# A Comparative Analysis of Unicast, Multicast, Broadcast and Anycast Addressing Schemes Routing in MANETs

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## ABSTRACT
The efficient addressing schemes based routing mechanism in MANETs is a challenging issue due to the dynamic nature of network topologies and resource constraints. Ad hoc networks do not rely on any fixed infrastructure. The performance of the addressing schemes such as unicast, multicast, broadcast & anycast affected by the widely varying mobility characteristics in ad hoc network. In this paper, we are giving a comparative analysis of these message addressing and transmission methods on the basis of different factors such as Time, Spectrum Efficiency, Privacy and Security. We present a comparative study of these message transmission methods and their use as a communication primitive before intrusion and after intrusion with a specific attention to Mobile ad hoc networks. We analyze and implemented these approaches and this evaluation supports our claim that Multicast is the best message transmission method in case of dynamic nature of ad hoc network. Through simulated analysis and extensive implementation, we explore the characteristics of these approaches and finally provide recommendation for best suitable approach for mobility model.

## General Terms
Addressing Schemes, Time, Spectrum efficiency, Privacy, Security.

## Keywords
MANETs, Unicast, Multicast, Broadcast, Anycast.

## 1. INTRODUCTION
It has seen that there is no fixed infrastructure in mobile ad hoc networks. Nodes in Mobile ad hoc network move independently of one another as MANET have dynamically changing topology[5][9][18].As MANET lacks a fixed infrastructure so some of its nodes assist in routing of packets. Nodes can communicate each other if they are in each other's transmission range. Most of the research in MANETS has focused the connectivity of nodes, route discovery, and node failure as these issues are necessary to consider in order to cope up with the arising problems in dynamic MANETs. In MANETs each node itself acts as a router for forwarding and receiving packets to/from one another. In this paper we have focused on the efficiency of the different message transmission methods in order to provide better service in terms of Time, Spectrum efficiency, Privacy and Security[4]. For the transmission purpose there are different addressing schemes available such as Unicast, Multicast, Broadcast and Anycast.

Broadcasting is the process in which one node sends a packet to all other nodes in the network [8]. Network wide broadcasting, simply referred to as “broadcasting” for the remainder of the paper, Multicasting may be extremely helpful to execute a query only on a subset of nodes. Anycasting is the process in which Communication takes place over a network between a sender (a single node) and the nearest of a group of receiver

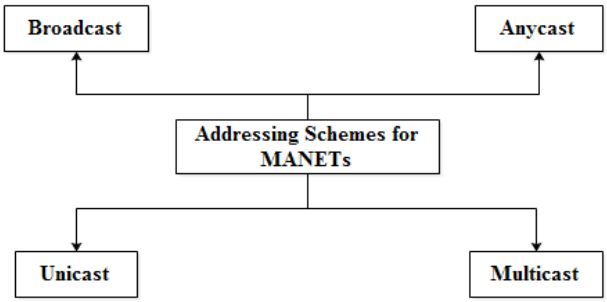


**Fig 1: Classification of Addressing schemes of MANET**

*Unicasting:* Most of the applications in Mobile ad hoc networks are based on unicast communication [14][16]. The process of unicast is to transmit data packet to the destination. At the time of forwarding data packet this message transmission method use the destination address in the data packet to look it up in the routing table. The overall process depends upon the destination address which is present in the routing table. Furthermore the data packet will be send o the corresponding hop. In MANET when unicasting approach used every node maintains the routing table. So the only problem occurs that how the routing table to be created and maintained in MANET [7][1].

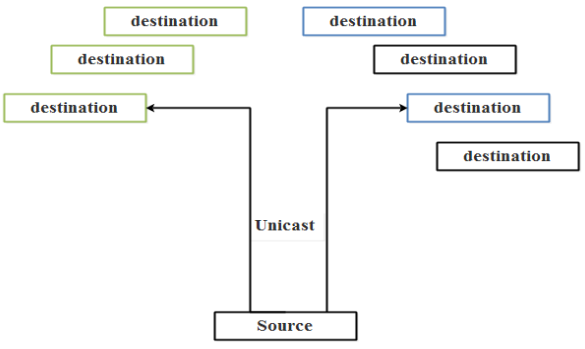


**Fig 2: Unicast message Transmission in MANETs**

*Multicasting:* Multicasting is an essential technology to efficiently support one-to-many flow of packets between a single source host and one or more destination hosts. In this approach the source host sends a single copy of the packet to multiple group members available at the destination address.

Multicasting have the transmission of packets to a group of more hosts called as the multicast group which can be identified by a single destination address. The multicast packets will be delivered to all destination hosts identified by the multicast group address. It is a set of network of clients and servers which are interested in sharing a specific set of data[10] [16].

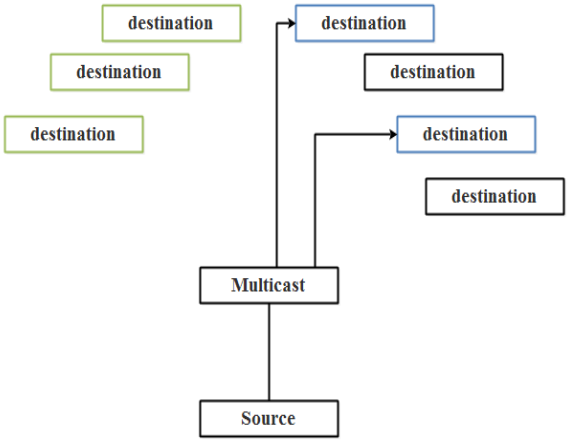


**Fig 3: Multicast message Transmission in MANETs**

Broadcasting: In many applications of MANETs broadcasting is the most frequently used operation. It is the term used to describe the data to be forwarded to entire network. The selected nodes are called forwarding nodes.in a localized manner the forwarding node set for broadcast. Each of the nodes determines its own status of forwarding or non-forwarding based on local information or the status of node is designed by its neighbors [16].

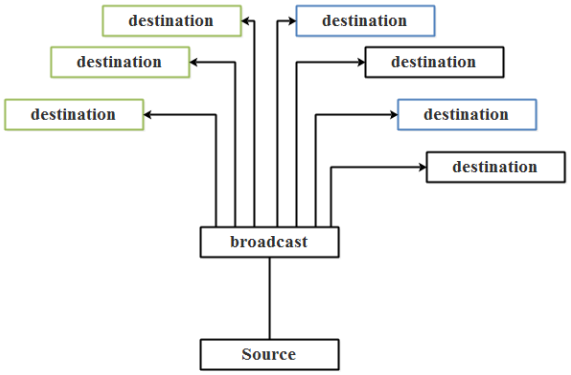


**Fig 4**: **Broadcast message Transmission in MANETs**

Anycast: In Anycast addressing schemes approach there is hop-to-hop flow of packets between a single client and the nearest destination server [11]. This destination server can be identified by anycast address. The client node would like to send data packets t any one of possible servers that offers a particular service. Within an anycast group a single anycast address is assigned to one or more servers contained. To multiple nodes a single anycast address is assigned and only one of the members of assigned anycast address communicates with the originator at a time. By placing the anycast address in the packet header, a client can send packets to an anycast server. The networks of routers are responsible to deliver the packets to server with the matched anycast address [3].

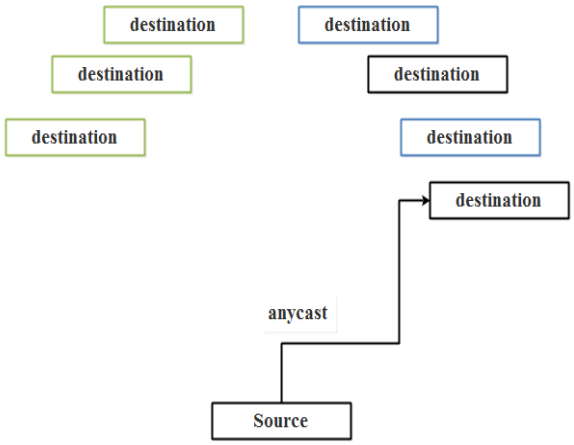


**Fig 5: Anycast message Transmission in MANETs**

We found that, from all the above mentioned Message Addressing & Transmission methods, every routing scheme has their own benefit in different MANET environment. So, in this paper a simulated comparative analysis of Unicast, Multicast, Broadcast and Anycast is proposed. Through simulated analysis and extensive implementation, the characteristics of these approaches are explored and finally provide recommendation for best suitable approach for MANETs environment.

## 2. BACKGROUND STUDY

Due to the increasing importance of addressing schemes in MANET environment various message transmission methods are available along with the challenges and issues existing in ad hoc networks. To make measurable progress routing of these addressing schemes certain factors need to be analyzed. Several ideas suggested improving the efficacy of MANETs. Camp et. al. in 2002 proposed that broadcasting in MANETs provides route establishment functionality for unicast and multicast protocols. They emphasize on a single methodology that efficiently delivers a packet from one node to all the other nodes present in the MANET environment. Broadcasting schemes categorized and each subset category compared side by side [9]. Casey Carter et. al. proposed that ad hoc networks encourages the deployment of distributed services. They found that a node should not need detailed knowledge of the network topology to choose servers with which it can communicate efficiently. Anycast and multicast are the special cases of Manycast and the target number of group members is one and infinity [6]. Li et. al. in 2004 conducted a survey a survey and proposed that in mobile ad hoc networks group communications explores solutions to the problems of wireless mobile communications [16]. Moukhtar A. Ali et.al in 2007 Suggested that applying the multicast message addressing and transmission methods in MANETs is a big challenge because most of the applications require same single copy of the data packets to many destinations. Multicast routing analyzed based on different viewpoints such as multicast topology, initialization, topology maintenance and dependency on unicast routing [17]. Sunil Pathak et.al. in 2013 suggested a survey of Unicast routing protocols in MANETs and found that mobile nodes can directly communicate with the other mobile nodes. Each of the mobile node will work as a router for the other mobile nodes and the node will be responsible to forward data packets within the transmission range. It's quite difficult to find out the suitable protocol that can perform better under different network conditions [7]. Despite a considerable number of proposed

addressing schemes individually, no comprehensive comparative analysis has been previously done.

## 3. FACTORS INFLUENCE MESSAGE TRANSMISSION IN MANET ENVIRONMENT

The idea behind the comparative analysis of Unicast, Multicast, Broadcast and Anycast is to identify the key factors that influence the MANET environment [16]. When the topology changes the use of independent dominating addressing schemes is problematic. Certain factors such as Time, Spectrum Efficiency, Privacy and Security are classified according to the different viewpoints in message transmission schemes [2][3]. However for the adoption of MANETs solving the connectivity alone is not sufficient. There is also a need to calculate the factors that influence network topologies and the overall mechanism of Data Forwarding. The basic idea behind all these addressing schemes is the mobile nodes use each other's services to exchange data. Dynamic Node mobility, affects service availability. Following are the factors that influence the MANET Environment [13] [17].

***Time:*** The total time taken by overall process which includes ***Join Query*** (From Source ***S*** to Destination nodes) and ***Join Reply*** (from Destination node to Source ***S***)[14]. The time may vary in case of any malicious activity occurs in the network. Time taken by various addressing schemes differ because of the associations and also due to the topological mobility of nodes. Unicast: Association is One-to-One (1:1). Broadcast: Association is One-to-One (1:1) but with nearest node. Multicast: Association is 1 to N-1 multicast members. Broadcast: Association is 1 to N (all nodes within the active ad hoc network)

***Security:*** It is one of the most important issues that many addressing schemes neglect to achieve it. The key point behind this factor is how the other factors affected when any malicious activity performed in the MANET environment. Initially the MANET will be secure and after the encroachment the security and other factors will be affected. When any unauthenticated node (a non member node) enters into MANET, the ad hoc environment may misbehave in receiving data packets. The previously mentioned proposals have not tried to achieve the security issues [14].

***Privacy:*** As all the mobile node coordinates known within the network so any node location change will be discovered. The overall privacy for Unicast, Multicast and Anycast addressing scheme is achieved and in case of Broadcast as the data packets delivered to all the nodes present in the environment so no privacy achieved in case of broadcasting [13].

***Spectrum Efficiency:*** Spectrum efficiency is the selection of the optimal routing scheme based on the network conditions and to the information rate can be transmitted over a given bandwidth in a specific communication ad hoc environment and to be obtained through information sharing, leading to the best use of the system resources. As MANETs are resource constrained so spectrum efficiency is crucial in terms of efficient use of resources [6].

Despite of the number of surveys, we believe that a comprehensive analysis of addressing schemes and open issues for secure MANET environment would be useful. The purpose of this paper is to provide a review on the state of art regarding the selection of best suitable addressing method approach for MANETs. In the following we will try to calculate the factors discussed above and will try to make a categorization according to the mechanism they utilize and their features. We will also highlight the impact of vulnerabilities in the MANET environment and how these factors get affected when any unauthenticated node enters into ad hoc network and try to deny the services of forwarded data packets from source to destination.

## 4. COMPARATIVE ANALYSIS OF ADDRESSING SCHEMES IN MANET ENVIRONMENT

To make measurable progress in the field of routing in MANETs using message transmission and addressing schemes several potential solutions to the unique problems have been proposed. As deployment is easier in MANETs so it is an easy choice for a variety of applications. Most of the applications in MANETs involve one-to-one and Many-to-One addressing methods. Furthermore, in the MANET environment node mobility creates a continuously changing communication topology in which routing paths break and new ones form dynamically [16]. Certain associations need to kept in mind as they affect the communication topology in which routing paths break and new ones form dynamically. MANETs have a limited bandwidth so the routing using different addressing methods will depend upon the association. If the association is 1:1 then Unicast and Anycast topology will be selected for routing in MANET environment [6][12]. Otherwise, if there is 1: N association they type of addressing methods will be Broadcast and if there is 1: (N-1) associations then Multicast message transmission will be used. The methodology used in which an ad hoc network created and coordinates of the entire network nodes discovered. After that the source node S and destination nodes will be defined. The dispatch node use the destination address while forwarding the data packets. Dispatch node will look up destination address in the in routing table. The data packet will send to the corresponding next hop, if the destination address found in the routing table. But before forwarding the data packet associated address scheme need to be considered. In such condition if there will be one-to-one association then Unicast addressing method will be used, if there will be a receiving group ready then Anycast addressing method will be used as only the nearest one will get the packet data. Further more if multicast member present in the MANET at the receiving end the association will become 1: N-1 and data may forwarded though Multicast intermediate node. Furthermore, if all the nodes in the ad hoc network are available at receiving end then Broadcasting scheme will be used. Every node maintains the routing table in network. So the problem faced in the previous proposal is removed using association of addressing schemes with the MANET environment [7].

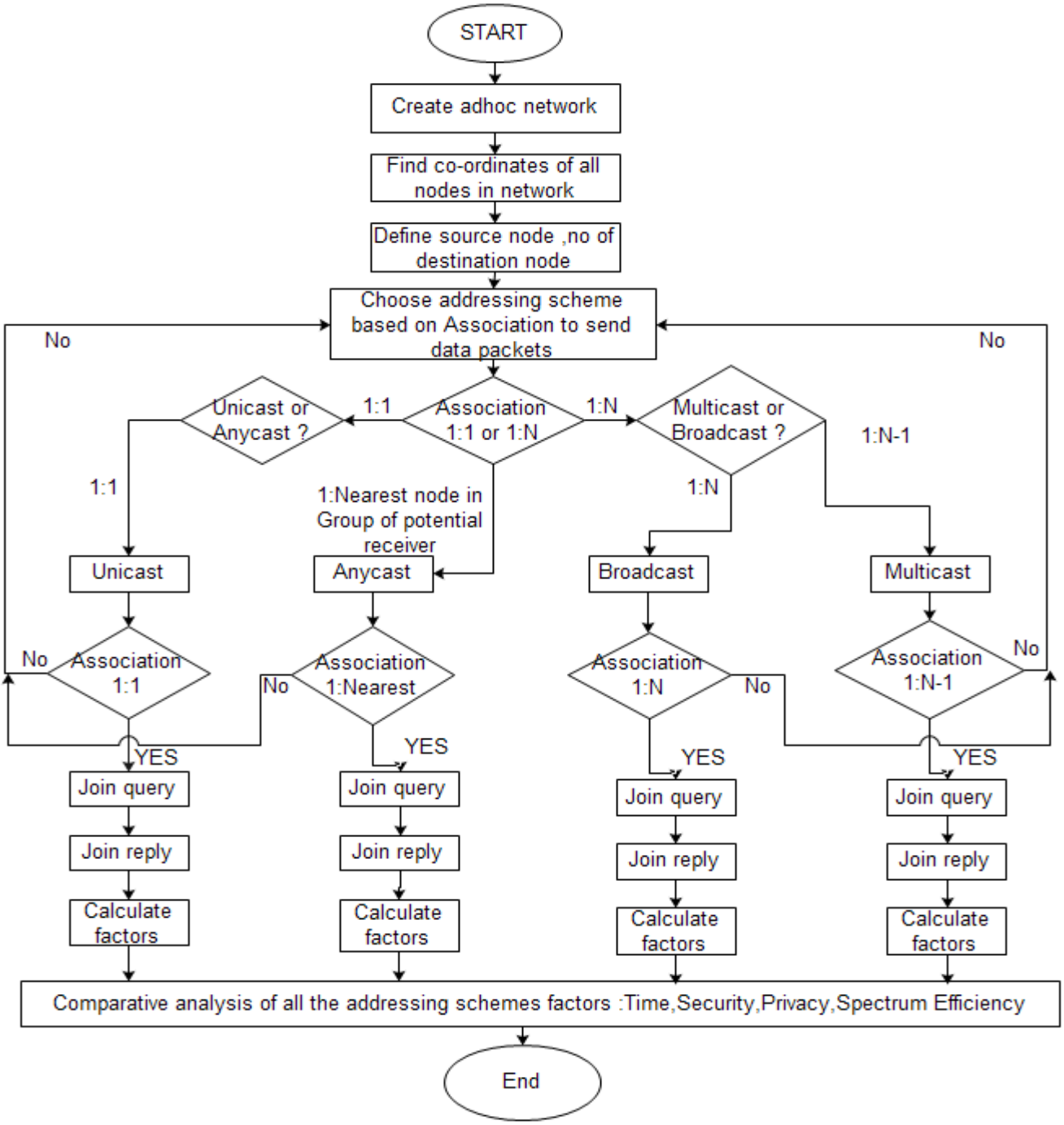


**Fig 6: The overall process of calculating factors affecting MANET environment**

## 5. ROUTE DISCOVERY OF UNICAST, MULTICAST, BROADCAST AND ANYCAST ADDRESSING SCHEMES

After finding the association in MANETs environment the process of data forwarding will take place by all the addressing methods[12][16]. Certain steps need to be followed in order to discover route for various addressing schemes.

1. ***S*** floods a ***Join Query*** based on Association to entire network to refresh membership.
2. ***During Join Query*** if there is one-to-one association then Unicast addressing will take place , for Multicast one sender N-1 receivers, for Broadcast "one sender- all receivers", for anycast "one sender-nearest node of a group" will receive.
3. After that Query will reach to the Unicast, Multicast, Broadcast and Anycast destination based on association.
4. In Join Reply phase destination nodes sends Join Query back to Source S
5. Data will be forwarded to the same path from where the Join Query came.
6. During Join Reply if any unauthenticated node will be present in ad hoc network, it will affect

Bandwidth i.e Spectrum Efficiency, Time, Privacy and Security of MANETs.

7. An acknowledgement will be sent back in the Reply Phase. 8. Join Reply is propagated by each Forwarding Group member until it reaches source through different addressing scheme.

# 6. SIMULATED RESULTS BASED ON COMPARATIVE ANALYSIS OF ADDRESSING SCHEMES IN MANETS

For most of the ad hoc networks efficient support of group communications is critical in terms of Time, Spectrum Efficiency, Security and Privacy. Furthermore, due to the mobility of nodes and routing path break a continuously changing communication topology formed dynamically. Ad hoc networks have to cope up with the vulnerabilities occurs during Data Forwarding as well as with the new vulnerabilities specific to the ad hoc context [2].

We have done detailed analyses of ad hoc networking security issues. We sum up the main directions of security and privacy in ad hoc networks. Active attacks can be performed against an ad hoc network. The mostly performed active attacks in ad hoc networks are: Impersonation, Denial of service, and Disclosure attack.

In addition to get well suited addressing scheme some common issues have considered in our comparative analysis. Below we are giving the simulated results in MANET environment:

## 6.1 Before Intrusion

In this approach we assume that the MANET will be secure in for different addressing schemes. The routing protocols will have to cope with malicious nodes that can disrupt the correct functioning and affect the delivery of data packets. There will be no change in the privacy of the ad hoc network as all the co-ordinates are known. In case of Broadcast and Unicast security will be less as in broadcasting there is no specific receiver node available and in Unicast there is hop-to-hop data forwarding used. Every time the communication begins from the source node.

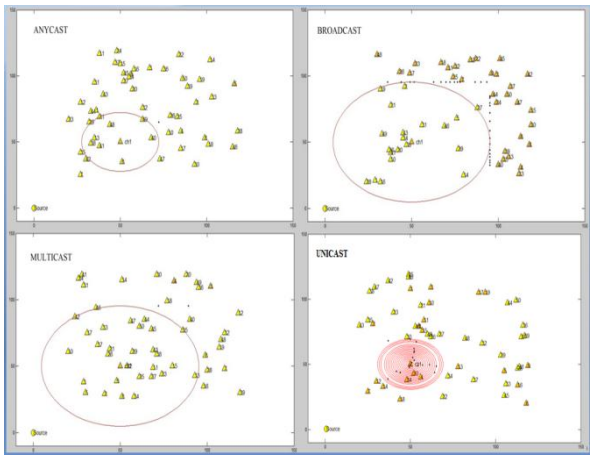


**Fig 7: Simulated MANETs environment of addressing methods Before Intrusion**

In Figure given above, we have created an ad hoc network environment and there are mobile nodes present within the network which are responsible for dispatch data and forward to the other nodes. Every time a source sends a data packet by JOIN QUERY it will be forwarded to next hop of within the destination path [12][16]. The process continuous until packet reaches the Unicast, Multicast, Broadcast or Anycast destination. It will declare its joining by a JOIN REPLY.

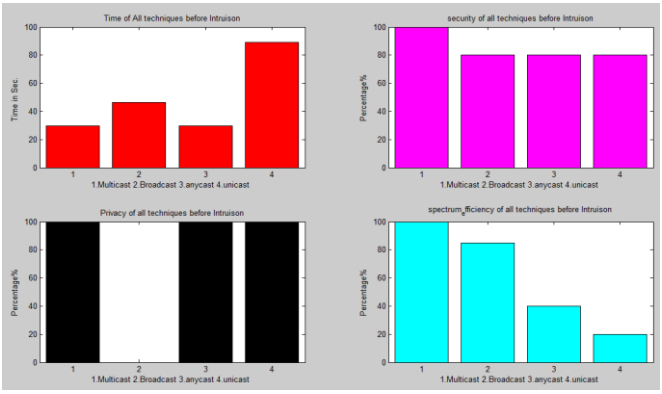


**Fig 8: Combined output of addressing methods based on Time, Security, Privacy and Spectrum efficiency before intrusion**

So in all the addressing schemes a node receives a route request (RREQ), it checks whether it reply to the RREQ. The node act as the requested node and an intermediate node has an active route in its routing table. Send a route reply (RREP) to the RREQ initiator and route Information else the RREQ is re-broadcast by the node [15][5]. In Fig 8. We have shown the combined output of all the addressing methods on the basis of parameters i.e. Time, Security, Spectrum Efficiency and Privacy.

**Table 1: Parameter values of addressing schemes Before Intrusion**

| Iteration | Multicast | | | | Broadcast | | | | Anycast | | | | Unicast | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time | Privacy | Security | Spectrum Effiency | Time | Privacy | Security | Spectrum Effiency | Time | Privacy | Security | Spectrum Effiency | Time | Privacy | Security | Spectrum Effiency |
| 1 | 28.59 | 100 | 100 | 100 | 41.29 | 0 | 80 | 85 | 28.73 | 100 | 100 | 40 | 92.29 | 100 | 80 | 20 |
| 2 | 26.31 | 100 | 100 | 100 | 45.25 | 0 | 80 | 85 | 24.41 | 100 | 100 | 40 | 85.27 | 100 | 80 | 20 |
| 3 | 31.02 | 100 | 100 | 100 | 52.24 | 0 | 80 | 85 | 25.66 | 100 | 100 | 40 | 102.5 | 100 | 80 | 20 |
| 4 | 30.37 | 100 | 100 | 100 | 47.81 | 0 | 80 | 85 | 29.79 | 100 | 100 | 40 | 93.71 | 100 | 80 | 20 |
| 5 | 27.84 | 100 | 100 | 100 | 44.58 | 0 | 80 | 85 | 28.51 | 100 | 100 | 40 | 95.37 | 100 | 80 | 20 |

In the analysis of addressing schemes we have taken data of five iterations and found that if time taken for data forwarding is less, then the spectrum efficiency will be more means that bandwidth will be more in case there is no vulnerabilities occur in the MANET environment.

***6.2 After Intrusion:*** Whenever an unauthenticated node, enters in the mobile ad hoc network the security get affected but the privacy still remain same as all the coordinates locations are known and data will not be forwarded to the unauthenticated node..

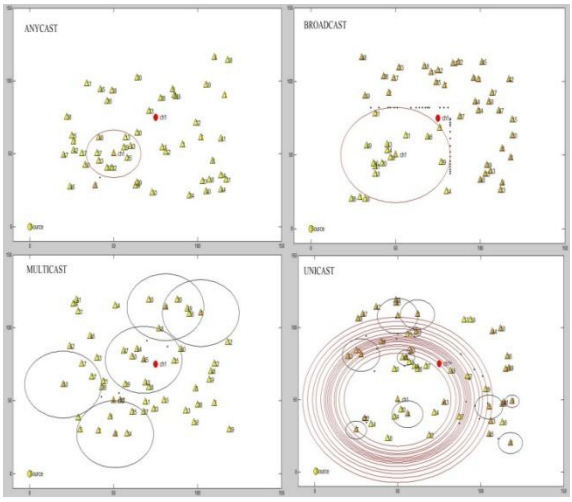


**Fig 9: Simulated MANETs environment of addressing methods Before Intrusion**

Only a delay in packet delivery can take place. In addition to performance of the ad hoc network addressing schemes, the common parameters have a significant effect on packet delivery in MANET environment. in Figure 9, Every time a source sends a data packet by JOIN QUERY it will be forwarded to next hop of within the destination path. But if there will be any unauthenticated node present in the network it will start delaying the packet delivery. So in accordance, the bandwidth or Spectrum efficiency will be less due to the invader entrance in the ad hoc network which leads to more time consumption in data forwarding [6][18]. The process continuous until packet reaches the Unicast, Multicast, Broadcast or Anycast destination. It will declare its joining by a JOIN REPLY.

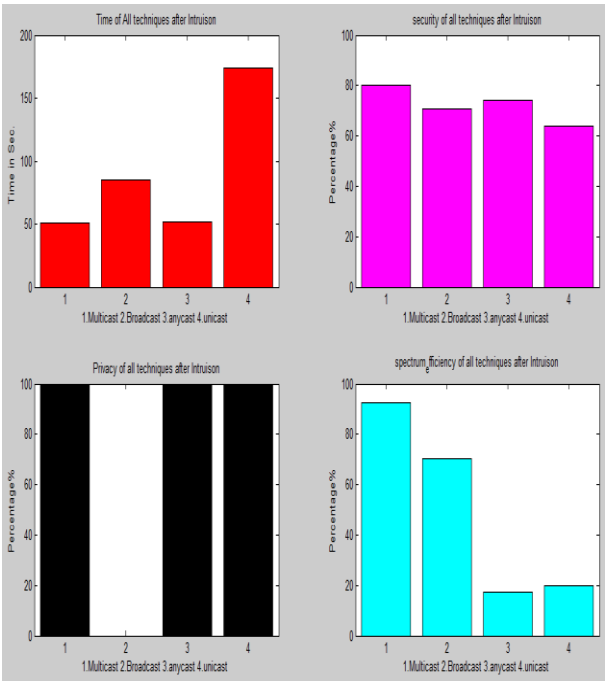


**Fig 9: Combined output of addressing methods based on Time, Security, Privacy and Spectrum efficiency before intrusion**

In Figure 9, combined output after the malicious activity is shown for all the addressing schemes, it represents that either in case of intrusion the Multicast addressing scheme is efficient A basic requirement for keeping an ad hoc network operational is to enforce ad hoc nodes and keeping all the coordinates of present nodes in the MANET environment for better packet forwarding and routing. So in ad hoc networks those functions are carried out by all available nodes.

**Table 2: Parameter values of addressing schemes Before Intrusion**

| Iteration | Multicast | | | | Broadcast | | | | Anycast | | | | Unicast | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time | Privacy | Security | Spectrum Effecency | Time | Privacy | Security | Spectrum Effecency | Time | Privacy | Security | Spectrum Effecency | Time | Privacy | Security | Spectrum Effecency |
| 1 | 51.93 | 100 | 80.16 | 92.11 | 76.03 | 0 | 70.78 | 70.56 | 47.73 | 100 | 74 | 17 | 180.1 | 100 | 63.9 | 15.55 |
| 2 | 47.19 | 100 | 81.34 | 90.34 | 86.64 | 0 | 70.43 | 60.67 | 40.91 | 100 | 75 | 15 | 168.9 | 100 | 61.34 | 16.45 |
| 3 | 53.32 | 100 | 84.37 | 94.11 | 101.4 | 0 | 65.55 | 50.23 | 46.86 | 100 | 75 | 15 | 198.9 | 100 | 62.56 | 17.98 |
| 4 | 53.64 | 100 | 80.56 | 94.33 | 88.53 | 0 | 70.22 | 60.95 | 53.78 | 100 | 75 | 15 | 183.7 | 100 | 62.99 | 15.67 |
| 5 | 55.09 | 100 | 83.23 | 95.46 | 82.77 | 0 | 69.45 | 59.54 | 48.45 | 100 | 75 | 15 | 186.9 | 100 | 67.22 | 16.43 |

In order to check performance of all addressing schemes at the the time of vulnerabilities in the MANET environment we found that Multicast addressing scheme is efficient because this message transmission using this technique in case of secure routing and in case of encroachment routing multicast communication model can facilitate effective and collaborative communication. From all of the proposed addressing mechanisms as in the MANET environment all nodes vary in terms of route topology and state maintenance.

Finally, we given the stringent nodal budget for all the addressing schemes based on their parameters. With the advances in support for group communications and hop-to-hop communication each addressing scheme has their own benefits. Based on the previous surveys and proposals and from the comparative analysis we found the Multicast addressing scheme efficient.

## 7. CONCLUSION

This paper represented a novel comparative study of all the addressing schemes. Due to the wide varieties of mobile nodes in MANET environment it becomes a challenging issue to select efficient addressing scheme. So this comprehensive analysis approach is feasible to improve the time and spectrum efficiency and also to choose best suitable addressing scheme in case of vulnerabilities. By the simulated results it is clear that multicast addressing method is well suited in dynamic environment of MANETs and also it will get rid of the looping overhead. Through simulated analysis and extensive implementation, we explore the characteristics of these approaches and finally provide recommendation for best suitable approach for mobility model. By the comparative study of these message transmission methods and their use as a communication primitive before intrusion and after intrusion with a specific attention to Mobile ad hoc networks, we found that Multicast addressing scheme is well suited as the impact of vulnerabilities and various attacks is less on this scheme. It simultaneously uses the most efficient strategy to deliver the messages over each link of the network. Various improvements in the message transmission and addressing methods still in progress and will be reported in the upcoming paper.

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