The time of the hourglass has elapsed

Laurent Toutain, Nicolas Montavont
Institut télécom ; télécom Bretagne; UEB
Cesson Sévigné 35576 Cedex - France
Email: {*firstname.name*}@telecom-bretagne.eu
Dominique Barthel
France Telecom Orange
Meylan - France
Email: Dominique.Barthel@orange-ftgroup.com

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1 Statement

Until now, porting IP to different layer 2 technologies has been fairly easy since they were relatively similar. The work done at 6LoWPAN has shown that adapting IPv6 to LoWPAN networks is a more complex task. In some sense, 6LoWPAN and RPL have changed the nature of IP. IPv6 is moving away from an interconnection paradigm, highlighted by the famous hourglass model where the same protocol is present on all nodes, to an interface architecture (or a convergence layer) where different flavors of the protocol co-exists and interact.

One immediate result of this new perspective is that IPv6 no longer simply needs to be ported to different L2s but must be adapted to match their new behaviors. In the case of 6LoWPAN, this adaptation aims at reducing the overhead of IPv6 on LoWPAN networks, as well as coping with sleeping nodes.

2 State of the art

2.1 Architecture Evolution

The 6LoWPAN WG aims at running IPv6 and associated protocols on Low power Wireless Personal Area Networks (LoWPAN) [1]. We'll consider two aspects of the 6LoWPAN work, namely header compression and general control traffic reduction.

From an architectural point of view, the compression work done by the 6LoWPAN WG is quite different from other compression mechanisms already defined by IETF such as Van Jacobson PPP compression or even RoHC. The latter schemes were designed for point-to-point links where the packet is uncompressed before being processed by the IP Layer. In a route-over LoWPAN, it is hard to imagine that implementators will refrain from having routers process compressed packets instead of uncompressing/compressing them during the forwarding phase. So, in essence, a LoWPAN network will not forward pure IPv6 packets, but a new packet format instead.

A parallel can be established with IEEE 802 architecture. IEEE 802.3 defines a frame format used to transport information on Ethernet networks. But this format is also the common format used to bridge over to other technologies. For instance, IEEE 802.11 defines a totally different framing containing more information than IEEE 802.3 in order to manage CSMA/CA algorithms or to select a specific Access Point.

Bridges extract the information to build an Ethernet frame out of an 802.11 frame and vice-versa. Instead of having a single protocol covering all cases, we have different protocols each adapted to a particular environment. But this is totally transparent to hosts which are enticed to believe they are connected to an Ethernet network. Interconnection is eased by some architectural constraints such as address format and universal identifiers: since the Ethernet frame format contains the minimal information needed to send a frame, this information is always found on other L2 technologies frames.

At layer 3, the same argument can be made and the 6LoWPAN work shows the way. IPv6 also contains the minimal set of information needed to forward packet (source address, destination address, upper layer protocol,...). 6LoWPAN adds some fields (such as broadcast, fragmentation) to allow the LoWPAN management. Fragmentation is a symptomatic example. An IPv6 fragmentation extension exists, but it has been preferred to design another dispatch code to make fragmentation local to the LoWPAN and not global to all networks crossed.

2.2 Multi-homing

As stated above, 6LoWPAN reproduces IPv6 behavior on LoWPAN environments and therefore includes some of the drawback of IPv6. For instance Multi-homing is not solved. The Group worked hard to efficiently allocate prefixes to nodes in LoWPAN (emulating what traditional IPv6 does). However, prefixes create problems when implementing multi-homing.

Multihoming can be defined as a network having several exit routers. In a 6LoWPAN, multihoming can be provided by several 6LBR connected to different providers, each announcing a different prefix (see Figure 1). This scenario is needed in an Urban LoWPAN. Both 6LBR can be used to exit the LoWPAN. In the current IETF proposals (especially in 6LoWPAN and Roll), there is not support for multihoming.

```
       +----+            +----+
/-----| R1 |----------| R2 |-----\
|      +----+            +----+      |
|        o        o  o              |
|          o              O         |
|   A        o                      |
\--------------------------------/
```

Figure 1: Multi-homed network

In Figure 1, assume Node A selects a prefix announced by router R2, but its packets is routed through R1 (this may happen since the source address is not used by the routing protocol). R1's ISP may rightfully reject the packet since the prefix of the source address was not allocated by this ISP (known as ingress filtering).

In the early days when the IPv6 protocol was defined, some proposals such as GSE [2] suggested to split an address into two parts. Using today's vocabulary, when a host generates a new packet, it only inserts the IID part of the source address and the edge router adds the prefix part. One reason why this proposal was rejected was that IID uniqueness can not be guaranteed. In a LoWPAN network, since DAD has been made mandatory, EUI are supposed globally unique.

More recently NAT66 [4] proposes that the exit router adds or modifies the prefix of outgoing packets, and, in order to avoid a change in the L4 checksum, that it also modifies the IID part of the address. Thus, NAT66 allows guaranteeing the uniqueness of the global address, given that the chosen IID on the node is unique.

While these multi-homing proposals are not widely accepted in the traditional Internet, their usage in LoWPAN networks could be very useful in terms of energy consumption and code footprint since IPv6 and NDP stack can be made smaller this way. The deployment of these solutions does not impact the whole internet but only the LoWPAN area.

3 A proposal: Neighbor Discovery suppression

The I-D [3] gives an extensive view of our proposal for different types of network (star, mesh-under, route-over topologies). In this paper, we focus in the last one, which is likely be the most popular one, especially in urban LoWPANs. In our proposal, the global IPv6 prefix is not disseminated in the LoWPAN, so as to reduce the control traffic overhead. Instead, one of the 6LoWPAN context entry is allocated to an "implicit prefix": 6LNs do not know their global prefix, they use `::/64` instead when they compute L4 checksum.

When a 6LN starts, it has to inform the network of its position in the network to be able to receive incoming packets. The 6LN sends a RPL DIS message to discover surrounding 6LRs, 6LRs send a RPL DIO message and the 6LN registers its address (`::IID/64`).

The compressed IPv6 header is thus 28 bytes long if no compression is made on the destination address. The code to generate this IPHC also smaller.

The packet is routed toward the 6LBR which decompresses the header, then a NAT66 translation of the source address is performed. As was already alluded to above, there are two different approaches to translate the address:

- either the IID is changed to make the new address neutral to checksum computation. The layer 4 checksum does not have to be modified, but handling of the IID at the far end become more complex, especially in the case of Multi-Homing since a same 6LN will have different IIDs. This can be a drawback if the IID is used to identify the 6LN.
- or the L4 checksum is modified to take the source address change into account. In this case, the IID is unchanged.

Incoming packets undergo the reverse process. In some situations, it may happen that the 6LBR did not previously receive a packet from that 6LN, yet an Internet node needs to iniate a communication to it. In this situation, the 6LBR can not determine whether the 6LN supports the implicit prefix or not. To allow the 6LBR to learn that a 6LN indeed supports the implicit prefix, we suggest a different global prefix be allocated on the Internet to 6LNs that are known to support implicit prefix.

References

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