

Telemetry / Telecommand Frontend

Anoop R Santhosh

Indian Institute of Technology, Madras

anoop@cse.iitm.ac.in

May 9, 2014

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- Mission Life Time : greater than 1 year

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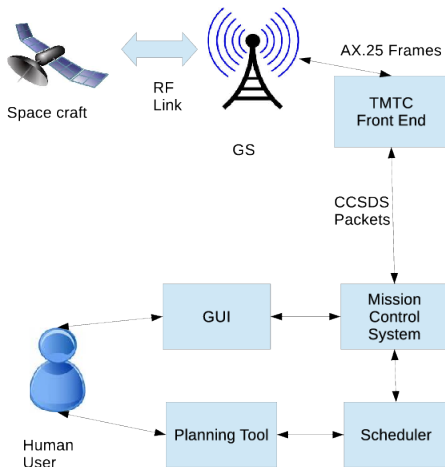
- Various subsystems, both hardware and software involved.
- The focus here is on Ground Station software, especially a module within it, TMTC Frontend.

- Handles Operations of the satellite from ground.

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- Processes the information transmitted by satellite.
- Three major components
 - User Interface
 - Mission Control System
 - TMTC Frontend

Ground Station Block Diagram



TMTC Frontend - Problem Statement

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- Link layer between MCS and satellite.

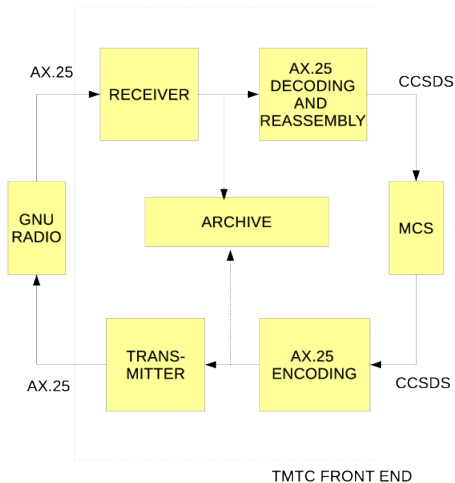
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- Link layer between MCS and satellite.
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TMTC Frontend - Problem Statement

- Link layer between MCS and satellite.
- Implement a robust TMTC Frontend.
- The main functionalities of TMTC Frontend are
 - **Uplink**
 - Encoding CCSDS packets (telecommand) to AX.25 frame.
 - Archive AX.25 telecommand frames.
 - Flow Control (resending, counters, acknowledgments etc).
 - **Downlink**
 - Decode AX.25 frame (telemetry) and reassemble the application data to obtain CCSDS packets.
 - Archive raw AX.25 telemetry frames.
 - **Replay**
 - Provide functionality to replay archived raw AX.25 telemetry frames.

TMTC Frontend - Block Diagram



Motivation

- Communication link may not be very reliable.
- Limited time of communication.
- Need to transfer data reliably in that time.
- A robust link layer is essential for that.

- SwissCube Ground Station Software.
- Our design is loosely based on it.

Main Contribution

- Implementation of modified AX.25 protocol encoding/decoding.
- Modification of TC Transmitter.
- Reassembly unit.
- Implementation of entire module in general.

Modified AX.25 Frame

Flag	AX.25 Transfer Frame Header (128 bits)				Information Field	Frame Check Sequence	Flag
	Dest. Address	Source Address	Control Bits	Protocol Identifier			
8	56	56	8	8	0 – 2048	16	8

Figure: Frame Structure. Adapted from [1].

- In case of telecommand frames, first byte of information field is set as counter.

Telemetry Information Field Usage

Telemetry Transfer Frame Secondary Header (32 bits)						Data	Telemetry Transfer Frame Trailer			
Frame Identification			Master Frame Count	Virtual Channel Frame Count	First Header Pointer		Frame Status			Time
Version Number	Virtual Channel ID	Spare					Time Flag	Spare	TC count	
2	3	3					8	8	8	

Figure: Frame Structure

- Virtual Channels.
- Large Data Transfer.

TMTC Frontend consists of four major sub modules :

- AX.25 Packet Encoding/ Decoding.
- TC Transmitter.
- TM Receiver.
- Replay Controller.

Limitations of Swiss cube TC Transmitter Design

- It can support only 4 outstanding packets.
- Packets are transmitted one at a time.
- Transmission of packets are manually controlled by the user through MCS.
- There was no option of resending at TMTC Frontend layer.
- In the event of packet drop, the information is carried back to the application level, where a human user decides to resend the packet again.

Modified Design

The important features of the modified design are :

- Packets are transmitted when transmitter is on and positive beacon signal is received.
- All the packets in the ready queue are dispatched at the same time one after another. The number of packets is expected to be in the order of 10, which is way less than the 256 outstanding packets allowed.
- Transmitter is half duplex. So we are not implementing an explicit timeout. Acknowledgment for a frame sent in a transmitter period is expected to come in the immediate next receiver period.
- If acknowledgement is not received in the immediate next reception, packet is resent. A packet will be resent a fixed number of times, after which packet drop will be announced to MCS.

There are three states :

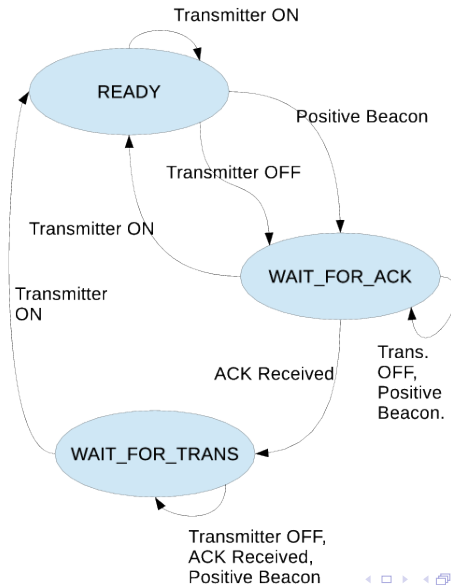
- READY .
- WAIT_FOR_ACK .
- WAIT_FOR_TRANS .

External Triggers

The external triggers are :

- Transmitter ON : Indicates switch to transmission mode.
- Transmitter OFF : Indicates switch to reception mode.
- Positive Beacon : Indicates that satellite is in field of view and ready for reception.
- Ack received : Indicates the reception of acknowledgement packet by receiver.

State Diagram

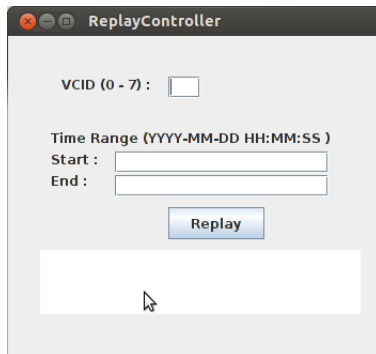


TM Receiver Design

Processing steps after reception of an AX.25 telemetry frame in that order is as follows.

- 1 Receive AX.25 frame.
- 2 CRC check to detect frame bit errors.
- 3 Check the GS and Satellite SSID and Callsign.
- 4 If the frame is an acknowledgement frame, trigger Acknowledgment received of receiver.
- 5 Otherwise Archive the raw frame in database .
- 6 Forward the frame to appropriate virtual channel.
- 7 Transfer the frame to reassembly unit of the virtual channel.
- 8 After a CCSDS packet is completely reassembled, forward it to the MCS on appropriate port or channel.

Replay Controller



The screenshot shows a window titled "ReplayController" with a light gray background. At the top, there are standard window control buttons (close, minimize, maximize). Below the title bar, the text "VCID (0 - 7) :" is followed by a small rectangular input field. Further down, the text "Time Range (YYYY-MM-DD HH:MM:SS)" is displayed. Under this, there are two labels: "Start :" and "End :", each followed by a rectangular input field. Below these input fields is a blue button with the text "Replay" in white. At the bottom of the window is a large, empty white rectangular area. A mouse cursor is visible over this area.

Figure: User Interface

Implementation Details - Development environment

- **Development Language :** Java 1.6.0
- **Development Environment :** Eclipse IDE
- **Database server :** MySQL 5.5.35
- **Operating System :** Ubuntu 12.04

Important Modules

The important modules with TMTC Frontend are :

- AX.25 encoding/decoding.
- TC Transmitter.
- TM Receiver.
- Replay Controller.
- Archiving Frames.
- Reassembly Unit.






Testing Details

- Different units were tested individually by writing various test cases.
- Simulators not available for MCS or SDR.
- Approximate conditions were simulated and various features like frame drop, resend etc were tested.

Summary

- TMTC Frontend implemented in Java taking care of current expected scenario.
- Modified the design to suit IITMSAT requirements.
- Limited testing was done based on available details.
- Integration with other modules and rigorous testing after integration are left.

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