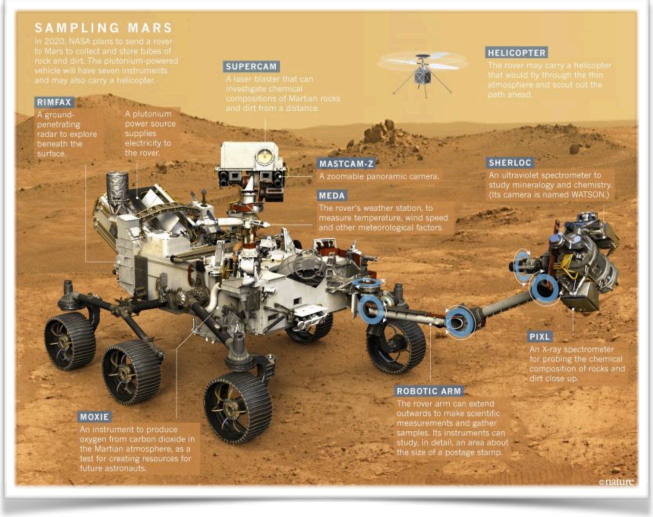
SAMPLING MARS
In 2020, NASA plans to send a rover to Mars to collect and store tubes of rock and dirt. The plutonium-powered vehicle will have seven instruments and may also carry a helicopter.
SUPERCAM
A laser blaster that can investigate chemical compositions of Martian rocks and dirt from a distance.
HELICOPTER
The rover may carry a helicopter that would fly through the thin atmosphere and scout out the path ahead.
RIMFAX
A ground-penetrating radar to explore beneath the surface.
A plutonium power source supplies electricity to the rover.
MASTCAM-Z
A zoomable panoramic camera.
SHERLOC
An ultraviolet spectrometer to study mineralogy and chemistry. (Its camera is named WATSON.)
MEDA
The rover's weather station, to measure temperature, wind speed and other meteorological factors.
PIXL
An X-ray spectrometer for probing the chemical composition of rocks and dirt close up.
ROBOTIC ARM
The rover arm can extend outwards to make scientific measurements and gather samples. Its instruments can study, in detail, an area about the size of a postage stamp.
MOXIE
An instrument to produce oxygen from carbon dioxide in the Martian atmosphere, as a test for creating resources for future astronauts.
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Sunil Yadav

sunil016@yahoo.com

+91 9670809702

Yet Another Mission Control System (Yamcs)

Space Application Service (SAS)

Table of Content

Before digging deeper into the application concept, It is crucial to familiarise ourself with some terminologies, that are normally used in to and from communication of remote devices to other applications.

1. Telemetry
2. Telecommand

Telemetry

Telemetry is the collection of measurements or other data at remote points and their automatic transmission to receiving equipment for monitoring.
Telemetry may be commutated to allow the transmission of multiple data streams in a fixed frame.

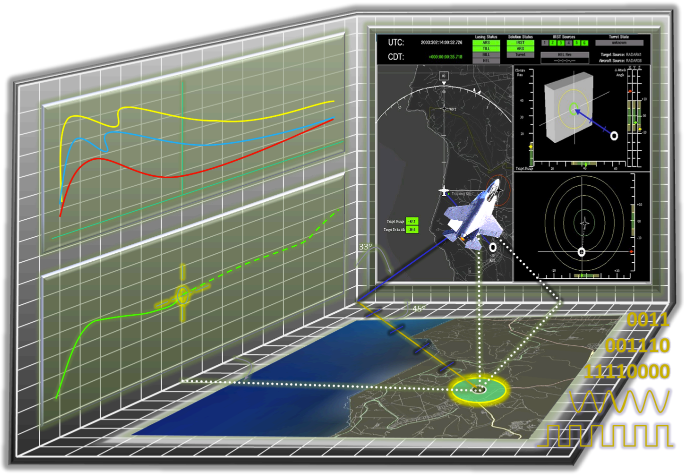
*A **telemeter** is a physical device used to remotely measure any quantity. It consists of a sensor, a transmission path, and a display, recording, or control device.

Use of Telemeters in Space Science -

Telemetry is used by manned or unmanned spacecraft for data transmission. Distances of more than 10 billion kilometres have been covered, e.g., by Voyager 1.

Protocol Used -

Space Data Link - CCSDS - 132.0.B.2.



Telecommand

A **telecommand** is a command sent to control a remote system or systems not directly connected (e.g. via wires) to the place from which the telecommand is sent. The *telecommand* can be done in real time or not depending on the circumstances (in space, delay may be off days). Remote devices are programmer to listens and understands the telecommand through which it will be performing its action.

Protocol Used -

Space Data Link - CCSDS - 232.0.B.2.

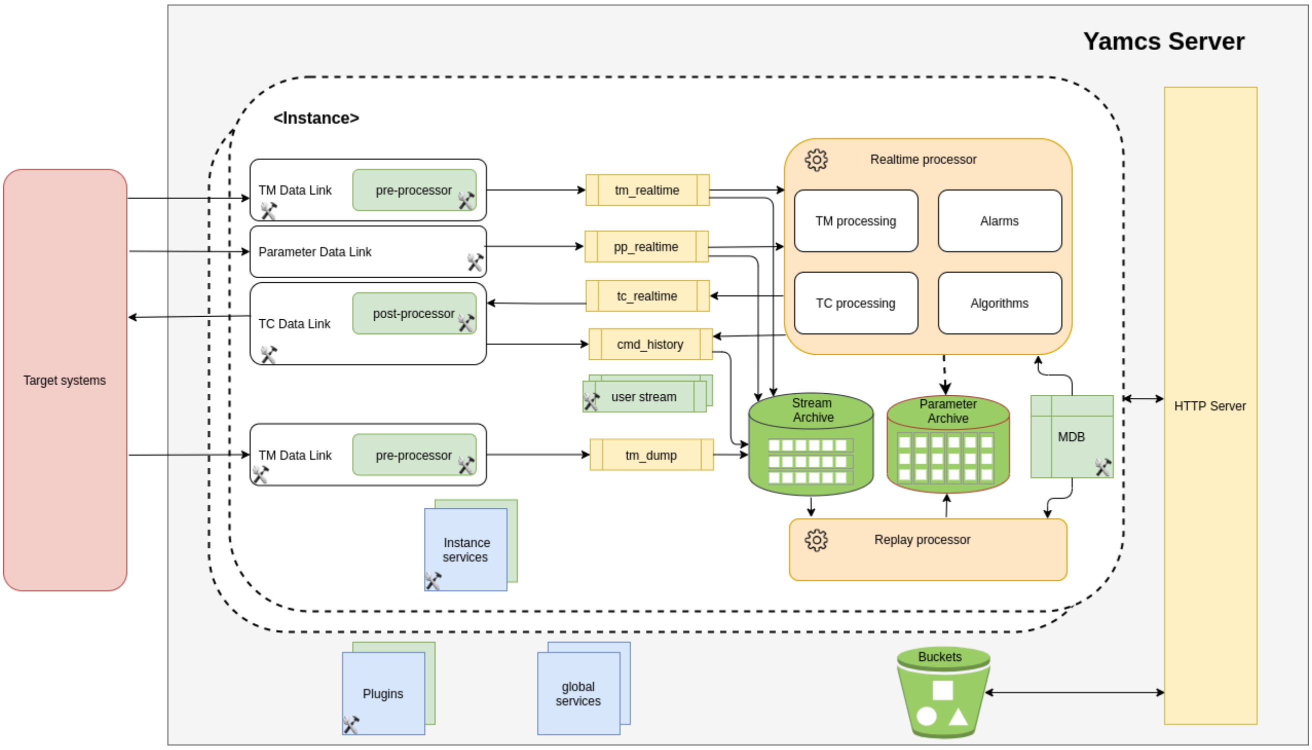
Introduction to Yamcs

Yamcs, is the central component to monitor and control the remote devices. *Yamcs stores and processes packets, and provides an interface for end-user applications to subscribe to realtime or archived data.*

Yamcs exposes its functionality over a well-documented HTTP-based API. So, tomorrow if Alpha Application wants to have the data from this repository of Yamcs, or Alpha needs the live realtime data from Yamcs, it (Aplha), can either use REST endpoints or it can subscribe to Yamcs via WebSocker and listens to realtime TM data.

Yamcs Implementation :
Language - Java
Server - Netty Server

Database - RockDB
Preferred OS - Linux. In Yamcs, Remote DevicesSystems is represented through a set of parameters, which are sampled at regular interval. i.e Remote device is sending its Telemetry Data at a fixed interval in particular format based on CCSDS protocol (binary packets), and Yamcs is listening to those data and parsing it.



Parameters can either be received directly from the remote device or can be computed locally by **algorithms,** I.e Engineered Parameters.

These parameters that are coming to Yamcs, has certain expiration as well, after the time is exceeded the remote devices is considered as lost and its status becomes unknown.
A telecommand is made up by a name and a number of **command arguments**.

Some commands can have an elevated **significance**, which may mean that a special privilege or an extra confirmation is required to send the command. Once the command has been sent, it passes through a series of execution stages. Users are not enforced to use these predefined-stages.

Instances in Yamcs

Yamcs application allows us to monitor/control the different payloads or satellites at same time, for each of those remote devices we have to create an instance.

Data Link

Data link is a component responsible to connect the remote device to the ground (target system). One instance can have multiple data links. Data link are of three types -

Telemetry *Binary Chunk coming from remote device to the system, for mission control.*
Telecommand *Reverse of Telemetry, this is sending instructions back to remote device after analysis.*
Parameters *Processed Data, that helps in checking for limits and for safe keeping for future analysis.*

In Yamcs, there are built-in data links like one that is listening for data at port 10015 over UDP.

Streams

Steams are the components inside Yamcs, that transports tuples. While switching from One Component to other component, we can change the stream based on our requirement to get specifics data relevant to that component only.

Yamcs Processor

Processor is where most of the monitoring and control parts are done. Here Packets are transformed from binary chunks to the parameter based documents, limits and alarms are monitored, commands are generated and verified.There may exists multiple processors in single instance.

Mission Database

Mission database is the repository that holds description of telemetry and telecommand, that contains limits, alarms, algorithms, relevant constraints and pre-post verification.

Services

Yamcs, takes the configuration through Yaml, configuration file.
1. The global definition, that are needed at server level and can be accessed by all present instance is written in - yamcs.yaml

2. The instance specific configuration like in and out data link with their ports are written in - yamcs.{instance}.yaml

3. Processor specific configuration are written in - processor.yaml

We can change the default working nature of Yamcs application by creating our custom class that implements the defined interfaces.

Plugins

Plugins are the custom jars, that can be loaded to Yamcs, that alters with the default functionality of Yamcs, to make Mission Specific Functionality.

Stream Archive

Realtime archive, TM and TC data are inserted as soon as it gets it over the stream.

Parameters Archive

Optimised storage of parameter, for its retrieval, when asked in limited set over a longer period of time. Archive is not realtime, it gets its data after the Reply processor, processes the stream archive data.

Buckets

Data Object Storage facility, that is used to store file and documents that are received from the On-Board system. We can make use of these via REST endpoints, that Yamcs, exposed.

* Yamcs, is the server tool, that accepts data from Remote devices over CCDSD protocol, parses it, stores it and facilitates the end-user to make mission critical decisions and analysis on the data. It contains its constraints, breach of that by any parameter will create an alarm and attentions the operator for the immediate check on the remote device. It also contains Mission Specific data in order to verify and generate telecommand, that will be sent as an instruction to the remote device. Yamcs, exposes quite a lot of REST endpoints and it also facilitates for WS endpoints, that different application can make use for its analysis or visuals or for giving instruction to device.

Configuration in Yamcs

Based on out requirements with Yamcs, we have multiple options to manipulate the configuration for Yamcs server. Root Configuration file that is responsible for Keeping primary traces about Service and Instances is /etc/yamcs.yaml.

We have to declare the Instance, the operational directories. Also we are required to give the server ClassPath and the Port to expose the Yamcs Service, if we are supposed to use some different Hosting Server for Yamcs.
While declaring Instances, it is required to have a dedicated configurational file for each instance, as each instance is responsible for handing communication from one Remote device. The format for Instance configurable file is - /etc/yamcs.{instance-name}.yaml

Mission Database

MD, is a storage system, that keeps the description for Telemetry and commands that are processed by Yamcs Processor. It helps Yamcs, to Encode and Decode Telemetry and Telecommand.

It contains definitions of -

Parameter Definition
Alarm Definition
Algorithm Definition
Command Definition
TM/TC Definition.

Data Link

It is a communication component, that establishes the connection between the Ground and the target instrument and spacecraft. It is off three types - TM,TC,PP.
TM and PP, are received at Ground and they are pumped to Realtime or Dump TM.
TC is subscribe to External Systems and sends the Commands to it whenever required.

Processor

Processor is the one that process TM and TC. It has clients that receives TM and sends TC. Internally, Yamcs creates a replay processors for tasks like filling up the Parameter Archive. On-request replay processors, processing data from the archive.

Commanding

When the ground needs to instruct the target system, Yamcs processor generated a Telecommand that will be send to Target System, it is checked intensively based on pre-conditions and post-conditions constraints.