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Enhancing Route Recovery in Autonomous Mobile Mesh Networks

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ABSTRACT

Mobile ad-hoc networks are self-organizing network having a concise radio range and limited bandwidth without having any proper infrastructure. Suddenly the topology of the ad hoc network may change. Hence they suffer from network partitioning. So this limitation makes MANETs unsuitable for large application terrains, where intergroup communication is essential. But in Autonomous Mobile Mesh Network, the mobile mesh nodes are capable of following the mesh clients and generate suitable network topology adaptation for communicating. If route failure occurs, source node finds the nearest neighbor through multipath local routing and thus minimize the over heading issue. It establishes a local recovery path using recovery nodes from its route cache. The performance metrics such as routing overhead, throughput, end-to-end delay are normalized using packet delivery time notations. Degradation and frequent collision is prevented by the route recovery management technique in the network performance.

Keywords: Mobile Ad hoc Network, client tracking, dynamic topology deployment, route recovery, route discovery, route failure, route cache

1 Introduction

Generally in an ideal network, a source automatically knows how to reach the destination, hence the network connection is always reliable. Whereas in a wireless mobile network, or an ***ad hoc network***, frequently network connections may break as the network topology changes and wireless connectivity is reliable, a source needs to update the location of the mobile destination and intermediate nodes constantly. Hence the major challenge in the wireless mobile environment is routing.

Among the most popular network communication technologies, MANETs are one of them. In designing powerful MANETs, one great challenge is to minimize network partitions. Continuously, the network topology might change, as mobile users autonomously shift from one place to another place in a MANET, and hence segments of the network may become partitioned periodically. A new class of mobile ad hoc network which is robust, called AMMNET is proposed to address this problem. To maintain the communication between all nodes even if they are in different groups, mesh Nodes are used. Mesh Nodes are those which have the capability of changing its nature into Inter-group router or Intra-group router, or even as a bridge router according to the situation. To make the communication effective One-hop neighbor information update is used to find the shortest path between any two nodes.

Usually, routing and relay capabilities are provided by stationary mesh nodes in a standard wireless mesh network. These form a wireless mesh network where mobile mesh clients are allowed to communicate with each other via multi-hop communications. A mesh node can be simply replaced by a new one if it fails, and the new mesh node will be recognized automatically by the mesh network and reconfigures itself. The existing Autonomous Mobile Mesh Network has the following additional advantage, (i.e.,) due to the stationary mesh nodes, mesh clients mobility is serviced to the particular fixed area by a standard wireless mesh network. Other than relay functionality and standard routing, these mobile mesh nodes move along with their mesh clients, and have the ability to adapt the network topology dynamically. Autonomous Mobile Mesh Network is a good proposal as it can adapt to dynamic environment. To maintain better communications for mobile networks another option is Delay tolerant network (DTN) [1]. Conversely, to forward data, there is no assurance of finding a routing path. DTN can be used, if the number of mesh nodes in Autonomous Mobile Mesh Network is not enough to support full connectivity and to improve the probability of data delivery for the entire terrain.

Here assumption is done such that, each mobile mesh node is outfitted with a localization device such as GPS. Mesh clients detection is done within its sensing range by a mobile mesh node, but cannot find their exact locations. For example, this can be achieved by detecting beacon messages transmitted from the clients. Instead for location-based applications, RFID has been proposed. Likewise, an inexpensive RFID is tagged for mesh clients and to spot the existence of mobile nodes an RFID reader is set to the mobile mesh nodes within their sensing range.

2 Existing System

2.1 Overview of Autonomous Mobile Mesh Network

Similar to stationary wireless mesh networks, an Autonomous Mobile Mesh Network is a mesh-based infrastructure that forwards data for mobile clients. A client can connect to any nearby mesh node, which helps relay data to the destination mesh node via multi-hop forwarding. Like stationary wireless mesh networks, where routers are deployed in fixed locations, routers in an Autonomous Mobile Mesh Network can forward data for mobile clients along the routing paths built by any existing ad hoc routing protocols. Routers in an Autonomous Mobile Mesh Network are mobile platforms with autonomous movement capability [2]. They are equipped with positioning devices such as GPS, to provide navigational aid while tracking mobile clients. Clients are not required to know their locations, and only need to periodically probe beacon messages. Once mesh nodes receive the beacon messages, they can detect the clients within its transmission range. A two-dimensional airborne terrain is considered, where there is no obstacle in the target field. Mesh nodes can exchange information, such as their locations and the list of detected clients, with their neighboring mesh nodes. The radio range of each node is not a perfect circle in an application domain with obstacles. This factor may affect the accuracy of the sensing mechanism and to a minor degree, the coverage. However, this does not affect the general applicability of the proposed techniques for Autonomous Mobile Mesh Network. Applications where clients follow group mobility patterns [3] are considered to move toward different directions in smaller groups, (i.e.,) clients belonging to the same group have similar movement characteristics. Though, different groups of clients might move in different directions. In an extreme case, each client can be thought of as a group that contains only one user, and the design of Autonomous Mobile Mesh Network can still be applied to support connectivity for those independent clients.

To support such a dynamically changing mesh topology, mobile mesh nodes can be classified as three different types of routers according to their current roles in the network. A mesh node is said to be an intra-group router if it detects at least one client within its radio range and is in charge of monitoring the movement of clients in its range. These intra-group routers that monitor the same group of clients can communicate with each other via multi-hop routing. A mesh node is said to be an intergroup router, (i.e.,) square nodes, if it plays the role of a relay node helping to interconnect different groups. For each group, at least one intergroup router is designated that can communicate with any intragroup routers of that group via multi-hop forwarding as the bridge router. A mesh node is said to be a free router if it is neither an intra-group router nor an inter-group router.

A scenario is considered where clients originate in one given location, and the radio range of a single mesh node is covered. Thus, the primary configuration of the Autonomous Mobile Mesh Network consists of only one intragroup router, and all remaining routers are free. In tracking the mobile clients, the mobile mesh nodes change their operation modes based on distributed client tracking. In case of intra-group movement adaptation, if a group of clients moves from place to place, the area they occupy may change over time. The intra-group routers must adapt these changes to move along with the clients and dynamically adjust their topology accordingly to continue the communication coverage for the clients. In case of reclaiming redundant routers, when the topology changes due to client mobility, some intra-group and inter-group routers should be reclaimed as free routers for future use as they might become redundant. In case of interconnecting groups, clients of a group may split into smaller groups that move in different directions. In this case, some free routers should change their operation mode to become intergroup routers to interconnect these partitioned groups.

2.2 Mobile client tracking in a distributed manner

Consider each beacon message interval. After considering interval of each beacon message, client switches to router 'r' mode. There are three types of router modes.

If missing clients are detected, then mesh node switches to Intra-group mode. So in order to find out the missing clients, it requests for the client list from neighboring Intra-group routers. After inspecting the neighboring client list, if the neighbors are covering all its clients, then the mesh node switches to the Inter-group mode from the Intra-group mode. If all its clients are not covered by neighbors, then free routers are assigned to navigate its coverage boundary. After switching to Inter-group bridge router, location in the forwarded packets is piggybacked. The locations of remaining bridge routers and the inter-group routers identity is retrieved along the bridge networks from the forwarded packets. If necessary, topology adaptation is initiated. In case of free routers, if the tracking request is received from Intra-group routers then the assigned segment is navigated to detect the missing clients. If any missing clients are located after navigation, then switched to Intra-group mode. Finally, some of the free routers are requested to follow this new Intra-group router. In case of Intra-group adaptation, two types of scenarios happen. As we already know that beacon messages are continuously broadcasted by each client to convey their presence within the intra-group router's ratio range. Once the missing client is detected by a free router, then the free router becomes an intra-group router by switching its mode and stops navigating. Now we notice that this newly created intra-group router will be having connectivity to the remaining rest of the intra-group routers because the original monitoring router r manages those routers, as they are within the radio range. By performing the following optimization, the disconnection time can be reduced for a missing client. Each active router's boundary is divided into k segments, where k is the minimum of 12 and N_f=N_a. Here N_f and N_a are the numbers of free and active routers, respectively. The advantage of this approach is two ways. First, by traversing different segments of the boundary simultaneously to search a given missing client in parallel, k free routers are available. Second, to enhance good performance at all client groups in the terrain, the free routers are equally distributed among the active routers. The neighboring intra-group router's clients list is requested by router r. If router r detects that the neighboring routers is covering all its clients, then a message is sent to inform to switch the operation mode of these neighbors of its intent. Router r can switch to become an intergroup router, after the acknowledgment is received from all these neighbors. There are three points to be noticed. Firstly, the multiple neighboring intra-group routers switch their mode simultaneously without coverage of some clients by intra-group routers, so to avoid this situation, switching protocol is used. Second, the redundant intra-group router instead of a free router, only itself can declare as an inter-group router, because there is a chance of it being a bridge which interconnects two partitioned groups. Third, by using this switching protocol more redundant inter-group routers might be generated, later during the topology adaptation phase which can be reclaimed to the free-router pool. Local intra-group routers must support each of the new groups to avoid network partitioning, and to support the inter-group communications, these inter-group routers are structured themselves into a sub network of bridges.

2.3 Topology adaptation schemes

The protocol discussed so far states that the connectivity for all clients is maintained by the mesh nodes. The resulting networks, potentially with too many unnecessary intergroup routers may sustain long end-to-end delay because the bridging networks are constructed independently. The excessive use of the intergroup routers is another potential drawback. To improve this condition, two topology adaptation schemes are proposed, (i.e.,) local adaptation and global adaptation, to shorten the communicating paths between groups. Here three autonomous bridging networks can be replaced with a star network to save intergroup routers. Generally a star topology provides shorter relay paths, so that only few intergroup routers are required. Bridge routers are let to exchange information of their location, and local adaptation is performed to construct a star topology, during detection of some bridge routers is done if they are close to each other. When different groups of clients are communicating with each other, the corresponding bridge routers can exchange their location information by piggybacking the information in the data packets.

In a star topology for effective interconnection, one of the bridge router can act as the coordinating bridge router or coordinator to generate local topology adaptation. Particularly, the bridge router determines the minimum bounding rectangle for the locations of itself and remaining bridge routers; and uses the center of this rectangle as the center of the star topology. The coordinator also needs to ensure that the new constructed star topology will be connected to the rest of the Autonomous Mobile Mesh Network. When the number of intergroup routers is not sufficient for the construction of the new star network, the construction process is cancelled by the coordinator. During the coordination of inter-group routers, a three-way handshake protocol is used. Local topology adaptation provides local optimization. It is essential to also perform global topology adaptation to attain global optimality. The motto is to achieve end-to-end delay and free up intergroup routers for local adaptation. A simple option for global optimization is to construct a star network for all the bridge routers in the Autonomous Mobile Mesh Network. However such type of star network is ineffective and need more intergroup routers than required, mainly when there is significant number of groups in the network. In this paper, a hierarchical star topology also exists which is a optimal technique based on R-tree [4]. The R-tree is a multi-dimensional tree structure that suppresses at most M objects into a minimum bounding rectangle. Such rectangles of M are further aggregated into a larger bounding rectangle at the next higher level in the tree. This clustering process is repeated at the higher levels recursively until a single minimum-bounding rectangle is left at the root of the R-tree. To determine a suitable value of M, k-means clustering [5] or affinity propagation [6] can be applied to cluster the bridge routers in the network. After clustering, each bridge router is linked with separate cluster based on its Euclidian distance with the centroid of the cluster.

3 Proposed System

Generally in mobile ad hoc networks, frequent mobility causes route failure during transmission of data which results in route rediscovery. When the route failure occurs during the transmission of data between two network areas in the primary route, then a recovery node detects it and establishes a local recovery path from its route cache.

Route maintenance and recovery in MANET:

Route revelation, route maintenance and movement designation are the three segments incorporates in the multipath routing. The initial two segments create of various routes in the middle of source and destination hub. In addition the multipath routing convention tries discovering disjoint hubs, disjoint connection and non-disjoint routes. After the route is created, the portable hub begins sending the information parcels to the destination. Typically amid some circumstance, the route disappointment causes the sent bundles to be lost. Different circumstances cause the bundles to achieve the destination with some postponement. To handle this issue, route maintenance procedure is considered.

Route caching in MANET:

The as of late found routes ought to be reserved for utilizing it again when the comparable route is requested. The two sorts of route caching method accessible for on-interest steering convention are source route caching and moderate route caching. The on-interest directing conventions, for example, AODV and DSR grants the halfway hub which has stored route to the destination reacts to the source with the reserved route. The route reserve is vital for allowing commanding recuperation in MANET. The benefits of utilizing route store incorporate the accessibility of the backup course of action amid connection disappointment and controlling overhead which is important to repair the route.

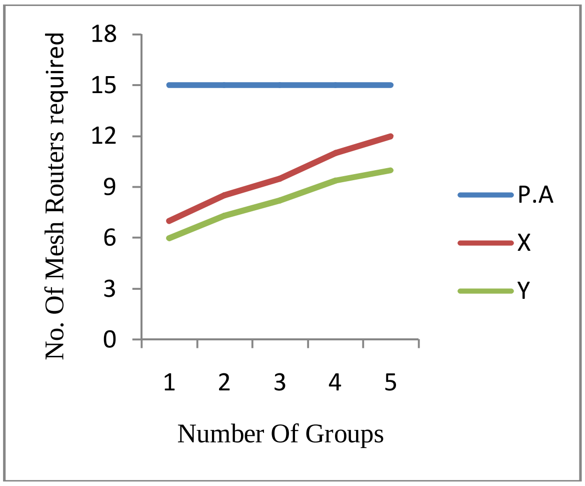
Route recovery technique:

During the data transmission, the node mobility and low battery power are the main issues that cause route breakage. To overcome this, a local recovery mechanism is applied which is based on the establishment of recovery nodes. The steps involved in the route recovery technique are as follows:

- The recovery nodes are selected based on the nodes that overhear transmitted data on the k sequence of nodes in the primary nodes.
- The recovery node detects the primary route which attempts data packet transmission to the failed route, and then initiates route recovery phase after detection.

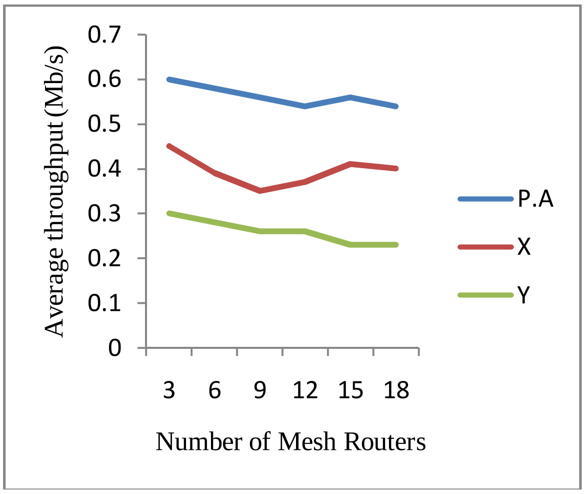
- Later after listening to the retransmission, the recovery node then waits for overhear acknowledgement, O_{Ack}.
- If recovery node do not overhear acknowledgement, O_{Ack}, then the Vary Route (VR) packet is forwarded by the recovery node to the node that attempts retransmission.
- When VR is received by the node, route cache is updated and the Acknowledgement is forwarded to the recovery node.
- When the Acknowledgement is received by the recovery node, the first route in its route cache is chosen as it has the maximum bandwidth, and that recovery route is used to retransmit the data packet.
- If the first route is busy or the first route cannot be established, it simply fetches the next route from the cache and proceeds so on.

4 Simulation Results



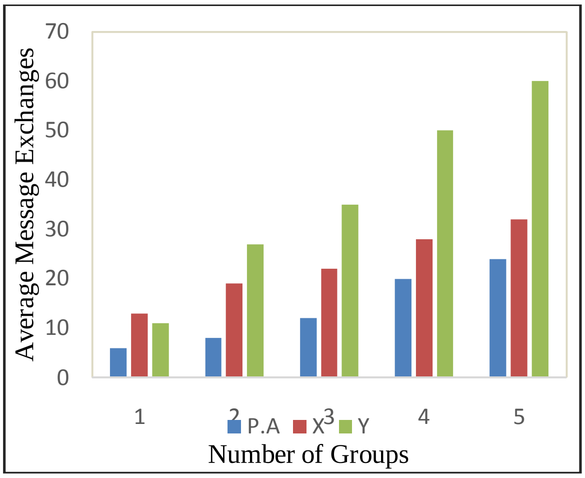
Graph 1: Number of routers required for number of groups

The above graph describes about the requirement of number of mesh routers for number of groups in three approaches (i.e.,) here X-approach is Grid-mesh. Y-approach is Autonomous Mobile Mesh Network. Proposed approach is Autonomous Mobile Mesh Network with Route Recovery mechanism technique.



Graph 2: Throughput comparison for number of mesh routers

The above graph describes about the average throughput in Mb/s for number of mesh routers in three approaches (i.e.,) here X-approach is Grid-mesh. Y-approach is Autonomous Mobile Mesh Network. Proposed approach is Autonomous Mobile Mesh Network with Route Recovery mechanism technique.



Graph 1: Message exchange overhead for number of groups

The above graph describes about the average message exchange overhead at each time slot for number of groups in three approaches (i.e.,) here X-approach is Grid-mesh. Y-approach is Autonomous Mobile Mesh Network. Proposed approach is Autonomous Mobile Mesh Network with Route Recovery mechanism technique.

5 Conclusion

For maintaining intra-group and inter-group communications effortlessly, the mobile mesh routers in Autonomous Mobile Mesh Networks track the users and dynamically adapt the network topology. To achieve full connectivity, there is no need of providing high cost network coverage at all the time for the whole terrain, since the mobile infrastructure in AMMNET follows the users. To decrease the excessive use of the inter-group routers and to shorten the relay paths between groups, two topology adaptation schemes are proposed based on autonomous mobile mesh routers. Along with this, route recovery technique is proposed based on the recovery nodes establishment. In addition, to avoid network performance degradation and frequent collision between the two network areas, route recovery management technique is handled. By simulation results, we have shown that the proposed approach improves the network performance.

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