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**Design Approach for CCSDS Complied Command Operation
and Frame Operation Procedure for Integrated Spacecraft
Checkout**

Parul Khurana, Sangeetha K. and Vithal Metri (ISRO)

Indian Space Research Organization (ISRO)



OUTLINE



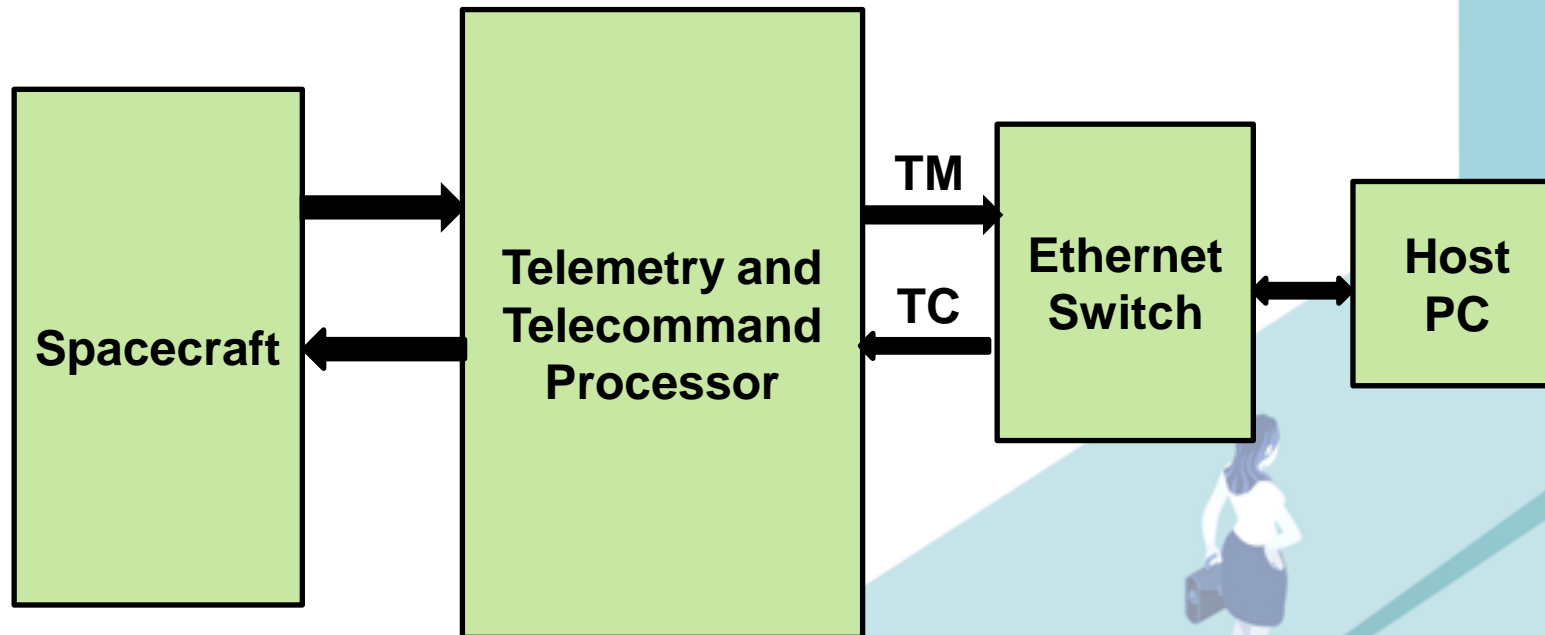
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Design Approach for CCSDS Complied Command Operation and Frame Operation Procedure (COP – FOP) for Integrated Spacecraft Checkout - Scheme for communicating with satellites



Communicating With Satellites (in Checkout – Baseband Level)



Challenges with Procured Telemetry and Telecommand (TTC) Units

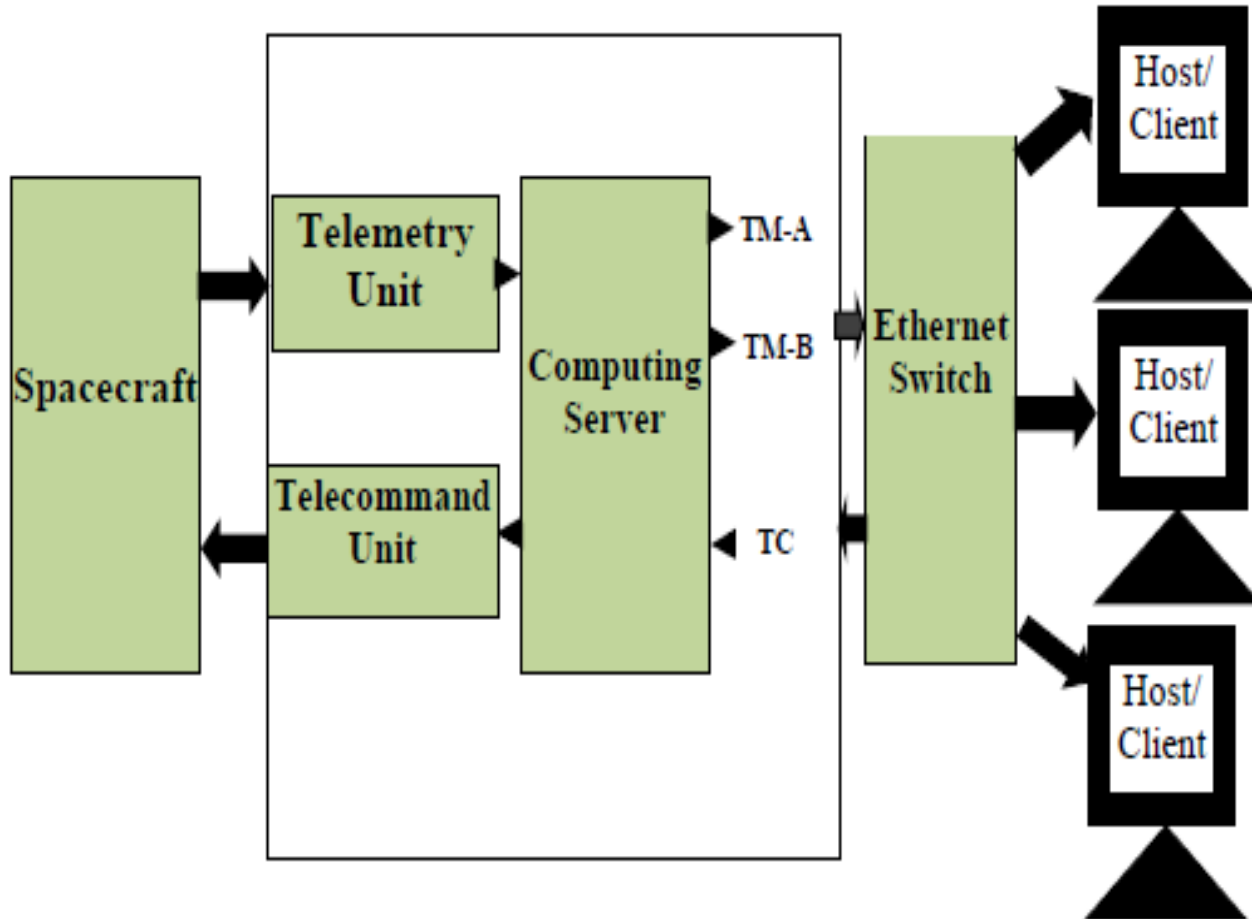
- ❖ Procurement cost is very high.
- ❖ High Annual Maintenance Cost.
- ❖ Non Configurable to adapt new requirements.
- ❖ Comes as single unit, incase of fault either in Telecommand or in Telemetry we need to replace full unit.
- ❖ Time Consuming.
- ❖ Does not support Non-CCSDS formats.



In-House Technology Demonstration/Development of CCSDS complied Telemetry and Telecommand Processor



TTCP (Telemetry and Telecommand Processor)



❖ Cost Effective

❖ Expertise available, easy to maintain

❖ Adaptable to new requirements

❖ Configurable

❖ Available as separate units, need to replace only faulty unit (if needed)

❖ Self reliance, considered as part of 'Make in India' campaign

Telecommand Schemes

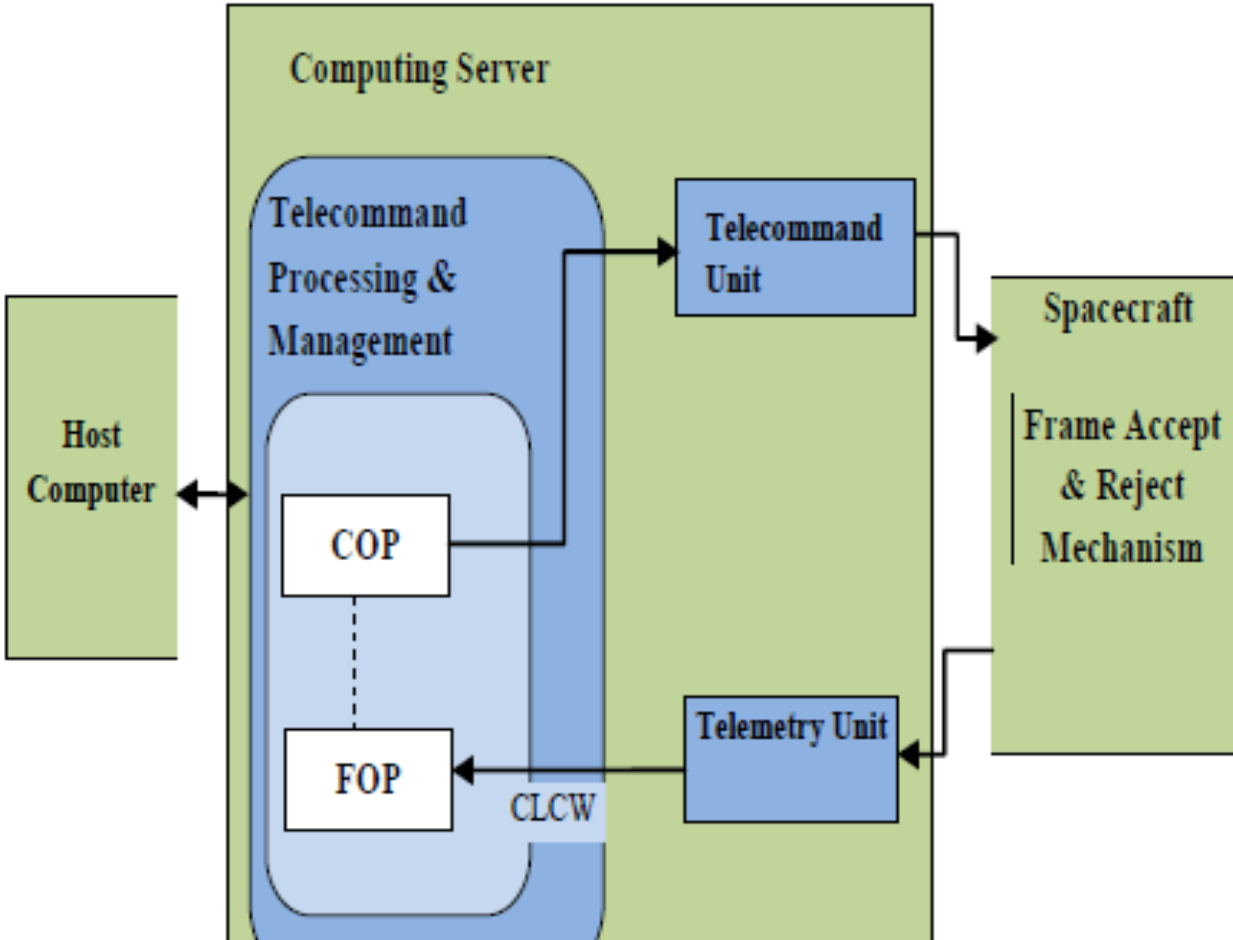
- ❖ Consultative Committee for Space Data Systems (CCSDS)
- ❖ Non- CCSDS

Why CCSDS?

- ❖ Variable length commanding
- ❖ Uniform standard across the globe.
- ❖ Promotes interoperability and cross support among cooperating space agencies
- ❖ Increased throughput by variable length commanding (reception of message with short delay).
- ❖ Reduction in operational cost by sharing facilities.
- ❖ Need not to carry any equipments to different ground stations.

TTCP Telecommand Processing and Management

TTCP



❖ Three modes of commanding:

❖ BD frames

❖ AD frames

❖ BC frames

❖ Directive Requests

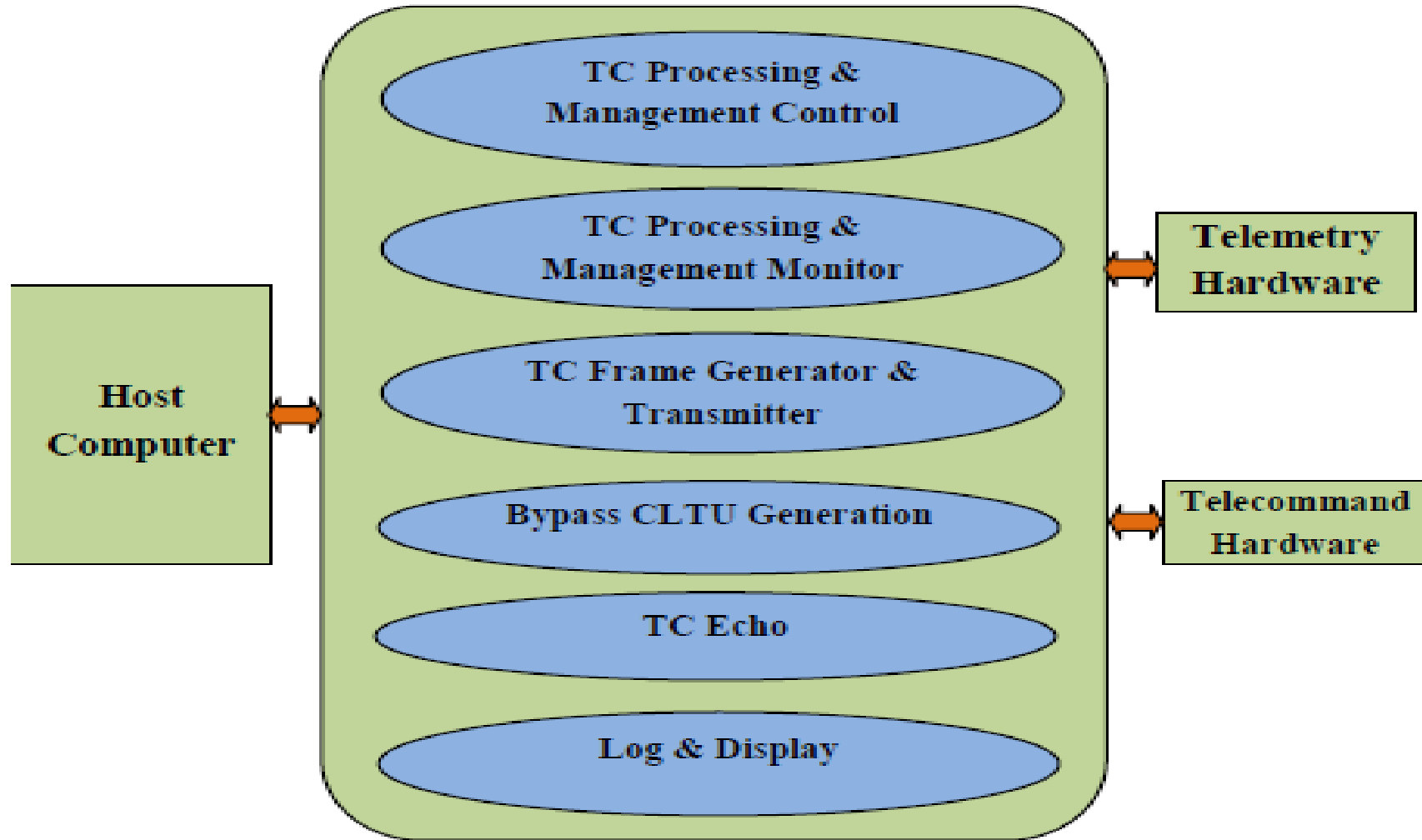
❖ COP, FOP at ground segment

❖ FARM at Space Segment

❖ COP generates, packetizes, transmits the commands to Telecommand Hardware Unit

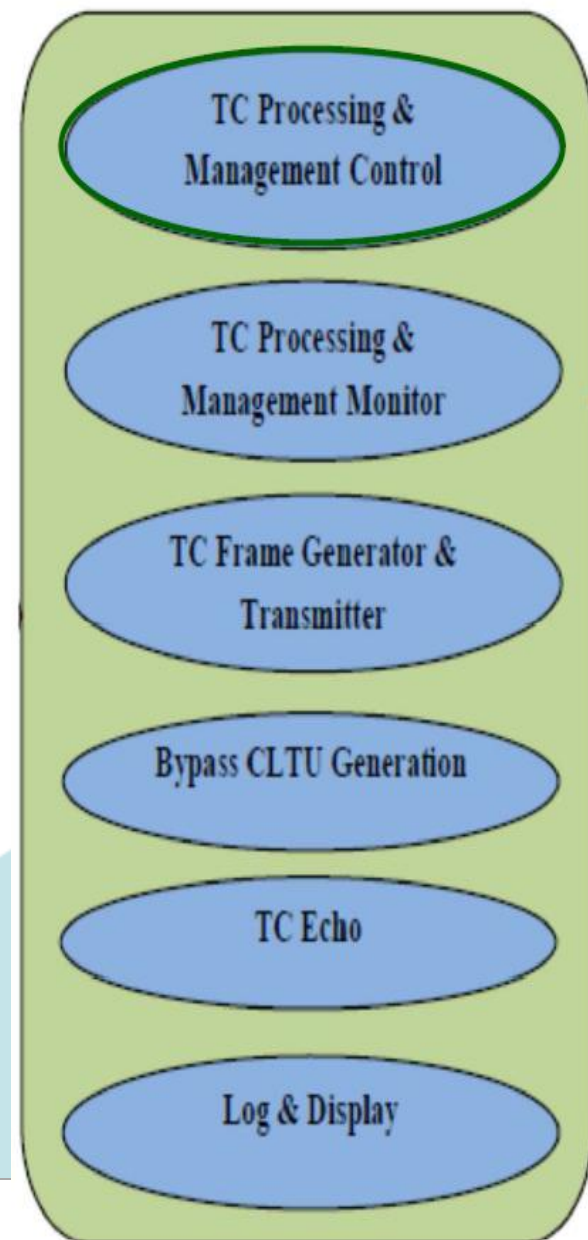
❖ FOP decides whether commands have reached successfully or retransmission is required in case of unexpected behavior/failure

Design Approach



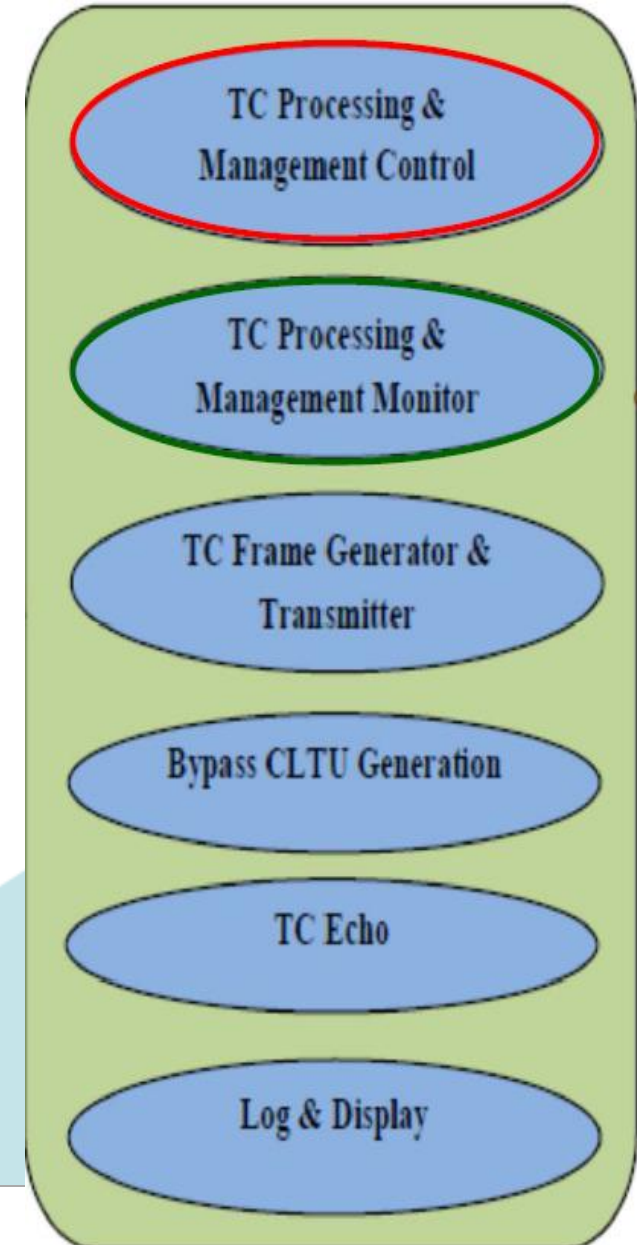
TC Processing and Management Control

- ❖ The purpose of this block is to program functional parameters like Spacecraft id, VCIDs, CLCW offset in Telemetry
- ❖ The parameters can be programmed remotely through Spacecraft Checkout Computer or through client GUI
- ❖ All this information will be used for telecommand processing and management
- ❖ This block will configure COP with spacecraft specific parameters
- ❖ All the information will be saved and reloaded automatically, incase of server shutdown, restart etc.
- ❖ Control block will support only one client at a time.

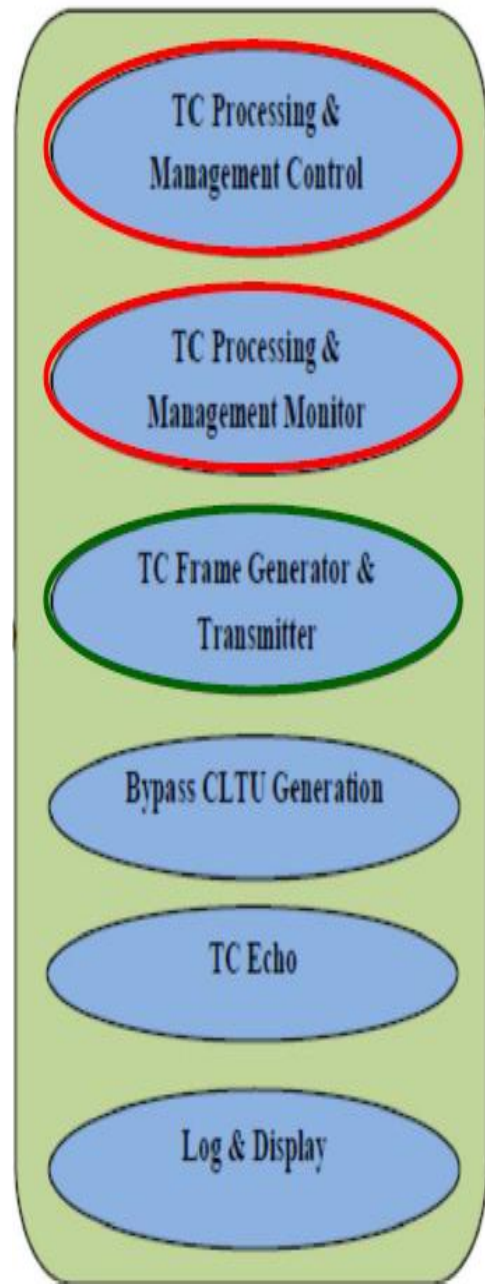
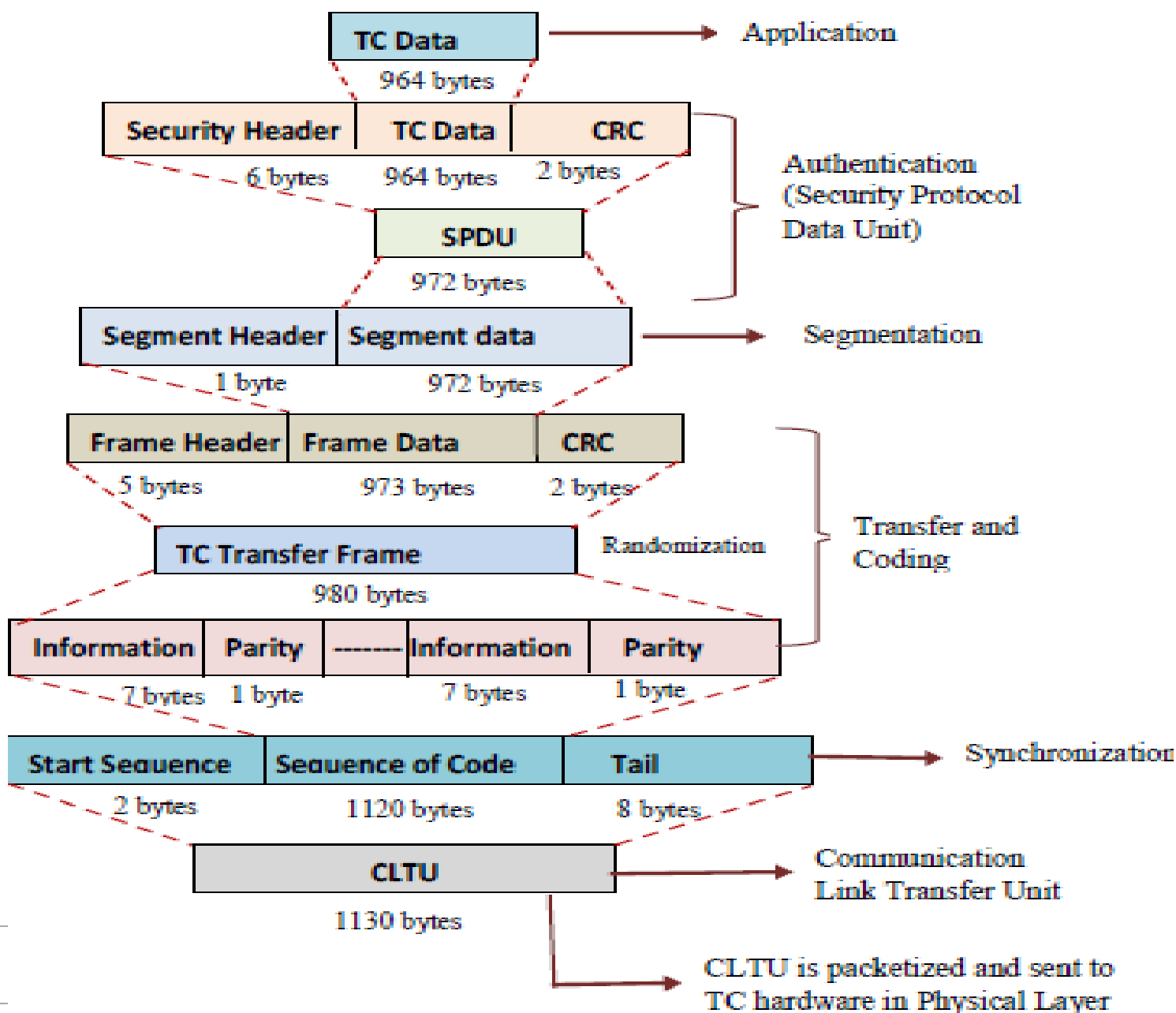


TC Processing and Management Monitor

- ❖ The purpose of TTCP TC processing and management monitor is to return back the parameters set using control block.
- ❖ This block also validates whether control parameters are set properly
- ❖ This block monitors COP configurable parameters only and is mainly used by checkout personnel
- ❖ Monitor Parameters can be read remotely or can be seen on GUI
- ❖ Client access is restricted to 4 clients at a time



TC FRAME GENERATOR

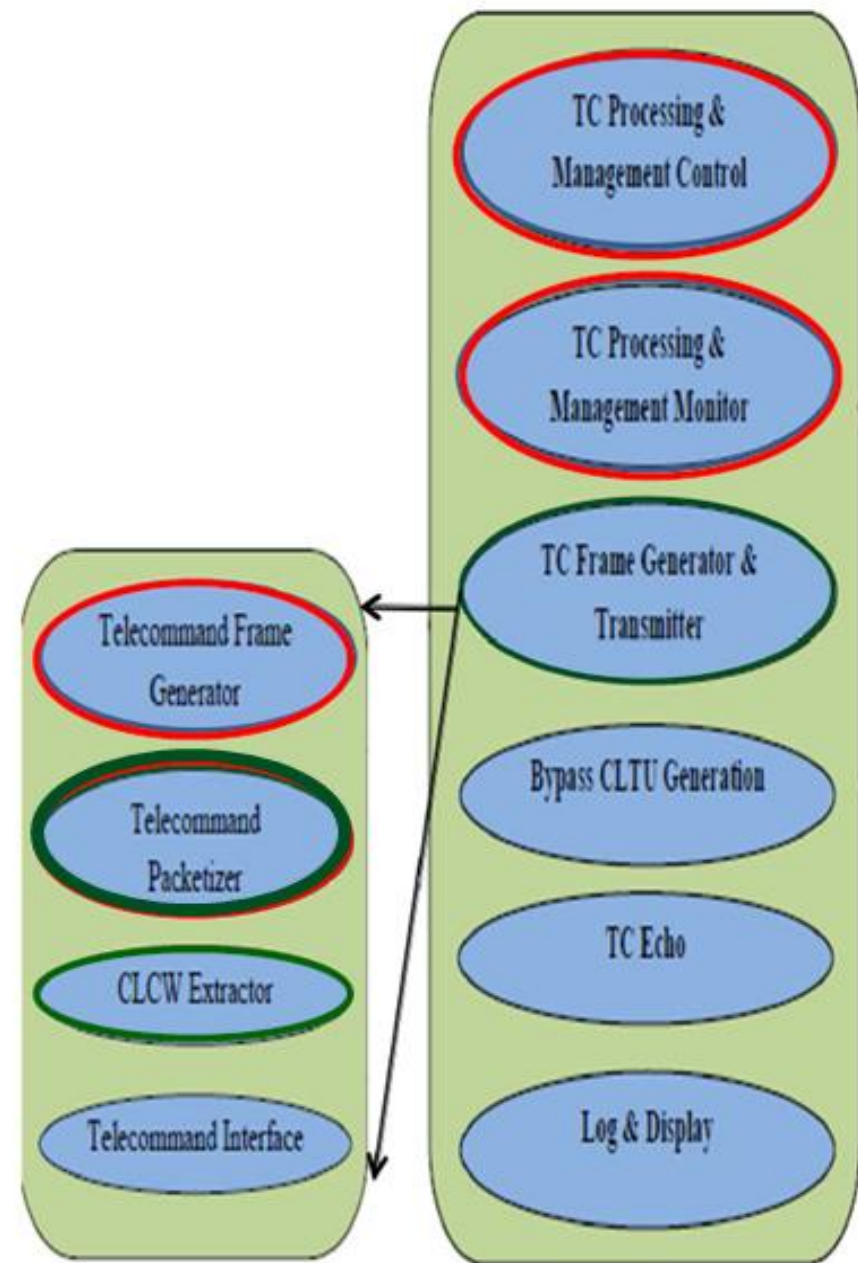


TC Packetizer

- ❖ Generates command packets.
- ❖ Various requests and response packets
- ❖ Packets for Control, Monitor, Command and Echo

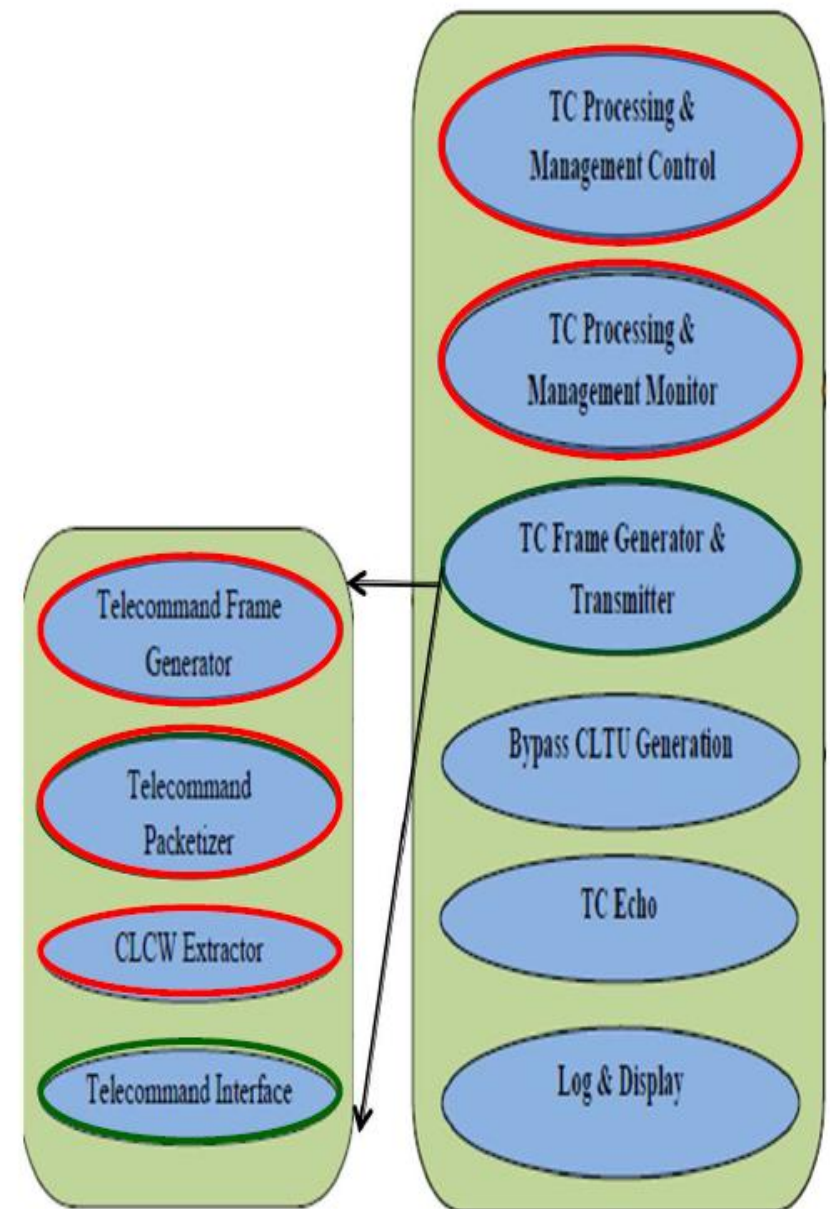
CLCW Extractor

- ❖ For AD and BC frames, TTCP TC Processing and Management Software requests for Communication Link Control Word (CLCW) from TM Hardware.
- ❖ Various flags and report values will get extracted for processing AD, BC mode of commands



TC Interface

- ❖ Establishes and handles connections with host computer, TC and TM hardware
- ❖ Calls required modules from various blocks of TTCP Telecommand Frame Generator and Transmitter to handle BD, AD, BC frames and directives
- ❖ Each request from host will be validated, processed as per state of TC Processor

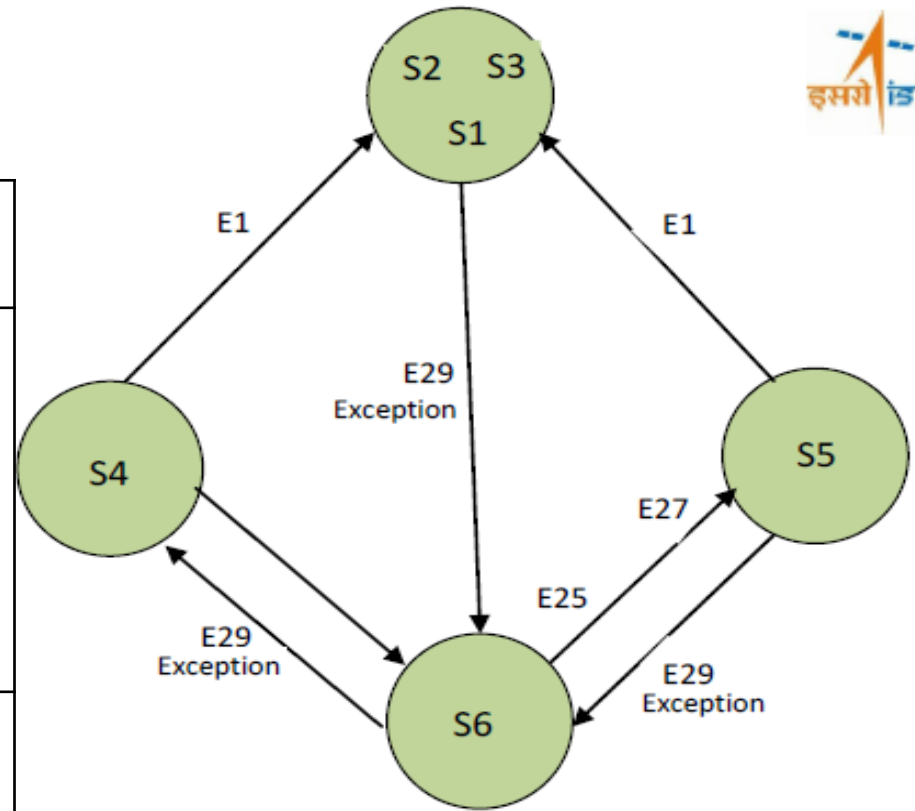


TC Processor States

- ❖ **Active (S1)**: This is a normal state where there are no recent errors and flow control problems.
- ❖ **Retransmit Without Wait (S2)**: This state describes that 'Retransmit' flag is 'on' in CLCW but there are no exceptional circumstances.
- ❖ **Retransmit with Wait (S3)**: Software enters in this state if 'wait' flag is 'on' in CLCW.
- ❖ **Initializing without BC Frame (S4)**: TC Processing and Management software is in S4 state after receiving Initiate AD Service (with CLCW check) directive while in Initial state. A successful CLCW check will result in a transition to S1.
- ❖ **Initializing with BC Frame (S5)**: The software is in S5 state after receiving BC directives. A successful transmission of BC request and a clean CLCW will result in transition of S1.
- ❖ **Initial (S6)**: Initial state is the first state of TC Processor.

Sample State Transition Diagram

No.	Event Details
E1	CLCW arrives in form of valid COP-1 Pattern as: Lockout Flag = 0, $N(R) = V(S)$, Retransmit Flag = 0, Wait Flag = 0, $N(R) = NN(R)$
E25	Receive Directive From Management Function Initiate AD Service (with CLCW check) Directive, BC_Out_Flag = Ready
E27	Receive Directive From Management Function Initiate AD Service (with Set V(R) Directive), BC_Out_Flag = Ready
E29	Receive Directive From Management Function Terminate AD Service Directive



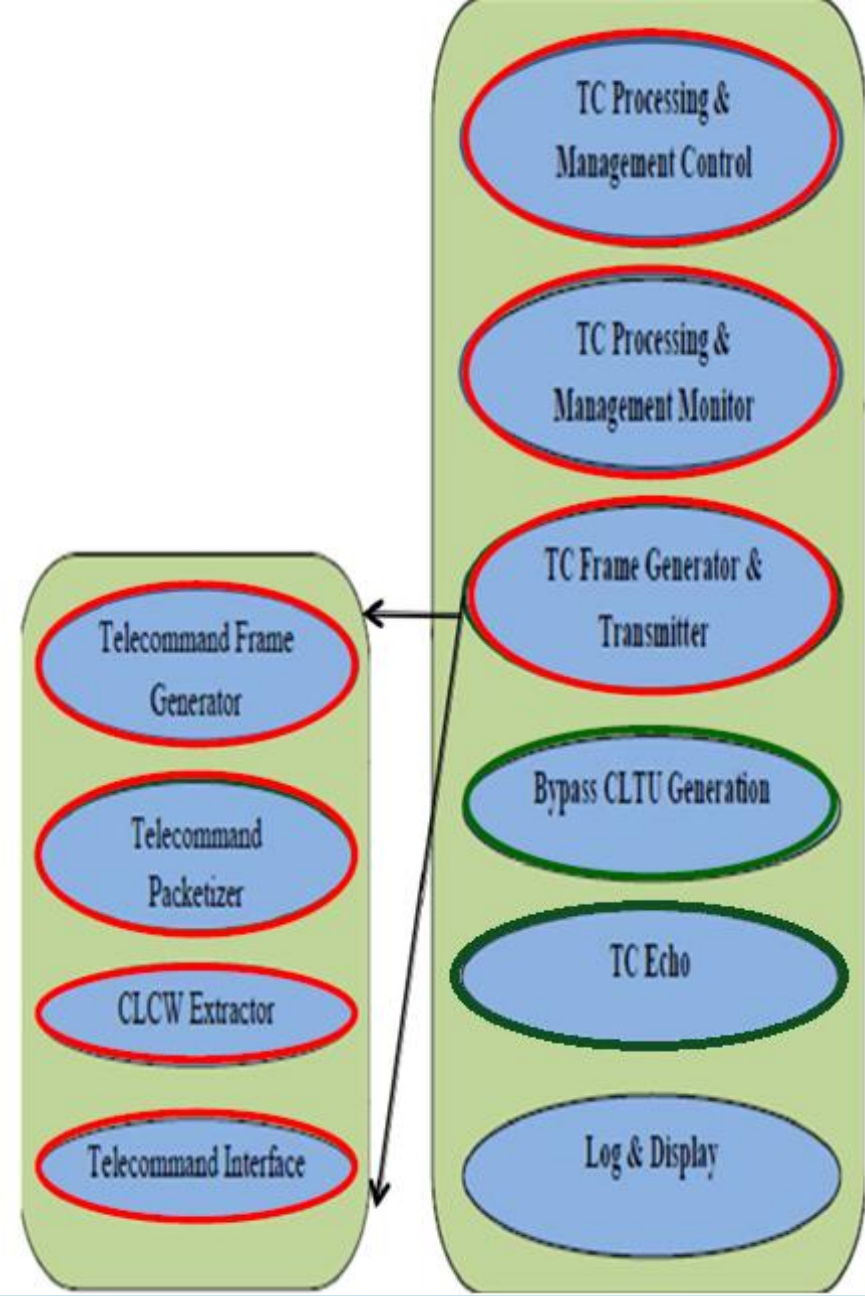
$N(R)$ = Frame Sequence Number in CLCW
 $NN(R)$ = Next expected Frame Sequence No
 $V(S)$ = Transfer frame sequence Number

Pass CLTU Generation

- ❖ Directly transmits the command to TC Hardware bypassing all the processing related to CLTU generation.

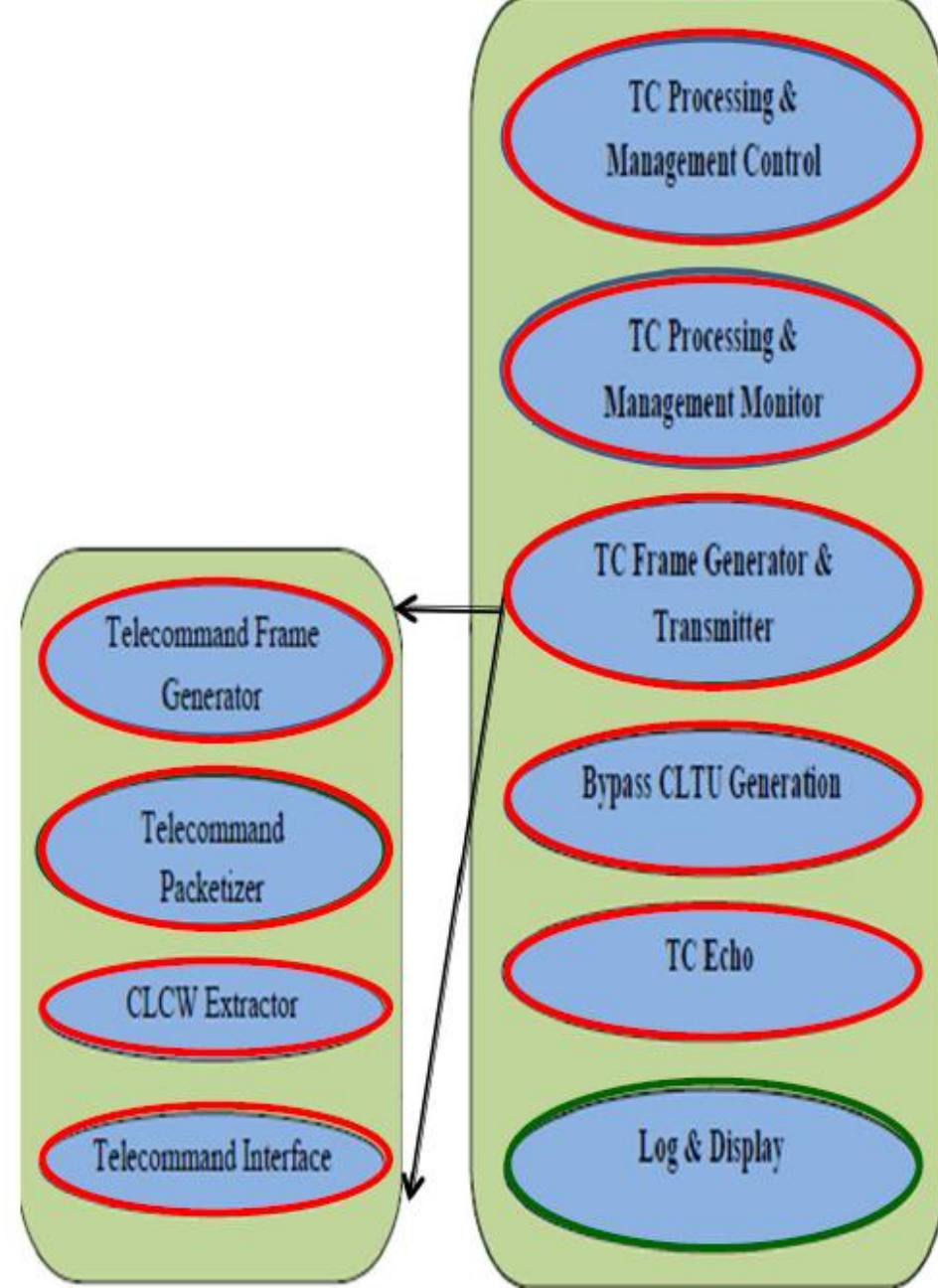
TC Echo

- ❖ Dumps either CLTUs or Transfer frame based on the request by clients
- ❖ Provides command to different agencies involved during testing.
- ❖ Provision is provided to support 8 clients.



Log and Display

- ❖ Deals with the logging and display of commands
- ❖ Logging of commands will be done along with CLTU and the commands issued from host computer.
- ❖ Time reference is also logged for each command.
- ❖ Display will show the transmission status, date and time and the command code in GUI for quick reference.



Conclusion

- ❖ Self Reliance and Customization as per Requirements
- ❖ Gradually removing the dependencies on off the shelf equipment
- ❖ The successful implementation of CCSDS based Telecommand Processing and management software for in-house developed TTCP has resulted in significant cost reduction for checkout operations
- ❖ In future, the software will be upgraded for commanding in both CCSDS and Non-CCSDS based projects. Also, possibilities of deploying it for ground stations will be explored.

References :

- CCSDS BLUE BOOK 232.0-B-1 (TC Space Data Link Protocol)
- CCSDS BLUE BOOK 231.0-B-1 (TC Synchronization And Channel Coding)
- CCSDS 202.1-B-1 (Command Operation Procedure)
- Software Requirement Document for TTCP Server Software
- Software Design Document for TTCP Server Software