A UBIQUITOUS PROTOCOL FOR ADDRESS DYNAMICALLY AUTO CONFIGURATION FOR MOBILE AD HOC NETWORKS

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Abstract

The main work of this research work is to overcome a problem of address configuration in MANET. Address configuration in MANET is very difficult because it is multi-hop wireless network and topology of the network can change randomly due to unpredictable mobility of nodes and propagation characteristics. This paper introduce a Ubiquitous protocol for dynamic IP address assignment to nodes in MANETs which provide a guaranteed unique IP address assignment under a variety of network conditions including message losses, network partitioning and merging. The selection of some parameters in the algorithm is investigated, leading to different address tree structures.

***Index Terms*:** Ad Hoc Networks, IP Address Auto configuration, IP-networks, Routing Protocols.

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1. INTRODUCTION

Mobile Ad Hoc Networks are collections of mobile hosts dynamically establishing short lived networks in the absence of fixed infrastructure. MOBILE ad hoc networks (MANETs) are multi-hop wireless networks of mobile nodes without any fixed or pre-existing infrastructure. Nodes within the wireless range of each other can communicate directly. Nodes outside each other's wireless range must communicate indirectly, using a multi-hop route through other nodes in the network. This multi-hop route may change if the network topology changes. Several routing protocols like DSR [5], CBR [6], DSDV [9], AODV [10], etc. have been proposed for MANETs. MANETs may operate in a stand-alone mode, or may have gateways to interconnect to a fixed network. In the stand-alone mode, the network is spontaneously formed by nodes gathering at a remote location with no network infrastructure. Such a network can also be formed when the gateways to the external world fail or when all the existing network infrastructure goes down due to natural/man-made disasters. In the presence of a gateway, a MANET is envisioned to operate as a stub network connected to a fixed internetwork. In most networks, including MANETs, each node needs a unique identifier to communicate. It may be argued that the MAC address or the home IP address of the node should be sufficient for this purpose. However, use of the MAC address as a unique identifier has the following limitations:

1) MANET nodes are not restricted to using network interface cards (NICs) with a 48-bit IEEE-assigned unique MAC address. In fact, the TCP/IP protocol stack should work on a variety of data-link layer implementations. So, if this approach were to be employed, specific implementations would be required for each type of hardware.

2) The uniqueness of a MAC address cannot always be guaranteed, as it is possible to change the MAC address using commands like *ifconfig*.

3) There are known instances of multiple NIC cards from the same vendor having the same
MAC addresses [11] [12].

The home IP address of the mobile node may not be usable as a unique identifier at all times. The home IP address may not be permanent, for example when the node acquires an IP address during boot up through DHCP and releases it when it leaves the network. It is possible that two nodes belonging to the same home network, at different times, may join the MANET with the same home IP address. Moreover, even if a node owns a unique home IP address, it needs a unique care-of IP address in the MANET if it is to be addressable from the Internet. Static IP address assignment for MANET nodes is difficult as it needs to be done manually with prior knowledge about the MANET's current network configuration. Dynamic configuration protocols like Dynamic Host Configuration Protocol (DHCP) [1] require the presence of centralized servers. MANETs may not have such dedicated servers. Hence, centralized protocols cannot be used to configure nodes in MANETs. In this paper present a distributed protocol for dynamic IP address assignment. The proposed solution is targeted towards the stand-alone mode of operation.

It may also be used in situations where the gateway only provides connectivity to external network(s) with no support for IP address assignment. While limit the examples to IPv4, the proposed protocol is applicable to both IPv4 and IPv6 networks.

2. The Prophet Allocation Protocol

In this scheme, every host in the network maintains a function f(x) and has a state value to generate IP
addresses to new hosts. This function f(x) seems to satisfy the following two properties:
• f(x) generates the same address in the same sequence at very large intervals.
• The probability of same address generated by function f(x) in different sequences is very low.
When a new host requests an address, the initiator generates the address in two steps:

- Initiator updates its state value as the state value provided to requester.
- Function f(x) generates a free address and provides new state value to requester.

Every initiator in the network acts the same manner to generate free addresses for new hosts. Regarding MANETs merger, two alternative mechanisms have been proposed. The first mechanism performs with high overheads and does not provide an answer regarding what function to use in future allocations.

The second mechanism requires giving up all addresses in one network obtaining new addresses according to other network address sequence. This leads to unnecessary address changes. Every configured host in the network is able to act as initiator to new hosts for address allocations. It maintains distributed allocation table and pending allocation table, which are a set of configured IP addresses in use and a set of IP addresses whose allocation has been initiated but not yet completed respectively. The purpose of distributed allocation table is to find efficiently unconfigured address from the address space and the pending allocation table avoids concurrent address allocations.

When the requester contacts an initiator by broadcast message for a free address, the initiator responds with an unconfigured address. Simultaneously, the initiator floods the network with a message asking for all hosts whether this address can be allocated. If all replies confirm the uniqueness of the pending allocation, then it is assigned. If not, then repeat the procedure with new address.

Authors proposed to identify network partition with partition ID and Universal Unique Identifier (UUID – host with smallest IP address in the network). Informing partition ID to every host in the network required proactive routing protocols or periodically transmitting messages. It usually consumes higher network resources and increased network overhead Network merging was the interesting part but we note some drawbacks with regards to the mechanism. Maintaining two tables and periodically transmitting control messages increases communication overheads. Frequent updating of such table with reactive routing protocols may reduce the efficiency of entire network communication.

3. Protocol Messages

The following messages are exchanged during IP address assignment:

1. IP Address Request: A local broadcast message from the *requester* to neighboring nodes in the network requesting an IP address.

2. IP Address Avail: Unicast2 responses to *IP Address Request* from the neighboring nodes of the *requester*. This message contains the replying node's IP address and proposed block of IP addresses, if any.

3. Allocator Chosen: Unicast messages from the *requester* to all its neighbors on electing an *allocator* from among the neighbors that sent *IPAddressAvail* messages. This message contains the IP address of the chosen *allocator*.

4. IP Address Assign: Unicast message from the *allocator* to the *requester* assigning an IP address. This message contains an IP address block for the *requester*, IP address range from which the addresses can be assigned to nodes, and the *network id*.

5. IP Address Update: Network-wide message exchanged between nodes to update the network configuration information. This message is sent to all nodes in the network: (i) by the *allocator* responsible for reclamation of IP addresses during IP address allocation process, and (ii) by the *merge agent* during network-merging process.

6. Wait Period: Unicast message from the *allocator* informing the *requester* to extend its *assign ip* timer.

4. Efficient Network Layer Addressing

This mechanism utilizes variable length addressing and an attachment agent. When a new host enters a network, the agent acquires the address for the new host. It is not totally clear how the attachment agent selection criteria priorities among close hosts around joining host. Similarly to MANET Conf, the attachment agent responds to joining host saying allocation is pending and simultaneously requesting a confirmation of the address uniqueness from entire network. Receiving negative reply indicates pending allocation address may be in use and allocation can be cancelled to avoid conflict allocation. Concurrent assignment of same address in the network may occur through missing of reply messages requested by attachment agent. The main drawback is that IP compatible addresses. These are not assigned and when networks merge, every host must change its address if the total number of hosts in the merged network is greater than the current available address space. Variable address length scheme can reduce network communication overhead considerably.

5. Conflict Free IP Addressing Mechanism

Here it is consider that Stand-alone Mobile Ad Hoc Networks. We assume that a block of IPv4 private addresses is used for addressing the hosts within a MANET. The blocks provided for private addressing are:

10.0.0.0 - 10.255.255.255 (10/8 prefix)

172.16.0.0 - 172.31.255.255 (172.16/12 prefix)

192.168.0.0 - 192.168.255.255 (192.168/16 prefix)

It is consider, the introduce block, which provides 24 bits for addressing. We need to consider 2 issues: We want to generate conflict free addresses for each MANET, but also we need to bear in mind that as hosts from different MANETs may come into contact with each other, they should be able to identify, by the address used, that they are from different MANETs. By structuring the address space into MANET ID and Host ID, both objectives can be achieved, at least statistically. Note that MANET ID is not used for routing as in wire line networks, but to differentiate between different MANETs in case of mergers. The routing inside a MANET needs only consider the host ID.

5.1 Network Initialization

When the very first host wishes to join the network it sends broadcast message to its neighbors and simultaneously starts the acknowledgement timer. At least one acknowledgement message should be received from requester’s surrounding hosts (although in this case there are none) before timer expires. If not it repeats the procedure few times (threshold time). If requester’s timer expires without any response from its surrounding hosts then this requester decides to configure by itself with very first IP address of the network. It selects randomly a MANET ID, and takes the very first address in the host ID space.

5.2 Address generation in the Network.

The network is capable of generating a range of addresses, and the range of addresses of any two hosts in the MANET is disjoint. A new host receives an unused IP address as will be explained next. Each host is numbered, according initially to the order of arrival on the MANET, but when a host departs from the MANET the number is reused, in which case it will not represent the order of arrival of the new host. Any given host, whose number is n, can allocate the following addresses:

$$\sum_{i=0} \mathbf{n} \times \textbf{Base Value} + \mathbf{i} \qquad (1)$$

Where Base Value = 2, 3, 4, …….
Host Number **n** = 0, 1, 2, ……
i = 0, 1, 2, 3,…(Base Value – 1)

The values obtained in Eq.(1) are then added to the first address in the host range to generate a new address. This algorithm leads to a tree structure in the way the addresses are generated, as shown if Figure 2 for the base value of 2. The higher the base value, the wider the tree and the higher the number of leaves with free addresses to allocate. This relation between the number of nodes in the MANET, the base value and the number of nodes with free addresses is depicted in table A and Figure 1.

Base Value	No of Hosts with Free Addresses for MANET with			
	50 Hosts	100 Hosts	200 Hosts	500 Hosts
2	24	50	100	250
3	33	66	134	333
4	38	75	150	375
5	40	80	160	400
6	42	84	167	417
7	42	86	171	428
8	44	88	176	437
9	44	89	178	445
10	45	90	180	450
11	45	91	182	454
12	46	92	183	458
13	46	92	184	462
14	46	93	185	463
15	46	93	187	466
16	47	94	187	468
17	47	94	188	470
18	47	94	189	472
19	47	94	190	474
20	48	95	190	475

Table 1. No of nodes with addresses

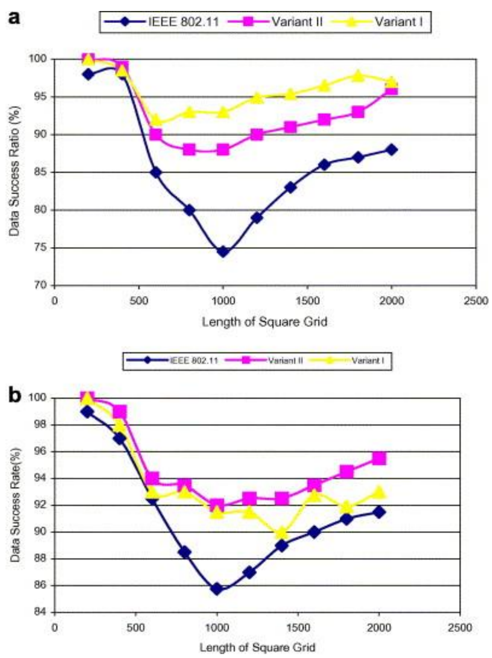

Fig 1. No of Free Hosts for various Base Values.

This shows how the algorithm generates the sequence of addresses. The very first host selects randomly the MANET ID and picks as its IP address the first address in the host ID range. The first host generates the address of the second host, which generates the address of the third and fourth, and so on.

5.3. Host Joining the Network

When a new host comes to join the network, it sends a broadcast message requesting a new address to join the network. One or more hosts, those with available addresses, will respond to that broadcast message. If a new joining host receives more than one response from other hosts, it gives priority to the address allocating host with the lowest address.

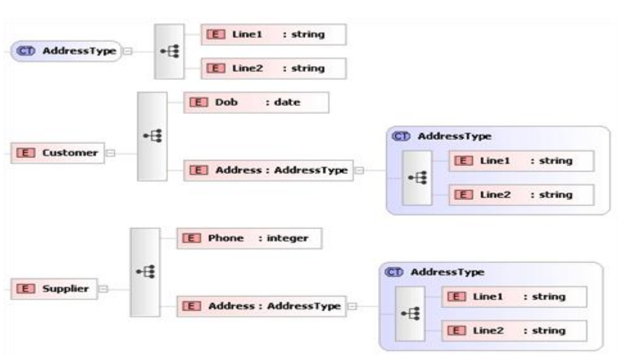

Fig 2: Address Generating Sequence

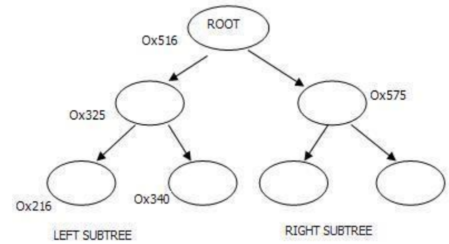

Fig 3. Address Allocation Tree

The host that allocates the address, the address allocator, will assign new address to an address requester according to the address allocator’s available IP address(es). If more than one is available, it selects the lowest value.

5.4. Host Departing Network

Host departure message is received by neighbor hosts, they will inform the host who will be responsible for regenerating the departing node’s address. In other words, the parent host or a host that has replaced the parent in the tree. If the parent host place is vacant, say because the parent has left the network and has not been replaced, then the parent of the parent is informed, so that when the parent’s address is regenerated it knows that there is a vacant address to generate. Naturally, if the parent of the parent is also vacant, then its parent is notified, and so on.

When an existing host abruptly departs the network, there is no opportunity to inform the network about this departure. When a new host next comes to join the network, after receiving a new address it broadcasts a message informing its new address. Then all of members in network respond to new member acknowledging the new address. With these messages newly configured host knows which hosts are not present in the network. The newly configured host sends unicast messages to the missing hosts. If there is no reply, the new hosts will inform the parent of the missing host, just as in the case of a graceful departure.

6. CONCLUSIONS

As the results show the dynamic distributed conflict-free address configuration algorithm for MANETs that provides address assignment to mobile hosts during the initiation, formation and maintenance of a network. The number of addresses each host can generate is the base value in the algorithm, and we considered a few possible values for comparison purposes. It is observed that increasing the base value leads to an increment of available free addresses. And function of the base value, and the impact of the merger of two MANETs with coinciding MANET IDs.

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