                 Terminology for Constrained Node Networks
                      draft-ietf-lwig-terminology-01

Abstract

   The Internet Protocol Suite is increasingly used on small devices
   with severe constraints, creating constrained node networks. This
   document provides a number of basic terms that have turned out to be
   useful in the standardization work for constrained environments.

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1. Introduction

   Small devices with limited CPU, memory, and power resources, so
   called constrained devices (aka. sensor, smart object, or smart
   device) can constitute a network, becoming "constrained nodes" in
   that network. Such a network may itself exhibit constraints, e.g.
   with unreliable or lossy channels, limited and unpredictable
   bandwidth, and a highly dynamic topology.

   Constrained devices might be in charge of gathering information in
   diverse settings including natural ecosystems, buildings, and
   factories and send the information to one or more server stations.
   Constrained devices may work under severe resource constraints such
   as limited battery and computing power, little memory and
   insufficient wireless bandwidth, and communication capabilities.
   Other entities on the network, e.g., a base station or controlling
   server, might have more computational and communication resources and
   can support the interaction between the constrained devices and
   applications in more traditional networks.

   Today diverse sizes of constrained devices with different resources
   and capabilities are becoming connected. Mobile personal gadgets,
   building-automation devices, cellular phones, Machine-to-machine
   (M2M) devices, etc. benefit from interacting with other "things" in
   the near or somewhere in the Internet. With this, the Internet of
   Things (IoT) becomes a reality, built up out of uniquely identifiable
   and addressable objects (things). And over the next decade, this
   could grow to large numbers [fifty-billion] of Internet-connected
   constrained devices, greatly increasing the Internet's size and
   scope.

The present document provides a number of basic terms that have
turned out to be useful in the standardization work for constrained
environments. The intention is not to exhaustingly cover the field,
but to make sure a few core terms are used consistently between
different groups cooperating in this space.

2. Terminology

The main focus of this field of work appears to be _scaling_:

o Scaling up Internet technologies to a large number [fifty-billion]
   of inexpensive nodes, while

o scaling down the characteristics of each of these nodes and of the
   networks being built out of them, to make this scaling up
   econmically and physically viable.

The need for scaling down the characteristics of nodes leads to
constrained nodes.

2.1. Constrained Nodes

The term "constrained node" is best defined on not meeting certain
widely held expectations:

Constrained Node: A node where some of the characteristics that are
   otherwise pretty much taken for granted for Internet nodes in 2012
   are not attainable, often due to cost constraints and/or physical
   constraints on characteristics such as size, weight, and available
   power.

While this is less than satisfying as a rigorous definition, it is
grounded in the state of the art and clearly sets apart constrained
nodes from server systems, desktop or laptop computers, powerful
mobile devices such as smartphones etc.

(An alternative name, when the properties as a network node are not
in focus, is "constrained device".)

There are multiple facets to the constraints on nodes, often applying
in combination, e.g.:

o constraints on the maximum code complexity (ROM/Flash);

o constraints on the size of state and buffers (RAM);

o constraints on the available power.

Section 3 defines a small number of interesting classes ("class-N"
for N=0,1,2) of constrained nodes focusing on relevant combinations
of the first two constraints. With respect to available power,
[RFC6606] distinguishes "power-affluent" nodes (mains-powered or
regularly recharged) from "power-constrained nodes" that draw their
power from primary batteries or using energy harvesting.

The use of constrained nodes in networks often also leads to
constraints on the networks themselves. However, there may also be
constraints on networks that are largely independent from those of
the nodes. We therefore distinguish _constrained networks_ and
constrained node networks.

2.2. Constrained Networks

We define "constrained network" in a similar way:

Constrained Network: A network where some of the characteristics
   pretty much taken for granted for Internet link layers in 2012 are
   not attainable.

Again, there may be several reasons for this:

o cost constraints on the network

o constraints of the nodes (for constrained node networks)

o physical constraints (e.g., power constraints, media constraints
   such as underwater operation, limited spectrum for very high
   density).

Constraints may include:

o low achievable bit rate

o high packet loss, packet loss (delivery rate) variability

o severe penalties for using larger packets (e.g., high packet loss
   due to link layer fragmentation)

o lack of (or severe constraints on) advanced services such as IP
   multicast

2.2.1. Challenged Networks

A constrained network is not necessarily a _challenged_ network
[FALL]:

Challenged Network: A network that has serious trouble maintaining
   what an applicaton would today expect of the end-to-end IP model,
   e.g., by:

o not being able to offer end-to-end IP connectivity at all;

o exhibiting serious interruptions in end-to-end IP connectivity;

o exhibiting delay well beyond the MSL defined by TCP.

All challenged networks are constrained networks in some sense, but
not all constrained networks are challenged networks. There is no
well-defined boundary between the two, though. Delay-Tolerant
Networking (DTN) has been designed to cope with challenged networks
[RFC4838].

2.3. Constrained Node Networks

Constrained Node Network: A network whose characteristics are
   influenced by being composed of a significant portion of
   constrained nodes.

A constrained node network always is a constrained network because of
the network constraints stemming from the node constraints, but may
also have other constraints that already make it a constrained
network.

2.3.1. LLN ("low-power lossy network")

A related term that has been used recently is "low-power lossy
network" (LLN). The ROLL working group currently is struggling with
its definition [I-D.ietf-roll-terminology]:

   LLN: Low power and Lossy networks (LLNs) are typically composed of
   many embedded devices with limited power, memory, and processing
   resources interconnected by a variety of links, such as IEEE
   802.15.4 or Low Power WiFi. There is a wide scope of application
   areas for LLNs, including industrial monitoring, building
   automation (HVAC, lighting, access control, fire), connected home,
   healthcare, environmental monitoring, urban sensor networks,
   energy management, assets tracking and refrigeration.. [sic]

It is not clear that "LLN" is much more specific than "interesting"
or "the network characteristics that RPL has been designed for".
LLNs do appear to have significant loss at the physical layer, with
significant variability of the delivery rate, and some short-term
unreliability, coupled with some medium term stability that makes it
worthwhile to construct medium-term stable directed acyclic graphs
for routing and do measurements on the edges such as ETX. Actual
"low power" does not seem to be required for an LLN
[I-D.hui-vasseur-roll-rpl-deployment], and the positions on scaling
of LLNs appear to vary widely [I-D.clausen-lln-rpl-experiences].

Also, LLNs seem to be composed of constrained nodes; otherwise
operation modes such as RPL's "non-storing mode" would not be
sensible. So an LLN seems to be a constrained node network with
certain constraints on the network as well.

2.3.2. LoWPAN, 6LoWPAN

One interesting class of a constrained network often used as a
constrained node network is the "LoWPAN" [RFC4919], a term inspired
from the name of the IEEE 802.15.4 working group (low-rate wireless
personal area networks (LR-WPANs)). The expansion of that acronym,
"Low-Power Wireless Personal Area Network" contains a hard to justify
"Personal" that is due to IEEE politics more than due to an
orientation of LoWPANs around a single person. Actually, LoWPANs
have been suggested for urban monitoring, control of large buildings,
and industrial control applications, so the "Personal" can only be
considered a vestige. Maybe the term is best read as "Low-Power
Wireless Area Networks" (LoWPANs) [WEI]. Originally focused on IEEE
802.15.4, "LoWPAN" (or when used for IPv6, "6LoWPAN") is now also
being used for networks built from similarly constrained link layer
technologies [I-D.ietf-6lowpan-btle]
[I-D.mariager-6lowpan-v6over-dect-ule].

3. Classes of Constrained Devices

Despite the overwhelming variety of Internet-connected devices that
can be envisioned, it may be worthwhile to have some succinct
terminology for different classes of constrained devices. In this
document, the following class designations may be used as rough
indications of device capabilities:

```
+---------+-----------------------+------------------------+
| Name    | data size (e.g., RAM) | code size (e.g., Flash) |
+---------+-----------------------+------------------------+
| Class 0 | << 10 KiB             | << 100 KiB             |
|         |                       |                        |
| Class 1 | ~ 10 KiB              | ~ 100 KiB              |
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    |         |                       |                        |
    | Class 2 | ~ 50 KiB              | ~ 250 KiB              |
    +---------+-----------------------+------------------------+
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Table 1: Classes of Constrained Devices

As of the writing of this document, these characteristics correspond
to distinguishable sets of commercially available chips and design
cores for constrained devices. While it is expected that the
boundaries of these classes will move over time, Moore's law tends to
be less effective in the embedded space than in personal computing
devices: Gains made available by increases in transistor count and
density are more likely to be invested in reductions of cost and
power requirements than into continual increases in computing power.

Class 0 devices are very constrained sensor-like motes. Most likely
they will not be able to communicate directly with the Internet in a
secure manner. Class 0 devices will participate in Internet
communications with the help of larger devices acting as proxies,
gateways or servers. Class 0 devices generally cannot be secured or
managed comprehensively in the traditional sense. They will be most
likely preconfigured and if ever will be reconfigured rarely with a
very small data set. For management purposes, they could answer
keepalive signals and send on/off or basic health indications.

Class 1 devices cannot easily talk to other Internet nodes employing
a full protocol stack such as using HTTP, TLS and related security
protocols and XML-based data representations. However, they have
enough power to use a protocol stack specifically designed for
constrained nodes (e.g., CoAP over UDP) and participate in meaningful
conversations without the help of a gateway node. In particular,
they can provide support for the security functions required on a
large network. Therefore, they can be integrated as fully developed
peers into an IP network, but they need to be parsimonious with state
memory, code space, and often power expenditure for protocol and
application usage.

Class 2 can already support mostly the same protocol stacks as used
on notebooks or servers. However, even these devices can benefit
from lightweight and energy-efficient protocols and from consuming
less bandwidth. Furthermore, using fewer resources for networking
leaves more resources available to applications. Thus, using the
protocol stacks defined for very constrained devices also on Class 2
devices might reduce development costs and increase the
interoperability.

Constrained devices with capabilities significantly beyond Class 2
devices exist. They are less demanding from a standards development

point of view as they can largely use existing protocols unchanged.
The present document therefore does not make any attempt to define
classes beyond Class 2. These devices can still be constrained by a
limited energy supply.

With respect to examining the capabilities of constrained nodes,
particularly for Class 1 devices, it is important to understand what
type of applications they are able to run and which protocol
mechanisms would be most suitable. Because of memory and other
limitations, each specific Class 1 device might be able to support
only a few selected functions needed for its intended operation. In
other words, the set of functions that can actually be supported is
not static per device type: devices with similar constraints might
choose to support different functions. Even though Class 2 devices
have some more functionality available and may be able to provide a
more complete set of functions, they still need to be assessed for
the type of applications they will be running and the protocol
functions they would need. To be able to derive any requirements,
the use cases and the involvement of the devices in the application
and the operational scenario need to be analyzed. Use cases may
combine constrained devices of multiple classes as well as more
traditional Internet nodes.

4. Security Considerations

TBD

5. IANA Considerations

This document has no actions for IANA.

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