination by flooding the network with a Energy efficient route request (ERQ). ERQ is an extended format of RREQ used in Mtrace with the transmission competence constraint. The transmission competence constraint consists of the required transmission competence (rtc) and minimum available transmission competence ($\overline{mtc}$) representing maximum transmission competence of the application and minimum available transmission competence (bottleneck transmission competence) of an egress channeluseful for path selection.

The sender records rtc and compares with the local Energy Levels (el_l) of the egress channel. If C_{res} is higher than rtc, the source node records the value of el_l in the $\overline{mtc}$ field which, initially is considerably large and broadcast the ERQ packet to its neighbor nodes. On receiving ERQ packet, an intermediate node calculates its Energy Levels el_l . If el_l is greater than rtc, the node forwards this ERQ. Otherwise this ERQ is discarded. The node also updates the $\overline{mtc}$ field if el_l is less than earlier $\overline{mtc}$.

3.3 Energy Efficient Route Reply Phase

RPRT extends RREP packet format of M-Trace with the minimum transmission competence field($\overline{mtc}$).

The destination sends a ERP in response to the first received ERQ; after that only limited ERPs are sent in order to avoid route reply storms. RPRT does not update the QoS during route reply since the QoS does not change significantly during this time. Updating QoS both ways would use battery power of the mobile node, add processing outlay and cause the source wait longer for a ERP.

3.4 QoS Route Maintenance Phase

In route maintenance that opts in RPRT, An ERR packet will be generated by a hop level node during fatal transmission problem raised at its MAC layer and this ERR routes to source node that alerts about a link failure. Upon receiving ERR, the source node updates route cache by discarding the path effected by link failure. The source node then selects a new valid alternate routing path, with the maximum bottleneck transmission competence $(\overline{mtc})$. If route cache is empty or having path less than given threshold then new route discovery process will be instigated..

4. SIMULATION AND RESULT DISCUSSION

A simulation model developed using MXML and actionscript to form the basis of the evaluation of the proposed RPRT scheme whose performance is to be contrasted with M-Trace that provides no direct QoS support. The previously proposed routing schemes [17] [18][19][20] obtained results assuming IEEE 802.11 unique standard operating at 2 Mbps. at present, however, the IEEE 802.11b is the de facto suggestion technology for MANETs. There have been relatively few earlier studies into the ability of the IEEE 802.11b standard operating at 11 Mbps to support QoS in MANETs. Therefore, in this study, IEEE 802.11b standard operating at 11 Mbps is used as the underpinning MAC.A dedicated 'Utilization Monitor' module (UMon) is developed and integrated into the IEEE 802.11Ext implementation [29] within network simulator NS-2.33 [24]. UMon effectively monitors and records the state of the interface and is linked to the channel activity function to estimate the channel utilization. As the Energy Levels can change over time, it is important to measure it suitably. A moving window of w=0.5 seconds is utilized to estimate the Energy Levels. The simulation environment consists of 50 wireless nodes forming an ad hoc wireless network, moving over a 700 x 500 m2 flat space. The propagation model is a two ray ground with 250 m transmission range, 550 m carrier sensing range and a supposed bit rate of 11 Mbps.

4.1 Traffic and Mobility Model

The Constant Bit Rate (CBR) are considered as traffic sources to analyze the contending schemes. CBR traffic is recognized between nodes using a connection pattern generator script cbrgen.tcl [24] and VBR traffic is recognized between nodes using an exponential ON/OFF traffic generator expogen.tcl [24]. The number of active sources is 20 nodes, chosen arbitrarily from the full set of nodes generating 512 byte data packets. The network load (traffic intensity) is varied by changing the rate of the active sources. Mobility is characterized by speed arbitrarily distributed between 0-10 m/s following the random waypoint model with a pause time of 30 seconds, which can be setup using a scenario producer script set dest [24]. Simulations are run for 900 seconds of real time.Every data point represents an average of twenty runs using different seeds with the corresponding confidence interval of 95% [30].

4.2 Performance Analysis:

The key metrics used in measuring each scheme's energy efficiency are:

• Energy Utilization per Packet: It is defined by the total energy utilization divided by the total number of packets delivered. This metric indicates the energy efficiency for each topology.

Average RTS Retransmissions required for each Data Packet: It is defined by the total number of RTS retransmissions divided by the total number of packets delivered. The RTS packet is transmitted at the utmost energy usage level and the packet size is very little. The majority of RTS retransmissions are due to collisions, together with the collisions of both RTS messages and data packets. Hence, this metric can indicate the pace of the collision for each topology. Higher collision rate will cause more energy utilization, higher end-to-end delay, and lower throughput.

The simulation results are shown in Fig. 1 and 2. According to these results, RPRT performs the best in terms of Energy Utilization per Packet as well as Average RTS Retransmission per Data Packet that compared to MTrace

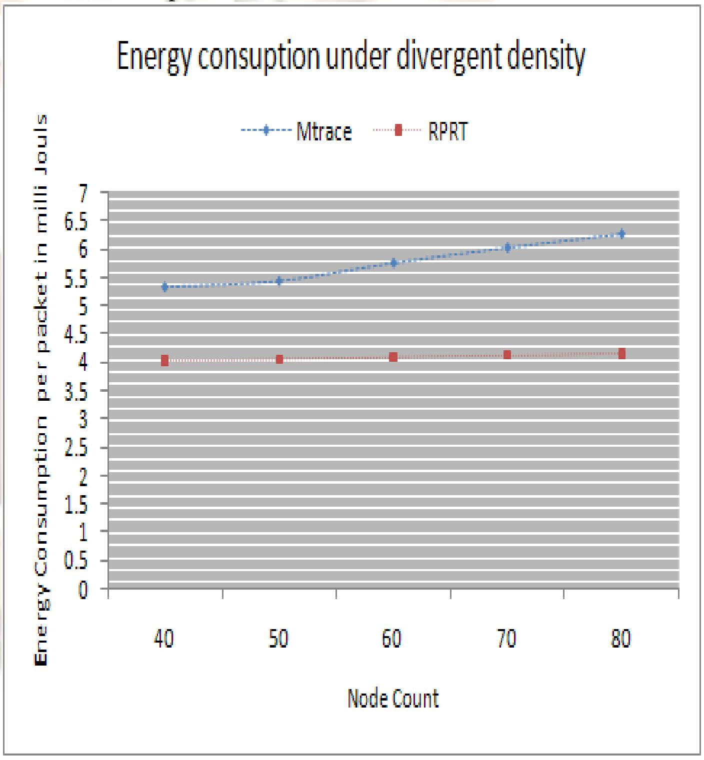

Figure 1: Energy Utilization ratio between RPRT and MTrace

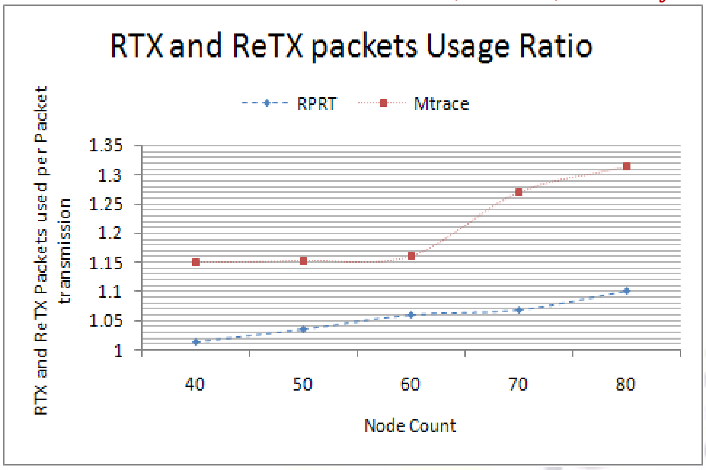

Figure 2: RTX and ReTX packets usage Ratio comparison between RPRT and MTrace

5. CONCLUSION AND FUTURE WORK

This paper proposes a new transmission competence-constrained QoS-aware routing scheme referred as Shortest Multipath Source (RPRT) routing scheme to overcome the shortcomings of M-Trace routing scheme. The scheme permits nodes to depend on their estimation of the Energy Levels to make appropriate channel admission control decisions to ensure QoS support in MANETs. The performance of RPRT demonstrates the merits of the algorithm. Simulation results show that RPRT achieves better performance than M-Trace in terms of energy efficiency, especially at low to intermediate traffic loads.

In the RPRT scheme, there is no provisioning of any predictive way to anticipate a route break, which causes performance degradation mainly in mobile scenarios. Therefore, some pre-emptive preservation mechanisms such as periodic transmission competence estimation during data transmission can help find a new route before the old route is broken so that the routing scheme can react much better to mobile scenarios. The accurate measurement of the transmission competence is an open issue. The choice of window size for suitable transmission competence estimation is a major impediment to such window-based schemes and further study could be helpful to mitigate the limitation of the previous approaches.

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