Performance Evaluation of Group Mobility in Mobile Ad hoc Networks

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Abstract

Mobility of nodes is an important issue in mobile adhoc networks (MANET). Nodes in MANET move from one network to another individually and in the form of group. In single node mobility scheme every node performs registration individually in new MANET whereas in group mobility scheme only one node in a group i.e group representative (GR) performs registration on behalf of all other nodes in the group and is assigned Care of Address (CoA). Internet protocol (IP) of all other nodes in the group remains same. Our simulated results prove that group mobility scheme reduces number of messages and consumes less time for registration of nodes as compared to single node mobility scheme. Thus network load is reduced in group mobility scheme. This research paper evaluates the performance of group mobility with single node mobility scheme. Test bed for this evaluation is based on Network Simulator 2 (NS-2) environment.

Keywords: *Mobile Adhoc network, Group Registration, Group Representative, Care of Address*

1. Introduction

The application of mobile adhoc network is increasing in the modern age. It is a network that is developed on the run without any prior infrastructure [1]. Every node in the network acts as a router or relay station to forward data to the designated node. In mobile adhoc network (MANET) nodes are mobile and constantly changes its location from one MANET to another.

MANET is developed without any prior infrastructure so security is a big issue in it [2]. Nodes in MANET roam from one network to another. In roaming between different networks the main aim is to receive data in its new location without any delay and disruption. For this purpose mobile IP functionality is used to allow roaming of nodes [3]. Mobile IP allows a node to acquire a virtual IP address called Care of Address (CoA) in the new network.

In mobile IP scenario [4] when a mobile node (MN) is in its original location, that network is known as home network. When it moves to a new network, hat network acts as a foreign network. When a mobile node moves from its home network to foreign network, it sends registration request to foreign agent. The foreign agent sends registration request to home network of the mobile node. The home agent sends registration reply to the foreign agent. The foreign agent send registration reply to mobile node and it is assigned a Care of Address in the foreign network.

A group registration with group mobility scheme is proposed [6]. In this scheme nodes moves in the form of a group. Groups are established on the basis of similar interests like army soldiers can form infantry, artillery or armored group. Groups can be identified as business or educational groups. There is a fixed node in the network which is the overall controller of MANET. This fixed gateway keeps the mobility location of all nodes in the network. Every group has a group representative (GR) which is controller of the group. When nodes move in the form of a group, this GR performs registration on behalf of all other nodes in the group. Only GR is assigned an individual CoA. IP of all other nodes in the group remains same.

The rest of this paper is organized as; section 2 describes the related work. The proposed solution is presented in section 3. The mathematical function is described in section 4. In section 5 simulation results are described. Section 5 concludes the contribution of this paper. At the end of this paper references are given.

2. Related Work

There are various schemes for mobility in MANET. One of the schemes Kock and Schimidt [7] used to support mobility which proposed a mechanism in which mobile IP routers are used for communication. In this network all the nodes are mobile and are globally reachable. The nodes offer gateway functionality to nodes in ad hoc network. The mobile IP routers have two interfaces. One interface is connected to outside world and other interface is connected to ad hoc network. The gateway or mobile IP router should combine functionality of mobile node (MN), foreign agent (FA) and home agent (HA). The mobile IP router uses its WAN interface IP address as collocated care of address with HA. The mobile IP router serves as a tunnel end point between itself and MN that is using his gateway functionality. All IP addresses are global addresses. The ad hoc routing protocol runs in the 1.0.0.0/24 subnet. Here 2.0.0.0/24 addresses are acquired from WAN network. The mobile nodes use their home addresses in ad hoc network. The MN use COA that they acquired for use on their WAN interface.

Berg [2] describes different types of attach in ad hoc network. Impersonation attacks are also called spoofing attacks. The attacker assumes the identity of another node in the network, thus receiving messages directed to the node it fakes. Usually this would be one of the first steps to intrude network with the aim of carrying out further attacks to disrupt operation. By carrying out a sinkhole attack, a compromised node tries to attract the data to it from all neighboring nodes. Since this would give access to all data to this node, the sinkhole attack is the basis for many other attacks like eavesdropping or data alteration. Sinkhole attacks make use of the loopholes in routing algorithms of ad hoc networks. In a wormhole attack, a malicious node uses a path outside the network to route messages to another compromised node at some other location in the network. Wormholes are hard to detect because the path that is used to pass on information is usually not part of the actual network. A wormhole attack itself doesn't have to be harmful; rather it lowers the time that takes for a packet to reach its destination. Sleep deprivation attack is to request the services a certain node offers, over and over again, so it cannot go into an idle or power preserving state, thus depriving it of its sleep. This can be very devastating to networks with nodes that have limited resources. In a Sybil attack a malicious node in a network may not only impersonate one node, it could assume the identity of several nodes, by doing so undermining the redundancy of many routing protocols.

Another scheme proposed by Zhao [8] for ad hoc network connection to the internet. In this scheme dynamic gateways are used that uses mobile IP functionality. Mobile nodes in

adhoc network use these dynamic gateways to connect to the internet. The gateways are multi-homed. The gateway node acts as a gateway in one time and a MANET node in the other. Any interaction between MANET nodes and internet has to be provided by these dynamic gateways. A dynamic gateway is a MANET node with extended capability, which is one hop away from foreign agent. These dynamic gateways use mobile IP for communication with remote nodes on internet and uses DSDV when they interact within the MANET. The dynamic gateway architecture has several advantages, like it eliminates the need of fixed gateways, reduces system complexity, improves reliability and lowers the cost.

In this scheme Zhou [5] proposed virtual track (VT) group mobility model. It models various types of node mobility such as group moving nodes, individually moving nodes as well as static nodes. Moreover, the VT model not only models the group mobility it also models the dynamics of group mobility such as group merge and split. This scheme is applied in military scenarios. Some stations are first randomly deployed in the field. These stations are then connected via virtual tracks with given track width. The grouped nodes must move the following constraints of the track. At station, a group can then be split into multiple smaller groups; some groups may even be merged into bigger group. Such group dynamics happen randomly under the control of configured split and merge probabilities. Nodes in the same group move along the same track. The proposed VT model is capable to model randomly and individually moving nodes as well as static nodes.

A scheme explained internet based Corson [9] focused on internet based mobile ad hoc networking. Each node in a mobile adhoc network (MANET) logically consists of a router with possibly multiple IP addressable hosts and also multiple wireless communications devices. A node may consist of physically separate network device or may be integrated into a single device such as laptop or handheld computer. End devices in MANET are mobile. In this approach a user identity depends upon whether the user adopts a temporary or permanent identifier. Conceptually, the emerging mobile internet can be divided into two layers; the mobile host and mobile router layers. The mobile host layer consists of hosts temporarily attached to routers on the fixed network, or fixed routers. These hosts are logically one hop from a fixed router, and their connections may be wired or wireless. Principal functions are handled by these technologies are location address management. End-to-end operation requires routing support from the fixed infrastructure.

Another scheme proposed by Farooq [10] to provide internet connectivity to the nodes in ad hoc network. As a solution, an integration of mobile IP and ad hoc networks is implemented in a way that mobile IP enables nodes to move between different gateways while maintaining the connectivity; and ad hoc routing protocols provide connectivity among the nodes within the ad hoc network. In order to be able to communicate with internet hosts, each mobile node must find a gateway called gateway discovery and obtain an address with the prefix of that gateway. With this new globally routable address, packets can be received from and sent to the internet. When a mobile node moves and selects a different gateway, it configures a new address with the new prefix. A mobile node obtains its globally routable address in following steps. Basically, it has an initial IP address (home address) which is routable in the ad hoc network, discovers reachable gateways in its surrounding, selects one gateway out of the set of reachable gateways and forms a globally routable IP address with the prefix of the selected gateway.

3. Proposed Solution

In this approach we have proposed group mobility concept with group registration. We divided our MANET in to different groups, each having nodes of similar interests. In war, the

army troops having same artillery or armor can form a group. Likewise here groups can be identified as educational and business groups which have same interests. In our scheme every node in ad hoc network is mobile except one node that is fixed. This fixed node in ad hoc network is a central point and acts as a gateway. The fixed gateway is the overall controller of whole ad hoc network and keeps the mobility location of all nodes in the network. Nodes moves from one location to another in the form of group.

In our proposed scheme individual node registration and group registration is possible. If nodes move individually to a new network then it is assigned individual Care Of Address. When nodes move in the form of a group they register themselves in the new network in the form of a group. Every group has a group representative which is responsible for communication with other groups. This group representative is the controller of the group. When a group moves and joins other group then this group representative checks the validity of the group from the fixed gateway. The fixed gateway send registration reply to the group representative which has asked registration and it will be assigned a Care Of Address. All other nodes do not send registration request. The group representative performs registration on behalf of all other nodes in the group; because of this registration concept, the number of messages to the register nodes individually is reduced. Nodes in different groups communicate with each other through its group representatives.

As in earlier schemes when number of nodes move from one network to another network, every node register individually in the new network. Every node is assigned an individual CoA in the new network after validation from its home network. In our approach group mobility with group registration is proposed. Every node in the network uses mobile IP functionality. In this approach only one node which is group representative is assigned CoA. It does registration on behalf of all other nodes in the group. Because of this proposed approach fewer networks are to be consumed therefore delay in registering of nodes is reduced. This new approach has a positive impact on routing table updates of one group have on effect on other group. Routing table updates is only restricted to groups. Routing table of other groups are only updated or changed when routing table of group representative changes or updates. In this approach there is no need to assign individual care of address to each node.

4. Mathematical Analysis

In this section we have performed mathematical analysis of group mobility scheme with single node mobility scheme [6].

The mathematical function shows the relationship of number of nodes with number of messages for single node mobility scheme.

$f(n) = m * n$ for all $n \geq 1$

m = no. of messages which is constant i.e 5

n =no. of nodes

If n=1 $f(1) = 5 * 1 = 5$

If n=2 $f(2) = 5 * 2 = 10$

If n=3 $f(3) = 5 * 3 = 15$

If n=4 $f(4) = 5 * 4 = 20$

If n=5 $f(5) = 5 * 5 = 25$

The relationship of number of nodes with number of messages in group mobility scheme is

$f(n) = m$ for all $n \geq 1$

If n =1 f (1) = 5

If n =2 f (2) = 5

If n =3 f (3) = 5

If n =4 f (4) = 5

If n =5 f (5) = 5

In single node mobility scheme as no. of nodes increases in the MANET, no of messages increases. In group registration concept as the number of nodes increases, the no. of messages to register node in the new group remains same because in this scheme only one node i.e GR performs registration on behalf of all other nodes in the group.

Table 1. Comparison of messages between single & group mobility scheme

SCHEMES	NUMBER OF NODES				
	1	2	3	4	5
	NUMBER OF MESSAGES				
SINGLE NODE MOBILITY SCHEME	05	10	15	20	25
GROUP MOBILITY SCHEME	05	05	05	05	05

In Fig. 1 the number of messages is shown at horizontal axis while the vertical axis shows the number of nodes. In single mobility scheme the number of messages tends to grow with the increasing number of nodes. While in group mobility scheme the number of messages remains constant with the increasing number of nodes as compared to single node mobility scheme.

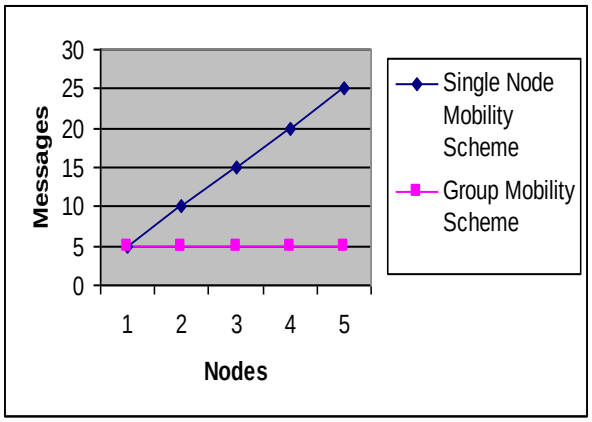

Fig. 1 Comparison of message consumption for registration between single and group mobility schemes

5. Simulations

In this section we have discussed the simulations environment, simulation detail and its results. We have performed our simulation results on NS-2.

5.1 Message Size

The architecture consists of 5 mobile nodes in a group, 5 in other group and one node that is fixed in group mobility scheme. In this scheme when a group moves, GR of group sends 5 messages to register itself in new group. Each message is of 128 bits in length. The total size of messages for registration of GR is 640 bits in length.

In single node mobility scheme there are 5 mobile nodes in a MANET and 5 nodes in other MANET. One node in each MANET is fixed that acts as a gateway. In this scheme every node sends individual registration request message. The message size is 128 bits in length and one node sends 5 messages for registration so it takes 640 bits for registration of one node, so total size of message for registration of 5 nodes is 3200 bits length.

5.2 Registration Time

In group registration scheme when a group moves, GR of group only send registration request message. This registration process of whole group is completed in 4.30 ms. In this scheme only GR sends registration request as it does registration on behalf of all other nodes in the group. So registration of whole group is completed in this time.

In single node mobility scheme when 1st node moves to a new MANET, it completes registration process in 4.30 ms. Second node completes its registration process in 8.60 ms. Third node completes this process in 12.90 ms. Fourth node completes this process in 17.20 ms. Fifth node completes this process in 21.50 ms.

Table 2. Registration Time for Nodes

SCHEMES	NUMBER OF NODES				
	1	2	3	4	5
	TIME FOR REGISTRATION (ms)				
SINGLE NODE MOBILITY SCHEME	4.3	8.6	12.9	17.2	21.5
GROUP MOBILITY SCHEME	4.3	4.3	4.3	4.3	4.3

In Fig. 2 the time in milliseconds has been shown at horizontal axis while the vertical axis shows the number of nodes. In single mobility scheme the registration time tends to grow with the increasing number of nodes. While in group mobility scheme the registration time remains constant with the increasing number of nodes as compared to single node mobility scheme.

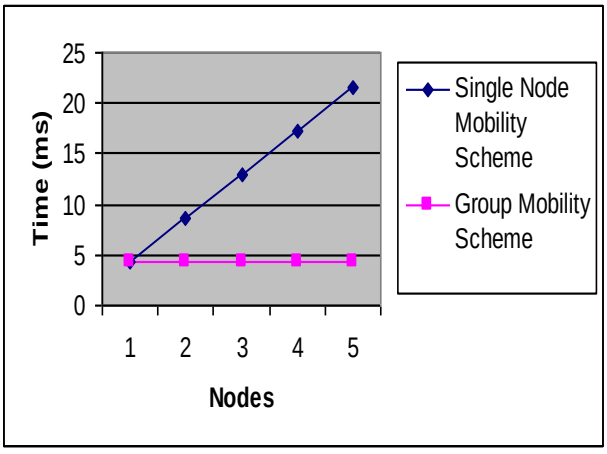

Fig. 2. Registration Time for Nodes

5.3 Network Load

Network load is reduced in group mobility scheme as compared to single mobility scheme. In group mobility scheme network load for registration of a group is 0.625 Kbps. The network load in single node mobility scheme for registration of nodes in MANET is 3.125 Kbps.

Table 3. Network Load for Single & Group Mobility Scheme

	NETWORK LOAD Kbps
SINGLE NODE MOBILITY SCHEME	3.125
GROUP MOBILITY SCHEME	0.625

6. Conclusion

In this research paper we have focused on the mobility aspect of adhoc network and simulated the results of group mobility and single node mobility schemes in MANET. We have discussed the simulation scenarios, mathematical functions and simulation results which validate the efficiency of group mobility scheme. The validated result shows that group mobility scheme not only reduces the number of messages, it also reduces the network load and time for registration of nodes.

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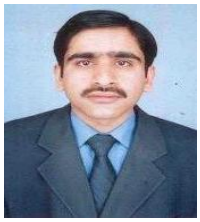

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