

ETSI TS 103 179 V1.2.1 (2023-06)



Satellite Earth Stations and Systems (SES); Return Link Encapsulation (RLE) protocol

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[ETSI TS 103 179 V1.2.1 \(2023-06\)](https://standards.iteh.ai/catalog/standards/sist/9f781dbd-4de5-4162-a3f7-5a5d1079b07d/etsi-ts-103-179-v1-2-1-2023-06)

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Reference

RTS/SES-00458

Keywords

MSS, protocol, satellite

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Modal verbs terminology

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1 Scope

The present document specifies the Return Link Encapsulation (RLE) Protocol, which is used to encapsulate and if necessary fragment network layer packets such as for example IP datagrams to allow their transmission over the return link of an interactive satellite network.

RLE has been derived from the Generic Stream Encapsulation (GSE) protocol [1], used in the forward links of interactive and broadcasting satellite networks, which are normally characterized by continuous transmission, limited variability in the size of network layer packets, and large physical layer frames typically capable of carrying more than one network layer packet. RLE was designed to maximize the system efficiency on the return channel, which is in turn characterized by bursty traffic, highly variable size of network layer packets, smaller physical layer bursts, and multiple access constraints.

The RLE protocol is designed to provide three main functionalities which are fully specified in the present document, namely:

- encapsulation;
- fragmentation;
- frame packing.

RLE is today used in DVB-RCS2 [2] as well as in the S-MIM [3] standards.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are necessary for the application of the present document.

- [1] [ETSI TS 102 606](#): "Digital Video Broadcasting (DVB); Generic Stream Encapsulation (GSE) Protocol".
- [2] [ETSI EN 301 545-2](#): "Digital Video Broadcasting (DVB); Second Generation DVB Interactive Satellite System (DVB-RCS2); Part 2: Lower Layers for Satellite standard".
- [3] [ETSI TS 102 721-5](#): "Satellite Earth Stations and Systems (SES); Air Interface for S-band Mobile Interactive Multimedia (S-MIM); Part 5: Protocol Specifications, Link Layer".
- [4] [IETF RFC 4326](#): "Unidirectional Lightweight Encapsulation (ULE) for Transmission of IP Datagrams over an MPEG-2 Transport Stream (TS)".
- [5] [IEEE 802.3-2012™](#): "IEEE Standard for Ethernet".
- [6] [IETF RFC 4944](#): "Transmission of IPv6 Packets over IEEE 802.15.4 Networks".

2.2 Informative references

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] IETF RFC 5163: "Extension Formats for Unidirectional Lightweight Encapsulation (ULE) and the Generic Stream Encapsulation (GSE)".
- [i.2] ETSI EN 301 790: "Digital Video Broadcasting (DVB); Interaction channel for satellite distribution systems".
- [i.3] DVB Document A155-2: "Digital Video Broadcasting (DVB); Second Generation DVB Interactive Satellite System (DVB-RCS2); Part 2: Lower Layers for Satellite standard", January 2013.
- [i.4] ETSI TS 102 721-3: "Satellite Earth Stations and Systems (SES); Air Interface for S-band Mobile Interactive Multimedia (S-MIM); Part 3: Physical Layer Specification, Return Link Asynchronous Access".
- [i.5] ETSI TS 102 721-4: "Satellite Earth Stations and Systems (SES); Air Interface for S-band Mobile Interactive Multimedia (S-MIM); Part 4: Physical Layer Specification, Return Link Synchronous Access".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

Protocol Data Unit (PDU): unit of data produced by a layer of the network stack and given to the next lower layer for transport to the remote peer layer instance

NOTE 1: It contains control information from the current layer and may contain user data from the layer above.

NOTE 2: The SDU of a given layer is the PDU of the layer above.

RLE receiver: entity processing received physical layer frame or burst payloads to reconstruct original network layer packets.

RLE transmitter: entity processing network layer packets to produce physical layer frame or burst payloads to be transmitted through the corresponding physical layer

Service Data Unit (SDU): unit of data that is passed from one layer of the network stack to the next lower layer which has not yet been encapsulated into a PDU by that lower layer

NOTE: It is the set of data given by the user of a layer service to that layer to be transmitted semantically unchanged to the peer service user. The SDU of a given layer is the PDU of the layer above.

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACM	Adaptive Coding and Modulation
ALPDU	Addressed Link PDU
ARQ	Automatic Repeat reQuest
bslbf	bit string, left bit first
CDMA	Code Division Multiple Access
CoS	Class of Service
CRC	Cyclic Redundancy Check
CRDSA	Contention Resolution Diversity Slotted ALOHA
DAMA	Demand Assignment Multiple Access
DCH	Dedicated CHannel
DVB-RCS	Digital Video Broadcasting - Return Channel via Satellite
FEC	Forward Error Correction
FPDU	Frame PDU
GSE	Generic Stream Encapsulation
IP	Internet Protocol
LLC	Logical Link Control
MAC	Medium Access Control
NCC	Network Control Center
PDU	Protocol Data Unit
PPDU	Payload-adapted PDU
QEF	Quasi Error Free
QoS	Quality of Service
QS-CDMA	Quasi Synchronous - Code Division Multiple Access
RACH	Random Access CHannel
RLE	Return Link Encapsulation
ROHC	RObust Header Compression
rpchof	remainder polynomial coefficients, highest order first
SDU	Service Data Unit
S-MIM	S-Band Mobile Interactive Multimedia
SNAP	Subnetwork Access Protocol
SNDU	SubNetwork Data Unit
SSA	Spread Spectrum ALOHA
SVN	Switched Virtual Network
TCP	Transmission Control Protocol
uimsbf	unsigned integer, most significant bit first
VoIP	Voice over Internet Protocol

4 System Aspects

4.0 General

The main use of the RLE protocol is the transport of data on the return link of transparent or regenerative interactive satellite networks and on the direct links between terminals in fully meshed systems (see Figure 4.1).

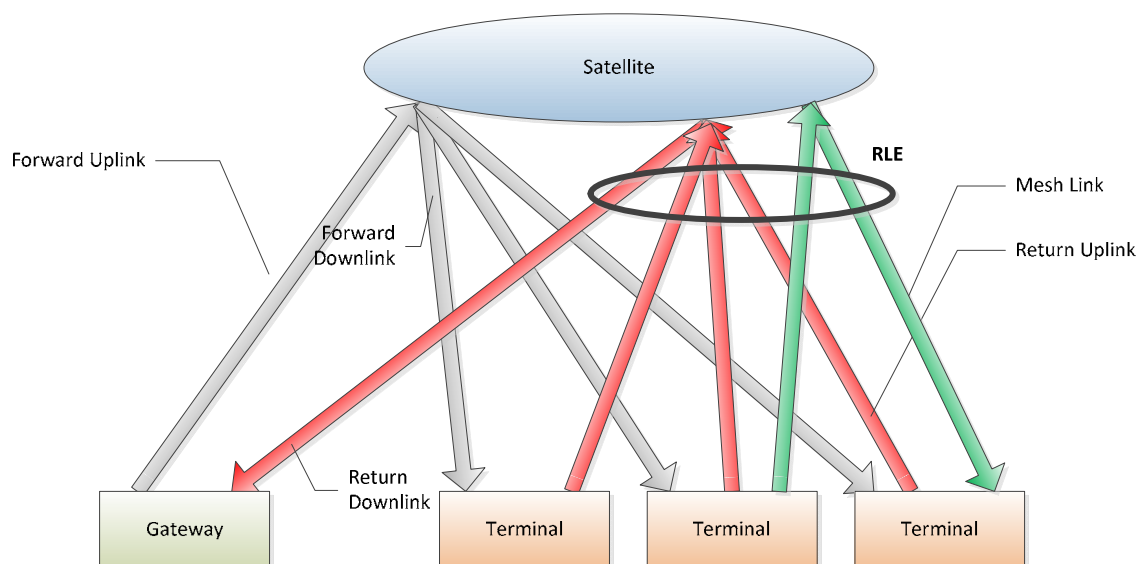


Figure 4.1: Interactive Satellite Network

The terminal transmitter contains the transmit side of the RLE protocol (RLE transmitter) which processes network layer packets and produces physical layer frame or burst payloads. The gateway receiver or the terminal receiver (in the meshed case) contain the receiving side of the RLE protocol (RLE receiver) which reconstructs network layer packets from the received burst or frame payloads. In regenerative satellite systems the RLE receiver may also partly or completely be located in the satellite.

4.1 Protocol Stack

The RLE protocol resides in the Data Link Layer of the communication system (see Figure 4.2). The RLE transmitter gets network layer packets from the network layer (for example IP datagrams) and produces burst or frame payloads that are delivered to the physical layer for transmission. On the receiver side burst or frame payloads are processed to extract the network layer packets and deliver them to the network layer.

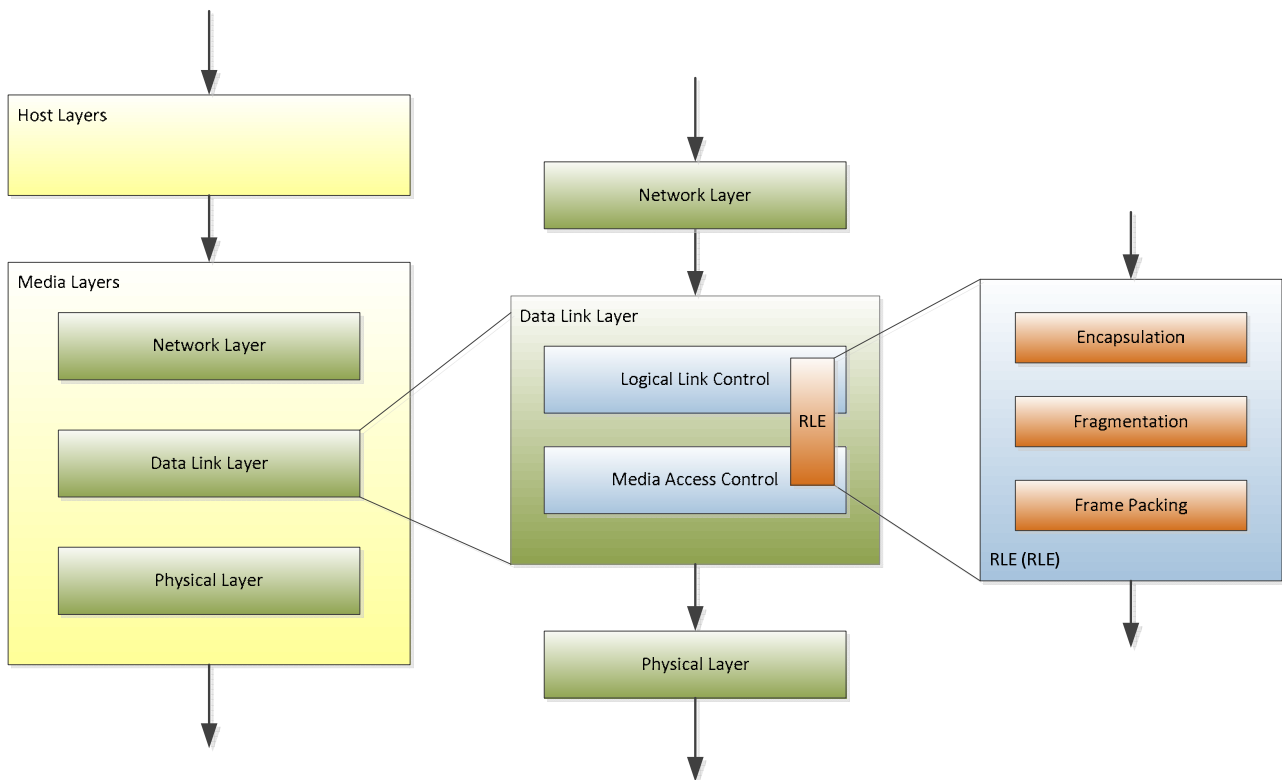


Figure 4.2: Network Protocol Stack

RLE has three distinct functions:

- 1) The Encapsulation function which is partly related to the Logical Link Control Layer takes higher layer packets and associated protocol type and label information and packs these into Addressed Link PDUs (ALPDUs). On the receiver side the ALPDUs are unpacked and dispatched to the network layer instance handling the given protocol type. The Encapsulation function realizes the protocol multiplexing function of the Logical Link Control Layer.
- 2) The Fragmentation function fragments ALPDUs into smaller units producing Payload-adapted PDUs (PPDUs), which are then multiplexed into a single stream. The fragmentation takes into account size information about the physical layer payload fields and may take into account priority information and other system-specific constraints. This sublayer normally includes a scheduler selecting packets to be processed based on this information. On the receiving side PPDUs are reassembled into ALPDUs, checked for errors and, in the success case, delivered upstreams. The fragmentation process is controlled by the current payload sizes required by the physical layer and the current ALPDU sizes. The physical layer payload sizes may change on a frame by frame or burst by burst basis (for example in systems using ACM) and the ALPDU sizes will adapt to the variable size of the higher layer protocols (TCP/IP, for example).
- 3) The Frame Packing function takes the stream of PPDUs and packs one or more of these into a Frame PDU (FPDU). It may optionally add signaling information, a label and provide additional error detection capabilities if the physical layer does not provide those. On the receiver side the Frame Packing function optionally checks for transmission errors, extracts all PPDUs from each FPDU and dispatches them to the right instance in the Fragmentation layer for reassembly of ALPDUs. Both the Fragmentation and the Frame Packing function are related to the Medium Access Control sublayer.

The protocol can be employed not only in single hop (direct transmitter to receiver) configurations, but also in multi-hop scenarios using switching. The switching can occur between any of the sub-layers of the protocol in which case the intermediate node implements only the sub-layers below the switching point. Examples are provided in Annex E.

4.2 Protocol Tailoring and Configuration

The RLE protocol can be tailored and configured to fit the transmission system requirements as good as possible. This involves two steps:

- 1) Selection of the capabilities and options to be implemented in the transmission system. This is done based on the system requirements and on the characteristics of the surrounding layers (physical layer and network layer). Features that are not needed and options that can be set to fixed values reduce the implementation and testing effort. The remaining options shall be provided with either configuration or signaling (or both) support in the system.
- 2) Configure the system operation. The limits of this configurability are defined by the previous step.

Complete information on protocol tailoring and configuration is provided in clause 6.

4.3 Physical Layer Requirements

RLE can operate over physical layers with fixed burst or frame sizes as well as over physical layers with burst or frame sizes varying from burst to burst or frame to frame as they occur in systems like DVB-RCS2 when using adaptive coding and modulation (ETSI EN 301 545-2 [2]). The RLE transmitter dynamically adapts the fragmentation to the available burst or frame size.

The following conditions shall be met by the physical layer:

- 1) The physical layer burst or frame payload shall have a certain minimum size. This size depends on the configuration of the FPDU (see clause 5.4) and the PPDU (see clause 5.3). The burst or frame payload size shall be large enough for the FPDU to be able to carry at least one PPDU. The space for the PPDU shall be large enough so that a PPDU with the `start_indicator` set to "1" and the `end_indicator` set to "0" fits into that space.
- 2) The physical layer shall either never reorder physical layer bursts or frames or it shall do so only in exceptional cases. In the latter case the `use_alpdu_crc` option shall be used for reassembly error checking. If reordering occurs then all the higher layer PDUs data of which is carried in the reordered frames or bursts are lost.
- 3) The physical layer shall either operate quasi-error-free or the `use_frame_protection` option of the FPDU shall be used with a protection scheme that reduces the residual errors to quasi-error-free operation.

5 RLE Data Format

5.0 General

The RLE transmitter transforms the network layer PDU into an Addressed Link PDU (ALPDU), sections the ALPDU into one or more Payload-adapted PDUs (PPDUs) as required, and assembles PPDUs into FPDUs that fit into burst payload.

On the receiving side the FPDUs from the physical layer are unpacked, the resulting PPDUs are reassembled into ALPDUs. These in turn are decapsulated and the contained network layer PDUs are sent to the next upper layer (see Figure 5.1).

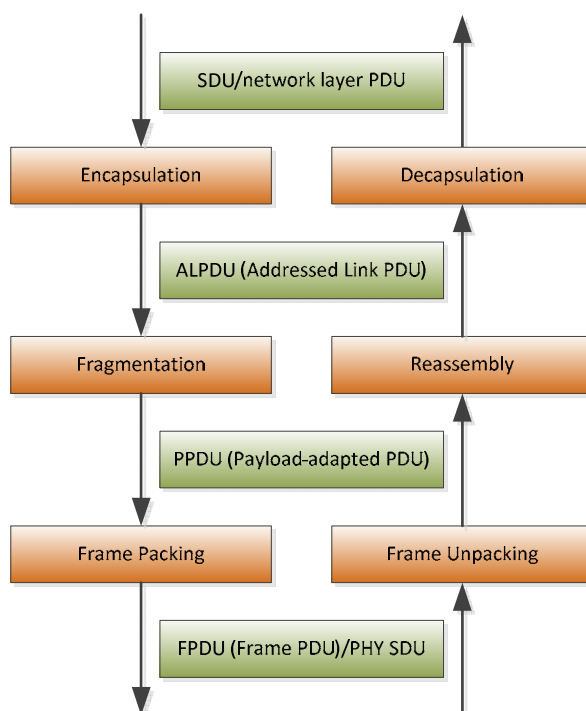


Figure 5.1: PDUs within RLE stack

5.1 Higher Layer SDU

The SDU is constructed from extension headers and higher layer PDUs, for example IP packets according to the rules in IETF RFC 4326 [4]. Each of the two parts, but not both at the same time, is optional. Associated to the SDU is a 16-bit protocol type value which is either the type value of the outermost extension header or the actual protocol type of the higher layer PDU if there are no extension headers. Also associated to the SDU may be a label of up to 15 bytes carrying address or other information.

5.2 The Addressed Link PDU (ALPDU)

5.2.0 General

The RLE transmitter shall build ALPDUs that, in addition to the SDU, may include an explicit protocol indication and an explicit address tag in a similar structure as for GSE (ETSI TS 102 606 [1]). When both fields are included the label field is appended after the protocol type field and before the SDU. Both fields are optional. The ALPDU may have a non-zero size protection field (called PRO in the figure). This is illustrated in Figure 5.2.

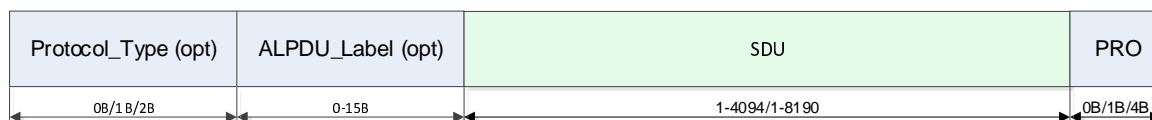


Figure 5.2: Addressed Link PDU Format

The ALPDU provides limited explicit integrity protection and thus relies on the integrity protection provided by the lower protocol layers. If the ALPDU fits into a single PPDU it is not provided with a protection (PRO) parameter field. When fragmented into multiple PPDUs, the ALPDU contains an integrity protection parameter field of either 1 byte or 4 bytes.