Web Based Visualization of Spacecraft Checkout Telemetry Data

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Abstract—**Continuous visualization of spacecraft telemetry data plays an important role in maintaining the satellites. Data for remote monitoring of spacecraft is referred to as telemetry data. Web based visualization provides display of telemetry data from different satellites. If there is an alert from the satellite, web based Page Display System (PDS) will alert the user through the web based visualization system. This paper describes the disadvantages of existing system for display of spacecraft telemetry and how the proposed system overcomes the limitations of the existing system. Proposed system provides the view of telemetry data for multiple satellites on a single system. Proposed system allows navigation between multiple user selectable pages which is advantageous over existing system. The telemetry data continuously updates at a given interval depending upon the satellite. Asynchronous JavaScript and XML (AJAX) is used for the purpose of displaying the telemetry data from the satellite for different parameters. For display to various users, telemetry data is to be fetched from the data server and displayed on multiple user terminals by requests to web server. Since web-based application is being used, accessing telemetry data from remote location over the network is possible. The resulting implementation ensures the monitoring of health status of various satellites by multiple users at the same time.**

Keywords-Telemetry data; Automatic Checkout Software System; Page Display System; Spacecraft; Asynchronous JavaScript and XML; Apache tomcat

I. INTRODUCTION

Satellites undergo extensive testing as part of ground checkout before launch. More than 3000 parameters are monitored using telemetry data. Automatic Checkout Software System (ACSS) is a set of software products, developed for the automation of Spacecraft Checkout operations [1]. The proposed system is a part of ACSS. ACSS runs on Checkout Servers which are on LINUX platform. ACSS will acquire spacecraft telemetry continuously from the Data Acquisition Systems in real time.

The objective of the proposed system is to display this processed data to the users in real-time in a telemetry page format.

This system will be realized by development of a web-based application which will display spacecraft telemetry to the user in real-time in the form of multiple user-selectable telemetry pages. The application runs on Web Server and fetches the telemetry data for selected telemetry page from the data server and displays it in a telemetry page format through a web browser on the client system. The application will use AJAX technology to provide the real-time display of telemetry data [2].

II. EXISTING SYSTEM

A. Overview

ACSS running on Spacecraft Checkout Server (SCC) connects to Data Acquisition Systems over Ethernet using Transmission Control Protocol (TCP/IP) to acquire two streams of real-time telemetry data. The acquired data is processed and displayed to the user in a terminal window on the SCC. This window provides a character user interface to accept user inputs and changes the display accordingly. This window appears on the SCC screen along with multiple other windows of ACSS providing display of plots, raw data and so on.

B. Disadvantages

- Application is keyboard-driven. User has to invoke it to view telemetry pages.
- Limited user interface makes it difficult for the user to switch between multiple pages of telemetry. Inhibits multiple users to view the spacecraft telemetry data.
- Users at remote locations are unable to access the telemetry data for purpose of analysis etc.
- The telemetry for multiple satellites cannot be viewed on a single-system.

III. PROPOSED SYSTEM

A. Overview

The proposed system replaces the existing system of telemetry display to the user. It consists of an application running on a Web Server, a data server and client systems

with a web browser. SCC will act as a data server where two streams of telemetry is available. The Web Server runs on windows platform and hosts the web pages for telemetry display.

The web application running on the Web Server connects to the data server over Ethernet using TCP/IP to fetch two streams of telemetry. It then transforms the fetched data to enable its display in a telemetry page format. The web application will be Java-based utilizing AJAX. As the display is real-time, AJAX is used in the application to handle faster rate of telemetry data update.

Fig. 1 shows System architecture of Data acquisition and display which is composed of 6 components.

- Satellite
- DAS
- DACQ Software
- TM Distribution Server
- Web Server
- Client

B. Satellite

The ground checkout equipment supports automatic linking up of Telecommand to the satellite resulting in the satellite generating a large amount of data that is transmitted back to the ground checkout equipment as telemetry data.

C. Data Acquisition System (DAS)

The data acquisition system collects electrical signals from satellites and sends them to DACQ software for processing. Data acquisition consists of transducer for converting variable processes into electrical signals, signal conditioner, sample and hold to keep signals constant while converting from analog or digital, Analog to digital converter, Digital to analog converter and Actuators.

The telemetry data sampled by the telemetry subsystem is transmitted to the data acquisition system that is used to monitor the health status of the satellite. The health of all subsystems of satellite is monitored continuously onboard and sent to the ground.

D. Data Acquisition Software (DACQ)

DACQ software will fetch the data from DAS. The telemetry data coming from the satellite consists of parameters from different subsystems of the satellite with varying sampling rates.

These all are stored into master frame which consists of about 16 or 32 or 64 sub frames and these sub frames are further categorized as 128 words per frame.
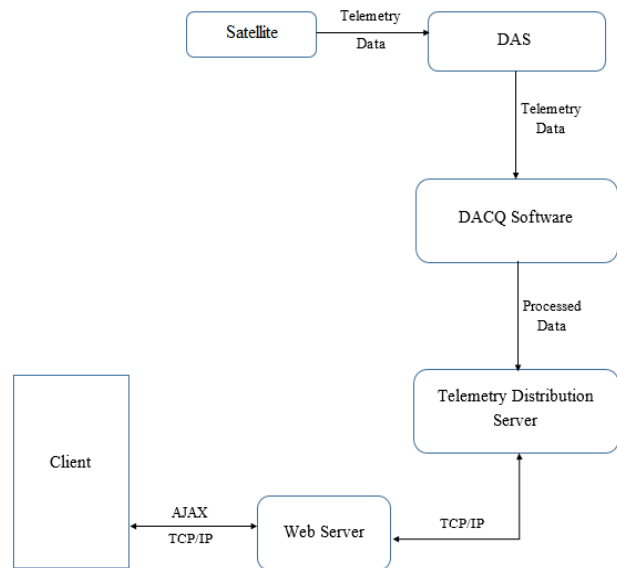

Fig. 1. Architecture of Data acquisition and Display

Fast varying parameters are monitored in every frames where as slow varying parameters are monitored once in a master frame.

E. Telemetry Distribution Server

The telemetry data once processed are stored in data server, which will provide the data to the user. User can fetch the data from server using TCP/IP connection by providing server IP and port number. SCC acts as data server.

F. Web server

For displaying the real time data at the client side user need to send the request to the web server such as apache tomcat through AJAX. The interface between the data server and web server is achieved by using Java.

G. Client

Client is one which sends the request to the server and waits for server response. Here the client is any system which uses the browser to monitor the telemetry data. By entering the URL, users can view the telemetry data in client system. By selecting a satellite, user can view the data and can analyze the data from the graph plotted for selected parameter. Since the application uses web server any system can run it through browser and that system is treated as client system.

H. Advantages

- Enables multiple remote users on the client systems to view the telemetry data through the web browser.
- Allows easier and quicker interaction with the user with a graphical user interface. The user is able to interact with the interface by supplying or requesting data when they choose.
- Enables view of telemetry data for multiple satellites on a single system.
- Allows easier navigation to users across multiple telemetry pages.

- Real-time data is displayed at the required rate as web pages are not reloaded when their content is changed, data is updated selectively.
- Provides flexibility to add functionality as several multi-purpose applications and features can be handled using a single web page, avoiding the need for clutter with several web pages.
- For every change in telemetry data time versus value graph will plotted.

Hence, the proposed system will enable various users distributed at different locations of ISRO Centre to analyze the Checkout Telemetry Data.

IV. IMPLEMENTATION

The web based visualization system is designed and developed for monitoring the health of satellite using real time display of telemetry data. Data Server implemented in C runs on Linux platform which provides telemetry data to the web server running on Windows platform.

Apache Tomcat which is open source and easily configurable, is chosen to configure web server [3]. Application running on web server has been developed using JSP (Java Server Pages) with NetBeans IDE (Integrated Development Environment) as the development tool. It establishes a connection to the data server to fetch telemetry data as a series of frames. It is also responsible for display of web pages on the client systems.

The displayed web page is used for selection of telemetry pages and parameters and receives other user inputs. The web page gets updated in accordance with the user input. Also the value of telemetry parameters in the web pages get updated in real-time after a given time interval (in order of milli-seconds). AJAX (Asynchronous JavaScript with XML) is used for transfer of data to the client systems from web server to handle this fast rate of telemetry data update. JFreechart, an open source library of Java is used for display of real-time telemetry data for user selected parameters as a graph on the web page.

Fig. 2 shows the architecture of apache tomcat web server. In response to the request raised by the browser, apache will get data from tomcat which is connected to data server using socket connection.

Fig. 3 shows AJAX XMLHttpRequest and Response phase. Browser creates the XMLHttpRequest and sends it to the web server through java script call. JSP on the server side, process the request by fetching the data from data server and send it back to the callback function of browser.

The hidden frame of AJAX will get the response and provided to the browser using html for display.
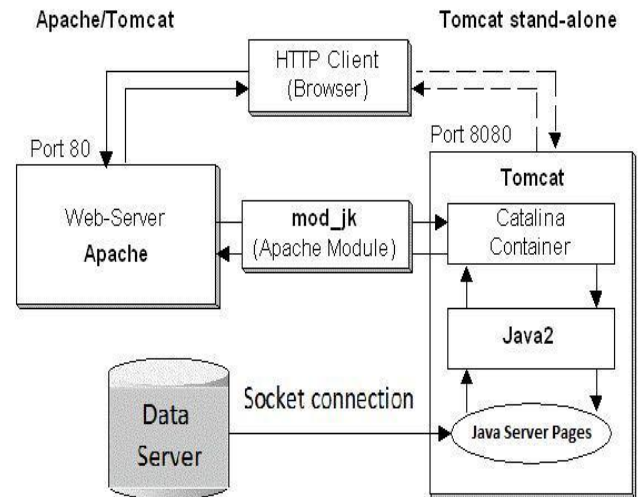

Fig. 2.   Architecture of Apache tomcat

There is no need of reloading the web page for getting updated values as the asynchronous feature of AJAX provides the data as it get updated.

Graphical user interface as shown by Fig. 4 is created by extending applet and using java swing components. List of satellites is displayed on the GUI for selecting a satellite for data retrieval. Offline display of telemetry data is provided by retrieving for a specified parameter and time or day.

The value of selected parameter versus time will get plotted on the graph. As the value of parameter changes, value versus time plot will also get changes with no delay. The list of parameter names are provided for particular page. PID monitor is used for displaying individual parameter value by specifying the parameter index. Java Server Pages (JSP) is used for development of web server application [4].
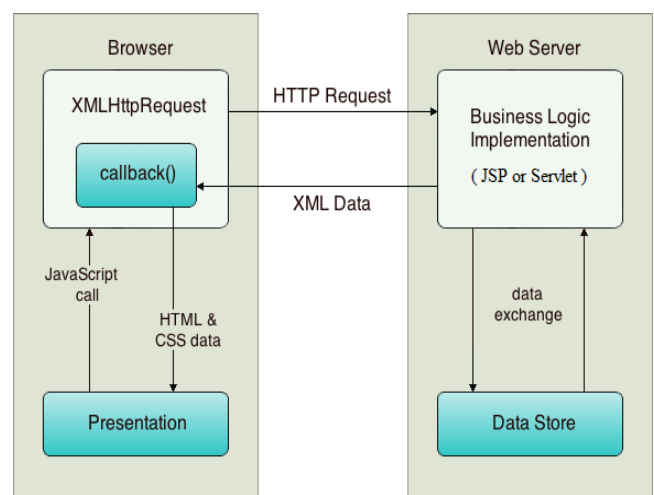

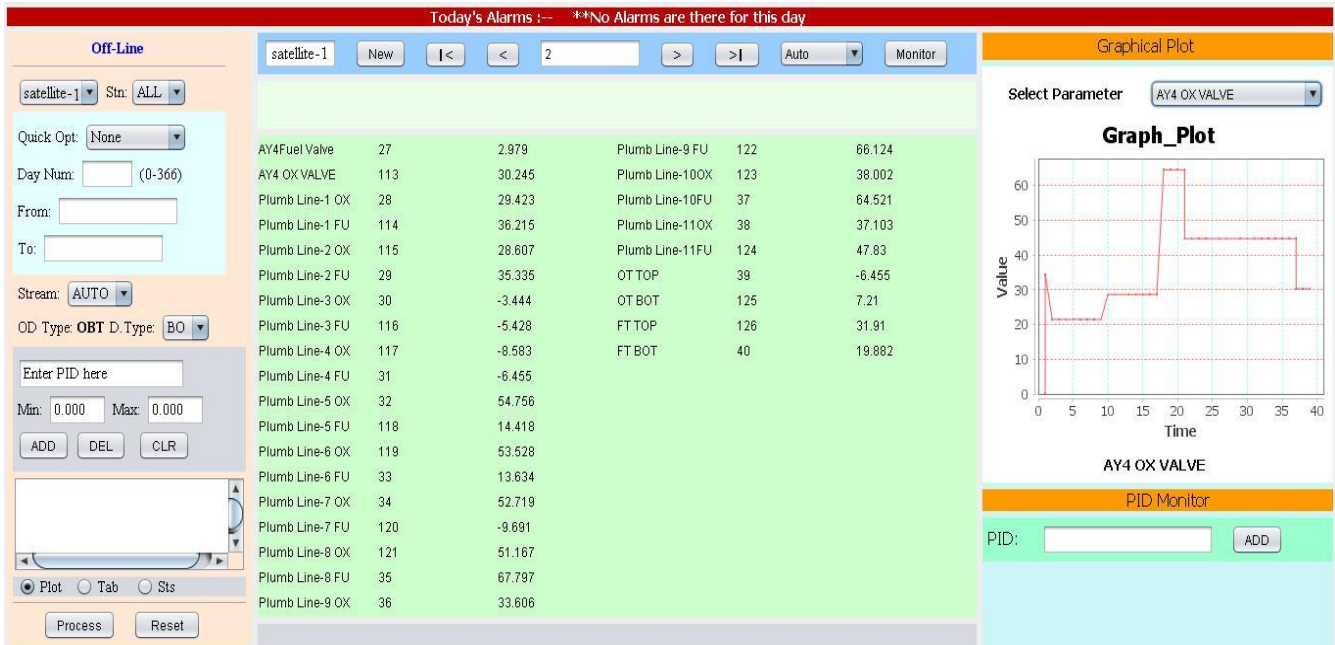Fig. 3.   AJAX XMLHttpRequest and Response

Fig. 4. Implementation of web based visualization of telemetry data

No alert is displayed for the day. By entering the date, time and adding parameter index the offline display of telemetry data can be viewed. Navigating to next, last, previous and first page can be achieved. New button will provide display of telemetry data in a new window (except offline display). The telemetry data display panel provides the display of names, indices and values of parameter of selected page.

In Fig. 4 page 2 is selected among multiple user selectable pages and AY4 OX VALVE is selected for getting plot of value versus time. Selected parameter name is displayed below the graph. For every second graph will be plotted irrespective of change in value. The parameter value of 30.245 is showing after 40 seconds. By providing parameter index the individual parameter values can be monitored.

V. CONCLUSION

In this paper the real time display of telemetry data was proposed for monitoring the health of the satellite continuously and also used for the purpose of research. As the AJAX technique was used for fetching the dynamic data and displaying it had no delay. Except offline display other displays of telemetry data are asynchronous.

REFERENCES

[1] Software Requirements Specification for Automatic Checkout Software System (ACSS v3.0), ISRO-SCG-CSAD-SW-2013-06 v1.0, October 2013.

[2] http://www.ukoln.ac.uk/cultural-heritage/documents/briefing-43/briefing-43.doc

[3] http://www.akadia.com/download/soug/tomcat/html/tomcat_apache.html

[4] http://www.studytonight.com/jsp/introduction-to-jsp.php.