Abstract
This document describes the short AID (adaptation identifier) in place of full IPv6 address, related AID-IPv6 address mapping and related features. This document is a part of a series of work for the global adaptation layer, effective frame format design specified for adaptation layer for global as well as local communication.
Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

Readers are expected to be familiar with all the terms and concepts that are discussed in "IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs): Overview, Assumptions, Problem Statement, and Goals" [RFC4919], and "Transmission of IPv6 Packets over IEEE 802.15.4 Networks" [RFC4944].
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1. Problem Statement

6lowpan developed with aim to provide internet connectivity to IEEE 802.15.4 network, so IN-node communicates IPv6 packet. For these reasons an adaptation layer was proposed to accommodate IPv6 packet over IEEE 802.15.4 network.
Figure 1. Global connectivity

[RFC 4944, RFC 6282] define the IPv6 header compression scheme to reduce the size of IPv6 header, and able to compress 40 byte header ... with AID, presence of link-addresses in adaptation layer, AID field size as well as mobility scenario and AID mechanism.

2 Adaptation Identifier (AID)

In [I-D. Global connectivity in 6LoWPAN] author proposed a two AID value for source and destination node IPv6 address. ... at gateway. Following session explain AID requirements, size of AID field and AID-IPv6 address translation table (AITT).
2.1 Presence of IN-node link layer address and AID

When the frame contains only AID value and does not contain IN-node link layer address, lead to certain issues.

Following issues suggest the requirement of link-layer address in adaptation header:

1. In case of any desynchronization between the node and gateway regarding AID value, particularly happens in case of a node with wrong gateway and insecure mobility behavior to switch of node from one network to another, it results in many cases without source link layer address.

2. Identify the packet whether it is come from an associate node or not.

So each frame SHOULD contain originator IN-node link layer address regardless of AID value.

2.2 Drawback of use of AID value for IN-node

1. Due to the stateless auto configurability characteristics of IPv6 addressing, we can configure IPv6 address from link-layer ID or Interface Identifier of a node and prefix ID of gateway. So use of AID for IN-node is illogical in presence (section 2.1) of IN-node link layer address in adaptation header.

2. 16 bit short ID for a node in PAN was chosen to support 2^16 nodes in PAN. If we use AID for IN-nodes, minimum length of AID field should be 16 bit. Still it is larger and does not provide effective compression.

Above mentioned reasons (section 2.1 & 2.2) suggests that AID value for IN-node IPv6 address SHOULD not use and link-layer ID of IN-node SHOULD be present in packet.
2.3. AID value Generation

In [I-D. Global connectivity in 6LoWPAN] author mentioned that new AID value for IPv6 address is generated by gateway. This process is done to avoid the overlapping of AID values across different gateways. However, if multiple gateways generate different AID values for the same OUT-node IPv6 address, it complicates the AID value management.

Also, it obviates the need of AID generation by gateway each time whenever mobile IN-node visit different network.

2.4. AID field & AITT

Now it is clear that AID value SHOULD use for IPv6 address of OUT-node only. But the question is what will be the size of AID field and AITT format. Let's look at different possible scenario.

(1) PAN with single or few destinations

In many practical situations, data collected through sensors and sent to one central storage system, so all nodes communicate with a single OUT-node. A format shown in figure 2, is sufficient and efficient. As there are only few destinations, shorter AID field required.

<table>
<thead>
<tr>
<th>AID</th>
<th>IPv6 address</th>
<th>Time-Stamp</th>
</tr>
</thead>
</table>

Figure 2 AITT without Link-Layer ID

(2) PAN, with multiple destinations

In this scenario, above mentioned table format can work, but due to larger number of destinations, require larger AID field. However, the AID field can be divided into separate fields for each destination. Let's 10 destinations with 10 OUT-nodes and 10 IN-nodes. Then, IN-nodes can be divided into 10 groups, where each group can communicate with corresponding different OUT-nodes. It is also efficient for the first scenario.
The combination of link-layer ID with AID value in AITT increases the uniqueness of AID value in AITT (fig 3).

+-------------------------------------------------+
| Link-Layer ID | AID | IPv6 address | Time-Stamp |
+-------------------------------------------------+

Figure 3. AITT without Link-Layer ID

3. AID messages & AID values mechanism

3.1 AID messages

3.1.1 AID update message

When IN-node gets AID request message (contain IPv6 address of OUT-node) from gateway, IN-node searches for existing AID value. If an AID value does not exist, it sends the AID request message to IN-node. When gateway receives AID request message, it checks its database for the corresponding AID value. If found, it sends AID update message with the corresponding IPv6 address to IN-node. If not found, it sends a negative response to IN-node.

3.1.2 AID request message

When AID value does not exist for IPv6 address of IN-bound packet at gateway, it sends the AID request message to IN-node. When IN-node receives the AID request message, it generates a new AID value and sends the corresponding AID update message to gateway. Gateway stores the AID value in its database and responds with the corresponding IPv6 address. In response, IN-node returns the corresponding AID update message. AID request message contains IPv6 address.
3.1.3 IPv6 request message

When AID value does not exist at gateway or IN-node on receiving AID frame, receiving node sends IPv6 request message to sender to report AID value corresponding to AID frame. In response, sender node returns AID update message.

3.2 Mechanism of AID value

3.2.1 For Out bound traffic

1. When IN-node wants to send packet to OUT-node, first it checks the existence of AID value for OUT-node IPv6 address in AITT.

2a. If AID value present at IN-node for corresponding IPv6 address, it sends AID packet to gateway. But, if gateway does not have AID value, it sends IPv6 request message for corresponding AID value to IN-node, and IN-Node reply back AID Update message.

2b. If AID value does not present at IN-node, it generates the new AID value for OUT-node IPv6 address and sends AID update message to gateway.

3.2.2 For In bound traffic

1. When Gateway received the packet from OUT-node, it checks the existence of AID value for OUT-node IPv6 address in AITT.

2a. If AID value present at gateway, it sends the packet in AID frame to IN-node. But, if IN-node does not have AID value, it sends request message to gateway for corresponding AID value. Gateway reply backs AID update message.

2b. If AID value does not present at gateway, it requests a AID value for given IPv6 address to IN-node, and IN-node reply back AID update message.

3.3 Time stamping & deletion of AID in AID-IPv6 translation table

Whenever IN-Node generate AID, it also time-stamps the AID value simultaneously and sends it with AID update message. Whenever translation information expires for given IPv6 address, the entry is deleted automatically. If the AID value not utilized for some threshold period, the corresponding row is deleted.
4.1. 6lowpan TCP/IP Stake

In figure 4, TCP/IP stake shown for AID based 6lowpan. Physical and MAC layer are similar to IEEE 802.15.4 standards. Adaptation layer lies above the MAC layer and use AID frame structure for OUT-node (global communication) and Local frame for IN-node (mesh communication). Security layer is optional. Application layer keep at top above, and only required application are kept according to need.

+-------------------------------------------------+
<p>|            Application Layer                    |</p>
<table>
<thead>
<tr>
<th>(Restricted Applications )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security Layer</td>
</tr>
<tr>
<td>(Optional)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>MAC layer (IEEE 802.15.4)</td>
</tr>
<tr>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>PHY layer (IEEE 802.15.4)</td>
</tr>
</tbody>
</table>
|+-------------------------------------------------+

Figure 4. AID based 6lowpan TCP/IP stake

4.2. AID-IPv6 address Translation Table (AITT)

AITT translate the IPv6 address to corresponding AID value and vice versa (fig 5 & 6). It is present in IN-node as well as gateway, but AID frame to IPv6 packet and vice-versa translation take place at the gateway using AID-IPv6 table.
Link-Layer ID | Bit | AID | IPv6 address | hop limit | Timestamp |
+------------------------------------------------------+

Figure 5. AITT for Gateway

Bit: Length of AID field in bits (1, 2, 4, 8 bit(s))
AID: AID value
IPv6 address: IPv6 address of corresponding OUT-Node
Hop limit: Hop limit for out bound traffic
Timestamp: Time of last use of AID

4.3 Adaptation Layer Header

Adaptation layer header contains Dispatch field, followed by AID or Local mesh frame and fragmentation header which is optional, only present when payload is large and required fragmentation. It is according to [RFC 4944]

Dispatch field specify the frame type or field carried in to the adaptation header that follow after the dispatch.

<table>
<thead>
<tr>
<th>Dispatch</th>
<th>AID, LMF</th>
<th>Fragmentation header</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BCH</td>
<td>(optional)</td>
</tr>
</tbody>
</table>

Figure 7. Adaptation layer header

4.3.1 Dispatch field

Dispatch field specify the frame type or field carried in to the adaptation header that follow after the dispatch.
<table>
<thead>
<tr>
<th>Dispatch</th>
<th>Header Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>00 000000</td>
<td>NALP - Not a lowpan frame</td>
</tr>
<tr>
<td>01 000001</td>
<td>IPv6 -IPv6 uncompressed frame</td>
</tr>
<tr>
<td>01 000010</td>
<td>AID_1 -AID frame_1_bit_field_size</td>
</tr>
<tr>
<td>01 000011</td>
<td>AID_2 -AID frame_2_bit_field_size</td>
</tr>
<tr>
<td>01 000101</td>
<td>AID_3 -AID frame_4_bit_field_size</td>
</tr>
<tr>
<td>01 000110</td>
<td>AID_4 -AID frame_8_bit_field_size</td>
</tr>
<tr>
<td>********</td>
<td>Reserved</td>
</tr>
<tr>
<td>10 100001</td>
<td>BCF - Broadcast Frame</td>
</tr>
<tr>
<td>10 100011</td>
<td>LMF - Local Mesh Frame</td>
</tr>
<tr>
<td>********</td>
<td>Reserved</td>
</tr>
<tr>
<td>01 111111</td>
<td>ESC - Additional dispatch byte follows</td>
</tr>
</tbody>
</table>

Figure 8. Dispatch Type

4.3.2 AID frame

Whenever communication takes place between the IN-node and OUT-node, AID frame is used. Frame contains the AID value for corresponding IPv6 address.

| 01 000010 | AID frame | Fragmentation header (optional) |
| 01 000101 | header    | (optional)                      |

Figure 9 (a). Dispatches for AID frame
### Figure 9 (b). AID frame Header

<table>
<thead>
<tr>
<th>Bound</th>
<th>I</th>
<th>G</th>
<th>NH</th>
<th>Fr</th>
<th>hopelleft</th>
<th>LL ID</th>
<th>AID</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(1)</td>
<td>(1)</td>
<td>(4)</td>
<td>(1)</td>
<td>(4)</td>
<td>(16 or 64)</td>
<td>(1,2,3,8)</td>
</tr>
</tbody>
</table>

**Bound:**
- 0 - Outbound packet from PAN (Forward to Gateway)
- 1 - Inbound packet to PAN (Forward to IN-node at Link Layer ID address)

**Fr:**
- 0 - No fragmentation header follows
- 1 - Fragmentation header follows

**I:**
- 0 - 16 bit short ID in II ID field
- 1 - 64 bit interface identifier in II ID field

**G:**
- 0 - Any gateways
- 1 - Gateway specified (next to the AID field)

**NH:**
First Bit
- 0 - No Traffic class & flow label
- 1 - Traffic class & flow label field in Inline

Second Bit
- 0 - No more header compression
- 1 - HC2 header compression bits

Third & Fourth Bits
- 00 - Additional header follow
- 01 - UDP
- 10 - ICMP
- 11 - TCP

**Hopeleft:** (4 bits) Hope left within the PAN

**LL ID:** 16 bits short ID or 64 bits Link Layer ID

**AID:** AID value
4.3.3 If gateway specified (G set 1)

<table>
<thead>
<tr>
<th>Dispatch</th>
<th>AID header</th>
<th>F</th>
<th>Gateway ID</th>
</tr>
</thead>
</table>

Figure 10. Gateway specified AID frame header

F: 0- 16 bit address of Gateway
1- 64 bit address of Gateway
Gateway ID: 16 bits or 64 bits address of Gateway

4.3.4 Local Mesh Frame

Whenever communication occurs between the IN-nodes, Local mesh Frame should use. As in this scenario, AID is not required.

<table>
<thead>
<tr>
<th>01 100010</th>
<th>LMS header</th>
<th>Fragmentation Header</th>
</tr>
</thead>
<tbody>
<tr>
<td>(optional)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 11. (a) Local mesh frame

<table>
<thead>
<tr>
<th>V</th>
<th>F</th>
<th>NH</th>
<th>Fr</th>
<th>hopleft</th>
<th>source</th>
<th>Dest</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>(4)</td>
<td>(1)</td>
<td>(4)</td>
<td>(16 or 64)</td>
<td>(16 or 64)</td>
</tr>
</tbody>
</table>

Figure 11. (b) LMS header

V: 0- 16 bit originator ID in source field
1- 64 bit EUI ID in source field
F: 0- 16 bit originator ID in Destination field
1- 64 bit EUI ID in Destination field

NH: Same as in section 4.3.2

Hopleft: Hop count (within the mesh)

Source: 16 bits short or 64 bits EUI address of originator
Dest: 16 bits short or 64 bits address of final destination IN-node

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4.3.5 Local Broadcast frame

Whenever mesh routing required flooding mechanism, for that broadcast header is defined in figure xx. It contains dispatch type followed by sequence number of message.

+--------------------------+
| 01 100000 | Sequence No. |
+--------------------------+

Figure 12. Local Broadcast Header

Sequence No: This 8-bit field SHALL be incremented by the Originator whenever it sends a new mesh broadcast

5. Mobility and Header Compression

Aforesaid, IPv6 Header compression scheme in 6lowpan mainly relies on compression of source IPv6 address using stateless auto configuration. IPv6 address auto configuration is not feasible in mobile environment as node changes its prefix. Different protocols for mobility management such as MIPv6, and PMIPv6 [RFC 3775, RFC 5213] have been proposed and mainly rely on the source node prefix information. Recently, location ID separation protocol [I-D farinacci-lisp] which employs host ID apart from network prefix for management of mobility. As the compressed packet ([RFC 6282]) does not have any such network information during global communication, 6lowpan does not support mobility with compressed packet.

It is possible that when node moves to another network, and node associates with gateway, they exchange necessary information and association are carried out. But still individual packet does not contain any network information.

- Neighbor or gateway discovery: As neighbor node changes frequently in mobility, whenever new neighbor node comes, association and security information is maintained in database. Remaining mobility management is carried out using MIPv6, PMIPv6 or Location/ID based approaches.

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6. Header compression efficiency.

During global communication, as per header compression [RFC 6282], maximum compression of Source and destination address is 18 bytes (IN-node short, 2 bytes ID + OUT node IPv6 address, ... header if present). It also supports the mobility across different networks with efficient header compression.

7. Formal Syntax

The following syntax specification uses the augmented Backus-Naur Form (BNF) as described in RFC-2234 [RFC2234].

8. Security Considerations

TBD

9. IANA Considerations

TBD

10. References

10.1 Normative references


