SIMULATION OF PCM DATA UTILIZING A GENERAL PURPOSE COMPUTER[1]

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Summary. Due to the increased complexity and capabilities of modern missile telemetry systems, it has become increasingly difficult to provide an effective yet flexible simulation capability for the verification and validation of PCM decommutation systems.

Control Data Corporation, under contract with the Space and Missile Test Center (SAMTEC) at Vandenberg Air Force Base, California, recently completed the development of a powerful and flexible simulation system utilizing a CDC 3300 computer. This Telemetry Decom Validation System (TDVS) now allows personnel to develop a simulated PCM data stream using a telemetry-oriented compiler to generate telemetry instructions. The compiled program can then be executed in a microprogrammable processor which generates the defined PCM stream through the interpretation of the specially designed instruction set output by the compiler. Data can be simulated at rates up to 2 megabits using any of the seven IRIG code conventions or Miller Code.

Introduction. The primary function of the Space and Missile Test Center is to provide support for the relatively large number of various missiles launched from Vandenberg Air Force Base. Associated with this function is the requirement to provide telemetry decommutation systems capable of processing the telemetry transmitted by the missiles. One of the major problems in providing this support is the development of a decom system for a new missile or telemetry format. This problem is compounded because of the non-availability of historical data with which to verify the decom once developed. Realistic simulation of the data has, in the past, been a difficult, if not impossible, task. In order to help alleviate the problems imposed by this situation, Control Data Corporation was contracted by the Space and Missile Test Center to develop the Telemetry Decom Validation System.

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Discussion. The Telemetry Decom Validation System is a hardware/software computerized simulation system which was implemented on a CDC 3300 general purpose computer using the CDC Mass Storage Operating System (Figure 1). An additional hardware device, called the Telemetry Output Module, was designed to perform the actual transmission of PCM data. The Telemetry Output Module design is based on a microprogrammable processor.[2]

The software system is made up of three major elements (Figure 2). The key to the use of the Telemetry Decom Validation System is a Telemetry-Oriented Language (TELOL) Compiler. This compiler program, which executes in the CDC 3300 computer, was designed so that telemetry personnel with little or no computer background can develop a simulation program using common telemetry terminology. A simulated PCM data stream can be created to verify decommutation synchronization by defining only the frame format (i.e., frame length and sync patterns). This basic frame definition can then be expanded to include measurement definition (subcommutation, super-commutation), and measurement data values. Each measurement may also be assigned a unique and meaningful symbol which will allow direct reference to the measurement by name. Measurement data content can then be caused to vary on a timed basis in order to provide a realistic simulation. Thus it becomes very easy to develop a highly sophisticated simulation program on an incremental basis. This feature becomes very useful in the development of decommutation software in that simulation data can be developed as required without a large initial effort. Use of high level compiler language also reduces the possibility of error in the format of the simulated PCM data stream.

Another feature of the TELOL Compiler is its ability to automatically save and catalog the simulation program it has generated. Once cataloged, this program can be called up and executed at any time. The loading and execution of the program is controlled by a real time executive program.

The real time executive, in association with the Telemetry Output Module, performs the actual simulation and transmission of the PCM data. The Telemetry Output Module executes, via firmware emulation, the simulation program that was generated by the compiler. The real time executive controls the execution of the instructions and is also capable of modifying the instructions.

There are two methods of directing the real time executive to modify the simulation instruction set, thereby causing the output PCM data to be altered. The first method involves the time based measurement changes input to the TELOL Compiler. During the compilation of these timed measurement changes, the TELOL Compiler generates a list of

[2] D. J. Karleskint, "Microprogrammable Processors Applied to Telemetry Processing Systems" Proc. ITC Vol. VIII, pp 614-620, 1972.

new instructions along with the location of where they are to be placed within the simulation program. The generated list is then saved in a mass storage file as was the basic simulation program. Up to 24 of these timed measurement change files can be generated for each basic simulation program. The real time executive, if so directed, will retrieve and merge any combination of these timed measurement change files prior to an actual simulation. When the simulation of data begins, this merged list of measurement changes is referenced by the real time executive and the modification of the instructions takes place automatically. This method of data modification provides two powerful capabilities to a user of the system. The first one is that he may predefine a series of intricate measurement changes which will in turn be automatically incorporated into the PCM data stream. The second is the ability to describe measurement changes in several increments. In missile telemetry, each separate stage of the missile has a unique set of measurements associated with it. The measurements within each stage can therefore be described and simulated separately, or can be combined for a complete missile simulation. It is therefore possible to prepare a total and complex simulation program in incremental steps.

The second method of measurement data modification provided by the real time executive allows for dynamic changes in the measurements. The real time executive has within it a miniature and limited version of the TELOL Compiler. Each measurement described to the TELOL Compiler has a symbolic identifier associated with it. An operator of the real time executive can direct, via a CRT, a measurement data change by referencing its symbolic name. The real time executive will then alter the simulation instruction causing the telemetered data to be changed correspondingly. This function thereby allows the data to be modified as it is being transmitted providing the ability to perturbate measurements for decommutation system checkout.

Other controls provided by the real time executive allow for starting and stopping data output, starting and stopping the timed measurement changes, freezing the data output (causing it to repeat a frame of data with no measurement changes) and changing the data rate, code or polarity.

The third major software module associated with the Telemetry Decom Validation System is a file manager. The system utilizes punched cards, magnetic tape and mass storage for information storage and retrieval. Compiled programs, if saved and cataloged, reside on mass storage. Input to the TELOL Compiler may reside on any of the storage media. Manipulation of data between these various media is the function of the file manager.

The file manager can be operated in either a batch or interactive mode. In the interactive mode, control is provided by a CRT. In the batch mode of operation, the file manager will read commands from a card reader or magnetic tape. It is also possible to pass control

from one device to another causing the change from interactive to batch mode, or vice versa. The file manager commands are the same in either mode of operation.

The file management command set allows for maintenance and modification of the various simulation files. Maintenance of files is provided for by commands that allow data to be transferred between files and other storage media. Modification of files is accomplished via another set of commands which allows deletion or insertion of files or records within a file. An optional log is available which contains a complete history of all transactions made during a file manager session.

The three software modules described thus far could be adapted to many simulation applications. The Telemetry Decom Validation System in operation at the Space and Missile Test Center bas associated with it other ancillary programs which are specifically applicable to the Space and Missile Test Center operation. Among these programs is one which uses historical data to generate TELOL source statements which, when compiled, will simulate selected measurements of that data stream. Another program uses theoretical data to generate measurement data. These two programs, both of which generate TELOL source statements, help alleviate the task of manually building a simulation program with complex measurement definitions.

The real time executive program has a feature which allows for a decom analysis program. As data is being telemetered from the simulation system, a file can be built which contains a complete history of the data transmitted. Utilizing this feature, a decom evaluation program was written which compares the data sent from the simulator to that received and recorded by one of two specific decommutation systems. This program provides an automated analysis of the decommutation systems capabilities and accuracy.

Conclusions. The Telemetry Decom Validation System is now in operation andhas proved its usefulness many times. A primary concern of the Space and Missile Test Center in providing support is that the data products produced on their systems are accurate. Therefore, prior to all real time operations involving telemetry, this system is used to verify that the decommutation system is operationally ready and configured properly. It has also, in the past, been used to pinpoint problem areas and to provide known data for hardware and software debugging.

There are two primary advantages of this system. The first advantage is the ability to develop a simulated PCM data stream using a high level compiler language. Because of the extended checks performed by the compiler and its diagnostic ability, the format of the data resulting from a simulation is extremely accurate. Provision is also made for identifying and referencing measurements by a symbolic name.

The second advantage of this system is the ability to modify the telemetered data, on a measurement basis, as it is being transmitted. This capability provides for true dynamic simulation.

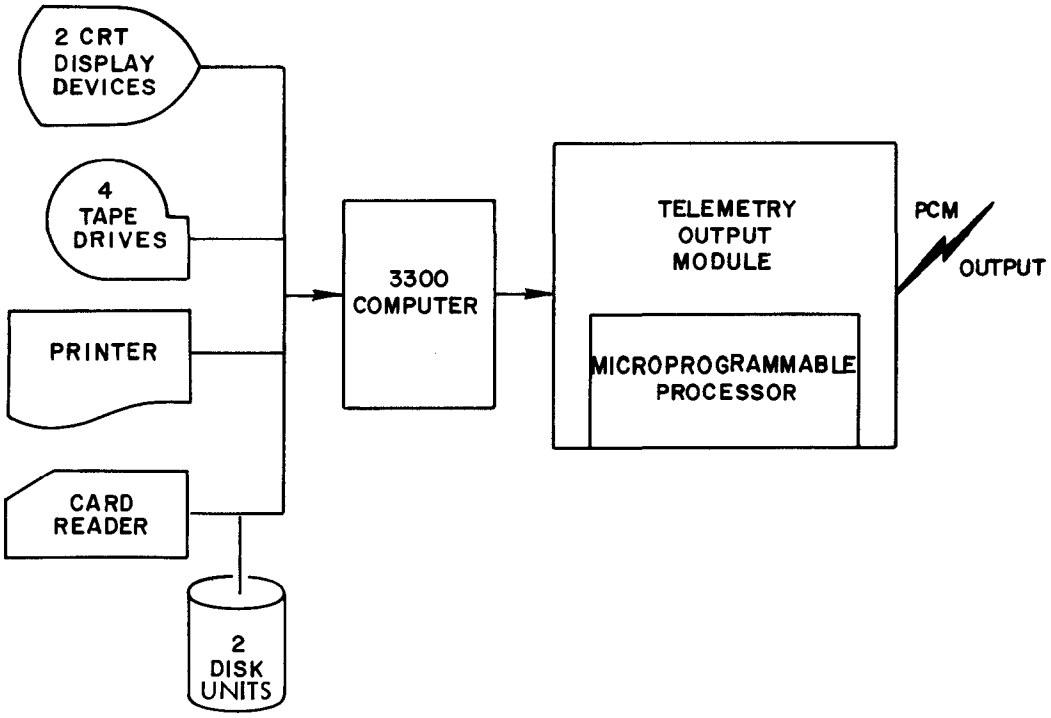

FIGURE 1. TDVS HARDWARE CONFIGURATION

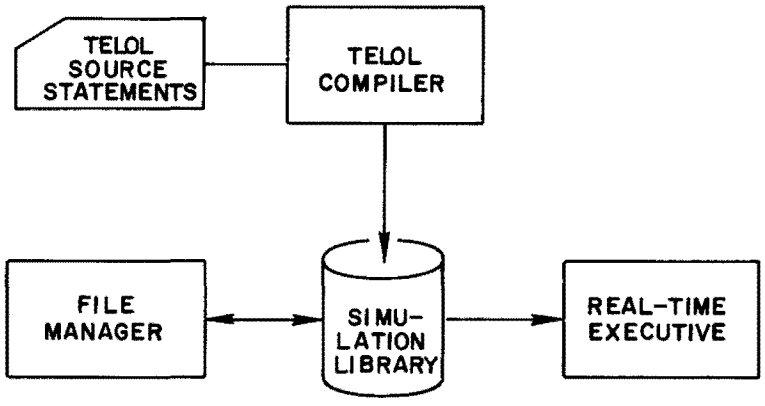

FIGURE 2. TDVS SOFTWARE DATA FLOW