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6LoWPAN Roadmap and Implementation Guide

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Abstract

6LoWPAN is defined in RFC 4944 in conjunction with a number of specifications that are currently nearing completion. The entirety of these specifications may be hard to understand, pose specific implementation problems, or be simply inconsistent.

The present guide aims to provide a roadmap to these documents as well as provide specific advice how to use these specifications in combination. In certain cases, it may provide clarifications or even corrections to the specifications referenced.

This guide is intended as a continued work-in-progress, i.e. a long-lived Internet-Draft, to be updated whenever new information becomes available and new consensus on how to handle issues is formed. Similar to the ROHC implementation guide, RFC 4815, it might be published as an RFC at some future time later in the maintenance curve of the specifications.

This document does not describe a new protocol or attempt to set a new standard of any kind - it mostly describes good practice in using the existing specifications, but it may also document emerging consensus where a correction needs to be made.

Status of This Memo

This Internet-Draft will expire on October 15, 2013.

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1. Introduction

(To be written - for now please read the Abstract.)

1.1. Terminology

This document is a guide. However, it might evolve to make specific recommendations on how to use standards-track specifications. Therefore: 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 RFC 2119. They indicate requirement levels for compliant 6LoWPAN implementations [RFC2119]. Note that these keywords are not only used where a correction or clarification is intended; the latter are explicitly identified as such.

The term "byte" is used in its now customary sense as a synonym for "octet".

2. 6LoWPAN

What is a 6LoWPAN?

The term, originally just the name of the IETF Working Group (WG) that created the specifications, nowadays refers to a specific way of building IP-connected wireless networks for embedded use cases. The 6LoWPAN core specifications are:

- o [RFC4944], as updated by
- o [RFC6282] and
- o [RFC6775].

While [RFC4944] defines 6LoWPAN specifically for IEEE 802.15.4 networks, 6LoWPAN concepts have been applied to other PHY/MAC layers.

6LoWPANs MAY use additional protocols, such as [RFC6550] for routing, or [I-D.ietf-core-coap] for application data transfer. However, the "6LoWPANness" of a network is caused by adherence to the core specifications.

2.1. Optional components of 6LoWPAN

Additional sub-protocols are being discussed in the IETF that may become optional protocols in 6LoWPANs.

For instance, [I-D.bormann-6lowpan-ghc] defines an extension to [RFC6282] that enables header compression of additional headers and header-like protocols, including ICMPv6 and RPL.

One other recent proposal, in a much more nascent stage, that may be of interest to application designers targeting link layers with small frame sizes is Adaptation Layer Fragmentation Indication (ALFI), [I-D.bormann-intarea-alfi].

The present document will track these sub-protocols and be amended once the sub-protocols reach formal status in the IETF.

2.2. 6LoWPAN MIB work

For management of 6LoWPAN networks, a MIB is being proposed in [I-D.schoenw-6lowpan-mib]. Besides the usual SMIv2 MIB format that directly enables management access via SNMP, this draft also demonstrates a JSON format using a version of the MIB translated into YANG [RFC6020] as defined in [RFC6643] and made available using the JSON representation defined in [I-D.lhotka-netmod-yang-json]. This may facilitate using CoRE protocols for management access [I-D.ersue-constrained-mgmt], reducing the number transfer protocols that need to be implemented on a constrained node.

3. 6LoWPAN family

In addition to the support for IEEE 802.15.4 provided by [RFC4944], additional PHY/MAC layers outside IEEE 802.15.4 (or even 802.15) are being addressed by 6LoWPAN technology.

E.g., [I-D.ietf-6lowpan-btle] applies 6LoWPAN technology to Bluetooth Low Energy ("Bluetooth Smart"). As this has passed both 6LoWPAN Working-Group and IETF Last Call and has received one round of IESG consideration (now waiting for the allocation of a number from the BT-SIG), it is becoming part of the "6LoWPAN family" as a companion specification to [RFC4944], if not part of the (IEEE 802.15.4 focused) term 6LoWPAN itself.

At an earlier stage of work, [I-D.mariager-6lowpan-v6over-dect-ule] aims to define 6LoWPAN technology for DECT ULE (Ultra Low Energy), which might become another companion spec to [RFC4944]. Similarly, [I-D.brandt-6man-lowpanz] is a first draft defining 6LoWPAN technology for the ITU-T G.9959 radio.

In the further evolution of the 6LoWPAN family, we have to be careful what changes apply to all members of the family, and which are PHY/MAC specific.

3.1. 6LoWPAN over Bluetooth Low Energy (BT-LE)

[I-D.ietf-6lowpan-btle] similarly specifies the combination of

- o [RFC4944], as updated by
- o [RFC6282] and
- o [RFC6775].

as the basis for IPv6 over BT-LE, removing a couple of features from [RFC4944] as they are covered by or become unnecessary in BT-LE:

o Mesh header

o Fragmentation

3.2. 6LoWPAN over DECT Ultra Low Energy (DECT-ULE)

[I-D.mariager-6lowpan-v6over-dect-ule] is stabilizing in parallel to the base documents that are maturing within ETSI. While silicon is already available, complete systems with final firmware (and thus stable specs) are expected within 2012.

3.3. 6LoWPAN over G.9959 (lowpanz)

[I-D.brandt-6man-lowpanz] was recently discussed at IETF86 in Orlando and will soon receive an update based on this discussion. The G.9959 radio used in this specification operates in various regionally available frequencies around 900 MHz ("sub-GHz") and is best known for its use in the Z-Wave suite of products. As with BT-LE, this MAC layer already defines a Segmentation and Reassembly (SAR) layer, so packets larger than the G.9959 MAC PDU can be transmitted without the need for [RFC4944] fragmentation. Similarly, MAC layer mesh forwarding is available for G.9959 already.

4. 6LoWPAN MTU

IPv6 defines a minimal value for the "Minimum Transmission Unit", MTU, of 1280 bytes. This means that every IPv6 network must be able to transfer a packet of at least 1280 bytes of IPv6 headers and data without requiring fragmentation.

A common Internet MTU is 1500 bytes (motivated by the Ethernet MTU). The gap between 1280 and 1500 allows tunneling protocols to insert headers on the way from the source of a packet to a destination without breaking the overall MTU of the path. As various tunneling protocols do indeed insert bytes, it is unwise to simply assume an end-to-end MTU of 1500 bytes even with the current dominance of Ethernet. Path MTU discovery [RFC1981] [RFC4821] has been defined to enable transport protocols to find an MTU value better than 1280 bytes, but still reliably within the MTU of the path being used. Path MTU discovery places, however, additional strain on constrained nodes, which therefore may want to stick with an MTU of 1280 bytes for all IPv6 applications.

6LoWPAN was designed as a stub network, not requiring any tunneling. As IEEE 802.15.4 packets are rather small (127 bytes maximum at the physical layer, minus MAC/security and adaptation layer overhead), 1280 bytes was already considered a somewhat large packet size. Therefore, the 6LoWPAN network MTU was simply set at the minimum size

allowable by IPv6, 1280 bytes, although the 6LoWPAN fragmentation mechanism is able to support packets with total lengths (including the initial IPv6 header) of up to 2047 bytes.

As a more recent development, some modes of operation of the RPL protocol [RFC6550] do indeed operate by tunneling data packets between RPL routers. Maintaining the MTU visible to applications at 1280 therefore requires making a larger MTU available to the tunnels.

6LoWPAN routers that employ RPL therefore MUST support a more appropriate MTU between routers that make use of tunneling between them. [The specific MTU value is TBD, to be chosen between 1280 and 2047 based on RPL considerations that need to be added to this document.]

5. PAN identifiers in IPv6 addresses

[RFC4944] incorporates PAN identifiers in IPv6 addresses created from 16-bit MAC addresses, in a somewhat awkward way (one of the 16 bits needs to be cleared to enable the U/L bit.).

As the use of PAN identifiers in 6LoWPAN networks has since become less and less meaningful, [RFC6282] provides specific support only for interface IDs of the form 0000:00ff:fe00:XXXX, i.e. PAN identifiers of zero. (Other forms can be supported by creating sufficiently long pieces of compression context information for each non-zero PAN identifier; however there is a limited number of context elements and each consumes space in all nodes of a 6LoWPAN.)

It is therefore RECOMMENDED to employ a PAN identifier of zero with 6LoWPAN.

(While this discussion is specific to IEEE 802.15.4 networks, the recommendation to build short addresses in a way that enables [RFC6282] compression may apply to other PHY/MAC technologies as well.)

6. IANA Considerations

This document has no actions for IANA.

7. Security Considerations

(None so far; this section will certainly grow as additional security considerations beyond those listed in the base specifications become known.)

8. Acknowledgements

(The concept for this document is borrowed from [RFC4815], which was invented by Lars-Erik Jonsson. Thanks!)

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