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H. Chen
J. Liu
W. Li
K. Zhao
Nanjing University
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SRv6 Segment Identifier Compression for Satellite Networks
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Abstract

This document defines a compression method for Segment Identifiers (SIDs) in Segment Routing over IPv6 (SRv6) specifically designed for satellite networks. By leveraging the topological location information of satellite nodes, a 128-bit SID is compressed into a 32-bit Compressed SID (C-SID). The method introduces a "SID Container" structure to support the co-existence of 128-bit SIDs and 32-bit C-SIDs within a single Segment List without modifying the SRv6 control plane or the fixed SRH header format defined in RFC 8754.

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1. Introduction

Satellite networks face unique constraints such as limited onboard computing power and storage resources. When applying SRv6 to satellite constellations, long service paths or complex policies lead to significant Segment Routing Header (SRH) [RFC8754] overhead, which reduces effective payload and increases the risk of MTU fragmentation. Existing compression schemes often rely on complex endpoint behaviors or rigid block planning, which are difficult to implement and maintain in dynamic satellite environments. This document [CHEN-SAT-CSID] proposes a lightweight compression method that maps satellite topological semantics (layer, orbit, and node index) directly into a 32-bit C-SID. This approach enhances network observability and efficiency while maintaining full compatibility with standard SRv6 data plane processing [RFC8986].

2. Conventions Used in This Document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

3. Terminology

SID Container: A 128-bit basic unit in the SRH Segment List used to carry either one 128-bit SID or multiple 32-bit C-SIDs.

C-SID: Compressed Segment Identifier, 32 bits in length.

CSI (Compressed SID Index): A field used to indicate the position of a C-SID within a SID Container.

C-Flag (Compression Flag): A flag used to distinguish between C-SIDs and standard SIDs.

4. Design Goals

This document targets satellite constellation environments where SRv6 policies may traverse long paths and frequently change. The mechanism is designed to achieve the following goals:

- * **Compatibility:** Preserve the fixed SRH header format and standard SRv6 processing model.
- * **No control-plane extension:** Avoid modifications to SRv6 control plane signaling; only the segment list representation is optimized.
- * **Topology awareness:** Encode satellite topological semantics (layer, orbit, and node index) directly into the identifier.
- * **Multi-scale orchestration:** Allow interleaving of compressed 32-bit C-SIDs and regular 128-bit SIDs within a single Segment List.
- * **Implementation simplicity:** Use lightweight packing/decoding logic suitable for resource-constrained onboard platforms.

- * 00: Slot 4 (bits 96-127)

C-Flag (1 bit): MUST be set to 1 if the unit is a C-SID; it MUST be set to 0 if it is a standard SID or padding.

6.2. SID Container and Multi-scale Orchestration

The SRH Segment List is reorganized into 128-bit SID Containers. Each container MUST function in one of two modes:

1. Standard Mode: Carries a single 128-bit uncompressed SID. The lowest bit (C-Flag) of the container MUST be set to 0.
2. Compressed Mode: Carries 1 to 4 C-SIDs. The lowest bit (C-Flag) of the container MUST be set to 1.

This design allows for multi-scale identifier orchestration where C-SIDs and standard SIDs are interleaved within the same Segment List. If a container is not fully filled with 4 C-SIDs, the remaining bits SHOULD be set to zero as padding, with their C-Flags marked as 0.

6.3. Forwarding and Decoding Logic

6.3.1. Identification and Reading

When a satellite node processes an SRH, it SHOULD locate the current SID Container via the Segment Left (SL) pointer. The type is judged by the lowest bit (C-Flag):

- * If C-Flag == 0: Read as a standard SID. After processing, decrement SL by 1.
- * If C-Flag == 1: Read the C-SID.
 - If CSI != 0: Process the C-SID and offset the internal reading pointer by 32 bits within the container.
 - If CSI == 0: After processing, the container is exhausted. Decrement SL by 1 to point to the next container.

6.3.2. Decoding to IPv6 Address

To facilitate forwarding, a 32-bit C-SID MUST be decoded into a 128-bit IPv6 destination address:

- * Prefix (48 bits): Taken from the common prefix of the satellite constellation (derived from the Source IP address).

- * C-Locator (16 bits): Appended to the prefix to form a 64-bit addressing prefix.
- * Behavioral Mapping (16 bits): C-SID bits C[15:0] MUST be mapped to bits 65-80 of the IPv6 address.
- * Final Flags: The C-Flag MUST be mapped to the lowest bit of the IPv6 address, with remaining bits set to zero.

6.3.3. Operational Advantages

- * No Protocol Extension: Works with existing SRH formats [RFC8754] and SRv6 control plane protocols.
- * Topological Awareness: Directly correlates SIDs with satellite coordinates (layer/orbit/node).
- * High Efficiency: Eliminates the need to carry 128-bit Block prefixes in the first segment of compressed lists.

7. Security Considerations

As satellite networks are vulnerable to link exposure, the integrity of the SID Container SHOULD be protected. Standard SRH security mechanisms SHOULD be applied [RFC8754].

7.1. Privacy and Topology Exposure

Because C-SIDs embed topological semantics, deployments SHOULD consider the risk of topology disclosure on untrusted links.

7.2. Address Scanning

Implementations SHOULD consider rate limiting and filtering to reduce scanning and probing risks in exposed environments.

8. IANA Considerations

This document requests no new allocations from IANA.

9. Acknowledgements

The authors thank the IETF SPRING working group and the satellite networking research community for discussions that motivated this work.

10. Normative References

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Authors' Addresses

Hongyan Chen
Nanjing University
163 Xianlin Avenue, Qixia District
Nanjing
Jiangsu, 210023
China
Email: chenhongyan6176@163.com

Jun Liu
Nanjing University
Nanjing
Jiangsu,
China
Email: Johnson.liu@nju.edu.cn

Wenfeng Li
Nanjing University
Nanjing
Jiangsu,
China
Email: wenfeng@nju.edu.cn

Kanglian Zhao
Nanjing University
Nanjing
Jiangsu,
China
Email: zhaokanglian@nju.edu.cn