CCSDS Link Layer Protocol Suite

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- Principle functions of the CCSDS link layer
- Overview of CCSDS link layer protocols
- Key characteristics of these protocols
- Example link layer configurations
- Link layer services
- To carry out the point to point transfer of error free* data
  - Capability to identify the sending source
  - Capability to address one out of many spacecraft
  - Capability to control the link configuration
  - Capability to compose (de-multiplex) a single physical stream from multiple logical streams
  - Capability to reorder the data based upon sequence control ARQ

- To transport Network Layer (CCSDS, IP, SCPs, Encapsulation) packets

- To transport point to point messages supporting remote control functionality

* See coding & sync viewgraph
NASA DATA SYSTEM STANDARDS PROGRAM

♦ Requirement on the link layer to deliver error free data (within a specified undetected error rate)
  ♦ Deep Space Telemetry Links
    ♦ Weak signal environment along with requirements to restrict mass and power dictate high coding gains
    ♦ Block codes used to provide higher coding gains which provide a basis for efficient code/frame sync
  ♦ Deep Space Command Links
    ♦ Strong signal environment, low latency delivery dictate short frames, minimal error correction and detection codes
For Low Rate (kbps) Direct to Earth downlink

- Routing based upon 8 Virtual Channels.
- No provision for ARQ.
- Supports CCSDS Space Pkt, SCPS-NP, IPv4 and CCSDS Encapsulation packets.

Packets are concatenated and placed into the Data Fields of fixed-length (up to 1115 octet) TM Frames.

A 'First Header Pointer' in the frame identifies the start position of the first whole packet in the Frame.

...are used to chain to the next packet in the frame enabling packet extraction.
Packets are concatenated and placed into the Data Fields of fixed-length (up to 1115 octet) Virtual Channel Data Units (VCDU).

A 'First Header Pointer' in the Frame identifies the start position of the first whole packet in the Frame.

Routing based upon 64 Virtual Channels.
• Currently no provision for ARQ
• Supports Isochronous data
• Supports CCSDS Space Pkt, SCPS-NP, IPv4 and CCSDS Encapsulation packets.

...and the packet length information in each packet...

...are used to extract Packets from VCDUs.
For Low Rate (kbps) Direct from Earth uplink

at Sending End:

- Packets are placed into the Data Fields of variable-length (up to 1024 octets) Telecommand Frames

- Data Source
  - Packet #1
  - Packet #2
  - Pkt #3
  - Packet #4
  - Packet #5

- Packet Mux & Frame Construction

at Receiving End:

- The packet length information in each packet is used to extract Packets from Frames.

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- For low rate (kbps) mission uplink
- HDLC Derivative
- Routing based upon 64 Virtual Channels.
- Supports Segmentation
- ARQ Provided by COP-1 Protocol.
- Supports CCSDS Space Pkt, SCPS-NP, IPv4 and CCSDS Encapsulation packets.
at Sending End:

Packets are placed into the Data Fields of variable-length (up to 2048 octets) Proximity-I Frames.

- Routing based upon 8 Port Ids/Phy Chnl.
- HDLC Derivative
- Supports Segmentation
- ARQ Provided by CCP-P Protocol.
- Full, Half Duplex, Simplex in-situ links
- Supports CCSDS Space Pkt, SCPS-NP, IPv4 and CCSDS Encapsulation packets.
- Supports session establishment/tear down
- Supports time tagging of incoming/outgoing frames for timing

at Receiving End:

The packet length information in each packet is used to extract Packets from Frames.
Data Link Types
- Synchronous (fixed length frame)
  - TM/AOS – to ensure robust synchronization using block codes over noisy links
- Asynchronous (variable length frame)
  - TC/Proximity-1 – to receive short messages over high SNR links

Multiplexing data over the physical link
- Virtual Channels (TM/AOS/TC)
- Port Ids (Proximity-1)

ARQ (Retransmission)
- Via sequence controlled in order, no gaps, no duplicate frame delivery: TC (COP-1), Prox-1 (COP-P)
- No ARQ mechanisms: AOS, TM (retransmission can be done by a higher layer protocol)
<table>
<thead>
<tr>
<th>Service Type</th>
<th>TM</th>
<th>TC</th>
<th>AOS</th>
<th>Prox-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packet Services</td>
<td>Packet &amp; Encapsulation Services</td>
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</tr>
<tr>
<td>User Defined Data</td>
<td>N/A</td>
<td>N/A</td>
<td>Isochronous (audio &amp; data) Bit Stream Service</td>
<td>Bit Stream &amp; Other user defined types</td>
</tr>
<tr>
<td>Timing</td>
<td>Time Correlation</td>
<td>N/A</td>
<td>Time Correlation</td>
<td>Time Correlation Time Xfer</td>
</tr>
</tbody>
</table>
Addressing of TM/TC/AOS

MAP Channel: (TC only, Optional)
  Identified by MAP ID

Virtual Channel:
  Identified by VCID

Master Channel:
  Transfer Frame Version # + Spacecraft ID

Physical Channel:
  Named Entity

Addressing of Proximity-1

Physical/Logical Port:
  Identified by Port ID

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Multiple Master Channels
Prox-1 Frame Version ID + Spacecraft ID

1 Physical Channel:
Mars Forward Link

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Port #0: Bulk Data to Earth
Port #1: For Consumption on the Orbiter
1 Master Channel
1 Physical Channel per Lander (FDMA)