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Autonomous Mobile Mesh Networks for Missed Node Detection Using Enhanced R-Tree Topology

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Abstract - Generally, in a static network, the shortest path from a source to a destination is usually the optimal route, but this scenario is not easily extended to Mobile Ad-hoc Networks because it need efficient distributed algorithms to determine the network organization, link scheduling and routing. Autonomous Mobile Mesh Network (AMMNET) [19] has been introduced to address this weakness and AMMNET mobile mesh nodes are capable of following the mesh clients and organizing themselves into a suitable network topology to ensure good connectivity and monitoring for both intra and inter-group mobile clients communications by assigning routers for each domain in a network. Basically the routers in stationary wireless mesh networks are deployed at fixed locations, where AMMNET routers are mobile platforms with autonomous movement capability. Even though, it moves dynamically AMMNET routers are failing to search the disappeared mobile clients once they go out of domain. This paper proposes a distributed client tracking solution to deal with the dynamic nature of client mobility and present techniques for finding disappeared mobile clients, minimizing routing paths and channel overlapping using enhanced R-Tree topology

Keywords: MANET, AMMNET, WMN, WSN, R-Tree, MBR, Enhanced R-Tree.

I. INTRODUCTION

In computer networking, an ad-hoc network[10] refers to a network connection established for a single session and does not require a router or a wireless base station. In other words, Ad-hoc wireless networks are interconnected sets of mobile nodes that are self-organizing, self-healing, survivable and instantaneously available without any need for prior infrastructure. Ad-hoc network can be classified into three types. They are,

- **Wireless Mesh Network (WMN)**
  A wireless mesh network (WMN) [4] is a communications network made up of radio nodes organized in a mesh topology. It is also a form of wireless ad hoc network. Wireless mesh networks often consist of mesh clients, mesh routers and gateways.
- **Mobile Ad-hoc Network (MANET)**
  It is an infrastructure less IP based network of mobile and wireless machine nodes connected with radio. In operation, the nodes of a MANET [15] do not have a centralized administration mechanism.
- Categories of MANET:
  - VANETs (Vehicular Ad-hoc Networks)
  - SPANs (Smart Phone Ad-hoc Networks)
  - MANETs (Internet based Mobile Ad-hoc Networks)
- **Wireless Sensor Network (WSN)**
  Wireless sensor networks (WSN)[10], sometimes called wireless sensor and actuator networks (WSAN), are spatially distributed autonomous sensors to monitor physical or environmental conditions such as temperature, sound, pressure, etc., to cooperatively pass their data through the network to a main location.

II. LITERATURE SURVEY

2.1 Autonomous mobile mesh networks

In this paper, "Autonomous Mobile Mesh Networks" the authors Wei-Liang Shen[19] and his research group stated that Mobile ad hoc networks (MANETs) [15] are ideal for situations where a fixed infrastructure is unavailable or infeasible. Today's MANETs, may suffer from network partitioning. To overcome this AMMNET (Autonomous Mobile Mesh Networks) has been introduced to prevent the network partitioning and provide the distributed client tracking solution to deal with the dynamic nature of client mobility, and offer techniques for dynamic topology adaptation in accordance with the mobility pattern of the clients.

2.2 Dynamic authentication for autonomous mobile mesh networks

In this article "Dynamic Authentication For Autonomous Mobile Mesh Networks" the author V.Muthulakshmi[11] stated that, In MANET fixed infrastructure is unavailable. So it suffers from network partitioning. Autonomous Mobile Mesh Networks (AMMNET) is a collection of client nodes and routers deployed in its location. Nowadays AMMNET make use of inter group router, intra group router, free router, bridge router for communication between client nodes in every application. AMMNET supports inter group router to prevent network partitioning.

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But it doesn't provide better security for data communication. This paper simulation results indicate that dynamic authentication can be provided secure communication by using AODV(Ad hoc On-Demand Distance Vector) routing protocol and maintain the confidentiality of the autonomous mobile mesh networks.

2.3 Effect of multipath routing in autonomous mobile mesh networks

In this paper "Effect Of Multipath Routing In Autonomous Mobile Mesh Networks" the authors Sangheethaa S [13], and her research group stated that in a multipath routing technology for AMMNETs provides better packet delivery ratio and also it increases throughput in AMMNETs. Multipath routing concept along with AMMNET and proved that, using multipath routing in AMMNET will increase the throughput as well as packet delivery ratio.

2.4 Connectivity in autonomous mobile mesh networks

In this paper, "Connectivity In Autonomous Mobile Mesh Networks" the authors sweta[18] and her research group stated that Generally, the conventional mobile ad-hoc network suffer from network partitioning, this problem was solved in the AMMNET. It supports both intra-routing and inter-routing. Here, the mobile mesh routers of an AMMNET track the users and dynamically adapt the network topology and perform routing. It simply forwards the date from source to destination via multiple hops. This infrastructure provides full connectivity without need of high cost of network coverage. AMMNET does not consider that, whether the routing path is the one, which is shortest distance between the source-destination pair. It maintains the information's such as location, ID, distance and mobility of its neighbors and provides cost-effective solution. This work results also indicate that AMMNET is scalable with the number of users. The required number of mobile mesh nodes does not increase with increases in the user population.

III. PROBLEM FORMULATION

A mobile ad-hoc network (MANET)[15] is a continuously self-configuring, infrastructure-less network of mobile devices connected without wires. In MANET, the nodes are free to move anywhere. So it may suffer from network partitioning. This limitation makes MANETs unsuitable for applications such as crisis management and battlefield communications, in which team members might need to work in groups scattered in the application terrain. In such applications, inter-group communication is crucial to the team collaboration. To overcome this weakness, Autonomous Mobile Mesh Network (AMMNET) concept introduced.

AMMNET is a wireless mesh network with independent mobile mesh nodes. Unlike conventional mesh networks, the mobile mesh nodes of an AMMNET are capable of following the mesh clients in the application terrain, and organizing themselves into a suitable network topology to ensure good connectivity for both intra- and inter- group communications. In addition to the standard routing and dispatch functionality, these mobile mesh nodes shift with their lattice clients, and have the cleverness to dynamically acclimatize the network topology to afford finest service. In particular, an AMMNET tries to prevent network partitioning to ensure connectivity for all its users. AMMNET is a mesh-based infrastructure that forwards data for mobile clients. A client can connect to any close by mesh node, which helps relay data to the destination mesh node via multihop forwarding.

In this existing methodology, if a client leaves from the network AMMNET will not search that particular client and the router for the particular boundary will not consider about missed client. To monitor each client in the boundary routing path becomes very congested and there is a chance of channel overlapping. To address this drawback, the work "Autonomous Mobile Mesh Networks For Missed Node Detection Using Enhanced R-Tree Topology" has been proposed.

IV. SYSTEM METHODOLOGY

4.1 Objective

The main objectives of this work are searching disappeared node from the autonomous network by using the concept of enhanced R-tree topology, minimize the routing path by allocating a single router to monitor both intra and inter group communications and reduce the channel overlapping.

4.2 Proposed System Methodology

In proposed system, all the existing system approaches are carried out. In addition, the following options are provided. A separate node searching logic is given to all the neighbor nodes of the disappeared node. The past communication path is kept in memory of all intermediate nodes for given time period so that during successive communication, the previous partial path information is used.

Below mentioned are the advantages of proposed system methodology:

- Tracks the users and dynamically adapt the network topology to seamlessly support both their intragroup and intergroup communications.
- Searching for disappearing mobile clients is carried out.
- Minimizing routing paths is considered.
- Jam packed of finding a routing path to forward data.
- If the number of mesh nodes in AMMNET is maintain full connectivity for the entire topography.
- The client node tracked by other router nodes based on the previous path, the approximate last location the

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node is disappeared is found out by a group of free routers.

4.3 Enhanced R-Tree Structure

R-trees[5] are hierarchical data structures and they are used for the dynamic organization of a set of d-dimensional geometric objects representing them by the Minimum Bounding d-dimensional Rectangles (MBR). Each node of the R-tree corresponds to the MBR that bounds its children.

Figure 4.1 shows a set of the MBRs of some mobile clients. Here A, B and C are different domains each having its mobile clients. R is assigned as common head router to monitor all the clients in different intra and inter domains. For example, If the client G moves from the domain A to B means A thinks that G was missed from its domain and B want to monitor and update newly entered client G (From where it comes). So to avoid this contra version the router R monitors all the clients in various domains and tracks it if they go out of boundary.

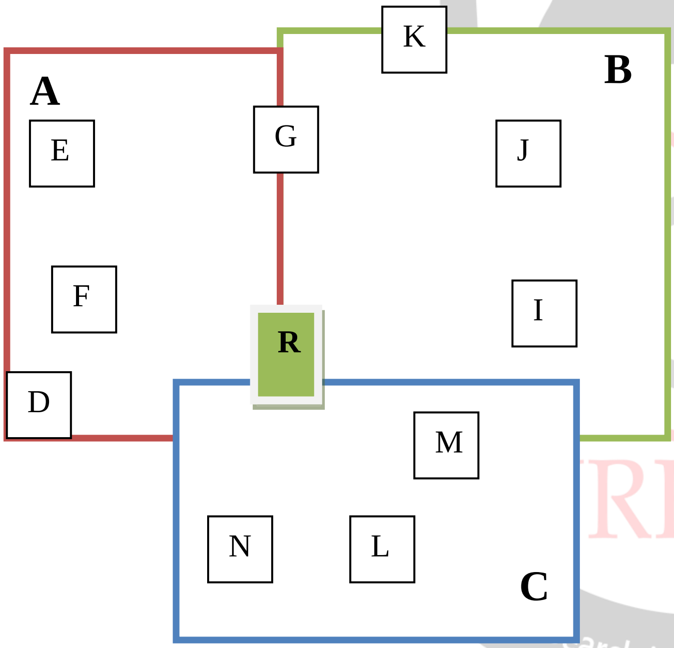

Figure 4.1 - Single router for both intra and inter domains

MBR Tree forms a hierarchical structure based on the router R. Figure 4.2 describes that the router R monitors A, B and C. A, B and C monitors its domain clients respectively.

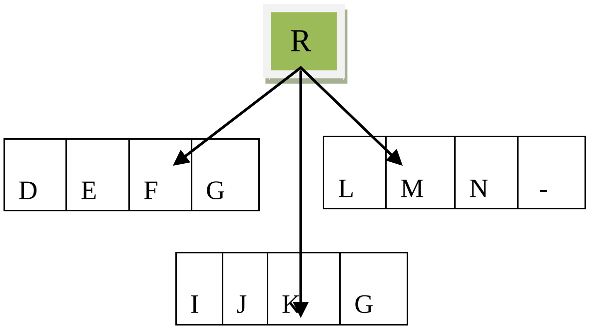

Figure 4.2 - MBR Tree

4.4 Enhanced R-Tree Algorithm

Insert(TypeEntry E, TypeNode RN)

/* Inserts a new entry E in an R-tree with root node RN */

Step 1

Traverse the tree from root RN to the appropriate leaf. At each level, select the node,L, who's MBR will require the minimum area enlargement to cover E.mbr

Step 2

In case of ties, select the node whose MBR has the minimum area,

if the selected leaf L can accommodate E

Insert E into L

Update all MBRs in the path from the root to L,so that all of them cover E.mbr

else

L is already full

Step 3

Let E be the set consisting of all L's entries and the new entry E Select as seeds two entries e1, e2 ! E, where the distance between e1 and e2 is the maximum among all other pairs of entries from E Form two nodes, L1 and L2, where

the first contains e1 and

the second e2.

Step 4

Examine the remaining members of E one by one and assign them to L1 or L2, depending on which of the MBRs of these nodes will require the minimum area enlargement so as to cover this entry

if a tie occurs

Assign the entry to the node whose MBR has the smaller area

endif

if a tie occurs again

Assign the entry to the node that contains the smaller number of entries

endif

Step 5

If during the assignment of entries, there remain entries to be assigned and the one node contains m " " entries

Step 6

Assign all the remaining entries to this node without considering the aforementioned criteria /* so that the node will contain at least m entries */

Step 7

Update the MBRs of nodes that are in the path from root to L, so as to cover L1 and accommodate L2

Step 8

Perform splits at the upper levels if necessary

In case the root has to be split, create a new root

Increase the height of the tree by one

Endif

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V. FINDINGS

The proposed system gives a better result when comparing an existing one. The following results have been analyzed based on the number of mesh clients.

- Error Rate Analysis
- Fault - Tolerance Analysis
- Performance Analysis

5.1 Error Rate Analysis

The Table 5.1 contains a mesh client node as a parameter to find an Error-rate analysis for both AMMNET and Classic AMMNET. After finding an error-rate, it came to know that an error could be decreased, which means that an average number of missed clients can be easily tracked by using common router.

The Figure 5.1 describes an experimental result for Error Rate Analysis existing and proposed system client tracing number of node client tracking system analysis. The figure contains number of mesh client node and given time interval to client tracking node details. When comparing an existing one proposed system brings a low error rate.

S.No.	Number of mesh client node [n_q]	Error rate analysis			
		AMMNET		Classic-AMMNET	
		Number of Node [N_o]	Error Rate [%]	Number of Node [N_o]	Error Rate [%]
1	100	70	0.30	75	0.25
2	200	150	0.25	162	0.19
3	300	253	0.15	265	0.12
4	400	324	0.19	341	0.15
5	500	467	0.07	469	0.06
6	600	585	0.02	594	0.01
7	700	645	0.08	658	0.06
8	800	788	0.01	793	0.008
9	900	853	0.05	876	0.03
10	1000	943	0.06	953	0.05

Table 5.1 Error Rate Analysis – AMMNET and Classic-AMMNET

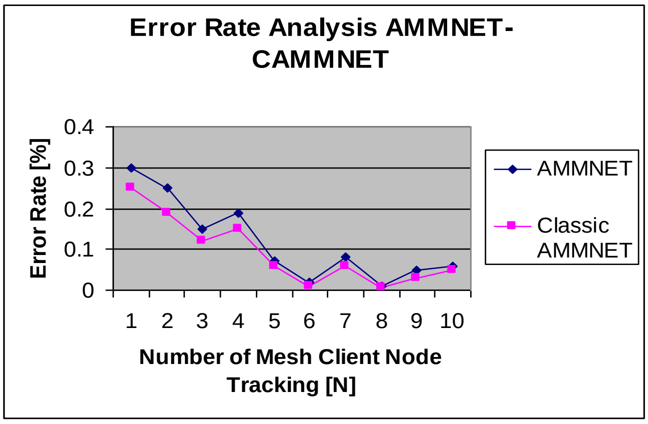

Figure 5.1 Error Rate Analysis

5.2 Fault-Tolerance Analysis

The Table 5.2 contains a mesh client node as a parameter to find an Fault - Tolerance analysis for both AMMNET and Classic AMMNET.The result of this analysis increases the accuracy of proposed AMMNET. An accuracy has been calculated by using the following formula,

$$(1-[N_f/N_a])$$

S.No.	Number of Mesh client Node [n_f]	Fault tolerance analysis			
		AMMNET		Classic-AMMNET	
		Number of Node [N_a]	Accuracy [%]	Number of Node [N_a]	Accuracy [%]
1	100	31	22	38	25
2	200	43	36	48	40
3	300	62	38	59	49
4	400	73	44	77	51
5	500	86	48	94	52
6	600	98	51	108	54
7	700	103	57	122	58
8	800	121	67	132	69
9	900	135	67	143	72
10	1000	145	68	152	76

Table 5.2 Fault-Tolerance Analysis

The following Figure 5.2 describes the experimental result for existing and proposed system of Fault – Tolerance Accuracy Analysis. The figure contains number of mobile client and accuracy details for a given time interval.

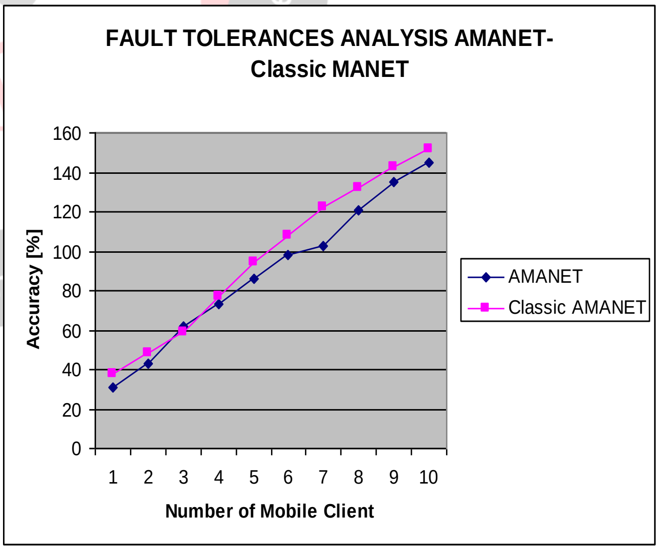

Figure 5.2 Fault Tolerance Analysis - Accuracy

The Figure 5.3 describes the experimental result for existing and proposed system of Fault – Tolerance Accuracy Analysis. The figure contains number of failure client node and accuracy details for a given time interval.

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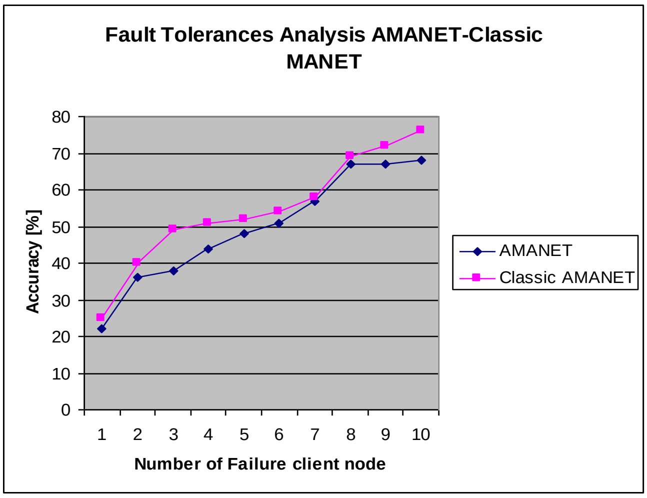

Figure 5.3 Fault Tolerance Analysis – Failure Accuracy

5.3 Performance Analysis

The Figure 5.4 describes experimental result of Performance Analysis for existing and proposed system in client tracking system analysis. The chart contains number of mesh client node and average mesh node.

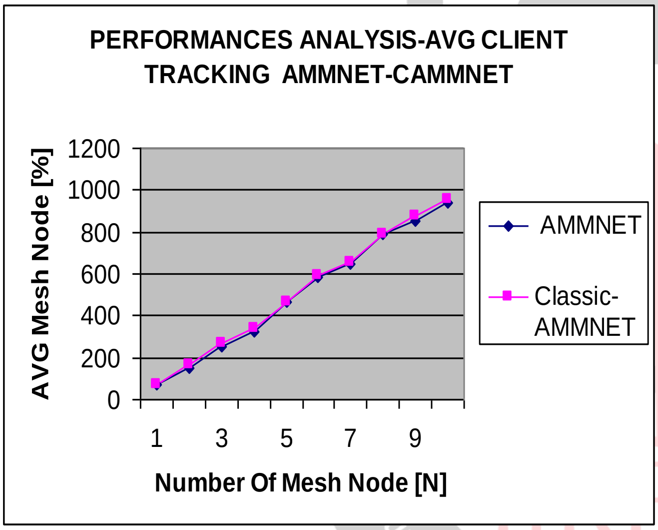

Figure 5.4 Client Tracking Performance Analysis

5.4 Comparative Analysis

The Table 5.3 describes that the comparison between an existing and proposed work.

Sample Input : 1000 clients

S.No.	Result Analysis	Existing (AMMNET)	Proposed (Classic–AMMNET)
1	Error – rate Analysis	0.06	0.05
		High	Low
2	Fault-Tolerance Analysis	68	76
		Low	High
3	Performance Analysis	Low	High

Table 5.3 Comparative Analysis

VI. CONCLUSION

This paper proposes a new searching logic to detect a missed node which goes out of region in an autonomous network using R-Tree Topology. This enhanced R-Tree topology gives a dynamic organization of autonomous nodes in a network. To find the movement of each node has been noticed by their domain router and routing paths are maintained in the corresponding domain routing table. In case, a node goes from one domain to another domain, the moved node will be considered as missed node in source domain. The common router has been assigned to detect that missed node by using its routing table. This table maintains the past communication path of all midway nodes for given time period. So during succeeding communication, preceding partial path information is used.

VII. FUTURE ENHANCEMENT

This work provides a best assistance in wireless client tracking system management. In future, the routing success ratio can be tracked and the routing log can be maintained. The application can be designed as a web site so that it can be accessed across the platforms. The protocol testing application if developed as web service can make use of it by many applications. The new system becomes useful if the above enhancements are made in future. The new system is designed such that those enhancements can be integrated with current modules easily with less integration work.

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