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Development of the Test and Monitor System for Satellite Communications Payload and Network

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Abstract

A satellite communications monitoring and control system(SCMCS) has been developed at ETRI to provide the capabilities of in-orbit test(IOT) for communications payload and communications system monitoring(CSM) for the satellite communications services. The paper discusses the system level design of SCMCS and its tasks.

1 Introduction

After launching a communications satellite, IOT is performed to investigate anomalies of the communications payload, telemetry and telecommanding subsystems before their service operations. For this purpose, SCMCS performs a series of tests with the dedicated microwave measurement instruments through the microwave RF links. The data obtained during these tests are analyzed and compared with the pre-launch test data to determine if communications payload of the satellite was successfully survived during launch process.

Also during the service operation, CSM should be performed to check the health of the satellite communications payload and satellite networks. SCMCS has been designed to monitor individual signals on the transponder output, look for unexpected signals, and measure overall transponder performance parameters under traffic loading conditions.

Another key function of SCMCS is to control and manage the global satellite network. Network control subsystem(NCS) of SCMCS manages network configuration data, measurement data, and operational data in database. The data collected from IOT, CSM and telemetric messages from ESCOS(ETRI satellite control software system) are stored in NCS database for later analysis. Using these near-real-time collected data, NCS judges the satellite network status as wel as the status of communications payload and displays their status on large scale project. Another use of these data are for long term analyses of payload performance degradation and for analysis of the possible service interferences.

SCMCS conducts a variety of microwave measurements. These include measurements of spacecraft input power flux density(IPFD), equivalent isotropically radiated power(EIRP), translation frequency response, gain transfer characteristics, group delay, antenna pattern, center frequency of carrier, bandwidths of carrier, power of carrier, and so on.

Although SCMCS is targeted for the laboratory model payload system, which has also been developed by ETRI. However, the generic structure of SCMCS and its capability are applicable to many other kinds of satellite, such as the next generation multipurposed low orbit satellite.

2. Design & Implementation

2.1 SCMCS Overview

SCMCS is a very complicated measurement and analysis system which is integrated with RF equipments, microwave measurement instruments and computers.

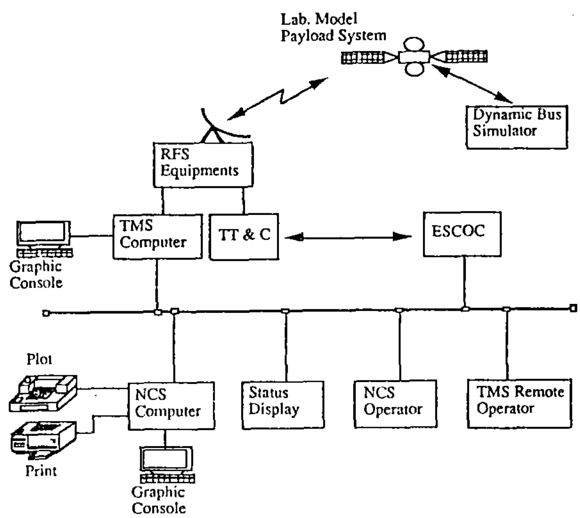

Figure 1 System Configuration

The system configuration of SCMCS is outlined in Figure 1. SCMCS consists of RF subsystem (RFS), test and monitoring subsystem(TMS), and network control subsystem(NCS). Software is built on HP 9000/700 workstation platforms with HP-UX which is HP's version of UNIX. Measurement instruments are connected to the TMS control computer with IEEE-488 GPIB bus. TMS and NCS are connected with ESCOS by LAN on TCP/IP protocols.

For easy operation, SCMCS use graphic user interface(GUI) based on OSF/Motif X-Window system and high resolution color monitor for the operator's visual display.

SCMCS is a very complex and mission critical system. Therefore, the design goals of system are focussed on hierarchically laid top-down design and independent modular design. Figure 2 shows SCMCS software hierarchy.

Each blocks of subsystems are independent and task specific. For the software reusability, application software is built on application specific library provided with Error handling and message logging capabilities. SCMCS is implemented in the C and C++ languages. In addition, for manual interactive test, a specially designed measurement language CALSTEP has been used which is described on the companion paper[4].

Databases are used for storage and retrieval of all data such as measurement data, payload configuration data, earth station data and operational data. The database of SCMCS is very well matched with object orient database concept because of their object inheritance properties.

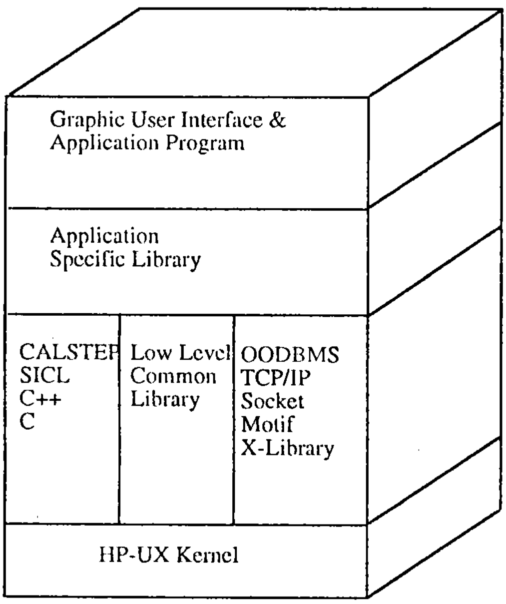

Figure 2 SCMCS Software Layer

SCMCS is built on two UNIX workstation in distributed environments. Each software block can be independent process and runs independently. For the inter-process communication, ipc library function has been designed.

2.2 RFS Subsystem

RF subsystem which is required for IOT and CSM consists of antenna, high-power amplifier(HPA), low noise amplifier(LNA), up/down converter, modulator and demodulator, and others. The frequency band used is Ku band.

The up-link signal is generated by the signal generator HP 83623A with HP 3325B function generator. The up-link power is measured by power meters that are fed from waveguide couplers in transmission line.

The down-link signal from the satellite is too small to be measured by power meter at the antenna feed. For this reason, amplified signal after LNA is measured with calibration techniques. For calibration purpose, the reference injection signal is applied on the receive waveguide through a calibrated coupler after antenna feed and before the LNA. A frequency counter is used for measurement of up-link frequency and down-link frequency.

2.3 TMS Subsystem

Recently satellite communication payload system becomes larger and more complex. Not only manual operations of measurement procedures are very tedious and error prone, but also it is impossible without mechanized measurement system. TMS is computer controlled measurement subsystem of SCMCS which controls RF measurement instruments, schedules and execute measurements. The result data is stored on NCS database through the distributed environment. TMS database keeps local database as a part of NCS global database.

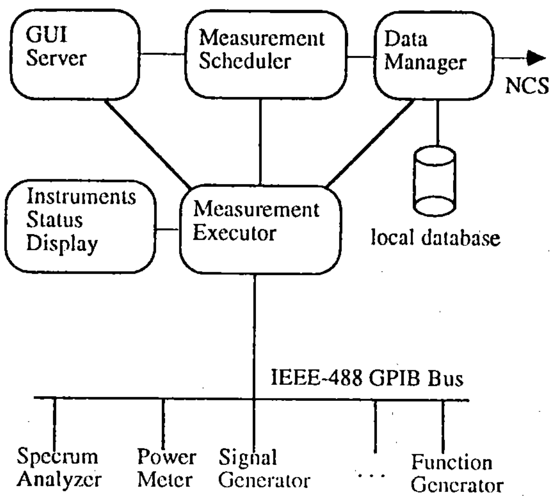

Figure 3. TMS Software Structure

- GUI Server

The functions of GUI server are to provide graphic user interface to operator. GUI reduces the chances of operator's mistake and provides user friendly environment. In user interface, it should be easy to use and flexible for a variety of measurement requirements, like interactive detailed test and automated scheduled test. And also it has been designed to have the ability of checking for erroneous user input.

The figure 4. shows manual test window. Operator can define target satellite, channel number and measurement parameter. At the right side of the window, operator can edit his own manual test procedure(MTP) with CALSTEP or read in a pre-edited stored MTP file. Also it can be customized for its own test.

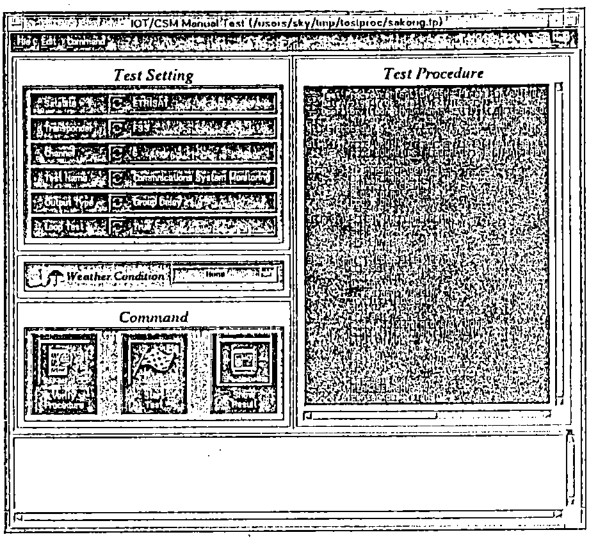

Figure 4 Manual Test Window

- Measurement scheduler

For scheduled test, automated test procedure(ATP) file is edited from GUI window and scheduled on queue by operator. The scheduled ATP can be executed on a certain interval or on a specific time. ATP can be any combination of multiple measurement. Operator can browse the scheduled queues and pop out a certain queue for a certain purpose.

- Instrument Status Display

The status of every instruments connected on IEEE-488 GPIB are displayed on graphic mimic status display panel. During the measurement operation, the status of every instrument is displayed for operator's easy monitoring.

- Measurement Executor

Measurement Executor is the kernel of measurement process. It interacts with instruments to do the measurements and data acquisition. During measurement execution, the measurement executor configures and controls the microwave measurement instruments. It also interacts with data manager to get configuration data of satellite payload, calibration data and others. After measurement, the measurement result date is stored in database. During the measurement process, the instance values of the measurement are displayed on X-window in textual and graphical form. If the measured value goes over the pre-defined threshold limit, then a measurement alarm message is generated for attention of operator. The generated measurement alarm message is displayed on page monitor.

Also in scheduled test, ATP message which is generated from measurement scheduler is forwarded to this measurement executor. Because of the limitation of measurement resources, only one measurement can be executed at one time. If one a measurement is on the process, the next measurement will be suspended until the measurement executor is free. During this waiting time, operator may de-queue the measurement request or abort the current measurement depending on his decision.

2.4 NCS Subsystem

The key function of NCS is status monitoring and management of global satellite communications network. NCS manages network configuration data and measurement data and operational data in database. Based on the data collected NCS judges network status and display it on large screen project or graphic display terminals with mimic diagram. Also the data are stored in databases for later analysis. Using test result analysis software, long term trend analysis of transponder performance characteristics can be possible. Another key function is the investigation of network problems caused by some interference or any other reason.

NCS shares TTC antenna with ESCOS. Telemetric messages from payload is forwarded to NCS. Also telecommanding request messages is forwarded to ESCOS for controlling payload during IOT or managing payload.

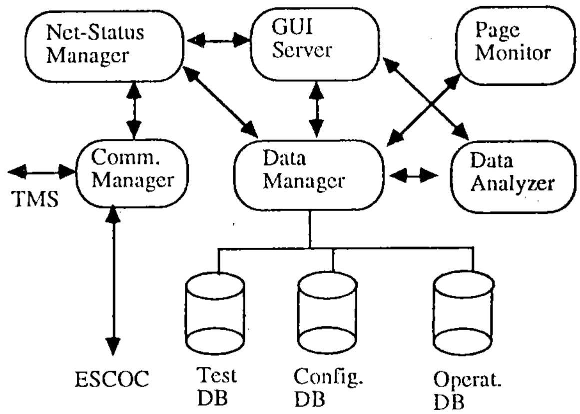

Figure 5 NCS Software Structure

As the same manner with TMS software, NCS software is built on UNIX, and each software block is function specific and independent from each other. Figure 5 shows the software structure of NCS.

- Data Manager

NCS database manager is a primary part of NCS, which manages test DB, configuration DB and operational DB. Whole network configuration data and characteristic data of payload are stored in this configuration database. They are transponder characteristics and configuration such as center frequency and bandwidth, transmit and receive beams, transponder gain settings, and orbital parameters; frequency plan of each services such as channels carrier slots, center frequencies, bandwidth, power threshold level, modulation; earth station characteristics, configuration and calibrations data.

NCS data manager is the master of TMS data manager. The kernel of data manager is Versant OODBMS which supports C++ interface and distributed database environment. The characteristics of SCMCS data is inherently well matched with OODBMS concept.

- Communication Manager

The communication manager keeps two communication paths. One is for TMS and the other one is for ESCOS. The communication path with ESCOS is to receive telemetry and transmit telecommand for controlling transponder during IOT campaign from TMS or managing transponder directly by NCS operator.

- Network Status Manager

From the data collected such as IOT, CSM and telemetric messages, status control manager judges the status of global satellite communications network and update its status information. If there were some changes, status manager updates the status display project screen or graphic display terminals. Depending on its level, some audible alarm is desired.

- GUI Server

Like TMS GUI server, GUI server provides interface with operator. At login time, it checks the permissions and capabilities of the operator.

- Page Monitor

During the operation of SCMCS, all generated messages can be displayed on page monitor. Also it can be controlled by operator depending on its message level. Logging level and display level are controlled independently for his convenience. Messages displayed are classified to alarm, event and error messages. Alarm messages are generated from measurement values which is out of limit or telemetric alarm messages from payload or measurement equipments failure or from any other reasons. Event messages are some important messages which is generated from internal software blocks for tracing some auditing purpose or erroneous operation. Error messages are also generated from internal software blocks during the operation when unexpected situation happens.

And also, telemetric messages and requested telecommand messages are displayed on a separate window.

- Data Analyzer

NCS data analyzer provides hardcopy plotting for most of the measurements and system operational data. Raw data may require additional manipulation, such as computation, averaging and statistical analysis. The raw data and processed data must be stored and retrieved conveniently to and from database. SCMCS can display the processed output with report on graphic terminal for the quick analysis and the graphic output can be printed for hardcopy.

3. Conclusion

For IOT and CSM measurements on modern satellite communications system takes lots of time and skills. Without computerized measurement system, it is impossible because it requires sophisticated measurement techniques and result analysis of the huge amount of measurement data. For applying to IOT and CSM measurement, a computerized automatic measurement and analysis system, SCMCS has been designed and implemented. The developed system will be enhanced for multi-purpose low orbit satellite. For the design of SCMCS, state-of-art computer technology has been adapted, such as distributed systems, object oriented programming, graphic user interface technology and etc. Specially in manual interactive test, new interpretive test language CALSTEP has been design and implemented for easy test.

For enhancing SCMCS as the global network management system of satellite communications network, the monitoring capabilities of traffic information and base-band spectrum is required. Currently earth station management and control function is not implemented, but in next phase it will be considered.

Acknowledgments

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