                  6LoWPAN Roadmap and Implementation Guide
                      draft-bormann-6lowpan-roadmap-02

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 acceptance 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.

   The current version -02 of this document is an early draft that is
   intended to spark the further collection of relevant information.

Status of this Memo

   This Internet-Draft is submitted in full conformance with the
   provisions of BCP 78 and BCP 79.

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   Internet-Drafts are draft documents valid for a maximum of six months
   and may be updated, replaced, or obsoleted by other documents at any

   time.   It is inappropriate to use Internet-Drafts as reference
   material or to cite them other than as "work in progress."

   This Internet-Draft will expire on March 10, 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 [I-D.ietf-6lowpan-nd].

(Note that, while still being referenced here as an Internet-Draft, [I-D.ietf-6lowpan-nd] has been approved as a standards-track RFC on 2012-08-24 and is now in the RFC editor queue waiting for final editing in order to be published.)

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 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.

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 necessitating some, mostly editorial, changes), 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].

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 [I-D.ietf-6lowpan-nd].

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.

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!)

9. References

9.1. Normative References

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