DATA ACQUISITION, ANALYSIS, AND SIMULATION SYSTEM (DAAS)

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ABSTRACT

The Data Acquisition, Analysis, and Simulation System (DAAS) is a computer system designed to allow data sources on spacecraft in the Flight System Testbed (FST) to be monitored, analyzed, and simulated. This system will be used primarily by personnel in the Flight System Testbed, flight project designers, and test engineers to investigate new technology that may prove useful across many flight projects. Furthermore, it will be used to test various spacecraft design possibilities during prototyping.

The basic capabilities of the DAAS involve unobtrusively monitoring various information sources on a developing spacecraft. This system also provides the capability to generate simulated data in appropriate formats at a given data rate, and to inject this data onto the communication line or bus, using the necessary communication protocol. The DAAS involves Serial RS232/RS422, Ethernet, and MIL-STD-1553 communication protocols, as well as LabVIEW software, VME hardware, and SunOS/UNIX operating systems.

KEYWORDS

Ethernet, Serial RS232/RS422, MIL-STD-1553B Communication Protocols, LabVIEW Programming

INTRODUCTION

The Flight System Testbed (FST) is a new area within Jet Propulsion Laboratory (JPL) designed to create a virtual spacecraft through simulated instruments, sensors, and subsystems. This will, in return, reduce costs, shorten schedules, and identify and resolve problems in the early stages of spacecraft development long before the spacecraft is built. The Data Acquisition, Analysis, and Simulation System (DAAS) is one component of the Flight System Testbed that will contribute to the attainment of future goals in the spacecraft industry at JPL.

FUNCTIONAL CAPABILITIES

Within the Flight System Testbed, the DAAS externally monitors spacecraft subsystems to detect possible problems during data transmission. The DAAS also provides the capability to simulate data, perform tests, and observe a particular instrument's behavior during prototyping. This system can most accurately be described as a "meta-tool" (i.e. a tool to build tools) since it will provide generic capabilities that can be customized for the needs of various flight projects. Much of the DAAS will be specific to each flight project. The Flight System Testbed will provide an environment (i.e. appropriate hardware and associated software) and assistance in constructing specific analysis routines from algorithms specified by the flight project design engineers. The system monitors data using various communication protocols, such as Ethernet, RS232, RS422, and MIL-STD-1553B across a communication medium from one spacecraft subsystem to another. This monitoring process is unobtrusive except for the possible necessity of a physical tap into the communication line or bus. The software is available to display data collected in digital and/or graphical forms in near real-time. The data acquired by the DAAS can then be time stamped and stored to data files for later off-line analysis.

ASSOCIATED HARDWARE AND SOFTWARE

As shown in Figure 1, the DAAS configuration diagram, a SPARC CPU-2CE running SunOS is installed within a VME chassis, acting as any other SPARCstation 2 within the Flight System Testbed and containing the same I/O interfaces. Physical connections to the spacecraft subsystems are necessary along the serial communication lines, while the MIL-STD-1553B and Ethernet communications occur along each bus through the VME backplane. This "embedded-sparc" may be accessed from any outside SPARCstation. VME FORCE drivers are installed on the embedded-sparc to access other boards within the chassis, such as the MIL-STD-1553B bus monitoring board currently within the chassis.

The data display package being used is LabVIEW, a visual programming language developed by National Instruments. LabVIEW is an excellent data display and analysis tool valued for its quick and easy program modification capabilities. LabVIEW uses graphical programming language, G, to create programs in block diagram form and relies on graphical symbols or icons rather than textual language and code. LabVIEW also allows existing C code to be integrated into the visual programs for additional programming flexibility.

ETHERNET

Various methods are available to capture data across ethernet within UNIX. The DAAS incorporates these methods and, combined with LabVIEW, displays the data on a customized Virtual Instrument (VI) that is made up of a variety of graphs and charts offered by LabVIEW. Various C programs were written, reviewed, altered, and incorporated into LabVIEW through the use of Code Interface Nodes (CINs). CINs allow these programs to communicate directly with and output the necessary data on the appropriate VIs.

To test the capability of obtaining data across ethernet, data was sent from one host to another via ethernet, captured by the Data Acquisition System, and then displayed using LabVIEW. During an open house demonstration for the Flight System Testbed, the DAAS was used to obtain data through ethernet socket connections. From a simulated command and data handling system using LabVIEW to display the communicated data, the simulation of the capabilities of capturing spacecraft data was complete.

SERIAL (RS232/RS422)

The DAAS is designed to capture the data transmitted through serial communication lines from one spacecraft subsystem to another and interface it using the manipulation and display capabilities within LabVIEW as discussed earlier. The DAAS RS232 serial communication lines act as "snoopers" between two point to point terminals (spacecraft instruments). The DAAS is connected externally from the inputs/outputs of the spacecraft instrument through specially designed cables. These cables allow a physical tap into the line without affecting data transmission; hence, they are unobtrusive. Because LabVIEW VIs have the capability to initialize, read, write, and display information to and from serial ports, LabVIEW is the preferred and well-valued tool for use with the DAAS. Various programs have been designed to allow the user to set-up desired serial port initializations, retrieve data from one or many serial ports simultaneously, and manipulate and display the data through LabVIEW. A daughter board is connected to the embedded-sparc for additional serial ports to monitor several ports simultaneously. Another valuable feature of the DAAS is the capability to simulate the data across serial communication lines. The DAAS acts as an input to a particular subsystem, allowing the spacecraft subsystem to retrieve data in a given format and at a specified data rate.

Monitoring RS422 is a similar concept with the exception of differences in added voltage, additional wires, and length capabilities. Adapters are available for the DAAS to convert the RS422 signal to a RS232 signal, in order for LabVIEW to recognize it.

Power supplies are also available to handle the increased voltage involved in RS232 to RS422 conversion. Additional serial communication protocols may be incorporated into the DAAS as flight projects evolve, with minor additions and modifications.

MIL-STD-1553B

A MIL-STD-1553B Board is installed in the VME chassis for MIL-STD-1553B bus traffic monitoring. Programs were written in C code and incorporated into LabVIEW through the use of Code Interface Nodes. These programs output the data in a standard output form, since MIL-STD-1553B data streams involve a variety of information within command, status, and data words. Generic control and information output panels have been designed to allow the user to retrieve the data and display the necessary information within LabVIEW programs specific to each project. Each input and output value may be displayed as decimal, binary, octal, or hex through the use of the pull down menus on the numerical displays within LabVIEW.

The LabVIEW interface is designed to retrieve data from the MIL-STD-1553B bus monitor, which captures data between the controller and various remote terminals, as well as between remote terminals. The monitoring of MIL-STD-1553B traffic involves the output of command words, data words, and status words, each word a length of twenty bits. The first three bits are used for synchronization and the last bit is the parity bit. Therefore, the sixteen bit information field will be acquired and displayed through LabVIEW. Command words specify the function the remote terminal is to perform. This word is transmitted by the active bus controller. The data words contain the actual information that will be specific to each user. The status word is only transmitted by a remote terminal in response to a valid message. This is used to tell the bus controller whether or not a message was properly received and the status. The information fields specific to each flight project can be output through various graphs and charts within LabVIEW . Simulated data was captured through the DAAS to represent the possible MIL-STD-1553B capabilities available for future missions.

Sending simulated MIL-STD-1553B spacecraft data to a particular spacecraft subsystem will be an available option as well, when specified by a particular flight project. This will allow simulated MIL-STD-1553B data to be delivered to a particular remote terminal according to MIL-STD-1553B standards, along with accessible data monitoring capabilities.

LabVIEW - OTHER AVAILABLE OPTIONS

Other LabVIEW options are available through programs and VIs (Virtual Instruments) specifically designed for the Data Acquisition System. Time stamping is available in LabVIEW through the use of various icons which display the current time and date in several forms. This time stamp is dependent upon LabVIEW, not actual real-time, so there may be a slight difference depending on the speed of the data being monitored. Time may be captured and displayed if already time stamped within data packets. Icons are available for storing, reading, and writing data to and from files. These may be used to store data for later off-line analysis. Another memory board can be installed to handle data storage to other disks and prevent loss of performance through LabVIEW.

Many other icons are available to display data graphically and digitally. With knowledge of LabVIEW programming, one may alter and combine any of the VIs explained previously along with ones already available from National Instruments to continue progress on this system for a specific user. Extensive data manipulation and display is available and relatively easy to alter with the use of LabVIEW visual programming and its applications.

CONCLUSION

The basics of unobtrusively monitoring data from Serial RS232/RS422, Ethernet, and MIL-STD-1553B communication protocols have been tested through the simulation and acquisition of real-time data. LabVIEW's limitations involving high data rates and complexity are currently unknown. It has not been discovered when the system will begin to slow down considerably and impact the data monitoring. Various data rates have been tested and LabVIEW seems to handle these quickly, but this is without the manipulation of data and all possible data sources being monitored simultaneously. The DAAS has been tested with multiple data sources and seems to retrieve data just as well. Other issues may arise depending on the complexity of the program designs and extensions.

In the near future, spacecraft may be moving towards MIL-STD-1773 as an on-board spacecraft communication protocol. The Data Acquisition System will adapt to this when necessary. It will evolve as various equipment, such as MIL-STD-1773 monitoring boards, become available within the Flight System Testbed at JPL. As flight projects evolve and become a part of the Flight System Tested, various private protocols will be specified by flight design engineers. Since these cannot be anticipated at the moment, they will be developed in the future as needed.

As previously mentioned, this system is designed as a "tool to build tools", so it will require further modifications specific for each flight project. It will now be quicker to obtain a user's particular configuration, since the basics of unobtrusively monitoring spacecraft data from various communication protocols have been explored. The hardware, software, and knowledge are available to meet the needs and requirements for specific flight projects within the JPL Flight System Tests.

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DATA ACQUISITION, ANALYSIS, AND SIMULATION SYSTEM CONFIGURATION

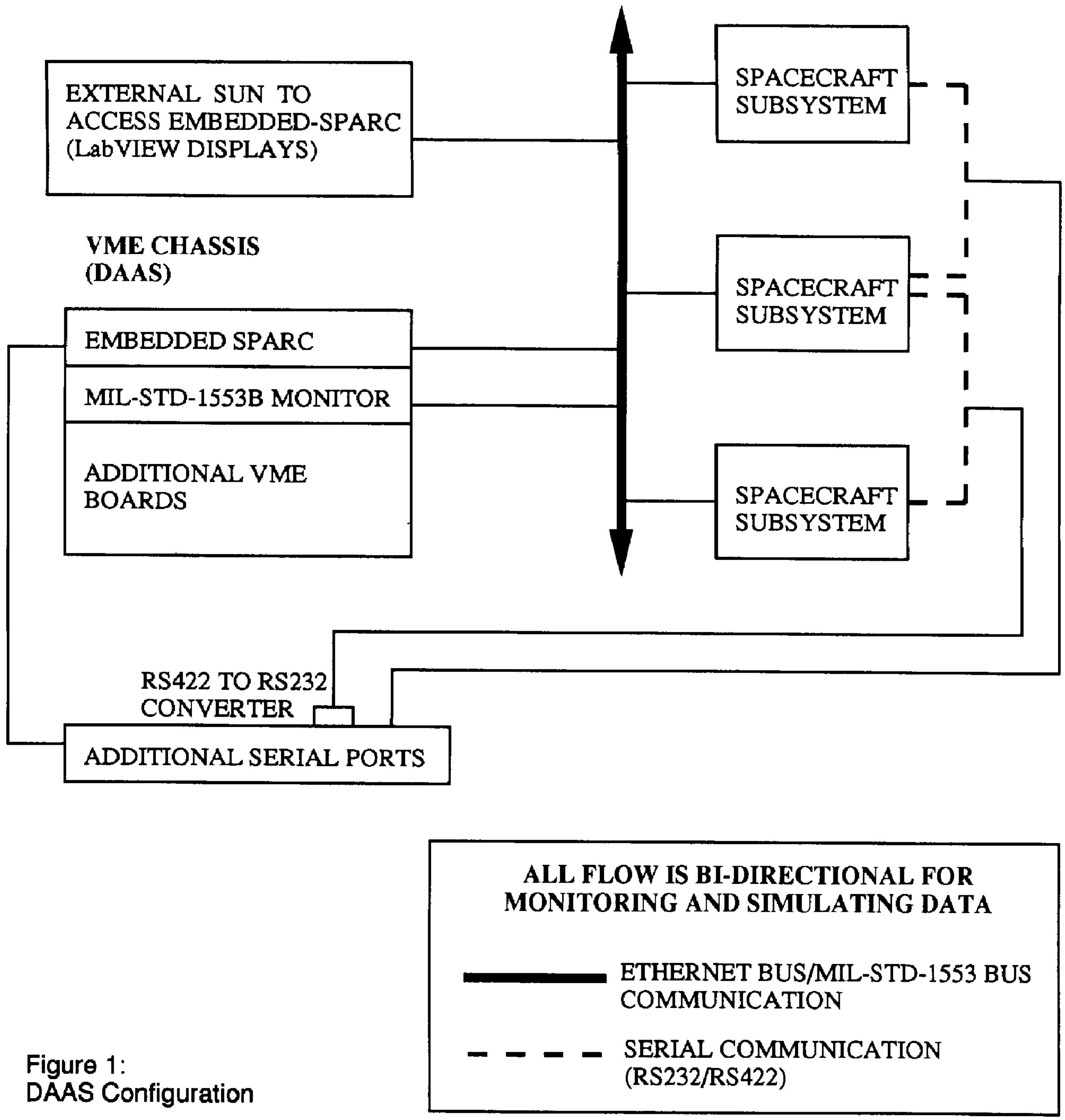

Figure 1:
DAAS Configuration