MANET Autoconfiguration using DHCP
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Abstract

Mobile Ad-hoc Networks (MANETs) comprise MANET routers and their attached devices, and connect to the global Internet via one or more MANET gateways. MANET routers that require global Internet access must have a way to automatically configure globally routable and unique IP addresses/prefixes. This document specifies mechanisms for MANET autoconfiguration (AUTOCONF) based on the Dynamic Host

1. Introduction

Mobile Ad-hoc Networks (MANETs) comprise MANET Routers (MRs) that have zero or more attached devices and participate in a routing protocol over limited-range (typically wireless) interfaces such that packets exchanged between MRs may need to be forwarded across multiple hops. MANETs attach to provider networks (and/or the global Internet) via zero or more MANET Gateways (MGs), and MRs may be multiple hops away from their nearest MG in some scenarios. MRs that require global Internet access must have a means to autoconfigure global IP addresses/prefixes and/or other configuration information.

MANETs that comprise MRs with homogeneous MANET interfaces can configure the routing protocol to operate as a Layer-2 mechanism (e.g., IEEE 802) for route calculations and packet forwarding such that the Layer-3 protocol (e.g., IP) sees the MANET as a non-broadcast, multiple access (NBMA) link. When a Layer-2 flooding mechanism is also used, the Layer-3 protocol sees the MANET as a unified broadcast/multicast capable link, i.e., the same as for a (bridged) campus LAN. In such Layer-2 MANETs, MRs and MGs can autoconfigure global IP addresses/prefixes using standard BOOTP/DHCP [RFC0951][RFC2131][RFC3315][RFC3633] and neighbor discovery [RFC0826][RFC1256][RFC2461][RFC2462] mechanisms.

MANETs that comprise MRs with heterogeneous MANET interfaces must configure the routing protocol to operate as a Layer-3 mechanism such that route calculations and packet forwarding are based on Layer-3 MANET-local addresses/prefixes (MLAs) to avoid issues associated with bridging media types with dissimilar Layer-2 address formats and maximum transmission units (MTUs). In such Layer-3 MANETs, standard DHCP and neighbor discovery mechanisms are not sufficient to support global IP address/prefix autoconfiguration since the MANET may appear as multiple links.

This document specifies DHCP and neighbor discovery extensions for MR autoconfiguration in Layer-3 MANETs as well as details of operation for multiple MGs that apply to both Layer-2 and Layer-3 MANETs. Solutions for both IPv4 [RFC0791] and IPv6 [RFC2460] are given.

2. Terminology

The terminology in the normative references apply; the following terms are defined within the scope of this document:
Mobile Ad-hoc Network (MANET)
a connected network region (i.e., a "site") that comprises MANET routers that maintain a routing structure among themselves in a relatively arbitrary fashion over dynamic (wireless) MANET interfaces. Further information on the characteristics of MANETs can be found in [RFC2501].

MANET Interface
a node’s attachment to a MANET.

MANET Router (MR)
a node with zero or more attached devices that participates in the MANET routing protocol on one or more limited-range (typically wireless) MANET interface(s). For the purpose of this specification, MANET routers configure both a DHCP client and relay that are tightly-coupled.

MANET Gateway (MG)
an MR that also provides gateway service to a provider network and/or the global Internet.

MANET Local Address (MLA)
a Layer-3 unicast address/prefix configured by an MR that is used only within the scope of the connected MANET. MRs can use MLAs for intra-MANET data communications. (For IPv6, Unique Local Addresses (ULAs) provide a natural MLA mechanism – see: [RFC4193] and [I-D.jelger-autoconf-mla]).

Extended Router Advertisement/Solicitation (ERA/ERS)
an IP Router Advertisement/Solicitation (RA/RS) message [RFC1256][RFC2461] encapsulated in an outer header for transmission over a Layer-3 MANET with destination address set to an MLA or a site-scoped multicast address (see: Section 3.5).

3. Autoconfiguration Extensions for Layer-3 MANETs

The following sections specify extensions necessary to support DHCP-based autoconfiguration for Layer-3 MANETs:

3.1. MANET Router (MR) Extensions

When an MR first powers on, activates a MANET interface, or when it receives an indication of movement to a new MANET, it configures one or more MLAs (through a means outside the scope of this specification) and engages in the MANET routing protocol. Next, if the MR requires global IP address/prefix delegations, it listens for either ERAs from nearby MGs or a MG indication carried via the MANET.
routing protocol through a means outside the scope of this specification. If ERAs or MG indications are heard, it sends a small number of ERSs to elicit immediate ERAs. When it needs to send ERSs, the MR should set a small value (e.g., 2, 5, 10, etc.) in the TTL (IPv4), Hop Limit (IPv6), or other Layer-3 protocol field of the encapsulating header to limit the scope.

After the MR discovers MGs, it selects one or more MGs as default MGs and selects one MG as its primary MG. The MR’s DHCP client function then forwards a DHCP DISCOVER (DHCPv4) or Solicit (DHCPv6) via its relay function to an MLA for its primary MG. The DHCP request must include an MLA for the MR in a DHCPv4 MLA option or the DHCPv6 "peer-address" field (see: Section 3.4) and will elicit a DHCP reply from the server with IP address/prefix delegations.

For IPv6, the MR can use DHCP prefix delegation per [RFC3633] and configure addresses for itself and/or its attached devices from the delegated prefixes per [I-D.thaler-autoconf-multisubnet-manets]. If the ERAs include prefix options, the MR can alternatively configure addresses from the advertised prefixes per [RFC2462]. In the latter case, MGs should not advertise the same prefixes to more than one MR so that multilink subnet issues are avoided - see: [I-D.thaler-intarea-multilink-subnet-issues].

After the MR configures global IP addresses/prefixes, it can send IP packets to off-MANET destinations using any of the MGs in its default MG list as egress gateways. For MANETs in which MGs can inject a ‘default’ route that propagates throughout the MANET, the MR can send the IP packets without encapsulation at the expense of extra TTL (IPv4) or Hop Limit (IPv6) decrementation. For MANETs in which MGs cannot propagate a default route, the MR either: a) encapsulates IP packets with an MLA for an MG as the destination address in the outer header (i.e., tunnels the packets to the MG), or b) inserts an IPv4 source routing header (likewise IPv6 routing header) to ensure that the packets will be forwarded through an MG.

The above MR specifications are analogous to the more detailed Mobile Node (MN) specifications found in ([I-D.templin-autoconf-netlmm-dhcp], section 4.1).

3.2. MANET Gateway Extensions

MGs send periodic/solicited ERAs on their attached MANET interfaces instead of sending periodic/solicited RAs. (In certain use case scenarios, MGs can inject MG indications into the MANET routing protocol instead of sending periodic ERAs.) The ERAs should set a small value (e.g., 2, 5, 10, etc.) in the TTL (IPv4), Hop Limit (IPv6), or other protocol field of the encapsulating header to limit
the scope. MGs should not advertise the same prefixes to more than
one MR so that multilink subnet issues are avoided - see:
[I-D.thaler-intarea-multilink-subnet-issues].

MGs act as BOOTP/DHCP relays for the DHCP requests/replies exchanged
between MRs and DHCP servers. (When the DHCP server function resides
on the MG itself, the MG acts as a DHCP server.) For DHCPv4, when a
MG acting as a relay forwards a MR’s DHCP request that includes an
MLA option, it writes its own address in the ‘giaddr’ field, i.e., it
overwrites the value that was written into ‘giaddr’ by the MR’s relay
function.

For each DHCP reply message it processes pertaining to address/prefix
delegation, the MG creates a tunnel (if necessary) with the tunnel’s
destination address set to the MLA for the MR encoded in the DHCPv4
MLA option or the DHCPv6 "peer-address" field (see: Section 3.4).
The MG then creates entries in its IP forwarding table that point to
the tunnel for each delegated IP address/prefix and relays the reply
to the MLA for the MR.

When MGs forward IP packets to an MR, they either: a) encapsulate the
packets with the MLA for the MR as the destination address in the
outer header (i.e., tunnel the packets to the MR), or b) insert an
IPv4 source routing header (likewise IPv6 routing header) to ensure
that the packets will be forwarded to the correct MR.

The above MG specifications are analogous to the more detailed Access
Router (AR) specifications found in
([I-D.templin-autoconf-netlmm-dhcp], Section 4.2).

3.3. DHCP Server Extensions

DHCP servers can reside on provider networks, the Internet or on the
MGs themselves.

DHCPv4 servers examine DHCPv4 requests for a DHCPv4 MLA option (see:
Section 3.4). If a DHCPv4 MLA option is present, the DHCPv4 server
copies the option into the corresponding DHCPv4 reply message(s).

No MANET-specific extensions are required for DHCPv6 servers.

3.4. MLA Encapsulation

For DHCPv6, the MLA is encoded directly in the "peer-address" field
of DHCPv6 requests/replies.

For DHCPv4, a new DHCPv4 option [RFC2132] called the ‘MLA option’ is
required to encode an MLA so that the MG can direct DHCPv4 replies to
the correct MR, which may be multiple Layer-3 hops away. The format of the DHCPv4 MLA option is given below:

```
| Code | Len | Ether Type | MLA |
+-----+-----+-----------+-----+
| TBD | n   | type      | a1  |
|     |     |           | a2  |
|     |     |           | ... |
```

**Code**
- a one-octet field that identifies the option type (see: Section 5).

**Len**
- a one-octet field that encodes the remaining option length.

**Ether Type**
- a type value from the IANA "ethernet-numbers" registry.

**MLA**
- a variable-length MANET Local Address (MLA).

### 3.5. MANET Flooding

MRs and MGs in Layer-3 MANETs that implement this specification require a MANET flooding mechanism (e.g., Simplified Multicast Forwarding (SMF) [I-D.ietf-manet-smf]) so that site-scoped multicast ERA/ERS messages can be propagated across multiple Layer-3 hops.

### 4. Operation with Multiple MGs

When the Layer-2 or Layer-3 MANET connects to provider networks or the global Internet via multiple MGs, MR operation and localized mobility management is based on the nature of MG deployment.

For a set of MGs that attach to the same provider network, MRs can retain their global IP address/prefix delegations as they move between different MGs if the network configures a mobility anchor point that participates with the MGs and MRs in a localized mobility management scheme, e.g., see: [I-D.templin-autoconf-netlmm-dhcp].

For a set of MGs that attach to different provider networks and/or serve different global IP prefixes from within the same provider network, MRs must configure new global IP addresses/prefixes as they change between different MGs unless inter-MG tunnels and routing protocol exchanges are supported, e.g., see: [I-D.templin-autoconf-netlmm-dhcp], Appendix A.
Global mobility management mechanisms for MRs that configure new
global IP addresses/prefixes as they move between different MGs are
beyond the scope of this document.

5. IANA Considerations

A new DHCP option code is requested for the DHCP MLA Option in the
IANA "bootp-dhcp-parameters" registry.

6. Security Considerations

Security considerations for this document are the same as for
[I-D.templin-autoconf-netlmm-dhcp].

Threats relating to MANET routing protocols also apply to this
document.

7. Related Work

Telcordia has proposed DHCP-related solutions for the CECOM MOSAIC
program. Various proposals targeted for the IETF AUTOCONF working
group have suggested stateless mechanisms for address configuration.

8. Acknowledgements

The Naval Research Lab (NRL) Information Technology Division uses
DHCP in their MANET research testbeds.

The following individuals (in chronological order) have provided
valuable input: Thomas Henderson.

9. References

9.1. Normative References

[RFC0791] Postel, J., "Internet Protocol", STD 5, RFC 791,
September 1981.

[RFC0826] Plummer, D., "Ethernet Address Resolution Protocol: Or
converting network protocol addresses to 48.bit Ethernet
address for transmission on Ethernet hardware", STD 37,
RFC 826, November 1982.


9.2. Informative References


[I-D.thaler-autoconf-multisubnet-manets] Thaler, D., "Multi-Subnet MANETs", 

Appendix A. Change Log

Changes from -01 to -02:

  o minor updates for consistency with recent developments

Changes from -00 to -01:

  o new text on DHCPv6 prefix delegation and multilink subnet
    considerations.

  o various editorial changes

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