2 OVERVIEW

2.1 CONCEPT OF USLP SPACE DATA LINK PROTOCOL

2.1.1 ARCHITECTURE

The USLP Space Data Link Protocol is a Data Link Layer protocol (see reference [1]) to be used by space missions. This protocol has been designed to meet the requirements of space missions for efficient transfer of space application data of various types and characteristics over space-to-ground, ground-to-space, or space-to-space communications links (hereafter called space links).

Figure 2-1 illustrates the relationship of this protocol to the reference model of Open Systems Interconnection (reference [1]). Two sublayers of the Data Link Layer are defined for CCSDS space link protocols as shown in reference [B2]. The USLP Space Data Link Protocol corresponds to the Data Link Protocol Sublayer, and provides functions of transferring various data using either a fixed-length or a variable-length protocol data unit ~~called the Transfer Frame~~. ~~The Communication Operations Procedure (COP-1) reference [9], the Communication Operations Procedure Proximity (COP-P) reference [10] and the Space Data Link Layer Security Protocol reference [14] are all optional and provided within the Data Link Protocol Sublayer.~~ The Synchronization and Channel Coding Sublayer provides some additional ~~the~~ functions necessary for transferring Transfer Frames over a space link. These functions are delimiting/synchronizing ~~Transfer Frames~~protocol data units, error-correction coding/decoding ~~(optional)~~, and bit transition generation/removal (optional) and - depending on the applied coding scheme – some of those functions are optional or performed differently as explained later in this Recommended Standard. ~~Within~~ For the Synchronization and Channel Coding Sublayer, the following set of Synchronization and Channel Coding Recommended Standards (references [3] through [7]) must be used ~~are compatible~~ with the USLP Space Data Link Protocol with the limitations explained later in this Recommended Standard. How the USLP Space Data Link Protocol is used in overall space data systems is shown in references [02] through [04] and [B11].

Comment [GPC1]: When TC Coding is used, the protocol data unit transferred can contain several frames.

Comment [GPC2]: Similar to 232.0-B, there no need for mentioning COP at this point also considering that Figure 2-1 does not show COP. There is a dedicated section 2.1.2.4 here as 232.0-B has a dedicated mentioning in other sections under 2.1.2.4

Comment [GPC3]: Change Consistent with 132.0+232.0+732.0

Comment [GPC4]: Change Consistent with 132.0+232.0+732.0
In fact:
- delimiting/synchronizing Transfer Frames is mandatory in TM+AOS but NOT performed in TC (as it delimits codeblocks=one or more frames) ➔ delimit PDUs,
- error-correction coding/decoding is optional for TM+AOS and mandatory in TC,
- bit transition generation/removal optional for TM+TC+AOS

Comment [GPC5]: In this moment this is FALSE as Proximity-1 coding cannot detect the frame length filed of a USLP frame. To be DISCUSSSED whether this shall be removed from USLP doc as long as the Proximity-1 coding book is not updated (subject to work in C&S WG and to consensus by agencies).

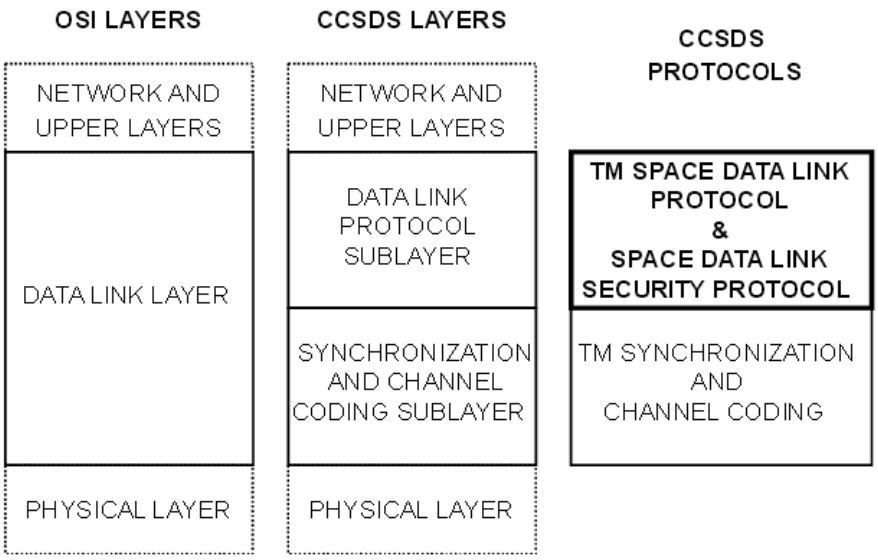

Figure 2-1: Relationship with OSI Layers

Figure 2-1: Relationship with OSI Layers

Comment [GPC6]: Modified figure as already discussed and agreed with Greg.

2.1.2 PROTOCOL FEATURES

2.1.2.1 Transfer Frames, Virtual Channels, and Multiplexer Access Points

The USLP Space Data Link Protocol provides the users with several services to transfer service data units over a space link. These protocol data units are known as USLP Transfer Frames (unless otherwise stated, the terms 'Transfer Frame' and 'Frame' in this document refer to the USLP Transfer Frame). Each Transfer Frame contains a primary header which provides protocol control information, identifying the length of the frame and signaling the inclusion of selected fields. The transfer frames carry upper-layer service data units within the Transfer Frame Data Field (TFDF). The TFDF contains a header that identifies both how the data field is organized and identifies the protocol to which the service data unit(s) are associated.

A key feature of the USLP Space Data Link Protocol is the concept of 'Virtual Channels' (VC). The Virtual Channel facility allows one Physical Channel to be shared among multiple higher-layer data streams, each of which may have different service requirements. Of particular importance is the Quality of Service (QoS) attribute associated with a VC. A single Physical Channel may therefore be divided into several separate logical data channels, each known as a 'Virtual Channel'. Each Transfer Frame transferred over a Physical Channel belongs to one of the Virtual Channels of the Physical Channel.

~~This~~ Moreover, this protocol enables service data units from different sources to be multiplexed together in one Virtual Channel using 'Multiplexer Access Points' (MAPs). MAP_ID assignments allow service data units arriving at the service access point (SAP) at the sending end to be transferred to the corresponding MAP_ID at the receiving end.

2.1.2.2 ~~Efficient Data Transfer~~Additional USLP Features

USLP has increased the allowable size of the transfer frame in order to reduce the operational frame handling process for high rate missions. The protocol also has increased the capability for identifying (using a larger addressing space) more spacecraft. Moreover, it provides the means to transfer service data units from CCSDS recognized protocols within the frame without the need for additional encapsulation services. USLP provides a configurable sized sequence counter in the frame primary header that is incremented to allow the receiving entity to determine, if any frames are missing.

2.1.2.3 ~~Segmentation/Blocking~~Efficient Data Transfer

The USLP Space Data Link Protocol provides the users with several services to transfer service data units over a space link. The major functions performed by this protocol are (1) segmentation and blocking of service data units and (2) transmission control of service data units.

Because the underlying space link inherently includes a noisy signal path, there is a finite probability that it will introduce an error. It is often desirable to break large service data units into relatively small pieces when the frame error rate for large frames is higher than required by the mission**.** Under those conditions each piece has a lower probability of being invalidated by transmission error than if the entire service data unit were sent contiguously. System throughput efficiency may be improved because only small pieces have to be retransmitted when errors are detected. However, there may also be situations in which the service data units are very small. For efficient transfer of service data units, it is desirable to group these small units into larger pieces. The USLP Space Data Link Protocol provides the capability to break large service data units into relatively small pieces (segmentation) and to group small service data units into larger pieces (blocking).

The USLP Space Data Link Protocol controls the transmission of service data units through the space link performing retransmissions needed to ensure delivery of service data units in sequence and without gaps or duplication. This function is provided by an automatic retransmission control mechanism called the Communications Operation Procedure (COP) as described in 2.1.2.4 below.

In addition, a systematic retransmission mechanism for use on deep space links can optionally be provided by the Synchronization and Channel Coding Sublayer when reference [6] is applied (see 2.4.2).

Comment [GPC7]: The current contents of this section are out of scope with respect to the title.

Comment [GPC8]: The following text is now aligned with 232.0-B and amendments should be checked.

Comment [GPC9]: This was the statement for TC, it is liley it should be a little softer for USLP…

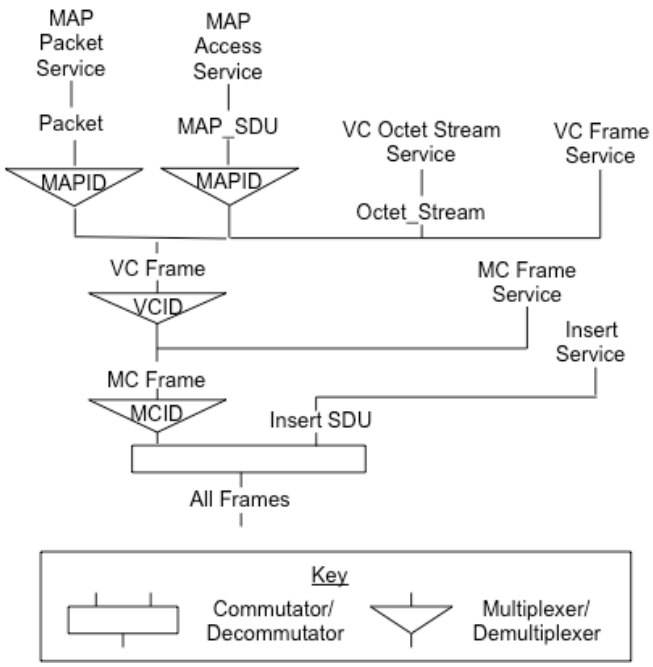

Figure 2-6: USLP Space Data Link Protocol Channel Tree

2.4 SERVICES ASSUMED FROM LOWER LAYERS

2.4.1 SERVICES ASSUMED FROM THE SYNCHRONIZATION AND CHANNEL CODING SUBLAYER

As described in 2.1.1, the set of Channel Coding and Synchronization Recommended Standards (references [3]~~[3]~~, [4]~~[4]~~, [5]~~[5]~~, [6] and [7]) ~~are compatible~~must be used with the USLP Space Data Link Protocol - with the limitations explained later in this Recommended Standard - as the Synchronization and Channel Coding Sublayer specification. The functions provided by the Synchronizaton and Channel Coding Recommended Standard are:

a) error control encoding and decoding functions (optional when the coding schemes defined in references [3] and [7] are used);

b) bit transition generation and removal functions (optional);

c) delimiting and synchronizing functions;

~~d) Addition/removal of idle octets when required to maintain the physical link.~~

NOTE – Currently the Proximity-1 Space Link Protocol-Coding and Synchronization Sublayer Recommended Standard (reference [P1C&S]) cannot be used with USLP.

Comment [GPC10]: Only TM & Proximity-1 coding includes the option UNCODED.
But inclusion of [7] in this version of USLP is sub judice.

When the coding schemes defined in references [3], [4], [5] are used, ~~T~~the Synchronization and Channel Coding Sublayer, then, transfers ~~variable~~fixed-length, delimited protocol data units ~~transfer frames~~ as a contiguous stream of ~~symbols~~ bits over a space link using the services of the underlying Physical Layer.

When the coding schemes defined in reference [6] and [7] are used, the Synchronization and Channel Coding Sublayer, then, transfers variable-length, delimited protocol data units as an intermittent stream of bits over a space link using the services of the underlying Physical Layer.

When the coding schemes defined in references [3], [4], [5], and [7] are used, a protocol data unit contains one Transfer Frame. When the coding schemes defined in reference [6] are used, a protocol data unit contains one or more Transfer Frames.

2.4.2 SYSTEMATIC RETRANSMISSIONS

In addition, the USLP Space Data Link Protocol, when reference [6] is applied, can request the Synchronization and Channel Coding Sublayer to perform systematic retransmissions of the data units submitted to it. The retransmissions can improve the probability of complete delivery for deep space missions on links with long light time delays. This mechanism is not efficient but may be the best approach when frame error rates are high or link connectivity is marginal.

The definition of the service interface to the Synchronization and Channel Coding Sublayer specified in reference [6] includes the ChannelAccess.request service primitive, which has an optional Repetitions parameter. The sublayer transfers the data unit the number of times specified by Repetitions. If the value of Repetitions is one, or if the sublayer does not support the Repetitions parameter, then no systematic retransmissions are performed, and the frame is transferred once.

The USLP Space Data Link Protocol requests the systematic retransmissions in accordance with parameters set by management. For each MAP, management sets the value to be used for the Repetitions parameter when requesting the transfer of frames carrying service data units on the Sequence-Controlled Service. For each Virtual Channel, management sets a similar parameter for frames carrying COP control commands. For a Physical Channel, management sets an upper limit for the value of the Repetitions parameter specified in reference [6].

When requesting the transfer of frames carrying service data units on the Expedited Service, the USLP Space Data Link Protocol does not limit the value of the Repetitions parameter.