

OLSR for IPv6 (OLSR6)

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Abstract—OLSR has been standardized at IETF and was published as RFC3626. OLSR is simple proactive routing protocol to adopt both IPv4 and IPv6. OLSR stated to extend messages to store 128 bit long address for IPv6, but there are some unclear issues to operate OLSR on IPv6. In this paper, we describe OLSR modification for OLSR IPv6 (OLSR6) and discuss IPv6 address usage and assignment, Neighbor Discovery Protocol and global connectivity for OLSR6.

I. INTRODUCTION

IETF Manet Working group has been discussed mobile ad-hoc network (manet) routing protocols and had standardized four routing protocols such as OLSR [1], AODV, DSR¹, and TBRPF. These four specifications are all based on IPv4. It is more necessary to specify manet routing protocols based on IPv6, because of its vast address space and plug & play support. Ad-hoc network is expected to deploy on vehicle network, cell-phone system, and home network. Those systems obviously need a lot of addresses. It is urgent matter to deploy ad-hoc network based on IPv6 and to deliver right specification to industry.

Note that routing protocol is basically nothing to do with IP protocol version except for IP address length and packet formats. In this paper, we describe detailed differences between IPv4 and IPv6 operations of OLSR. The goal of this paper is to guarantee interoperability for OLSR with IPv6 support. This paper also discusses global connectivity [2] and address assignment for OLSR6.

II. PACKET FORMAT CHANGE

As stated in Section 17 of OLSR specification [1], packet formats need to be modified for IPv6 support. The biggest difference between IPv4 and IPv6 is address length. Thus, the packet format must be extended to store IPv6 address as shown in Figure 1. The Multiple Interface Declaration (MID) message and Topology Control message are also extended like Figure 2.

Figure 2 also shows the modified Host and Network Association (HNA) message for IPv6. IPv6 network address is expressed by a Prefix address and its prefix length. In section V, we discussed further modification of HNA message for global connectivity. There is the Reserved field in modified HNA message, given alignment and future consideration. When the basic NEMO support protocol [3] is considered, some of manet nodes can bring its permanent mobile network prefix and announce the prefix to manet by using HNA message. It

might be needed to extend HNA message for the basic NEMO support [4] to indicate whether the prefix is a mobile network prefix or not.

| Packet Length | | Packet Sequence Number |
|------------------------------|-----------|------------------------|
| Type | Vtime | Message Size |
| Originator Address (128-bit) | | |
| TTL | Hop Count | Message Sequence |
| Message | | |

Fig. 1. Packet Format (Packet Header and Message Header)

III. ADDRESS ASSIGNMENT

IPv6 originally had three different address scopes for unicast addresses. These were link-local, site-local, and global. Site-local scope has already been deprecated. At the time we only have link-local and global scopes. A new scope is discussed in IPv6 working group. IPv6 also permits to assign multiple addresses on single interface. This is easily occurred when a node has Internet connectivity (i.e. link-local address and global address).

A. Broadcast address

An IPv6 limited broadcast address is all node multicast address which is link-local scope address, “ff02::1”. All nodes are joined to the all node multicast group and can use ff02::1 as a limited broadcast address on link. Since OLSR is required to disseminate control packets by an application level broadcast, it is necessary to use the limited broadcast address as an IPv6 destination address. Any control packets must not be blindly forwarded by generic IP forwarding. Thus, ff02::1 is always used for flooding control packets to a manet.

B. Manet Local Scope

OLSR6 requires to have a main address as an identifier of each router. In this section, we study which scope addresses

¹DSR is reviewed by IESG and waits for publishing as RFC

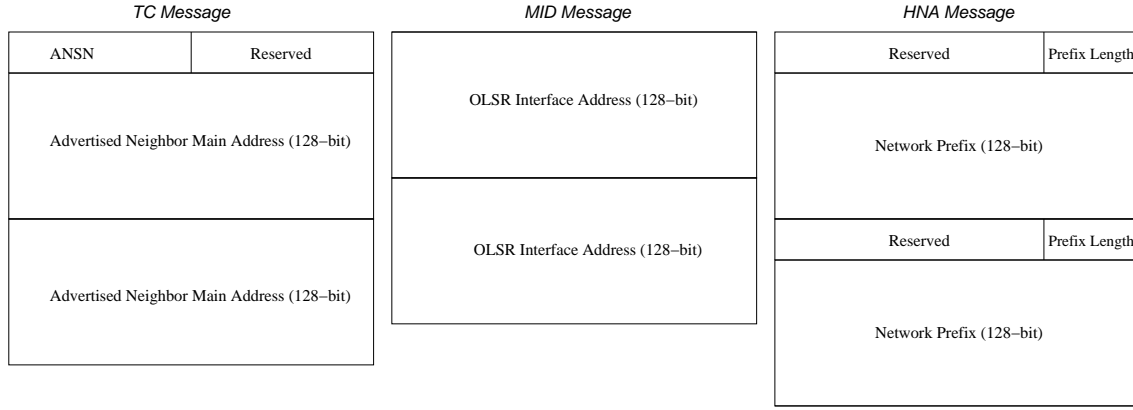


Fig. 2. TC, MID, HNA Message Formats

should be used for a main address and for IPv6 header's addresses.

Each manet node always has a link-local address and joins all node multicast group with its link-local address. For a global address, a manet node may have permanent global address called Home Address (Mobile IPv6 [5]) which is not always topology correct. A manet node may acquire global addresses, which are topology correct address, by using Neighbor Discovery Protocol (NDP).

Since link-local address is maintained by each manet node, it is simply better to select link-local address as a main address of OLSR6. The address is rarely changed and it brings the unique main address. The link-local address is altered only when the address is duplicated while Duplicate Address Detection (DAD) operations. However, the link-local scope is not allowed to send and to receive packets over multi-hop link. Link of all manet nodes are not directly connected (i.e. multi-hop). Even if a manet node-A has routes for a manet node-B, the manet node-A must not communicate the manet node-B by the link-local address which is the main addresses of the manet node-B. All manet nodes must wait for HID message which can bind the link-local address (i.e. main address) with another scope addresses (i.e. global address).

All link-local addresses must be guaranteed unique in the network. Although it is hard to provide uniqueness, the affect to IPv6 specification and NDP is not negligible. We describe NDP interaction in Section IV. NDP is complicated protocol which relies on link-local address and manet routing protocols should not give any impacts to the protocol at all.

Alternatively, when global address is used as a main address, one advantage is that a manet node can use a main address as a source or a destination address of incoming/outgoing packets. However, no global scope limited broadcast address is defined. If each manet node has different global prefix (ex. some nodes have home address which is not topology correct address), it is hard to specify an unique globally limited broadcast address. In addition, all manet nodes does not always have a global address. Some of nodes do not communicate to the Internet and do not have global address.

As a conclusion, we suggest to have manet specific scope on IPv6. The point of manet specific scope address is shown below. Detailed specification of manet scope address will be published as internet-draft later.

- All manet nodes have at least one manet scope address.
- A manet scope address is valid only within a manet. Any packets originated by a manet scope address must not be leaked to the Internet.
- The validity of a manet scope is an entire manet area.
- Each manet node uses a manet scope address for exchanging routing messages and establishing manet routes. It prohibits to use non manet scope address for communication except for communication within manet. This is important not to get system damages when an address is duplicated.
- All manet nodes may join to an all manet nodes multicast group with their manet scope addresses. The multicast address is not limited broadcast address, but can be used to disseminate packets to all manet nodes. This multicast address is optional.

C. Address Usage for OLSR6

Once a manet scope is assigned, OLSr6 operations become simpler. Table I shows the definition of each address scope. Each manet node uses its manet scope address as a main address. link-local address is used for IPv6 header of all OLSR6 messages. When messages are flooded, the destination address of the IPv6 header is the all node multicast address which is limited broadcast address. If a manet node has multiple addresses like a manet-local address and a global address, it disseminates MID messages to map the multiple addresses to the main address. The manet node should not distribute MID messages including link-local addresses. The link-local scope address should be used only for limited-broadcasting and running NDP protocol. (see more in Section IV)

When a manet node communicates with a node inside the same manet, it can use manet scope address as a source and a destination address of IPv6 header. It can also use a global address if it is available. However, if both manet scope

TABLE I
ADDRESS SCOPE

| Address Scope | validity | Who use | communication area |
|---------------|--------------|---------|------------------------------|
| Link-Local | on-link | NDP | on-link |
| Manet local | within manet | OLSR6 | on-link, manet local |
| Global | Internet | Global6 | on-link, manet local, global |

and global address are available, using manet scope address prevents to leak out packets to the Internet.

IV. NEIGHBOR DISCOVERY PROTOCOL

Neighbor Discovery Protocol (NDP) is basically operated in a same link, because the IPv6 Hop Limit field of both Router Solicitation (RS), Router Advertisement (RA), Neighbor Solicitation (NS), Neighbor Advertisement (NA), and Redirect message must be set to '255' all the time. The IP Hop Limit field set to 255 indicates that the packet could not possibly have been forwarded by a router.

A. Address Resolution

Although a manet does not have the clear definition of link, nodes can resolve a MAC address of one-hop neighbors by using NS and NA messages sent to and from link-local address. The MAC address resolution of one-hop neighbors is enough for nodes, since nodes does not share the physical link with two-hop neighbors. Therefore, even if a node can resolve a MAC address of a two-hop neighbor, it can not send packets directly to the two-hop neighbor anyway. Each manet node manages neighbor cache entry states for one-hop neighbors and confirms reachability for one-hop neighbors by using NS and NA. Neighbor nodes located more than one-hop away are confirmed their reachability by each manet routing protocols.

B. Address Auto-Configuration

IPv6 has the address autoconfiguration scheme conducting with RS and RA. OLSR6 can extend the address autoconfiguration to apply it to manet. The requirements of the address autoconfiguration is summarized in [6].

For Global-scope IPv6 unicast address, this has already been addressed and solved in global6 [2]. RS and RA are extended to send beyond one-hop neighbors. Alternatively, RS and RA can be sent from and to all manet node multicast address, which is manet local with an appropriate hoplimit value.

C. Duplicate Address Detection

Each addresses ideally needs to be guaranteed its uniqueness within a manet wide. In IPv6, Duplicate Address Detection (DAD) can guarantee the uniqueness of an address with one-hop neighbors by sending NS for a target address. If NA is detected in response to the NS, the address is duplicated. DAD only defends addresses on a physical link due to link-local scope limitation of NS and NA. DAD can be conducted to guarantee only the uniqueness of address within one-hop neighbors.

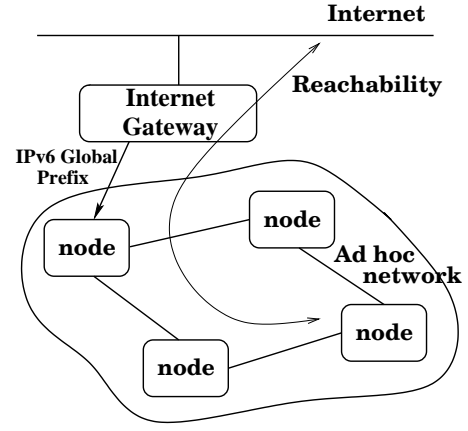


Fig. 3. Global Connectivity for IPv6

For the manet wide uniqueness, each NS and NA needs to be flooded to all manet nodes. Since this is considerable overhead, link-local addresses are given uniqueness only on physical link in manet, too. Even if a link-local address is duplicated between two nodes that are more than two hops away, the duplication does not cause errors for communication. This is because routes of link-local address are not maintained by OLSR6 and are not used as a source and a destination address of IPv6 header of communication packets as described in Section III. On-link uniqueness has been provided by DAD and is easily operated on manet.

On the other hand, manet scope address and global scope address must be unique within either manet or Internet. The general DAD operation with NS and NA should not operate to confirm the manet wide uniqueness of both manet scope and global addresses. It is better to have another solution or combine NDP with another scheme to conduct DAD on manet wide. It is hard to guarantee address uniqueness when two manets merge into single or when plenty of manet nodes participate to a manet at the same time with normal DAD. There are a number of proposals for DAD in a manet, but the solution is still open.

V. GLOBAL CONNECTIVITY

In this section, we study how Internet connectivity is provided to OLSR6. Internet Gateway has been proposed by [2]. Internet gateway is a router providing a global address and a route towards the Internet.

Global6 [2] describes how to provide Internet connectivity with mobile ad-hoc networks. It provides globally routable address assignments, Internet route assignments, internet gateway discovery, and internet gateway operations. Once a manet node obtains a global address from an internet gateway, it can exchange data with nodes on the Internet as shown in Figure 3. It also discuss the use of global connectivity with Mobile IPv6 [5] is specified. Mobile IPv6 will be deployed on mobile devices and it is expected that some of manet nodes have Mobile IPv6 feature.

| | | |
|--------------------------------------------------------------------------------------------------|----------|---------------|
| G | Reserved | Prefix Length |
| <p>Network Prefix (128-bit) <i>Note: it contains Internet Gateway's Global address.</i></p> | | |
| Valid Lifetime | | |
| Preferred Lifetime | | |

Fig. 4. Modified HNA Message Format

A. Global Connectivity for OLSR6

There are two core functions of Internet Gateway such as global address assignment and Internet route establishment. For global address assignment, IPv6 has Address Autoconfiguration mechanism specified in [7]. The Address Autoconfiguration mechanism must be reused on OLSR6, because the Address Autoconfiguration mechanism has been already widely deployed and implemented by most of IPv6 nodes.

As we stated before, link-local addresses are used only for on-link communication. Thus, HNA message is used for Internet route establishment and global address assignments on behalf of RA.

To provide global connectivity to OLSR6, each OLSR6 node needs to acquire following information from Internet Gateway described in section 5.1 of [2].

- Internet-gateway global address
- Network prefix address
- Network prefix length
- Lifetime
- Internet-gateway's manet address (option)

To comply with Global6 [2] and Address Autoconfiguration [7], HNA message is modified as shown in Figure 4. 'G' flag indicates that this HNA message contains global connectivity information. If G flag is set in HNA message, each receiver must process the HNA message according to [2]. An Internet Gateway include its prefix length in the Prefix Length field and stores its Internet Gateway global address in the Prefix Address field. A receiver can generate the prefix address from the prefix length and the Internet Gateway global address. The Valid Lifetime and the Preferred Lifetime is specified the valid address lifetime. These two lifetime are required for Address Autoconfiguration. Internet Gateway's manet address can be retrieved from Originator address of OLSR6 packet header. As explained in Section III, Internet Gateway uses its manet scope address as its main address. Each OLSR node processes the HNA message for address assignment and management as similar as [7] except for not using RS and RA.

TABLE II
ROUTE SETTING FOR INTERNET CONNECTIVITY

| Destination | Next Hop | Route Type |
|--------------------------|-----------------------------|---------------|
| 0::0/0 | Internet Gateway address | default route |
| Internet gateway address | next hop (one-hop neighbor) | host route |

B. Discussion of route towards the Internet

Global6 proposes to setup routes shown in Table II. If a manet node is edge node and communicates to the Internet for web browsing, email, VoIP, ssh, streaming, etc, it is more natural to use a default route on manet. Although manet routing protocols typically maintain host routes between end nodes, a route toward an Internet gateway is a special route of all the nodes located on the Internet.

If destination nodes of a manet node are limited to single network domain, it is not necessary to configure a default route. A manet node setup the Internet gateway as a next hop of a network route of the network domain. This situation is occurred when a manet node is moving inside a corporate building and communicates only to the corporate network. An internet gateway of the corporate network distributes the prefix of the corporate network by using modified HNA message shown in Figure 4. When a manet node has already had a globally routable address (ex. statically assignment), the Internet gateway does not need to set 'G' flag in HNA message. It just advertises the network prefix to a manet.

VI. CONCLUSION

This paper describes protocol modifications and IPv6 operational issues for OLSR6. Manet working group should consider a new manet scope address for address assignment to manet nodes. We describe how to apply IPv6 to OLSR. We will keep studying clear specification of OLSR6.

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