MANET Autoconfiguration (AUTOCONF)
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Address Autoconfiguration for Hybrid Mobile Ad Hoc Networks
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Abstract

Most of MANET address autoconfiguration mechanisms introduce significant load like message flooding, or are dependent on the underlying routing protocols. This document proposes a new mechanism that is intended to minimize these drawbacks. It is also designed to be applicable for hybrid MANET, where a MANET is connected to Internet through one or more MANET border routers.

Table of Contents

1. Introduction

Mobile Ad Hoc Network (MANET) is a self-organized network by wireless mobile nodes(MNs), without any pre-installed infrastructure. Its topology is frequently changed due to the MNs' mobility. Therefore, it is necessary to configure their addresses automatically.

"Hybrid MANET" is a mobile ad hoc network that has connectivity to other networks, like the Internet. The connectivity is provided by special MN called `MANET Border Router'. If MNs want to communicate with nodes on the external networks, the configured addresses must be globally unique.

Recently, several solutions have been proposed to autoconfigure addresses to MNs [9]. Most of solutions exploit either an independent algorithm and messages [5] or a mechanism combined with underlying MANET routing protocol [6]. But they still have some drawbacks. First, they introduce significant load like message full-flooding over a MANET. Second, they are coupled with the routig protocol and have more complex structure.

This document describes a mechanism of address autoconfiguration for a hybrid MANET, called `Hybrid MANET Address Autoconfiguration' (HAA). The mechanism is intended to minimize message full-flooding. HAA autoconfigures IPv6 addresses to MNs by using IPv6 Neighbor Discovery Protocol (NDP) [2-3] with some options and messages newly defined here. After this autoconfiguration process, each MN has two types of addresses: MANET-local address and global-scope address.

2. Terminology

Some of the terminology was borrowed from MANET architecuture I-D [13].

MANET Node (MN)

A MANET node includes a MANET router and zero or more hosts.

MANET Router (MR)

An entity that engages in a MANET routing protocol.

Duplicate Address Detection (DAD)

A process determining the uniqueness of an address to be configured. If any MN has already used the same address, the MN that has performed DAD process must select another address and then execute DAD process again.

Hybrid MANET

A MANET with a connection to the Internet is refered to as a hybrid MANET. Such a connectivity is provided by one or more MANET Border Routers (MBRs). Every MN in hybrid MANET can have multiple addresses to be accessible to variable scope of networks.

MANET-local Address

An address used in MANET-scope communications. MBRs do not forward the packets that have MANET-local addresses as their destination addresses. Unique local IPv6 unicast addresses (ULA) [10] can be used easily as MANET-local addresses.

Global-scope Address

An address used in MANET- and global-scope communications. The general format of IPv6 global-scope addresses is defined in IPv6 Address Architecture [11]. With this type of addresses, every MN in hybrid MANET can access to another MN in the MANET and to any host in the Internet.

Hybrid MANET Address Autoconfiguration (HAA)

The mechanism that configures MANET-local address and global-scope address to the MN in a MANET. Because each MN has the information about MBR and the MBR maintains the information of MNs, MANET-wide message broadcasting can be avoided.

MANET Border Router (MBR)

A router that participates in multiple routing domains. It provides MANET with network connectivity to other networks, like the Internet. MBR also performs MANET-scope DAD, and allocates global-scope addresses to the MNs.

Default Node (DN)

If a MN has one or more HAA messages to be delivered to corresponding MBR, the MN direct all messages to `Default Node'. Only one of the MN's neighbors can be a default node. This DN information is independent of any routing protocol.

HAA Path

If a MN wants to exchange address autoconfiguration messages with its corresponding MBR, the MN sends the message to its default node, one of its one-hop neighbors. The next hop MN then forwards this message to its default node repeatedly. As a result, the message is delivered to the MBR. `HAA path' is the chain of default nodes among the MBR and the MNs. HAA path is regarded as a tree path that has MBR as its root.

NDP Global Address Solicitation (GS)

This is a newly defined message here to deliver each MN's request for the allocation of global-scope address and MANET-scope DAD.

NDP Global Address Advertisement (GA)

This is a newly defined message here to deliver MBR's response of each MN's GS message. This contains the information about global-scope address to be allocated, or an error if necessary.

3. IPv6 Address Autoconfiguration for Hybrid MANETs

3.1. Link-local DAD

If a new MN A joins a MANET, the MN A makes its own link-local scope address, and then determines the duplication of the address. To detect address duplication, the MN A broadcasts NDP `Neighbor Solicitation (NS)' message to all of 1-hop neighbors. If there is not any NDP `Neighbor Advertisement (NA)' message for a period of time, the MN A uses the link-local scope address to get a global-scope address.

If there are one or more NDP NA messages, the MN A makes a new link-local scope address with a 64-bit long random value as a MN ID according to IPv6 Stateless Address Autoconfiguration (SAA) [3]. Then the MN A retries the link-local DAD by sending again a NDP NS message containing the new link-local address.

3.2. Default Node Selection

If a newly joined MN A fixes its link-local address, then it tries to get the information about the MBR and default node. For this, the MN A sends NDP `Router Solicitation (RS)' message to all of 1-hop neighbors.

Each neighbor that receives the MN A's RS message responses with NDP `Router Advertisement (RA)' message like a router of wired networks. In this RA message, a newly defined 'Default Node' option is attached. This option containes the addresses of MBR and default node (e.g. the sender of this message), the path length measured in hop counts between the MBR and the default node, and the lifetime of the information about default node.

The MN A then receives one or more RA messages. It selects one among these messages by searching the address of MBR and hop counts. For example, if MN B, C, and D send RA messages and the MN B's RA message has the shortest hop counts to the corresponding MBR, the MN A selects the RA message generated by the MN B.

If there is no RA message during a period of T_WAIT_RA seconds, then the MN A retries to send RS message. If there is still no RS message during N_RETRY_RS times retrial, then the MN A stops HAA process.

3.3. HAA path

If the MN A gets the addresses of MBR and default node, it participates in `HAA path'. At the begining of building a hybrid MANET, there is one MN that is MBR as infrastructure providing Internet connectivity. When there is not any MN except MBR, a newly joined MN does DAD with MBR and gets the MBR's address as a default node. As the following MNs are joined, each of MNs takes the former MN's address as a default node. As a result, HAA path becomes a tree path that has MBR as its root.

The HAA path is used for the porpose of address autoconfiguration only. Each MN's path toward MBR is independent of any routing protocol, but this HAA path infomation can be used by a routing protocol if needed.

3.4. MANET-scope DAD and Global-scope Address Configuration

Once a MN A acquires the information about MBR and default node, it can request the allocation of global-scope address by sending `Global Solicitation (GS)' message to MBR. GS message is newly defined here as an extension to IPv6 NDP. This message has the `Node Address' option that contains the address of the MN A. GS message is forwarded to the default node of each MN repeatedly, along the HAA path.

If the HAA path contains the loop by the mobility of some MNs, GS message will be silently dropped when its hop limit is decreased to 0. Then the MN can detect the loop, and change or remove the invalid default node. If the loop is created in transient, the loop path is fixed before the GS message's hop limit becomes 0.

If MBR receives the NDP GS message, then it performs MANET-scope DAD by comparing the MN A's address contained in GS message to the addresses from the list of registered MNs.

If there is no duplicate address used by the MN A's, then MBR sends NDP `Global Advertisement (GA)' message. This message is defined as an extension to NDP like GS message. It contains the global-scope address to be allocated to the MN A, and the length of prefix of its address. If the MN A receives the message, then the MN sets its address to the global-scope address.

If an address duplication is detected, then MBR sends the global-scope address allocation error message instead. This message uses the form of NDP GA message, but sets bit E to 1. If the MN A receives that, it generates a new address and try again.

Both GS and GA messages traverse along HAA path and are unicast messages. And message broadcasts are limited to 1-hop range, so the message overhead due to the HAA mechanism is relatively low.

3.5. Autoconfiguration without MBR

A MANET can lose its MBR if all MNs of the MANET are moved out of the radio range of the MBR. By the absence of the MBR, allocation of global-scope address and its DAD procedure, and Internet connectivity become unavailable. If any MN in the MANET cannot receive periodical GA messages from the MBR, it stops the use of its global-scope addresses and disconnects the sessions that were created using global-scope addresses previously. In contrary, the MN keeps its own MANET-local address. Abitrary MNs can join to and leave from MBR-less MANET, so periodical DAD process for MANET-local address is required. But MANET-local addresses use the format of Unique local address (ULA), that is combined with pre-defined prefix for MANET and interface identifier built from EUI-64. Hence, optimistic DAD [12] can be used for the check of duplication of MANET-local addresses.

4. HAA Message Formats

4.1. Default node option for RA message

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |     Type      |    Length     |           Hop Count           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                     Default Node Lifetime                     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                               |
   +                                                               +
   |                                                               |
   +                     Default Node Address                      +
   |                                                               |
   +                                                               +
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                               |
   +                                                               +
   |                                                               |
   +                          MBR Address                          +
   |                                                               |
   +                                                               +
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type
TBD

Length
8-bit unsigned integer. The length of the option in unit of 8 octets. The value 0 is invalid.

Hop Count
16-bit unsigned integer. The number of hops between MBR and the sender of this message.

Default Node Lifetime
32-bit unsigned integer and the length of time in seconds that this default node option is valid. The default value is TBD.

Default Node Address
An IPv6 address. This field contains the address of recommended MN as a default node.

MBR Address
The IPv6 address of MBR of the MANET in which the MN is participated.

4.2. Global Address Solicitation message

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |     Code      |          Checksum             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Reserved                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Options ...
+-+-+-+-+-+-+-+-+-+-+-+-+-
```

Type
TBD

Code
TBD

Checksum
The ICMP checksum.

Reserved
This field is unused.

4.3. Node Address option for GS message

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |    Length     |           Reserved            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Identifier                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
```

```
+                                                               +
|                                                               |
+                          Node Address                         +
|                                                               |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type
   TBD

Length
   8-bit unsigned integer. The length of the option in unit of 8
   octets. The value 0 is invalid.

Reserved
   This field is unused.

Identifier
   32-bit unsigned integer. This field separates one request of
   global-scope address from the others. MBR generates the response
   message for this message with the same identifier. The value is
   randomly generated.

Node Address
   IPv6 link-local address of the sender.

4.4. Global Address Advertisement message

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |     Code      |          Checksum             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Reserved           |         MBR Lifetime          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Options ...
+-+-+-+-+-+-+-+-+-+-+-+-+-
```

Type
   TBD

Code
TBD

Checksum
The ICMP checksum.

Reserved
This field is unused.

MBR Lifetime
32-bit unsigned integer and the length of time in seconds that the global address contained in this message is valid. The default value is TBD.

4.5. Node confirm option for GA message

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |    Length     |E|        Prefix Length        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Identifier                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                                                               +
|                                                               |
+                          Node Address                         +
|                                                               |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type
TBD

Length
8-bit unsigned integer. The length of the option in unit of 8 octets. The value 0 is invalid.

E
1-bit field that represents if there is an error or not in the request. E bit is set to 1 if duplicate address is detected.

Prefix Length
16-bit unsigned integer. The length of global-scope prefix.

Identifier
32-bit unsigned integer. The field separates one request of global-scope address from the others. MBR generates the response message for this message with same identifier. The value is randomly generated.

Node Address
IPv6 global-scope address to be allocated to the requester.

5. Security Considerations

This document does not describe any security facility of the hybrid address autoconfiguration. A malicious MN may block the process by misdirecting some of the HAA messages, or make a newly joined MN configure its address with invalid information.

6. Revision of the Draft

Version 3 of the draft has been revised as follows.

- Section 2 `Terminology' was been updated.
- Terminology of MANET entities were been changed.
- New reference [13] was been added.

Version 2 of the draft has been revised as follows.

- Section 2 `Terminology' was been updated.
- Section 3.5 `Autoconfiguration without Internet Gateway' was been updated.

Version 1 of the draft has been revised as follows.

- This section was beed appended.
- Section 3.5 `Autoconfiguration without Internet Gateway' was been appended.

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