VLFs – Review of Mission Needs

19/07/2022

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INTRODUCTION

- During CCSDS Spring meeting 2022, the C&S together with RFM, SLP and Optical WG put an action on all Space agencies, to provide possible missions' scenarios / use cases where the use variable length frames (VLFs) is a key element or can provide a significant advantage over the use of fixed-length frames.

- In this presentation, we summarize the findings of this analysis on ESA side for the following type of missions:
  - Earth Observation,
  - Science,

  and checked if VLFs can provide a significant advantage in any of these scenarios.

- As open point for discussions, it is reported a preliminary assessment about the transmission of Ethernet packets through CCSDS layer (that could be of interest for human/robotic exploration)

EO and SCI missions

In typical EO and SCI missions, we have dedicated communication windows (few minutes in case of EO missions, some hours in case of SCI missions) during which we must download the data generated (and stored) during a long period of time (an Earth orbit in case of EO missions, a day in case of SCI missions).

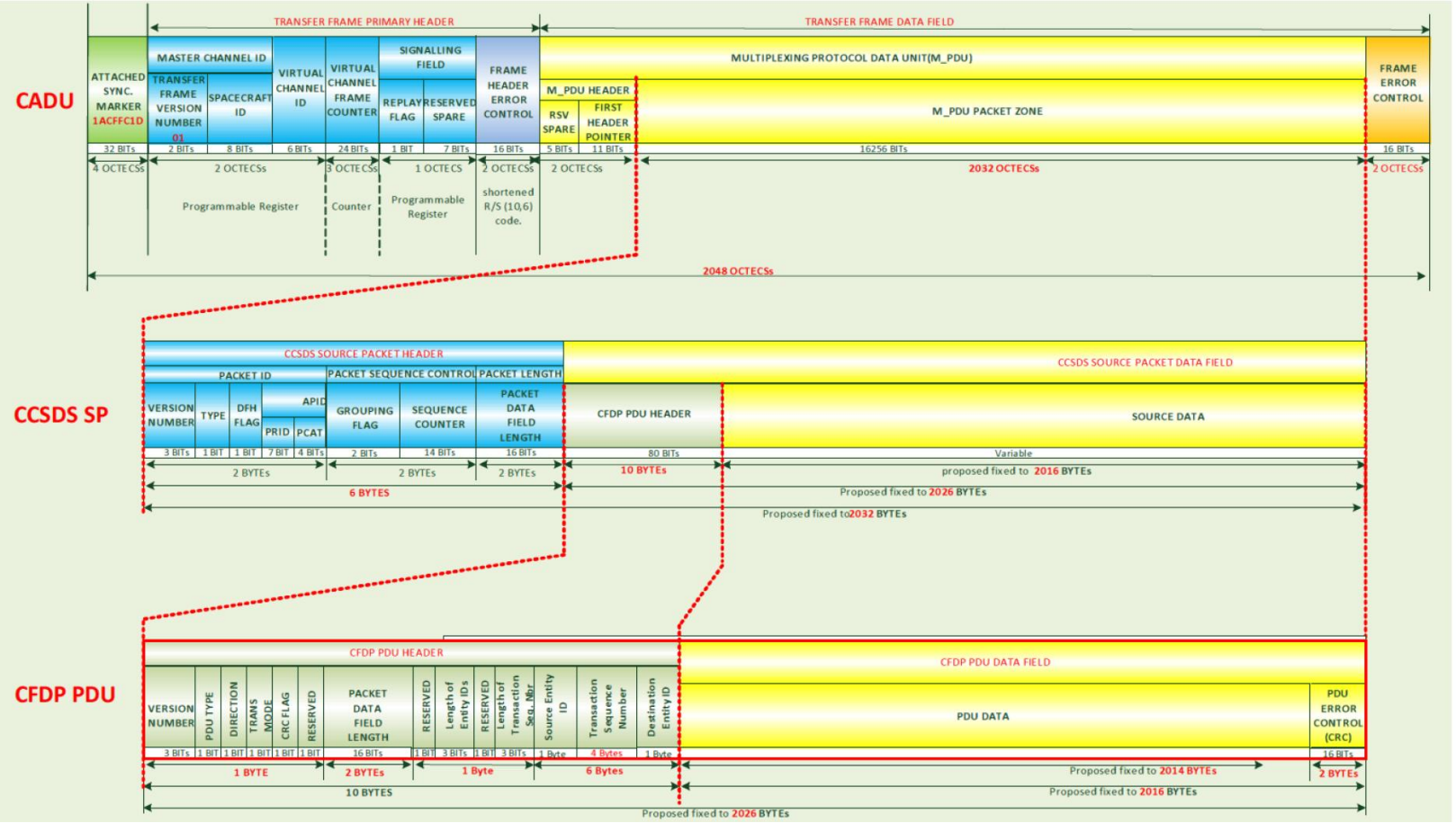
Because of this it is reasonable to assume we will have a quite constant packets generation flow of data stored in the on-board mass memory. In this case, the best strategy to download the data is to encapsulate the data into large frames (e.g., 16k bits), in order to minimize the number of frames to be used and so the total overhead that each frame is introducing (e.g. header).

One of the advantages of the introduction of VLF is the potential to bypass the packet layer (managing the variable length at frame level) so saving some overhead.

We performed a preliminary assessment of the possible advantages in having VLFs for some existing/future missions.

EO and SCI missions - CHIME Case

CHIME (Copernicus Hyperspectral Imaging Mission for the Environment) is an EO mission part of the Copernicus program currently in development and scheduled for launch at the end of the decade.



- 3.7 Gbps RF link
- About 2 Tbit per orbit to download
- Fixed-length frames and packets

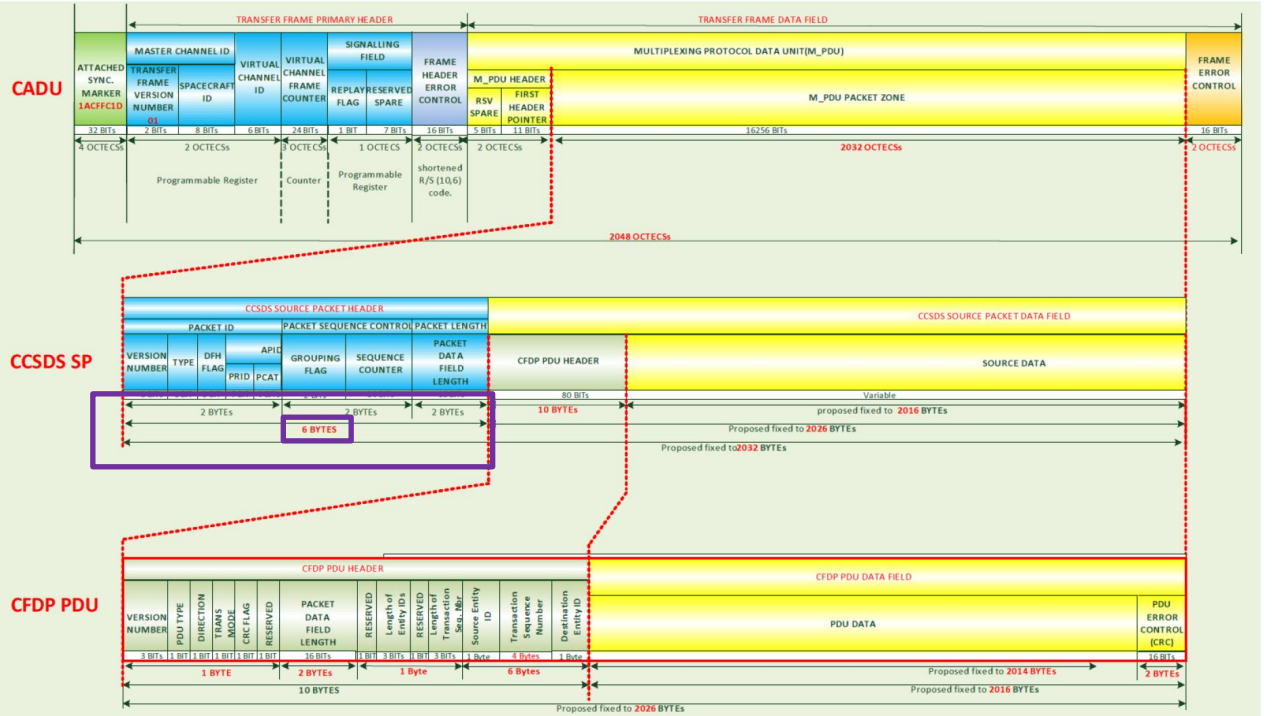
Let's assume we want to download the stored data with

- fixed-length frames and variable-length packets, or,
- Variable-length frames

EO and SCI missions - CHIME Case

Fixed-Length frame with possibly variable-length packets

- In CHIME the maximum SP source data length is 2026 byte, with 6 bytes header
- In the case of maximum length, the SP overhead is ~0.003, i.e., for 2 Tbit we have additional ~6 Gb, that would require only ~1.2 seconds of additional transmission per pass



- Even assuming ‘very short’ packets as 200 Byte, overhead is ~3%, ~60 Gbit extra, meaning, ~16 seconds of additional transmission per pass

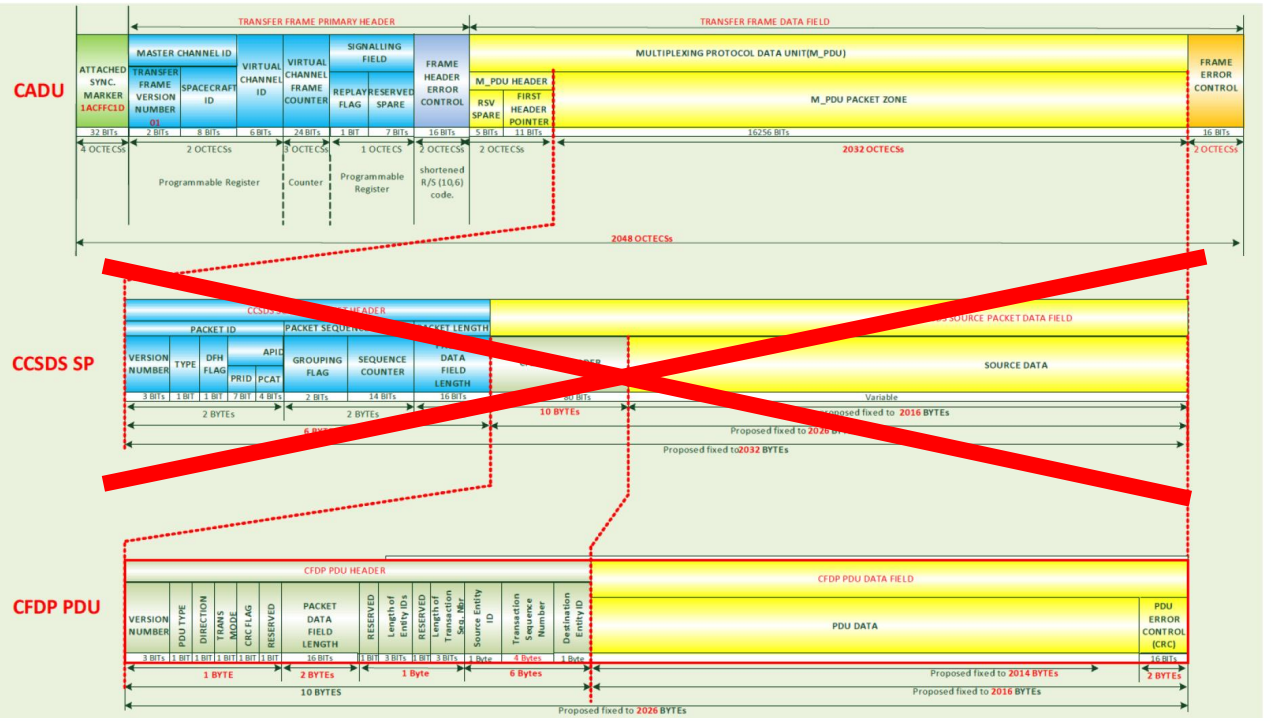
EO and SCI missions - CHIME Case

Variable Frame Length

This is a strong assumption, since it would require a re-design of the layer structure adopted by ESA missions.

Assumptions:

- When using VLF we skip the CCSDS SP layer
- For simplicity (since the structure of VLF has not been yet decided) we assume the length of the CADU header is the same as in the fixed length case (- ASM field + Frame Length Field)



So we are saving some OH that could reduce the transmission of few seconds only

EO and SCI missions – GAIA

We want to calculate the amount of time spent in a comm window of 8 hours to transmit the overhead due to the CCSDS SP packet.

We evaluated the average length of the main data source on board the spacecraft.

The average length of the main data source is equal to 532 bytes.

The CCSDS Source Packet overhead is equal to 6 bytes. (1.1% of average length of the main data source)

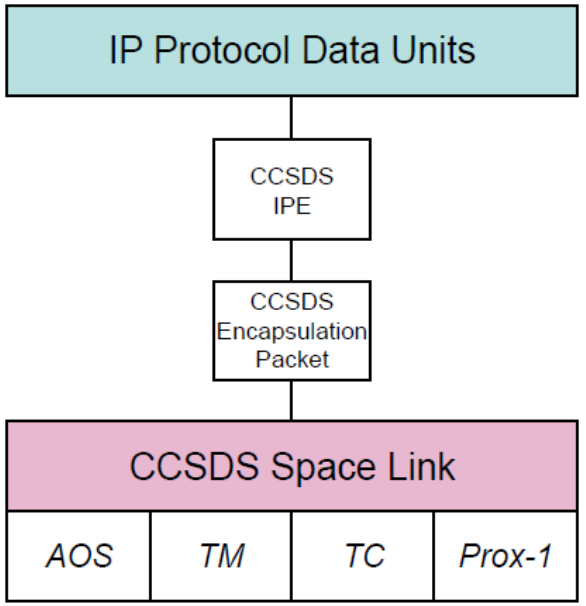
Assuming the average length of the main data source, we get a total amount of time used to transmit the CCSDS Source Packet overhead, over the 8 hours comm window, slightly higher than 5 minutes.

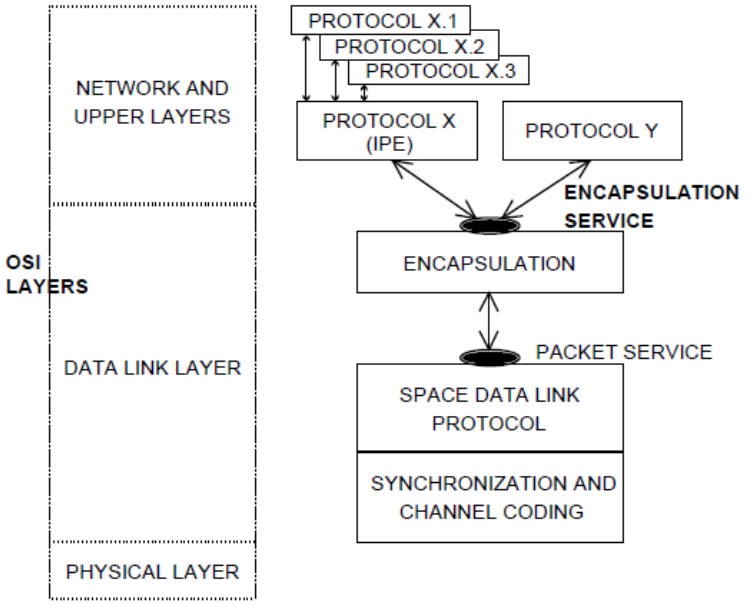
Even in this case, the over head introduced by the CCSDS Source Packet layer seems very limited.

IP OVER CCSDS SPACE LINKS

CCSDS 702.1-B-1

"*This document describes the recommended method for transferring IP PDUs over CCSDS SDLPs: Telecommand (TC), Telemetry (TM), Advanced Orbiting Systems (AOS), and Proximity-1 (Prox-1). IP PDUs are transferred by encapsulating them, one-for-one, within CCSDS Encapsulation Packets. The Encapsulation Packets are transferred directly within one or more CCSDS SDLP Transfer Frames. This method uses the CCSDS Internet Protocol Extension (IPE) convention in conjunction with the CCSDS Encapsulation Service over CCSDS AOS, TM, or TC Virtual Channel Packet (VCP) Service, TC Multiplexer Access Point Packet (MAPP) Service, or Prox-1.*"





Last version on this document is from 2014, so it may be time to update it (e.g., USLP is not included).

IP OVER CCSDS SPACE LINKS

- During Spring 2022 meeting it was reported as possible use case the transmission of Ethernet packets directly inside the TF

- Considering the availability of IPoC, that allows the transmission of IP packets directly, it is not currently fully clear the advantage in having Ethernet over VLFs (since Ethernet would replace SP).