

Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [802.15.4 and 6lowpan frame header compression]

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Source: [Phil Beecher] Company [Beecher Communications Ltd / Wi-SUN Alliance]

Address [Hove, SE England]

Voice:[], E-Mail:[phil@beecher.co.uk]

Re: [Liaison submission with 802.1, 802.3 w.r.t. frame size reduction]

Abstract: [802.15.4 Frame header compression]

Purpose: [Contribution under 802.15 Liaison to 802.1, 802.3]

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IEEE 802.15.4g (SUN PHYs) · 6LoWPAN · Smart Utility / IoT Networking

Frame Header Size Reduction with Short Addressing & 6LoWPAN

Extended analysis for 802.15.4g (SUN PHYs) frames up to 2048 bytes
(MR-FSK · MR-OFDM · MR-O-QPSK PHY modes)

2047 B

SUN PHYs Max PSDU

12 B

MAC Hdr Saving

Yes ✓

IPv6 in 1 Frame

802.15.4g AMENDMENT: WHAT CHANGED

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IEEE 802.15.4-2011 (Original)

Max PSDU	127 bytes
PHY layer	O-QPSK (2.4 GHz), BPSK (sub-GHz)
Data rate	250 kbps (2.4 GHz)
FCS	2 bytes (CRC-16)
PHY overhead	6 bytes (preamble+SFD+PHR)
MAC payload max	104 bytes (long addr)
IPv6 MTU fit?	NO — needs fragmentation
Target market	Personal area networks (PAN)

IEEE 802.15.4g-2012 Amendment

Max PSDU	2047 bytes
PHY layer	MR-FSK, MR-OFDM, MR-O-QPSK
Data rate	6.25 kbps – 800 kbps (MR-FSK)
FCS	4 bytes (CRC-32, default)
PHY overhead	~6–20 bytes (mode dependent)
MAC payload max	2016 bytes (long addr)
IPv6 MTU fit?	YES — 1280 B fits in one frame
Target market	Smart grid / Smart Utility Networks

802.15.4g FRAME STRUCTURE & OVERHEAD BREAKDOWN

PHY Layer (MR-FSK example)	
Preamble	2–8 B
SFD	2 B
PHR (length field)	2 B
Total PHY overhead	~6–12 B
PSDU (payload)	≤2047 B

MAC Header Fields			
Field	Long	Short	Save
Frame Control	2 B	2 B	—
Sequence Number	1 B	1 B	—
Dest PAN ID	2 B	2 B	—
Dest Address	8 B	2 B	6 B
Src Address	8 B	2 B	6 B
FCS (CRC-32)	4 B	4 B	—
TOTAL	25 B	13 B	12 B

◆ 12-byte header saving

Short addressing saves 12 bytes of MAC header vs long EUI-64 mode — from 21 B down to 9 B (FCF+Seq+DPAN+2×2B addr).

◆ IPv6 MTU in one frame!

The full 1280-byte IPv6 minimum MTU fits comfortably in a single 4g frame with either addressing mode. No fragmentation needed.

◆ CRC-32 costs 2 extra bytes

802.15.4g defaults to 4-byte CRC-32 (vs 2-byte CRC-16 in original). This partially offsets the gain from the larger frame.

SHORT ADDRESSING MODE: MAC HEADER COMPARISON

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LONG MODE (EUI-64) — 802.15.4g

Frame Control Field	2 B
Sequence Number	1 B
Dest PAN ID	2 B
Dest Address (EUI-64)	8 B
Src Address (EUI-64)	8 B
FCS (CRC-32)	4 B

Total overhead 25 B

Leaves 2016 B for IP payload

SHORT MODE (16-bit) — 802.15.4g

Frame Control Field	2 B
Sequence Number	1 B
Dest PAN ID	2 B
Dest Addr (short)	2 B
Src Addr (short)	2 B
FCS (CRC-32)	4 B

Total overhead 13 B

Leaves 2028 B for IP payload

Short addressing saves 12 bytes of MAC header per frame

Note: With PAN ID compression enabled (Frame Control bit), Src PAN ID is suppressed — saving a further 2 bytes when src PAN = dest PAN.

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Why IPHC Still Matters at 4g Frame Sizes

Even with 2028-byte capacity, the **48-byte IPv6+UDP overhead** still consumes bandwidth that IPHC can reclaim. In large sensor networks transmitting frequent small telemetry, these bytes add up to significant channel time.

Game-Changer: No Fragmentation for IPv6 MTU

With 4g's 2047-byte PSDU, the full IPv6 minimum MTU of **1280 bytes** fits in a single frame — eliminating 6LoWPAN fragmentation entirely for typical application payloads. This removes reassembly state, timers, and the risk of datagram loss from a single missing fragment.

Mesh & Hop-by-Hop Savings

Each intermediate hop in a mesh still forwards full frames — IPHC savings per frame are multiplied by hop count.

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Header Field	Raw	IPHC	Note
IPv6 Version (4 bits)	½ B	0 B	Constant, elided
Traffic Class + Flow Label	3½ B	0 B	Elided when=0
Payload Length	2 B	0 B	From MAC frame
Next Header	1 B	1 bit	Encoded in IPHC
Hop Limit	1 B	2 bits	3 common values
Source Address (128 bit)	16 B	0 B	Derived from MAC
Destination Address (128 bit)	16 B	0 B	Derived from MAC
UDP Source Port	2 B	4 bits	NHC compressed
UDP Dest Port	2 B	4 bits	NHC compressed
UDP Length	2 B	0 B	Elided
TOTAL (IPv6 + UDP)	48 B	~2–6 B	Best-case IPHC

USABLE PAYLOAD CAPACITY: FOUR CONFIGURATIONS COMPARED

BASELINE · 802.15.4 (127 B)

Long Addressing + Full IPv6/UDP

PHY: 6 B MAC: 21 B

FCS: 2 B IP/UDP: 48 B

50

bytes payload
39.4% efficiency

IMPROVED · 802.15.4 (127 B)

Short Addr + 6LoWPAN IPHC

PHY: 6 B MAC: 9 B

FCS: 2 B IP/UDP: 6 B

104

bytes payload
81.9% efficiency

4g STANDARD · 802.15.4g (2047 B)

Long Addressing + Full IPv6/UDP

PHY: 6 B MAC: 21 B

FCS: 4 B IP/UDP: 48 B

1968

bytes payload
96.1% efficiency

4g OPTIMISED · 802.15.4g (2047 B)

Short Addr + 6LoWPAN IPHC

PHY: 6 B MAC: 9 B

FCS: 4 B IP/UDP: 6 B

2022

bytes payload
98.8% efficiency

802.15.4g + Short Addr + IPHC yields 2022 B vs original 56 B baseline — a 36× increase in usable payload per frame

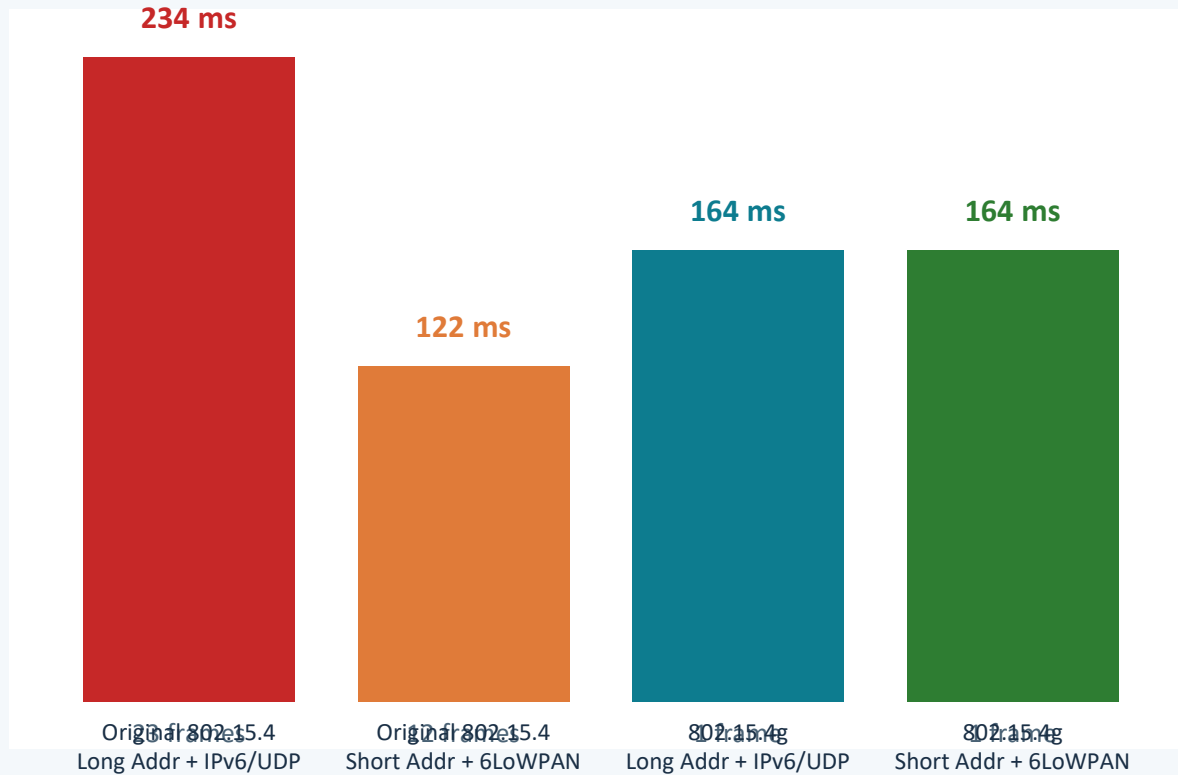
FRAGMENTATION ELIMINATED: FRAMES REQUIRED VS PAYLOAD SIZE

App Payload	Orig Long+IPv6	Orig Short+IPHC	4g Long+IPv6	4g Short+IPHC	Frame Saving
50 B	1	1	1	1	—
100 B	2	1	1	1	-1 (-50%)
256 B	5	3	1	1	-4 (-80%)
512 B	10	5	1	1	-9 (-90%)
1024 B	19	10	1	1	-18 (-95%)
1280 B	23	12	1	1	-22 (-96%)
1500 B	27	14	1	1	-26 (-96%)
2000 B	36	19	1	1	-35 (-97%)

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ON-AIR TIME & CHANNEL EFFICIENCY (MR-FSK 100 kbps)

On-Air Time to Deliver 1280-byte Application Payload (100 kbps MR-FSK)



Config comparison	
Original 802.15.4 Long Addr + IPv6/UDP	23 frames · 234 ms · 2921 bytes on air
Original 802.15.4 Short Addr + 6LoWPAN	12 frames · 122 ms · 1524 bytes on air
802.15.4g Long Addr + IPv6/UDP	1 frame · 164 ms · 2047 bytes on air
802.15.4g Short Addr + 6LoWPAN	1 frame · 164 ms · 2047 bytes on air

Battery

MR-FSK 100 kbps: 4g short-mode uses 1 frame vs 23 original frames for 1280B → 23× less TX energy.

Retries

Fewer frames = fewer ACKs needed = lower probability of a retry storm under heavy load.

Throughput

Channel utilisation drops dramatically: 1 frame of 2047B vs 23 frames of 127B clears the channel faster.

Latency

Single-frame delivery eliminates reassembly delay entirely — critical for real-time metering data.

802.15.4g PHY MODES: DATA RATES, FRAME SIZES & OVERHEAD

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PHY Mode	Freq Band	Data Rates	Max PSDU	SHR+PHR	Net MAC cap (short+IPHC)
MR-FSK	Sub-GHz (863–928 MHz)	6.25–400 kbps	2047 B	4–20 B	2022 B
MR-OFDM	Sub-GHz (863–928 MHz)	50–800 kbps	2047 B	6–8 B	2020 B
MR-O-QPSK	Sub-GHz 2.4 GHz	12.5–1000 kbps	2047 B	4–6 B	2022 B
O-QPSK	2.4 GHz	250 kbps	127 B	6 B	110 B (with IPHC)
BPSK	Sub-GHz	20/40 kbps	127 B	12–40 B	98 B (with IPHC)

802.15.4g MR-PHY modes (teal rows) all support the same 2047-byte PSDU, enabling single-frame IPv6 1280-byte MTU delivery across sub-GHz smart utility bands. Net MAC capacity assumes short addressing + 6LoWPAN IPHC + 4-byte CRC-32.

Short Address Management

- ▶ PAN Coordinator assigns 16-bit addresses — max 65,534 nodes per PAN
- ▶ Must handle address reuse after node departure or battery-flat events
- ▶ PAN ID compression bit (Frame Control) eliminates Src PAN if same PAN
- ▶ In large SUN deployments, consider multiple PANs with a backbone router

CRC-32 & PHY Overhead

- ▶ Default 4g FCS is 4 bytes (CRC-32) vs 2 bytes (CRC-16) in original 15.4
- ▶ CRC-16 option exists in 4g but rarely used — check interoperability
- ▶ PHY preamble length varies by MR-FSK mode (2–8 bytes SHR)
- ▶ Factor PHY overhead into payload calculations — mode-dependent

6LoWPAN in 802.15.4g Context

- ▶ Fragmentation rarely needed: 2028-byte cap >> 1280-byte IPv6 MTU
- ▶ IPHC context tables still needed for address compression (RFC 6775 ND)
- ▶ Mesh Addressing Header adds 4–8 bytes: still negligible at 4g frame sizes
- ▶ 6LoWPAN-ND preferred over standard NDP to limit multicast flooding

Stack & Protocol Checklist

- ▶ Enable MR-FSK/OFDM/O-QPSK PHY in radio driver for 4g operation
- ▶ Set MAC max frame size to 2047 in MLME-SET / PIB attribute
- ▶ Enable IPHC (RFC 6282) + ND context distribution (RFC 6775)
- ▶ Verify CoAP/DTLS/application layers handle larger MTU correctly

SUMMARY & KEY TAKEAWAYS

802.15.4g + Short Addressing + 6LoWPAN

2047 BMax 4g PSDU
(vs 127 B original)**12 B**MAC header saving
(short vs long addr)**36×**Payload increase
(baseline → 4g optimised)

802.15.4g extends the PSDU to 2047 bytes across MR-FSK, MR-OFDM and MR-O-QPSK PHY modes — designed for smart utility networks

Short 16-bit addressing saves 12 bytes per frame MAC header (EUI-64 removed: 16 B → 4 B addrs, offset by +2 B CRC-32 vs CRC-16)

6LoWPAN IPHC eliminates 42–46 bytes of IPv6+UDP overhead — still highly valuable even at 4g frame sizes for dense telemetry traffic

Critical: the full 1280-byte IPv6 MTU fits in a single 4g frame — fragmentation is eliminated for virtually all application payloads

For 1280-byte payload delivery: original 802.15.4 needed 23 frames; 4g short+IPHC delivers it in 1 frame — 23× fewer transmissions

Submission

IEEE 802.15.4-2011 · IEEE 802.15.4g-2012 · RFC 4944 · RFC 6282 · RFC 6775