# LP-WAN GAP ANALYSIS

draft-minaburo-lp-wan-gap-analysis

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# THANKS FOR THE DISCUSSION AND FEEDBACK ON THE LP-WAN MAILING LIST

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# OUTLINE

- LP-WAN Characteristics
- LP-WAN at IETF
- GAPs in the actual IETF protocols

# LP-WAN TECHNOLOGIES

| Technology | Range | Spectrum | ISM | Symmetric up/down | Data Rate | Throughput | Battery Life | Max Nodes | Geographic coverage | Operational Mode | Cost | Standard Status | Packet size | Modulation | Encryption | Authentication |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LoRa LoRaWAN | 2-5 km urban areas <15km suburban areas | 868 MHz (EU) 915 MHz (US) 433 MHz (Asia) | Yes | Depends on mode | 0.3 - 50kbps (adaptive) | 256 bytes | 10 years | millions/ hub | Excellent in remote and urban areas. Good penetration in ground and buildings | Public or private | Cheap | -LoRa: No -LoRaWAN: yeds | 256B (max) | Spread spectrum | EUI64 EUI128 | |
| SIGFOX | 50 km rural 10km urban | 868 MHz (EU) 902 MHz (US) | Yes | No | 100bps | max. 140 pkts/day | | millions/ hub | | Public | | No | 12B (payload) | UNB | | |
| IEEE802.15.4k LECIM | < 20 km LoS < 5 km NLoS | 169 MHz; 433 MHz; 470 MHz; 780 MHz; 863 MHz; 915 MHz; 2.4 GHz (different countries) | Yes | Yes | 1.5 bps to 128 kbps | | | | | | | Yes | 16/24/32 (payload) | DSSS and FSK | | |
| IEEE802.15.4g SUN | 2-3km LoS | 169 MHz 450 MHz 470 MHz 780 MHz 863 MHz 868 MHz 896 MHz 901 MHz 915 MHz 917 MHz 920 MHz 928 MHz 950 MHz 1427 MHz 2450 MHz | Yes | Yes | 4.8 kbps to 800 kbps | | | MAC/PHY spec | | | Cheap | Yes | 2047B (max) | MR-FSK MR-OFDM MR-O-QPSK | AES-CCM | AES-CCM |
| Qowisio | 2km urban 50km rural | | | | | | | | | | | | | UNB | | |
| RPMA | <65km line of sight <20km non line of sght | 2.4GHz | Yes | | Uplink: 624kbps Downlink:156kbps Mobile: 2kbps | 19000 bps/MHz | | 500k/hub | | Private (also public in the future) | | | | Spread spectrum | 256-bit | two-way 16-byte hash |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DASH-7 | 2km | 433 MHz 868 MHz (EU) 902 MHz (US) | Yes | | 9. kbps 55.55kbps 166.66kbps | | | | | | | DASH7 -- full OSI layers specification | 256B (max) | GFSK | | |
| Weightless-w | 5km urban | TV whitespace 470-790 MHz | | | 1kbps-10Mbps | | | | | | | | min 10B | | 128-bit | based on a shared secret key |
| Weightless-n | <5km urban areas 20-30km suburban | 800MHz-1GHz (ISM) | Yes | Uplink only | 30kpbs - 100 | | | 1M/hub | | Public or | | Yes | 20B (max) | UNB | 128-bit | based on a shared secret key |
| Weightless-p | >2km urban | | Yes | | e) | | | | | | | | | | | |
| NB-IoT | <15km<br>DL MCL: 164.1 dB<br>UL MCL: 165.6 dB | <1GHz (licensed)<br>180 kHz channels | No | Yes | <150 kbps | | >10 yrs | >50k per sector | Urban: deep in-building penetration<br>Rural: long range | Public | <$5 | 3GPP: 2016 completion | <200B | DL: OFDMA<br>UL: SC-FDMA | AKA (128 bit keys) | AKA (128 bit keys) |
| IEEE802.11ah (Aka Wi-Fi HaLow) | 1km (outdoor) | <1GHz (license-exempt bands below 1 GHz) -902-928 MHz(US), 863-868.6 MHz(EU), 915.9-928.1MHz(JP), 755-787 MHz(CN) | Yes | Yes | 150Kbps to 346.6Mbps | | Battery life exceeds product life (multi-yr.) | 8,191 per Access Point | Indoor: whole home coverage Outdoor: long range | Public or private | Cheap | IEEE: 2016 completion | Up to 7,991 Bytes (without Aggregation) up to 797,160 Bytes (with Aggregation) | OFDM | AES-CCM (128 or 256 bit keys) | AES-CCM (128 or 256 bit keys) |

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# LP-WAN TECHNOLOGIES

Constrained and challenged network (as defined RFC 7228)

License-exempt or Licensed bands

Property industrial deployments, huge potential

No Fragmentation ?


Deep Coverage

Battery powered devices with limited communications

Asymmetric Lines

Limit number of messages per device and per day

Small message size

Complex Device and Network management

Acknowledgement management

NO IP CAPABILITIES

# LP-WAN FAMILY CHARACTERISTICS

- Very small frame payload (15 – 100 bytes)
- Limit number of frames per day (10)
- Low bandwidth offering throughput between 50 bit/s to 250kbit/s
- High packet loss (caused by collisions or bad transmission conditions)
- MTU variable (changing with modulation)
- Highly asymmetric (up/down) links or unidirectional links only
- Thousand of nodes per gateway
- Sleepy nodes (not as DTN)
- No Fragmentation in L2 (not all)
- Mobility (not as mobile IP) and not all devices
- Star Topology

# LP-WAN AT IETF

- IP communication
  - Preserve End to End communication
  - Independence from L2
  - Use or adapt actual protocols
  - Use existing addressing spaces and naming schemes
- Strong Security
  - Adapted to the LP-WAN applications as: health, personal usages (water, gas, bus timing, etc.)
- Scalability
- High Reliability
- Interoperability
- Header Compression to reduce overhead

# IPv6 => LP-WAN

- The overhead of IPv6 is not compatible with LP-WAN
- The variable MTU gives a variable fragmentation solution
- Need to adapt NDP (Neighbor Discovery) to LP-WAN
- `draft-gomez-lpwan-ipv6-analysis-00`

# 6LoWPAN, 6Lo => LP-WAN

- 6LoWPAN reduces header overhead for reliable L2 protocols
- 6LoWPAN traditionally used for constrained node networks
  - The LP-WAN technologies are even more constrained than typical 6LoWPAN
- Challenge for 6LoWPAN mechanisms is that LP-WAN does not send ACK at L2
- 6Lo adapts 6LoWPAN for constrained devices
  - In LP-WAN the network is also constrained
  - In LP-WAN devices are challenged
- ROHC header compression reduces overhead (NB-IoT adopted)

# 6TISCH => LP-WAN

- Similar but different
- 6tisch use synchronization to performs determinism
- 6tisch infrastructure is MESH
  - LP-WAN does not have a slotted channel

# ROUTING => LP-WAN

- LPWAN topology is a STAR
  - Not need routing for the moment
- Future topologies could need an adaptation of a routing protocol

# CORE => LP-WAN

- Adapt CORE solution to:
  - Duty cycle
  - Limited throughput
  - To use CoAP

# MOBILITY => LP-WAN

- Different mobility from MOBILE IP
  - Not real-time communications
  - Not high frequency

# THANKS !!!

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# LP-WAN AT IETF

- Variable MTU
  - Depends on encoding
- Fragmentation
- Acknowledgements Management
- Sleepy nodes (not as DTN)
- Functioning Mode
  - Authentication through the application and not through network
- Structure
  - Service made by sessions
- Network Management
- Reduce Number of packet per day, Small size of packets

# Analysis of IPv6 over LPWAN: design space and challenges

`draft-gomez-lpwan-ipv6-analysis-00`

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# Motivation

- Connecting LPWAN to the Internet
  - Use of IPv6 over LPWAN
- 6Lo(WPAN) traditionally used for constrained node networks
- However, some LPWAN technologies/setups even more constrained than typical 6Lo(WPAN) ones:
  - Lack of L2 fragmentation support
  - Maximum payload size one order of magnitude less
  - Bit rate several orders of magnitude less
  - Further limited message rate
    - E.g. due to regulatory constraints on the duty cycle
- Challenge for 6Lo(WPAN) mechanisms

# Goals of this document

- Analysis of IPv6 over LPWAN
  - Analyze the applicability of existing 6Lo(WPAN) functionality
  - Identify possible challenges

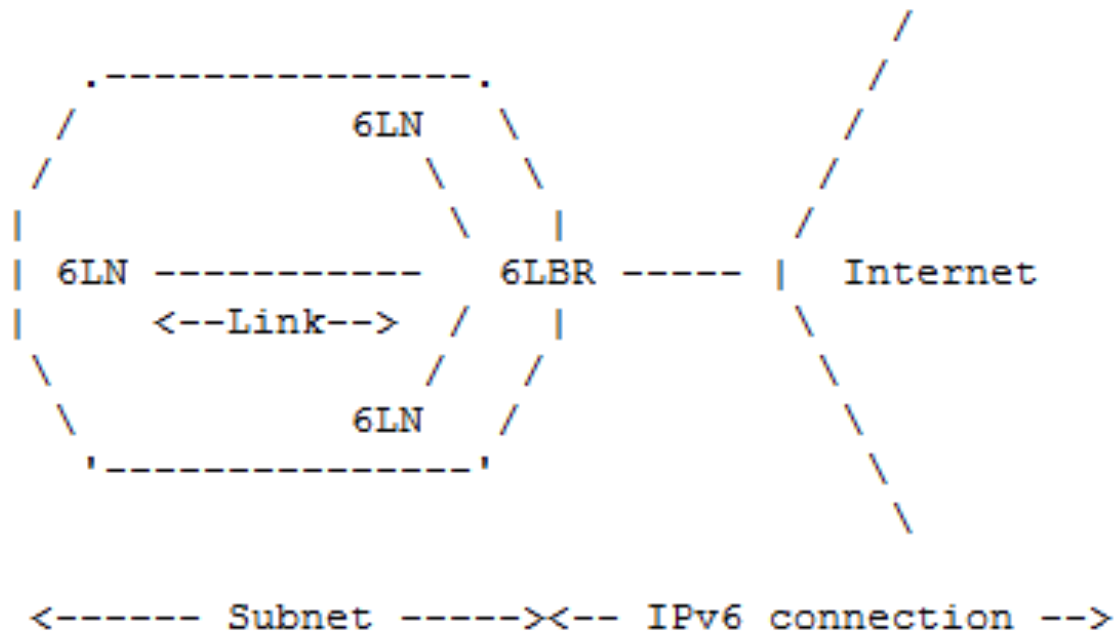
- Guideline for future IPv6 over foo (LPWAN) technologies
  - Design space dimensions, aspects to consider, and recommendations

# Protocol stack

- (If several options are possible) Which lower layer should interface with the adaptation layer?
  - Ability of enabling a link
  - Fragmentation support
    - Not necessarily better at the layer two
  - Multiplexing upper layer protocols

# Network topology and subnet model

- LPWAN typically follow the star topology
- Multi-link subnet model



# Address autoconfiguration

- IIDs traditionally derived from layer two address in 6Lo(WPAN)…
- Privacy concerns
  - LPWAN devices should not embed their link layer address in the IID by default

# Fragmentation

- Needed to satisfy the IPv6 MTU requirement
- If LPWAN technology supports fragmentation
  - Analysis needed: fragmentation may be performed at L2 or at the adaptation layer
- Otherwise, fragmentation at the adaptation layer
- 6Lo(WPAN) fragmentation header
  - High overhead for LPWAN
  - Only supports maximum L2 payload size ≥ 13 bytes
- Optimized approach
  - E.g. draft-gomez-lpwan-fragmentation-header

# Neighbor Discovery (ND) (I/III)

- RFC 6775 defined optimized ND for 6LoWPAN
  - Host-initiated interactions
  - Multicast-based host address resolution replaced by address registration mechanism
  - Multihop extensions (prefix dissemination, DAD)
    - Not needed in star topology networks
  - Optional support for header compression

- Suitable for LPWAN ?

# Neighbor Discovery (ND) (II/III)

- OK for some not so challenged LPWAN setups
  - Maximum payload size above ≥ 60 bytes
  - Duty-cycle-free or equivalent operation

- High overhead for more challenged LPWAN setups
  - Maximum payload size ~ 10 bytes
  - Message rate ~ 0.1 message/minute

# Neighbor Discovery (ND) (III/III)

- Behavior is tunable
  - Default Router Lifetime (RS/RA)
    - Max: 18 hours
  - Valid Lifetime in PIOs (RS/RA)
    - Max: infinity
  - Valid Lifetime in 6CO (RS/RA)
    - Max: 45 days
  - Address Registration Lifetime (NS/NA)
    - Max: 45 days

- More challenged LPWAN setups may need further functionality/ optimization beyond RFCC 6775

# Header Compression (HC)

- RFC 6282 defines 6LoWPAN HC
  - Stateless and stateful
  - 2-byte base encoding
  - 1-byte encoding for context-based HC
    - 16 contexts may be defined
    - Context may be disseminated by using 6CO in RAs
    - Each 6CO adds 16-24 bytes
  - Minimum compressed header with fully compressed global addresses: 3 bytes
    - Limited to 16 global addresses
  - Minimum compressed header with compressed prefix of only source or only destination: 11 bytes
  - Minimum compressed header with compressed prefix of both source and destination: 19 bytes
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# Thanks!

## Questions?

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