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NICKEL HYDROGEN BATTERY EXPERT SYSTEM

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INTRODUCTION

The Hubble Telescope Battery Testbed at MSFC employes the Nickel Cadmium (NiCd) Battery Expert system (NICBES-2) which supports the evaluation of performance of Hubble Telescope spacecraft batteries and provides alarm diagnosis and action advice. NICBES-2 provides a reasoning system along with a battery domain knowledge base to achieve this battery health management function. This report summarizes an effort to modify NICBES-2 to accomodate Nickel Hydrogen (NiH2) battery environment now in MSFC testbed.

The prototype version of NICBES (NICBES-1) was developed by Martin Marietta Corporation. It was implemented in Intel 8086 assembly language, C and Prolog and runs on an IBM PC/AT under the DOS. The current version of NICBES (NICBES-2) is implemented on a Sun Microsystem's 386i running SunOS4.0 (UNIX) and is written in SunOS C and Quintus Prolog. The system now operates in a multitasking environment along with a mouse and window based user interface.

A Digital Equipment Corporation LSI-11 based system sends the battery data to the Sun 386i via an RS-232 connection running at 9600 baud using XON/XOFF control. One telemetry burst is received every 30 seconds. NICBES-2 spawns three child processes: serial port process (SPP), data handler process (DHP) and the expert system process (ESP) in order to process the telemetry data and provide the status and action advise.

When data appears on the serial port, SPP collects it character by character and feeds it into a data pipe. The DHP reads the data pipe and converts the character data into numeric values and reduces the raw telemetry data (by calculating averages and means of various battery parameters) in preparation for use by ESP. ESP is awakened by the user's request for a consult/advice function. Each of the three processes is awakened only when its service is desired and they go to sleep when the function is completed. The SPP has the highest priority among the processes.

In short, NICBES-2 performs orbit data gathering, data evaluation, alarm diagnosis and action advice and status and history display functions.

MODIFICATIONS NEEDED

The adaptation of NICBES-2 to work with Nickel Hydrogen (NiH2) battery environment required modifications to all the three component processes. Although the general format of the telemetry input was retained, the components of the telemetry data are different in the case of NiH2 batteries. As such, the data input routines of SPP needed extensive changes. Because of the differences in the data collected between the NiCd and NiH2 batteries, all DHP routines required changes. The structure and the reasoning mechanism of ESP remain the same. But the rule base needs to be changed to accomodate the NiH2 battery domain.

STATUS

The modifications to SPP and DHP were completed earlier (4). Some data items in the telemetry (Ampere-hour Out, Time-to-Trickle, Telemetry temperatures and Main and Redundant heater flags) were not utilized earlier. The DHP is now modified to utilize these data.

Modifications to ESP required consultations with NiH2 battery experts to collect the rules appropriate to that domain. Several journal articles reporting on battery test environments were consulted along with the current rules in the NiCd case, to arrive at the rules for NiH2 batteries. An initial rule set is now in the knowledge base.

The rules are utilized by the ESP to provide status and action advise during consultations with it. These functions are based on the data over the last 12 orbits. The alarm conditions are generated by the ESP at every telemetry burst, if the ranges of the data do not conform to the established limits. Thirteen alarm conditions were incuded into the ESP, in addition to the ones that were in the system earlier.

WORK NEEDED

An extensive experimentation is needed to refine the current rule set into an optimum one for the NiH2 batteries.

The data files generated by the system seem to be unnecessarily elaborate, and create disk space shortage in the current system. File structures need to be examined to reduce their size if possible. If not, some of the files may need to be archived on the tape storage.

Several means and averages are now computed at 2 minute intervals (i.e. every 4 samples) rather than every other sample as in NiCad environment. Adequacy of these computation needs to be examined.

Battery health management in general depends on the data collected over a long period of time (years in some cases). As such, the data reduction routines in NICBES-2 should be generalized to expand the range from the current last 12 orbits mode.

The current structure of the system is dependent on 6 batteries and 22 cells per battery. The system need to be generalized to accomodate more general battery environments.

The system at present provides battery management advise only when consulted. The ultimate aim should be to place the system in closed control loop such that the management actions are automatically done.

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