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LPWAN Static Context Header Compression (SCHC) Architecture
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Abstract

This document defines the LPWAN SCHC architecture.

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1. Introduction

The IETF LPWAN WG defined the necessary operations to enable IPv6 over selected Low-Power Wide Area Networking (LPWAN) radio technologies. [rfc8376] presents an overview of those technologies.

The Static Context Header Compression (SCHC) [rfc8724] technology is the core product of the IETF LPWAN working group. [rfc8724] defines a generic framework for header compression and fragmentation, based on a static context that is pre-installed on the SCHC endpoints.

This document details the constitutive elements of a SCHC-based solution, and how the solution can be deployed. It provides a general architecture for a SCHC deployment, positioning the required specifications, describing the possible deployment types, and indicating models whereby the rules can be distributed and installed to enable reliable and scalable operations.

2. LPWAN Technologies and Profiles

Because LPWAN technologies [rfc8376] have strict yet distinct constraints, e.g., in terms of maximum frame size, throughput, and/or directionality, a SCHC instance must be profiled to adapt to the specific necessities of the technology to which it is applied.

Appendix D. "SCHC Parameters" of [rfc8724] lists the information that an LPWAN technology-specific document must provide to profile SCHC for that technology.

As an example, [rfc9011] provides the SCHC profile for LoRaWAN networks.

3. The Static Context Header Compression

SCHC [rfc8724] specifies an extreme compression capability based on a state that must match on the compressor and decompressor side. This state comprises a set of Compression/Decompression (C/D) rules.

The SCHC Parser analyzes incoming packets and creates a list of fields that it matches against the compression rules. The rule that matches best is used to compress the packet, and the rule identifier (RuleID) is transmitted together with the compression residue to the decompressor. Based on the RuleID and the residue, the decompressor can rebuild the original packet and forward it in its uncompressed form over the Internet.

[rfc8724] also provides a Fragmentation/Reassembly (F/R) capability to cope with the maximum and/or variable frame size of a Link, which is extremely constrained in the case of an LPWAN network.

If a SCHC-compressed packet is too large to be sent in a single Link-Layer PDU, the SCHC fragmentation can be applied on the compressed packet. The process of SCHC fragmentation is similar to that of compression; the fragmentation rules that are programmed for this Device are checked to find the most appropriate one, regarding the SCHC packet size, the link error rate, and the reliability level required by the application.

The ruleID allows to determine if it is a compression or fragmentation rule.

4. SCHC Applicability

4.1. LPWAN Overview

4.2. Compressing Serial Streams

[rfc8724] was defined to compress IPv6 [rfc8200] and UDP; but SCHC really is a generic compression and fragmentation technology. As such, SCHC is agnostic to which protocol it compresses and at which layer it is operated. The C/D peers may be hosted by different entities for different layers, and the F/R operation may also be performed between different parties, or different sub-layers in the same stack, and/or managed by different organizations.

If a protocol or a layer requires additional capabilities, it is always possible to document more specifically how to use SCHC in that context, or to specify additional behaviours. For instance, [rfc8824] extends the compression to CoAP [RFC7252] and OSCORE [RFC8613].

4.3. Example: Goose and DLMS

5. SCHC Architecture

5.1. SCHC Endpoints

Section 3 of [rfc8724] depicts a typical network architecture for an LPWAN network, simplified from that shown in [rfc8376] and reproduced in Figure 1.

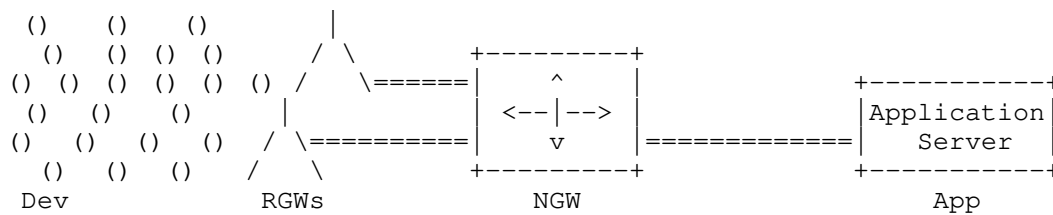


Figure 1: Typical LPWAN Network Architecture

Typically, an LPWAN network topology is star-oriented, which means that all packets between the same source-destination pair follow the same path from/to a central point. In that model, highly constrained Devices (Dev) exchange information with LPWAN Application Servers (App) through a central Network Gateway (NGW), which can be powered and is typically a lot less constrained than the Devices. Because Devices embed built-in applications, the traffic flows to be compressed are known in advance and the location of the C/D and F/R functions (e.g., at the Dev and NGW), and the associated rules, can be pre provisioned in the system before use.

The SCHC operation requires a shared sense of which SCHC Device is Uplink (Dev to App) and which is Downlink (App to Dev), see [rfc8376]. In a star deployment, the hub is always considered Uplink and the spokes are Downlink. The expectation is that the hub and spoke derive knowledge of their role from the network configuration and SCHC does not need to signal which is hub thus Uplink vs. which is spoke thus Downlink. In other words, the link direction is determined from extrinsic properties, and is not advertised in the protocol.

Nevertheless, SCHC is very generic and its applicability is not limited to star-oriented deployments and/or to use cases where applications are very static and the state provisioned in advance. In particular, a peer-to-peer (P2P) SCHC Instance (see Section 5.2) may be set up between peers of equivalent capabilities, and the link direction cannot be inferred, either from the network topology nor from the device capability.

In that case, by convention, the device that initiates the connection that sustains the SCHC Instance is considered as being Downlink, IOW it plays the role of the Dev in [rfc8724].

This convention can be reversed, e.g., by configuration, but for proper SCHC operation, it is required that the method used ensures that both ends are aware of their role, and then again this determination is based on extrinsic properties.

5.2. SCHC Instances

[rfc8724] defines a protocol operation between a pair of peers. A session called a SCHC Instance is established and SCHC maintains a state and timers associated to that Instance.

When the SCHC Device is a highly constrained unit, there is typically only one Instance for that Device, and all the traffic from and to the device is exchanged with the same Network Gateway. All the traffic can thus be implicitly associated with the single Instance

that the device supports, and the Device does not need to manipulate the concept. For that reason, SCHC avoids to signal explicitly the Instance identification in its data packets.

The Network Gateway, on the other hand, maintains multiple Instances, one per SCHC Device. The Instance is derived from the lower layer, typically the source of an incoming SCHC packet. The Instance is used in particular to select from the rule database the set of rules that apply to the SCHC Device, and the current state of their exchange, e.g., timers and previous fragments.

This architecture generalizes the model to any kind of peers. In the case of more capable devices, a SCHC Device may maintain more than one Instance with the same peer, or a set of different peers. Since SCHC does not signal the Instance in its packets, the information must be derived from a lower layer point to point information. For instance, the SCHC session can be associated one-to-one with a tunnel, a TLS session, or a TCP or a PPP connection.

For instance, [I-D.thubert-intarea-schc-over-ppp] describes a type of deployment where the C/D and/or F/R operations are performed between peers of equal capabilities over a PPP [rfc2516] connection. SCHC over PPP illustrates that with SCHC, the protocols that are compressed can be discovered dynamically and the rules can be fetched on-demand by both parties from the same Uniform Resource Name (URN) [rfc8141], ensuring that the peers use the exact same set of rules.

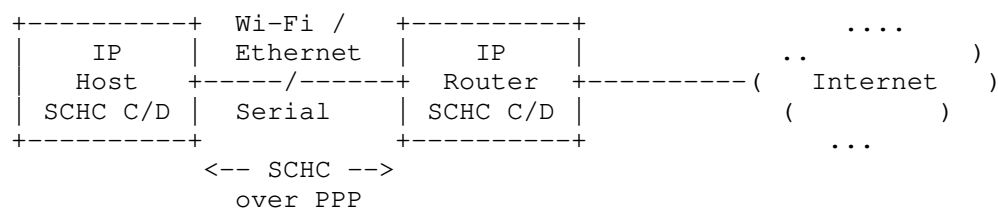


Figure 2: PPP-based SCHC Deployment

In that case, the SCHC Instance is derived from the PPP connection. This means that there can be only one Instance per PPP connection, and that all the flow and only the flow of that Instance is exchanged within the PPP connection.

5.3. Layering with SCHC Instances

[rfc8724] states that a SCHC instance needs the rules to process C/D and F/R before the session starts, and that rules cannot be modified during the session.

As represented figure Figure 3, the compression of the IP and UDP headers may be operated by a network SCHC instance whereas the end-to-end compression of the application payload happens between the Device and the application. The compression of the application payload may be split in two instances to deal with the encrypted portion of the application PDU. Fragmentation applies before LPWAN transportation layer.

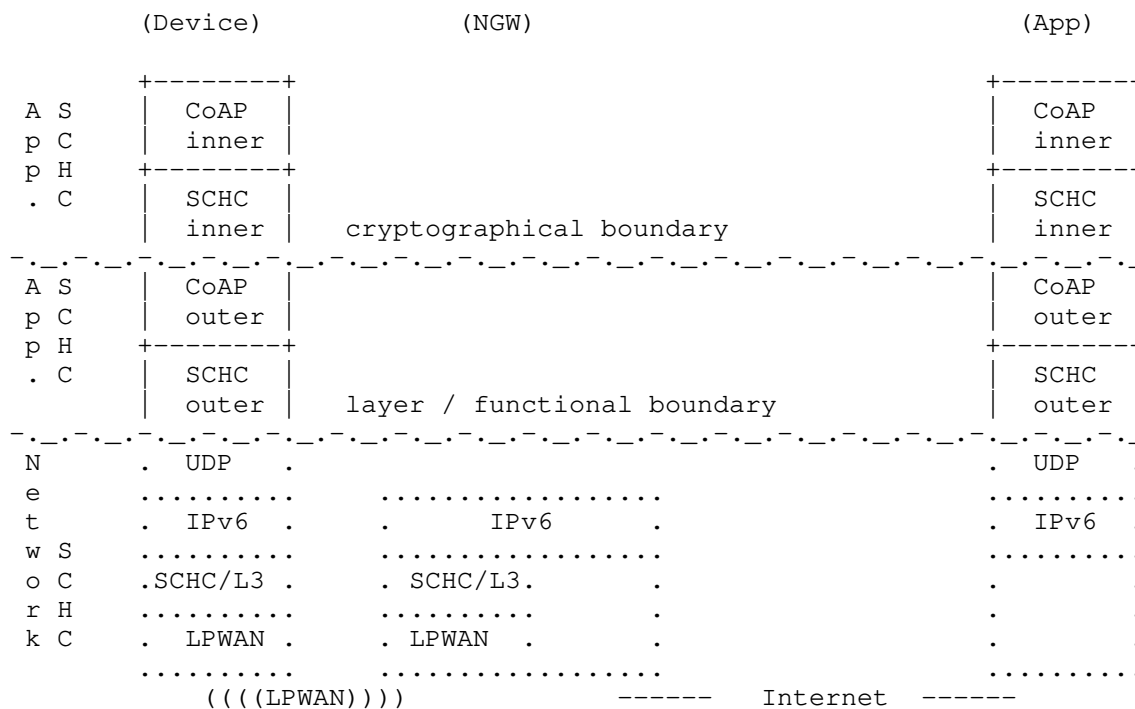


Figure 3: Different SCHC instances in a global system

This document defines a generic architecture for SCHC that can be used at any of these levels. The goal of the architectural document is to orchestrate the different protocols and data model defined by the LPWAN working group to design an operational and interoperable framework for allowing IP application over constrained networks.

6. SCHC Data Model

A SCHC instance, summarized in the Figure 4, implies C/D and/or F/R present in both end and that both ends are provisioned with the same set of rules.



Figure 4: Summarized SCHC elements

A common rule representation that expresses the SCHC rules in an interoperable fashion is needed to be able to provision end-points from different vendors. To that effect, [I-D.ietf-lpwan-schc-yang-data-model] defines a rule representation using the YANG [rfc7950] formalism.

[I-D.ietf-lpwan-schc-yang-data-model] defines a YANG data model to represent the rules. This enables the use of several protocols for rule management, such as NETCONF[RFC6241], RESTCONF[RFC8040], and CORECONF[I-D.ietf-core-comi]. NETCONF uses SSH, RESTCONF uses HTTPS, and CORECONF uses CoAP(s) as their respective transport layer protocols. The data is represented in XML under NETCONF, in JSON[RFC8259] under RESTCONF and in CBOR[RFC8949] under CORECONF.

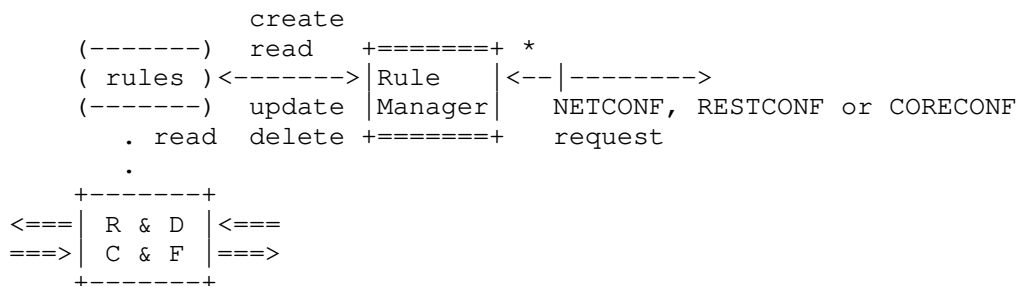


Figure 5: Summarized SCHC elements

The Rule Manager (RM) is in charge of handling data derived from the YANG Data Model and apply changes to the rules database Figure 5.

The RM is an Application using the Internet to exchange information, therefore:

- * for the network-level SCHC, the communication does not require routing. Each of the end-points having an RM and both RMs can be viewed on the same link, therefore wellknown Link Local addresses

can be used to identify the Device and the core RM. L2 security MAY be deemed as sufficient, if it provides the necessary level of protection.

- * for application-level SCHC, routing is involved and global IP addresses SHOULD be used. End-to-end encryption is RECOMMENDED.

Management messages can also be carried in the negotiation protocol as proposed in [I-D.thubert-intarea-schc-over-ppp]. The RM traffic may be itself compressed by SCHC: if CORECONF protocol is used, [rfc8824] can be applied.

7. SCHC Device Lifecycle

In the context of LPWANs, the expectation is that SCHC rules are associated with a physical device that is deployed in a network. This section describes the actions taken to enable an automatic commissioning of the device in the network. SCHC

7.1. Device Development

The expectation for the development cycle is that message formats are documented as a data model that is used to generate rules. Several models are possible:

1. In the application model, an interface definition language and binary communication protocol such as Apache Thrift is used, and the serialization code includes the SCHC operation. This model imposes that both ends are compiled with the generated structures and linked with generated code that represents the rule operation.
2. In the device model, the rules are generated separately. Only the device-side code is linked with generated code. The Rules are published separately to be used by a generic SCHC engine that operates in a middle box such as a SCHC gateway.
3. In the protocol model, both endpoint generate a packet format that is imposed by a protocol. In that case, the protocol itself is the source to generate the Rules. Both ends of the SCHC compression are operated in middle boxes, and special attention must be taken to ensure that they operate on the compatible Rule sets, basically the same major version of the same Rule Set.

Depending on the deployment, the tools that generate the Rules should provide knobs to optimize the Rule set, e.g., more rules vs. larger residue.

7.2. Rules Publication

In the device model and in the protocol model, at least one of the endpoints must obtain the rule set dynamically. The expectation is that the Rule Sets are published to a reachable repository and versioned (minor, major). Each rule set should have its own Uniform Resource Names (URN) [RFC8141] and a version.

The Rule Set should be authenticated to ensure that it is genuine, or obtained from a trusted app store. A corrupted Rule Set may be used for multiple forms of attacks, more in Section 8.

7.3. SCHC Device Deployment

The device and the network should mutually authenticate themselves. The autonomic approach [RFC8993] provides a model to achieve this at scale with zero touch, in networks where enough bandwidth and compute are available. In highly constrained networks, one touch is usually necessary to program keys in the devices.

The initial handshake between the SCHC endpoints should comprise a capability exchange whereby URN and the version of the rule set are obtained or compared. SCHC may not be used if both ends can not agree on an URN and a major version. Manufacturer Usage Descriptions (MUD) [RFC8520] may be used for that purpose in the device model.

Upon the handshake, both ends can agree on a rule set, their role when the rules are asymmetrical, and fetch the rule set if necessary. Optionally, a node that fetched a rule set may inform the other end that it is ready for transmission.

7.4. SCHC Device Maintenance

URN update without device update (bug fix) FUOTA => new URN => reprovisioning

7.5. SCHC Device Decommissioning

Signal from device/vendor/network admin

8. Security Considerations

SCHC is sensitive to the rules that could be abused to form arbitrary long messages or as a form of attack against the C/D and/or F/R functions, say to generate a buffer overflow and either modify the Device or crash it. It is thus critical to ensure that the rules are distributed in a fashion that is protected against tempering, e.g., encrypted and signed.

9. IANA Consideration

This document has no request to IANA

10. Acknowledgements

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