

IP header compression for LPWANs

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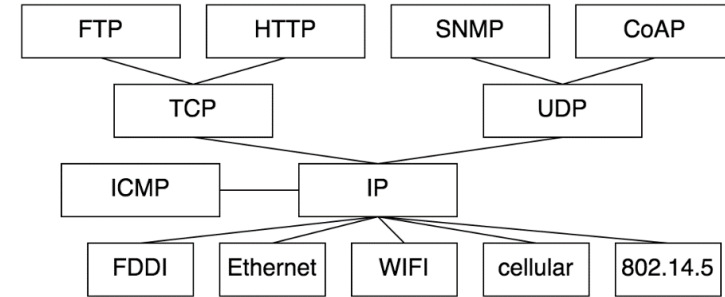


Orange Expert
Future
networks

Motivation

Why IP over LPWANs?

Internet Protocols (IP) have taken over the world of networking



Some Low-Power Wide Area Networks (LPWANs) have remained non-IP so far

- IP deemed too heavyweight, not needed
- Sigfox: 12 bytes uplink, 8 bytes downlink; LoRaWAN: US 11 bytes, EU 52 bytes min payload

Cost of custom LPWAN protocols, security models, APIs

- Technology-specific training and tools
- Protocol translation gateways

Long track record of IP Header compression, fragmentation

- Van Jacobson TCP/IP header compression, RFC1144 (1990)
- RoHC (Robust Header Compression) (2000-2010), see RFC 5795 for overview
 - Used in VoLTE: RTP/UDP/IP, AMR12.2 vocoder 28.8kbps → ~15 kbps
- 6LoWPAN (2005 - 2014), 6lo (2014 -), dedicated to IEEE 802.15.4, frames usually ~100 bytes



G3-PLC
Alliance

Why not just use 6LoWPAN for LPWANs?

RFC 4944 Header Compression

- Only compresses link-local prefixes
- Only compresses IIDs derived out of L2 address
- Best case is 7 bytes for UDP/IPv6 headers

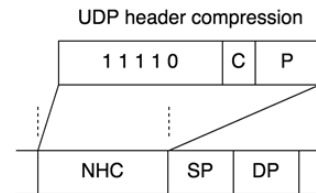
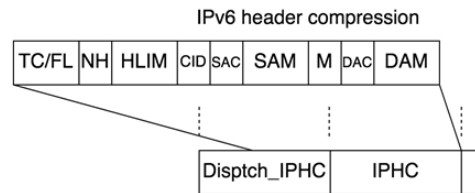
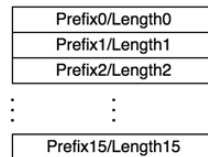
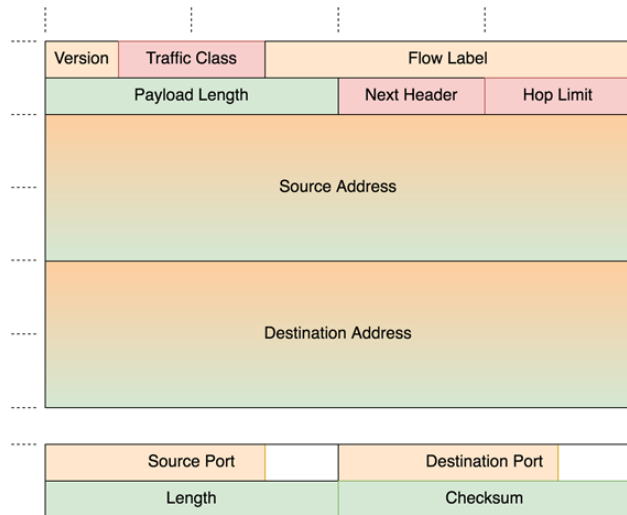
RFC 4944 Fragmentation

- 5 bytes Fragmentation Header
- Fragment Payload in 8 bytes increments
- No individual Fragment acknowledgement and retransmission

RFC 6282 Header Compression

- 4-6 bytes for UDP/IPv6 headers (routable addresses)
- Still byte-aligned, custom-tailored per protocol

→ Can do better with new standard



SCHC

SCHC fundamental principles

Assumes

- rare configuration/application changes
- very constrained transmission (energy, time on air)
- constrained memory, not-so-constrained computation
- point-to-point link, no out-of-order delivery

Supports

- unidirectional/asymmetric or bidirectional links
- constant or variable MTU

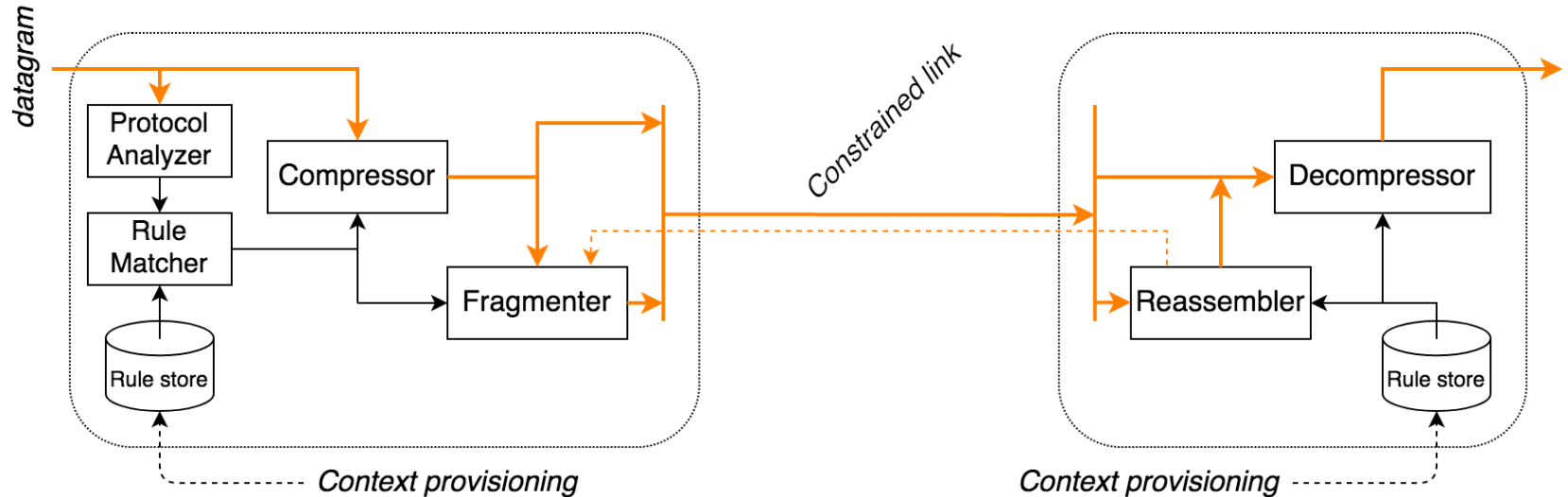
Provides

- flexible mechanism, not dedicated to any upper/lower layer
- extreme header compression
- efficient fragmentation
- little control dialog

SCHC generic architecture

SCHC: “*Static Context Header Compression and fragmentation*”

- **Context is static for the duration of the communication**
 - Contains Compression Rules, Fragmentation Rules
- **Compression is conducted according to Rule with a pattern matching the datagram**
- **Fragmentation is applied if needed**



SCHC generic framework

RuleIDs

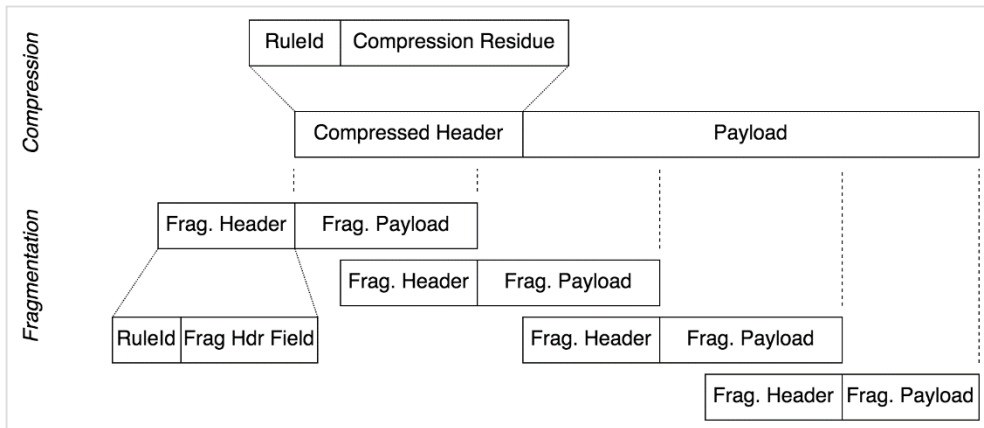
- No set RuleID size per RFC 8724
- RuleID can be of variable size (entropic encoding)
- Compression and Fragmentation Rules share the same name space
- Compression RuleIDs apply to a single data direction
 - Same RuleID can be re-used for a different Rule in the reverse direction
- Fragmentation RuleIDs apply to both directions, if link is bidirectional
 - Match ACKs with data

Encapsulation

- Compressed Packet is fragmented, if needed

RuleID assignment example

0	Compression Rule 1
1 0	Compression Rule 2
1 1 0 0	Compression Rule 3
1 1 0 1	Fragmentation Rule 1
1 1 1 0	Fragmentation Rule 2
1 1 1 1 x x	...



SCHC compression (1/3)

Matching Operators, Compression/Decompression Actions

For each expected Field

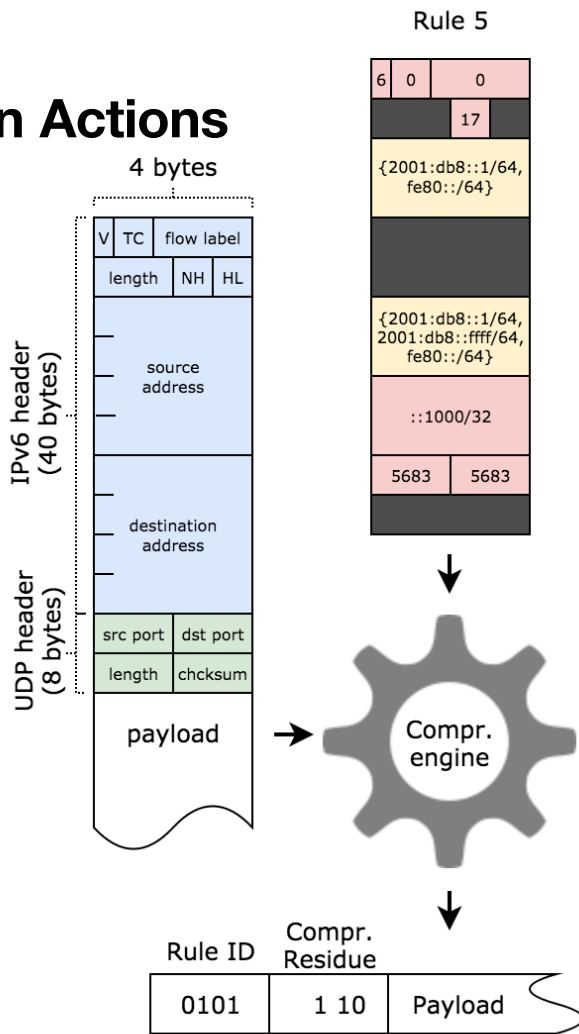
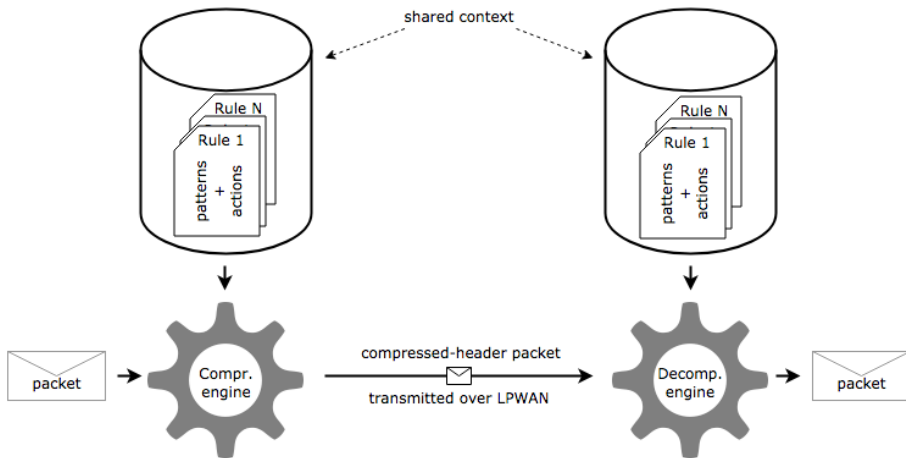
Target Value (scalar or list)

Matching Operator

- Equal, Ignored, Match-mapping, MSB(x)

C/D Action

- Elided, Sent, Recomputed, DevIID, Mapping-sent, LSB



SCHC compression (2/3)

More complex protocols

Not just bit-pattern matching on incoming packet

Protocol analyzer needed

- Itemizes and labels each Header Field
- Some Fields may be of variable length
 - CoAP uri-path, uri-query, ...
- Some Fields may occur multiple times
 - CoAP uri-path, uri-query, ...

Wireshark · Paquet 69 · 2020_10_15-23h36.pcapng

▶ Frame 69: 76 bytes on wire (608 bits), 76 bytes captured (608 bits) on interface
▶ Linux cooked capture
▶ Internet Protocol Version 4, Src: 161.106.2.62, Dst: 92.180.153.132
▶ User Datagram Protocol, Src Port: 5683, Dst Port: 56830
▶ **Constrained Application Protocol, Confirmable, PUT, MID:26424**

- 01.. = Version: 1
- ..00 = Type: Confirmable (0)
- 1000 = Token Length: 8
- Code: PUT (3)
- Message ID: 26424
- Token: 2c6a4b9610cba57d
- ▼ Opt Name: #1: Uri-Path: 3311
 - Opt Desc: Type 11, Critical, Unsafe
 - 1011 = Opt Delta: 11
 - 0100 = Opt Length: 4
 - Uri-Path: 3311
- ▼ Opt Name: #2: Uri-Path: 0
 - Opt Desc: Type 11, Critical, Unsafe
 - 0000 = Opt Delta: 0
 - 0001 = Opt Length: 1
 - Uri-Path: 0
- ▼ Opt Name: #3: Uri-Path: 5850
 - Opt Desc: Type 11, Critical, Unsafe
 - 0000 = Opt Delta: 0
 - 0100 = Opt Length: 4
 - Uri-Path: 5850
- ▼ Opt Name: #4: Content-Format: application/vnd.oma.lwm2m+tlv
 - Opt Desc: Type 12, Elective, Safe
 - 0001 = Opt Delta: 1
 - 0010 = Opt Length: 2
 - Content-type: application/vnd.oma.lwm2m+tlv
 - End of options marker: 255
 - [Uri-Path: /3311/0/5850]
 - [Response In: 71]
- ▶ Payload: Payload Content-Format: application/vnd.oma.lwm2m+tlv, Length: 4
- ▶ Lightweight M2M TLV (1 element)

0010	45 00 00 3c 76 e5 40 00	40 11 29 eb a1 6a 02 3e	E<v@.@.)..j>
0020	5c b4 99 84 16 33 dd fe	00 28 9a 1a 48 03 67 38	\...3... (.H.g8
0030	2c 6a 4b 96 10 cb a5 7d	b4 33 33 31 31 01 30 04	,jK....} .3311.0.
0040	35 38 35 30 12 2d 16 ff	e1 16 da 01	5850.... ..

Aide Fermer

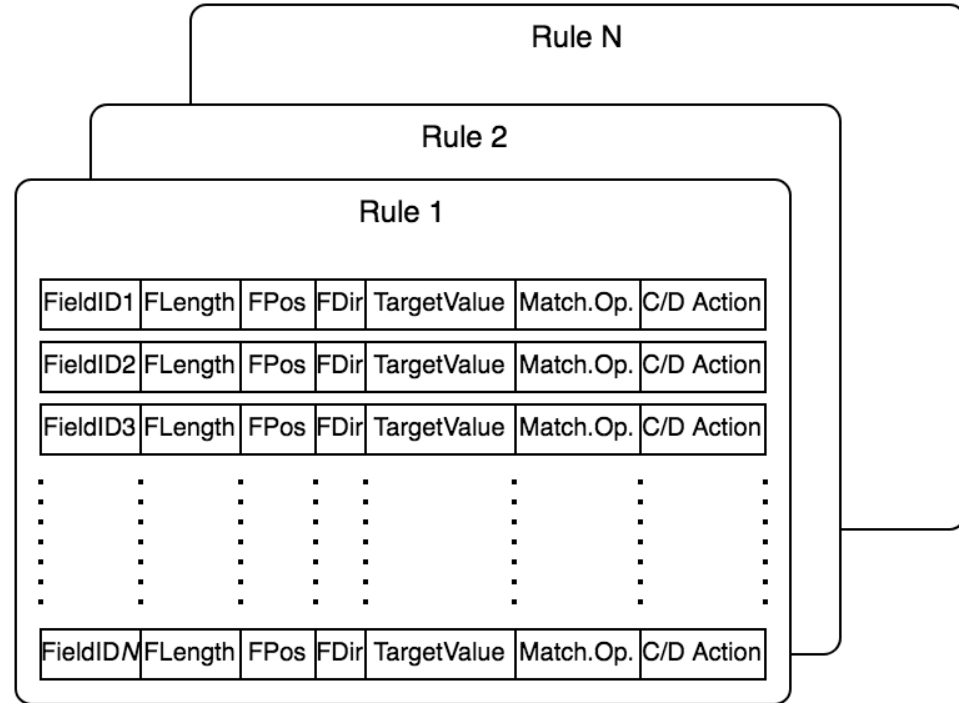
SCHC compression (3/3)

More complex headers

Rule includes

- **Field expected Position**
- **Field expected Length**
 - may be **Variable**:
Compression Residue Length needs to be transmitted
- **Direction Indicator**
 - **Allows sharing customized Rule between uplink/downlink**
 - **E.g., IPv6 Source/Destination prefixes swapped**

Formal Rules description in progress

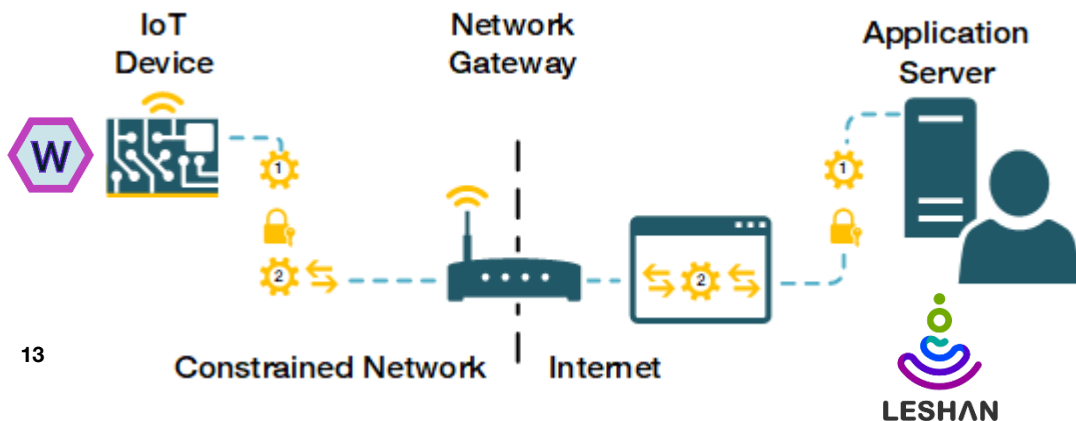


Using SCHC

LwM2M/OSCORE/CoAP/UDP/IPv6 compression

Smart Tracking application using LwM2M

- mangOH Red Wakaama client, Leshan server
- DTLS, OSCORE and SCHC proxies developed by Acklio
- double SCHC compression (before/after encryption)



mangOH® Red – Orange™ LTE-M Starter Kit



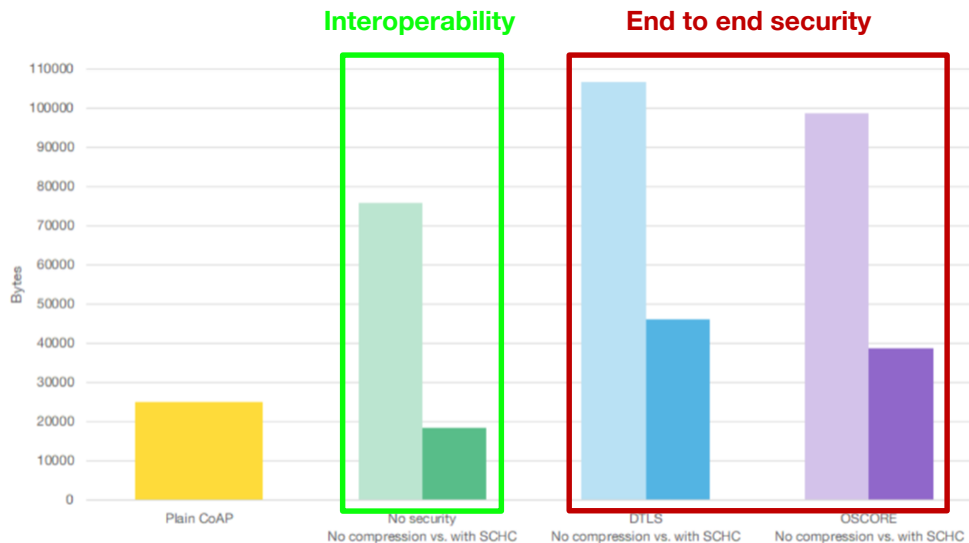
Build low-power LTE-M IoT applications that can run for up to 10 years on a battery with the newest and smallest mangOH platform and Orange LTE-M network in Europe, and send your IoT sensor data to Orange Live Objects cloud.

Longitude	48° 1'	Observe	Read	5.8600687980651855
Altitude	65/3	Observe	Read	
Radius	65/3	Observe	Read	
Velocity	65/4	Observe	Read	
Timestamp	65/5	Observe	Read	2021-01-23T16:26:31+01:00
Speed	65/6	Observe	Read	
Temperature				
Instance 0				
Min Measured Value	3303/0	Observe	Read	
Max Measured Value	3303/0/0601	Observe	Read	
Min Range Value	3303/0/0602	Observe	Read	
Max Range Value	3303/0/0603	Observe	Read	
Reset Min and Max Measured Values	3303/0/0604	Observe	Read	
Sensor Value	3303/0/0605	Observe	Read	31.579999923706055
Sensor Units	3303/0/0701	Observe	Read	
Light Control				
Instance 0				
Sensor Units	3311/0	Observe	Read	
Colour	3311/0/0701	Observe	Read	
Application Type	3311/0/0702	Observe	Read	
Cumulative active power	3311/0/0703	Observe	Read	
Power factor	3311/0/0704	Observe	Read	
On/Off	3311/0/0705	Observe	Read	
Dimmer	3311/0/0706	Observe	Read	
On time	3311/0/0707	Observe	Read	

LwM2M/OSCORE/CoAP/UDP/IPv6 compression demo

Smart Tracking application using LwM2M

- demo shown at the Orange 2021 “Salon de la Recherche”
- paper submitted to Globecom2021 IoTSN



DLMS over LoRaWAN

Stitching standards together rather than defining a new one

DLMS/COSEM

- an application protocol and data model
- widely used in electric/gas smart metering
- 400-500 bytes payloads typical



Wanted to allow LoRaWAN to carry DLMS

- Write new adaptation spec?

Already had DLMS/UDP/IP profile

- UDP/IPv6/LoRaWAN stack is the straightforward solution

To know more

- Official [announcement](#) (Oct 6th 2020)
- DLMS over LoRaWAN [introduction](#)

What's next

Conclusions and Perspectives

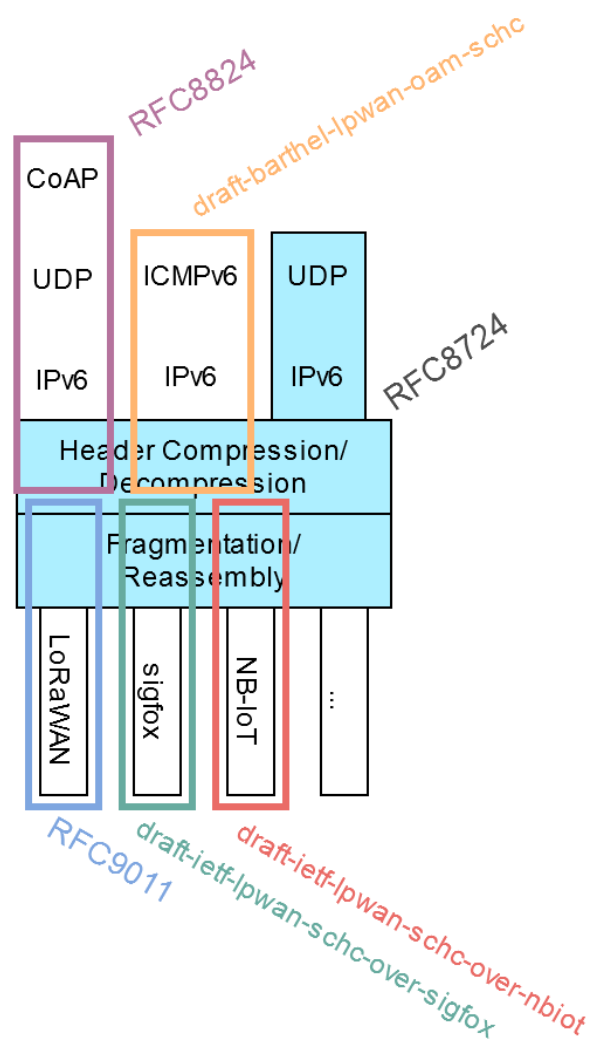
Achieved

- base technology established, standardized
- adoption started



Next steps

- Open source implementation <https://github.com/openschc>
- More profiles for upper layers
- More profiles for underlying layers
- Context formal definition
- Context provisioning protocol
- Automated rule generation
- Performance evaluation



Thanks

References

RFC 8376 « Low-Power Wide Area Network (LPWAN) Overview », May 2018, <https://www.rfc-editor.org/info/rfc8376>

RFC 8724 « SCHC: Generic Framework for Static Context Header Compression and Fragmentation », Apr 2020, <https://www.rfc-editor.org/info/rfc8724>

RFC 8824 « Static Context Header Compression (SCHC) for the Constrained Application Protocol (CoAP) », June 2021, <https://www.rfc-editor.org/info/rfc8824>

RFC 9011 « Static Context Header Compression and Fragmentation (SCHC) over LoRaWAN », Apr 2021, <https://www.rfc-editor.org/info/rfc9011>

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Open Source project <http://openschc.net>