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Hop Level Resilient Multipath Routing Strategy for Mobile Ad hoc Networks

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Abstract: In mobile ad hoc networks, common mobility during the communication of data causes route failure which results in path rediscovery. In this, we suggest Energy Efficient Alternative path routing topology for efficient local route recovery (EEAPR) in Mobile Ad hoc Networks . In this topology, every source and destination pair establishes multiple paths in the single route discovery and they are cached in their route caches. Approach: The cached routes be sorted on the basis of their bandwidth availability. In case of route failure within the main route, a resurgence node which is an eavesdrop neighbor, detects it plus establishes a local recovery path with maximum bandwidth from its route cache. Results: in simulation results, we explain that the proposed approach improves network presentation. Conclusion: The future route recovery management technique prevents the frequent collision and degradation in the network performance.

Keywords: Mobile Ad hoc Network , route recovery, route detection, routing topology, route malfunction, numerous paths, match up establishes, route cache, cached routes

1. INTRODUCTION

Mobile Ad hoc Network : A self- configured network of mobile nodes associated with wireless links in order to organize a random topology is termed as mobile ad hoc networks. The nodes travel in the random manner [8]. Quick deployment, strength, flexibility and essential support for mobility are some of the merits of the ad hoc networks. As ad hoc network is economically beneficial, it is utilized in the military application, collective and distributed computing, emergency services, and wireless mesh and sensor networks and even in hybrid networks.

The wireless transmission limit has undergone an extension with the help of the ad hoc networks on account of multi-hop packet forwarding strategy. This can support the situation during the pre-build infrastructure cannot cope up with the application. There is no existence of stationary infrastructure of the base station or switching centers in ad hoc network. The mobile nodes within radio limits interact directly through wireless routes and those that are distant depend on the other nodes to act as routers. The issues related to MANET routing are unpredictable of environment, unreliability of wireless intermediate, resource-constrained nodes plus active topology. These issues may result in faults such as broadcast errors, node failures, connection failures, direction breakages, congested nodes or links [7]. Route discovery, route maintenance and traffic allocation are the three components includes in the multiple path direction-finding. The first two apparatus establish of numerous routes between source and target node. Furthermore the Alternative path routing topology tries finding disjoint nodes, disjoint link and non-disjoint routes. After the route is established, the mobile node starts forwarding the data packets to the destination. Usually during some situation, the route failure causes the forwarded packets to be lost. Other situations cause the packets to reach the destination with some delay. To tackle this problem, route maintenance technique is considered. The recently discovered routes should be cached for using it again when the similar route is demanded. The two types of route caching technique available for on-demand routing topology are source route caching and intermediate path caching. The on-demand direction-finding topology such as AODV and DSR permits the intermediate node which has cached route to the destination respond to the source with the cached route. The route cache is necessary for granting forceful recovery in MANET. The merits of using route cache include the availability of the alternate route during link failure and controlling overhead which is necessary to repair the route. In this regard we can conclude that traditional on-demand routing protocols produce a large amount of routing control traffic by blindly flooding the entire network with RREQ packets during route discovery. The routing overhead associated with the dissemination of routing control packets can be quite huge, especially when the network topology frequently changes [1]. Alternative path routing protocols cache multiple routes to a destination in a single route discovery. However, in the existence of mobility, multiple path protocols incur additional packet drops and delay due to their dependency on potentially stale routes from caches Protocols using either limited broadcast or local error recovery have focused on reducing packet drops and not on utilizing the bandwidth efficiently during route recovery. We propose to develop a hybrid routing topology involving multiple path discovery and local error-recovery. In this topology, each source and destination pair establishes multiple paths in the single route discovery and they are cached in their route caches. The cached routes are sorted on the basis of their bandwidth availability.

Whenever a link or a route break is occurring, a local error-recovery is performed which in turn invokes the alternate route selection. An effective alternate route is selected from the route cache which is more consistent and having greater available bandwidth.

So our proposed hybrid routing method has the following advantages:

- Reduces packet drops
- Reduces the recovery time
- Reduces overhead
- Utilizes bandwidth efficiently

2. RELATED WORKS:

Ko et al [4] have proposed a location-based hybrid routing topology to improve data packet delivery and to reduce control message overhead in mobile ad hoc networks. In mobile environments, where nodes go continuously at a high speed, it is usually difficult to maintain and restore route paths. Therefore, their study suggests a new flooding mechanism to control route paths. The essence of their proposed scheme is its effective tracking of the destination's location based on the beacon messages on the main route nodes.

Ould-Khaoua et al. [1] proposed a new probabilistic route discovery method for routing in MANETs, referred to as Probabilistic Counter-based Route discovery (PCBR), which combine the features of counter-based and gossip-based approaches. The performance of PCBR is evaluated using AODV as the base routing topology, which traditionally uses the blind flooding. The effect of traffic load, mobility and topology size on the performance of the PCBR-AODV route discovery is not considered.

Kumar et al [2] have enhanced the performance of Split Alternative path routing protocols by using route update mechanism. Their proposal is useful in the route revival process. In MANET for sending the data packets through alternate path takes more time in comparison with stale route that was broken. So, they repair the broken route through a route update mechanism process and reduce the delay through the new updated path. In their proposal they are considering the high gain antenna terminal that adjusts transmission range of each node and follow a new technique for route update mechanism. So, they provide a heuristic approach to reduce the delay metric and increase the performance of MANET.

C.C. Tuan et al [12] have proposed a power saving routing topology with power sieving technique in wireless ad hoc networks. They partitioned the network area into several square grids using Global Position System (GPS). The routing is performed in a grid-by- grid manner. One node is elected as the great leader in its grid with a power sieving mechanism without broadcasting election packets. The advantage of this technique is that it saves more power for data transmission and the network lifetime is also prolonged.

J. Chen et al. [3] have proposed a new multiple path topologies called the Alternative path routing Protocol for Networks Lifetime Maximization in Ad- Hoc Networks (MRNLM) is proposed based on AOMDV. The topology sets the energy threshold to optimize the forwarding mechanism. At the same time it constructs an energy-cost function and uses the function as the criterion for multiple path selection. In transmission phase, they use a novelty method called "data transmission in multiple paths one by one" to balance the energy in multiple paths.

J.Y. Choi et al. [10] proposed a reliable and hybrid Alternative path routing topology which provides a proactive-like routing with less end-to-end delay and less control overhead. Also a fast error recovery scheme to cope with the potential route failures caused by node destruction by the enemy is proposed. The disadvantage of this approach is that load balancing and more efficient route maintenance is not taken into account.

R. Berangi et al [6] have projected a Alternative path routing with fault tolerance technique in MANETs. Their topology is an extension of DSR for enhancing the reliability by modifying the route discovery and route maintenance processes in DSR. The multiple routes are maximally node-disjoint in this topology. Their approach does not consider the quality of service into account for data transmission.

3. ALTERNATIVE PATH ROUTING TOPOLOGY FOR EFFECTIVE LOCAL ROUTE RECOVERY:

We proposed a hybrid routing topology involving multiple path discovery and route recovery. When the source node needs to forward a data packet to a target node, it broadcasts the Route Request packet to the entire network. The intermediate node updates its route caches about the routing information whenever it receives the RREQ packet and continues packet broadcasting. The destination node upon receiving all RREQ packets attaches the route code constituting available bandwidth information and feedback Route Reply packets. Upon reception of RREP packets, the source node selects the primary route based on the route code. In case of route failure in the primary route, the restoration node detects it and establishes a local recovery path with maximum bandwidth from its route cache. The route recovery management technique is handled to avoid the frequent collision and degradation in the network performance.

Available bandwidth estimation: After RREQ packets are forwarded, time slots of each route between source and destination is collected by the destination node at the same time. Thus the destination node keep the status for time slots related to every route.

By means of periodic intervals in the destination node, the route of maximum bandwidth can be found using following computation.

We assume that N routes (n1, n2,...,n_N) are discovered between source and destination nodes.

Using the function "Set_Tentative", bandwidth B of route n_i (i = 1,.,N) can be computed as follows:

B_i = Min (T/2, T_{bi})

Where:

T = Number of total time slots in every route T_{bi} = Number of free time slots in the bottleneck link of route Ni

3.1 Alternative path routing:

On the event of transmitting a data packet, if no route found then the source broadcasts the route request packets. If a unique RREQ reaches the intermediate nodes, it attaches the node ID to packet and continues broadcasting. If replicas of earlier received packets found, then drops if those replicated packets are not from local routes and this process we conclude as conditional dropping, which minimizes the packet loss. Even an intermediate node is aware of the path to target node, it is not allowed to initiate the root reply process since only the target node is eligible to perform route reply process. The destination node upon receiving all RREQ packets attaches the route code and feeds it back as RREP packets. Let n RREP packets are generated for the paths Pi, P_2,...,P_n. The route code is to recognize the available bandwidth. The RREP with route code RC1 has a maximum available bandwidth and RREP with route code RC2 has next maximum bandwidth availability and so on. The priority condition for bandwidth selection is as follows:

$B_1 > B_2 > B_3 > B_4 .... > B_n$, where B_1, B_2, B_3,..., B_n are the available bandwidth of the routes.

After the intermediate node receives RREP packets, they store the routes P_1,P_2,.,P_n in their route caches and then forward them to subsequent nodes. Once the route reply process is completed then the primary path will be opted by the source node. Against to the failure of the route currently in use the restoration node detects it and establishes a local recovery path with maximum bandwidth (which is the first available path) from its route cache. The route recovery technique is described as follows.

3.2 Route recovery Direct Acyclic Graph technique:

During the data transmission, the node mobility and low battery power are the issues causing route breakage. To handle this, a local recovery mechanism is triggered which is based on the establishment of restoration nodes.

Direct Acyclic Graph Process

We consider a network with a set of nodes and links denoted by *N* and *L*, respectively. We assume that links are bi-directional in nature, which may be realized using two unidirectional links. We denote a bidirectional link between nodes *i* and *j* as $i \rightarrow j$, while the directed link from *i* to *j* is denoted by $i \rightarrow j$. When a link *i-j* fails, we assume that both directed edges $i \rightarrow j$ and $i \rightarrow j$ fail.

Consider two directed acyclic graphs (DAGs) that are rooted at a node, say d. The two DAGs are said to be link-independent if for every node $s \in N \;\; s \neq d$, any path from *s* to *d* on one DAG is link-disjoint with any path from *s* to *d* on the other DAG. Similarly, the two DAGs are said to be node independent if for every node $s \in N$, $s \neq d$, any path from *s* to *d* on one DAG is node-disjoint with any path from *s* to d on the other DAG. Let P_{sd} and $P_{sd}^{'}$ denote any two paths from *s* to d, one from each DAG. The link-independent DAGs satisfy the following property.

Resilient Routing with IDAGs

The network is assumed to employ a link-state protocol, hence every node has the view of the entire network topology. Every node computes two DAGs, namely red (R) and blue (B), for each destination and maintains one or more forwarding entries per destination per DAG. The DAGs may be used in two different ways to achieve resilient routing. In the first approach, referred to as Red DAG first (RDF), the packets are assumed to be forwarded on the red DAG first. When no forwarding edges are available on the red DAG, the packet is transferred to the blue DAG. When no blue forwarding edges are available, the packet is dropped. The DAG to be employed for routing is carried in an overhead bit (DAG bit) in every packet header. In the second approach, referred to as Any DAG first (ADF), a packet may be transmitted by the source on the red or blue DAG. In addition to the DAG bit, every packet also carries an additional bit that indicates whether the packet has been transferred from one DAG to another (Transfer bit). A packet is routed on the DAG indicated in its packet header. If no forwarding edges are available in that DAG and if the packet has not encountered a DAG transfer already, it is transferred to the other DAG. If no forwarding edges are available on the DAG indicated in the packet header and the packet has already encountered a DAG transfer, the packet is dropped. Note that if the red and blue DAGs are (link- or node-) independent, then the network is guaranteed to recover from a single (link- or node-) failure when the packet is transferred from one DAG to the other. In addition, the network may tolerate multiple failures as some nodes may have many forwarding entries in each DAG.

Given a destination node *d* in the network, observe that the edges emanating from d cannot be utilized in the DAGs as we require the paths to terminate at d. To this end, we first construct two node independent DAGs in a two-vertex-connected network involving every edge, other than the edges emanating from the destination, in either of the two DAGs. We then construct link-independent DAGs in two-edge-connected networks employing all but a few edges emanating from the articulation nodes.

3.3 Node-Independent DAG

Two-vertex-connectivity is the necessary and sufficient requirement for constructing two node-independent DAGs utilizing all the edges except those emanating from the given destination node. This necessary part of the requirement follows directly from the condition required for constructing two node-independent trees - a special case of DAG. We show the sufficiency part of the requirement by constructing the desired DAGs. We first compute two base DAGs using the path augmentation technique, introduced in and later employed in to construct two independent trees. We then add the edges that are not present in either DAG. We maintain a partial order (precedence relation) among the nodes in both the red and blue DAGs. A node *x* precedes y, denoted by $x \prec y$ on a DAG if node *y* uses node *x* in at least one of its paths to *d*. This relationship is key to the construction as it avoids any cycle formation, hence the DAGs.

The procedure to construct two node independent DAGs rooted at node *d*. Step 1 initializes the partial order for the nodes on the two DAGs. Step 2 computes the first cycle to be augmented. Step 3 computes successive paths to be augmented. Note that the difference between the path augmentation employed for DAG construction here and that employed for tree construction in is the use of links $x \rightarrow \upsilon_1$

and $y \rightarrow \upsilon_k$ .As nodes *x* and *y* are distinct nodes and at least

one new node is included in the path, the above step does not result in cycles. Steps 3 and 4 ensure that all the nodes are included in the two base DAGs. Step 5 considers every edge that is not part of the DAGs and identifies the DAG to add this edge. The criteria for adding an edge $i \rightarrow j$ is to avoid cycle formation.

3.4 Link-Independent DAGS

Two-edge connectivity is a necessary and sufficient condition for constructing two link-independent DAGs. Similar to the requirement of node-independent DAGs, the necessary part of the requirement follows from the independent tree construction. We show the sufficiency part of the requirement by constructing the desired DAGs.

Figure 3 shows the procedure to construct two link-independent DAGs. We first divide the network into two-vertex-connected (2V) components (Step 1). A node may appear in more than one 2V-component and the removal of such a node (articulation node) would disconnect the graph. In addition, any two 2V-components may share at most one node in common. Given a destination node *d*, we identify the *root node* for every component (Step 2). In components that contain node d, the root node is assumed to be d. Let d_c denote the root node of component c that does not contain the destination node d. Observe that a link $d_c \rightarrow j$, where $j \in c$, may not be used as a forwarding edge on any DAG. As every path from *j* to *d* has to traverse d_c , the addition of $d_c \rightarrow j$ would result in a cycle. In each 2V-component, we compute two node-independent DAGs to the root of that component (Step 3). We then merge these node-independent DAGs to obtain the desired link-independent DAGs (Step 4).

As every network has a unique two-vertex-connected decomposition, hence unique root nodes for every 2V-component, the number of edges that cannot be used in either DAG is unique and is a property of the given network topology. It is straight-forward to see that the procedure LI-DAGs construction avoids only the edges emanating from the articulation.

The sequence of steps involved in the route recovery technique is as follows:

- The overhearing nodes on a sequence ‘ *k* ’ in primary route are selected as restoration nodes.
- In case the primary route attempts transmission of the data packet to the failed route, the restoration node detects it and initiates route recovery phase
- The restoration nodes listen to the retransmission and then waits for overhear acknowledgement. *ena*
- If no *ena* is heard, then the restoration nodes forwards Diverge Route Packet (*drp*) to the node that attempts retransmission
- When the node receives ‘ *drp* ’, it updates the route cache and forwards the ‘ *ack* ’ to restoration node
- When the restoration node receives the ‘ *ack* ’, it chooses the first route in its route cache since it has the maximum bandwidth and use that recovery route to retransmit the data packet. In case the first route is busy or cannot be established, it fetches the next route from the cache and so on.

3.5 Route recovery management:

The network may possess many restoration nodes in the dense environment. In case of the route failure, all the existing restoration nodes attempts route recovery, by sending ‘ *drp* ’ simultaneously. This results in frequent collisions and degradation of the network performance.

To conquer this drawback, we consider recovery route management technique which is as follows.

Every node has a various contention window (C) dimensions as per the overhearing count's number. If the number is large, the nodes C dimension is small. This reveals that the restoration node related to the primary route is more stable than other routes. The restoration node selects C in a random manner and waits for time t. In case restoration node hears ‘ *drp* ’ message sends by another restoration node, the timer is stopped. If ‘ *drp* ’ is not sent by any node within the time interval t, then the restoration node forwards ‘ *drp* ’ to discover the route.

In particular, our route management scheme restricts the collision avoidance to be performed by the first ‘ *drp* ’ message. There may be probability that first ‘ *drp* ’ may collide with ‘ *drp* ’ of other restoration nodes having the similar C value.

The mobility of restoration node causes it to misunderstand that route as failed even though original route is available to transmit the data. If the restoration node forwards ‘ *drp* ’ message to a node which connects to the subsequent node well, it discards the ‘ *drp* ’ and further restoration node is conscious about its misjudgment because it does not receive the ‘ *ack* ’.

4. RESULTS AND DISCUSSION

4.1 Simulation model and parameters:

We use MXML and actionscript to simulate our projected topology. In our simulation, the channel capacity of mobile hosts is set to default value 2 Mbps. We use the 802.11 DCF to represent MAC layer topology. It has the functionality to inform the network layer about link breakage.

In our simulation, mobile nodes of count 25 to 125 with increment of 10 for each attempt of evaluation metric values collection, which are in a 1000x1000 m region for 20 seconds simulation time. We assume every node moves independently with the same average speed. All nodes have the similar transmission range of 250 m. In our simulation, the minimal speed is 5 m sec^{-1} and maximal speed is 25 m sec^{-1}. The speed is diverse between 5 and 20 with periodic interval of 5 seconds. The CBR traffic is opted for simulations.

Table 1: Simulation parameters

No. of nodes	25 to 125 with increment of 10 for each iteration
Area size	1000x1000
Mac	802.11
Radio range	250 m
Simulation time	20 sec
Traffic source	CBR
Packet size	512
Mobility model	Random way point
Rate	100 Kb
Max. packet in queue	150

4.2 Performance metrics:

We compare our EEAPR topology with the Statistical QoS routing **Error! Reference source not found.**[11] topology. We evaluate mainly the performance according to the following metrics.

Average end-to-end delay: The end-to-end-delay is mean of all delivered data packets.

Average packet delivery ratio: The ratio of packets delivered out of packets sent.

Drop: Total number of packets dropped during routing process.

Control overhead: The control overhead is discrete as the total number of routing control packets normalized by the total number of receiving data packets.

Based on nodes: In the initial experiments, we considered the number of Nodes between 25 and 125 with increment of 10 for each validation.

4.3 Results Analysis:

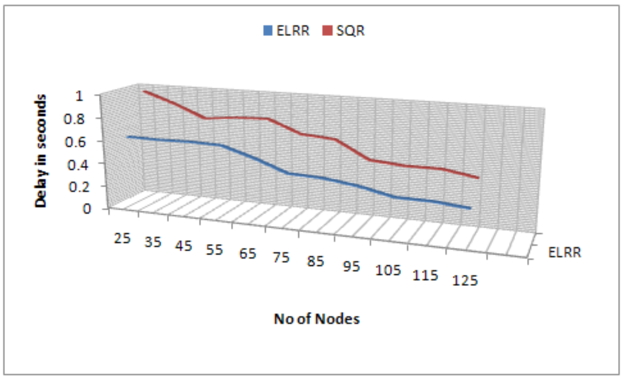

Fig. 1: Nodes Vs delay

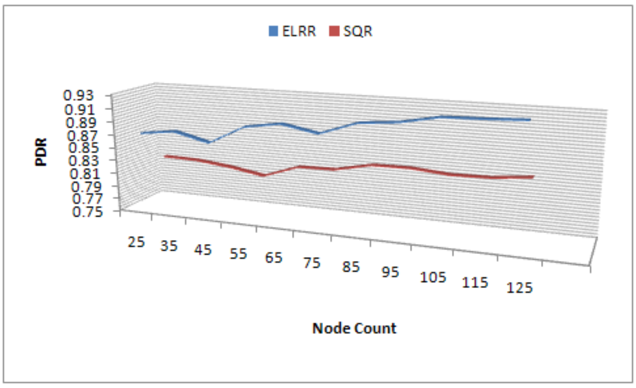

Fig. 2: Packet Delivery Ratio for divergence node count

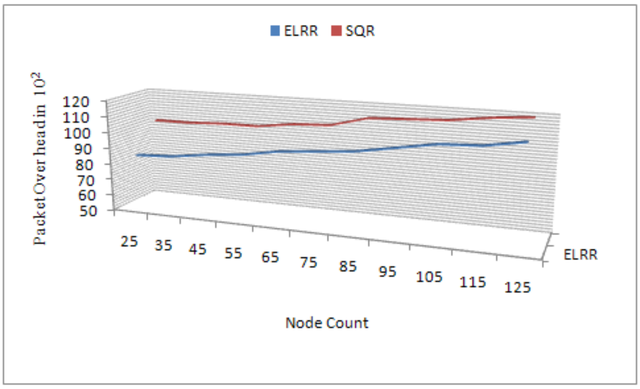

Fig 3: Normalized Load at divergence node count

From Fig. 1, we can see that the average end-to-end delay of the proposed EEAPR topology is less when compared to the Statistical QoS Routing (SQR) [11] topology. From Fig. 2, we can see that the packet delivery ratio for EEAPR increases, when compared to SQR, since it utilizes robust links. Figure 3 shows the control overhead of the protocols. The values are considerably less in EEAPR when compared with SQR.

CONCLUSION

In this, we propose Alternative path routing topologies for efficient local route recovery (EEAPR) in Mobile Ad Hoc Network. When the source requires forwarding a data packet to a destination, it broadcasts the Route Request packet to the entire network. The intermediate node on receiving RREQ packet updates its route caches and rebroadcast the packet. The destination node upon receiving all RREQ packets attaches the route code constituting available bandwidth information and feedback RREP packets.

The intermediate node updates the routing information in its route cache on receiving the RREP packet. When RREP reaches the source node, it selects primary route based on the route code. In case of route failure in the primary route, the restoration node detects it and establishes a local recovery path with maximum bandwidth from its route cache. The route recovery management technique is handled to avoid the frequent collision and degradation in the network performance. By simulation results, we have shown that the proposed approach improves network performance.

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