SIMULATIONS OF SPACE STATION DATA LINKS AND GROUND PROCESSING

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ABSTRACT

The telemetry group has begun a new program in conjunction with Goddard Space Flight Center to investigate the possibilities of using parallel processing configurations for the real-time processing of Space Station data. In order to evaluate the potential configurations, a program based on using discrete-event simulation models is being used. This modeling software allows for generic configurations to be modeled and the relevant parameters to be modified to see the effects on performance. This paper represents a description of the work we will be undertaking over the next 18 months and the environment to be used in creating the simulation models at NMSU.

Key Words: Telemetry Systems
Simulation and Modeling
Parallel Computer Applications

INTRODUCTION

Many studies have been performed for NASA as part of the Space Station program to assess the data throughput and processing needs for real-time data (see, for example, Horan 1988 and references therein). Any study of the overall Space Station requirements quickly comes to the conclusion that those requirements will strain the capabilities of any hardware and software systems which the major computer vendors have planned for introduction in the foreseeable future. One general class of computers which is expected to be necessary to accomplish the processing needs for Space Station is the parallel computer. Because the required systems are not available today and yet planning for the configuration of the Space Station ground-segment data
processing system must proceed, a need has arisen to find a method to gauge the effectiveness and possible configuration of such parallel architectures. We have decided to use discrete-event simulation software packages to simulate the expected performance of these computer systems in the expected Space Station ground-segment environment. This paper will describe the program presently being undertaken in conjunction with Goddard Space Flight Center to investigate the use of parallel computers in this application.

SPACE STATION GROUND SEGMENT DATA PROCESSING ENVIRONMENT

The Space Station will be producing data in volumes and at rates unprecedented in the space program. The portion of the overall system which is of most interest to us at NMSU is the Customer Data and Operation System (CDOS). The CDOS system is, itself, composed of several subsystems which perform the initial data processing and interface to the space network. The components of CDOS which we are concerned with modeling are the Data Interface Facility (DIF) and the Data Handling Service (DHS). The DIF performs the interface functions for CDOS to the TDRSS network including initial sorting of data, requesting of data re-transmits and other low-level functions. The general architecture of the DIF is given in Figure 1. The DHS performs what is referred to as Level-Zero Processing of the data and interfaces with the DIF. The general structure of the DHS is illustrated in Figure 2.

ADVANCED TELEMETRY PROCESSING PILOT PROGRAM

The Advanced Telemetry Processing Pilot Program (ATP$^3$) is a cooperative research agreement between NASA/Goddard Space Flight Center and New Mexico State University. The program was begun in the fall of 1988 and will run until the end of 1990. The investigative goals of the ATP$^3$ project are to conduct research in the following areas:

a) investigation of the application of parallel processing techniques to the specific task of real-time processing of space-to-ground data frames in the space-station environment,
Figure 1. The baseline DIF architecture (CDOS Concept Definition Document).

Figure 2. The baseline DHS architecture (CDOS Concept Definition Document).
b) investigation of architecture performance for a number of classes of parallel processing configurations from an applications point-of-view rather than from an architecture development point-of-view, and

c) investigation of parallel processing programming techniques, especially in the areas of high-level language support, programming development support, and relative benchmarking of languages on the various architectures.

**SIMULATION ENVIRONMENT**

The simulations are being conducted at the Computer Assisted Design and Simulation Laboratory (CADSL) at New Mexico State University. This is a laboratory dedicated to computing applications which require both extensive computing power plus a sophisticated user interface for input or output.

The hardware available in the laboratory for use in these simulations is illustrated in Figure 3. The environment is basically a Local Area VAX Cluster (LAVC) of engineering workstations with a work/fileserver. The LAVC is connected to the campus-wide ETHERNET backbone. With that interface comes the capabilities to network around the state of New Mexico using TECHNET and around the country using BITNET.

For use in the ATP^3 project, discrete event simulation software purchased from CACI is being used. The packages available are

a) SIMSCRIPT II.5 - a general-purpose, high-level simulation language with animation capabilities,

b) COMNET II.5 - a communications network simulation package for modeling virtual calls and datagrams, and

c) NETWORK II.5 - a Local Area Network simulation package for modeling the hardware and software configurations on the LAN.

Both COMNET and NETWORK are based on SIMSCRIPT but with pre-defined user interfaces, simulation building blocks, and animation capabilities.
EXAMPLE SIMULATIONS

The first example simulation configuration is illustrated in Figure 4. The COMNET simulation package is used for this example. The goal of this example is to model the end-to-end data flow of Space Station telemetry, voice, and video data as well as data requests from other NASA centers and user groups to Goddard Space Flight Center using the expected TDRSS channel characteristics for the space-to-ground data transport and realistic ground-to-ground channels for the communication links between White Sands and GSFC as well as from GSFC to the end nodes. This model is based on one of the configurations developed as part of a trade-off study performed for GSFC (CTA 1988). The operation of the DIF and DHS is buried in the general nodes labeled TGT and GSFC. In this study, we are looking to determine statistics relating to data backlogs and channel utilization based upon predicted mission models. The goal of the study is to provide an independent assessment of some of the results developed during the trade-off study.
Figure 4. A example end-to-end data transport model for the Space Station program (illustration produced with the CACI COMNET simulation package).
The second example simulation configuration is illustrated in Figure 5. The NETWORK simulation package is used for this example. The goal of this example is to model a possible multi-processor configuration for the DIF return-data and forward-data processing environments. The model allows for variations in the processing speed of the software to execute the processing of the data packets, the speed of the communication buses, the amount of storage available, and the method for coordinating the processing. This model uses a double-buffered storage with processing “ping-ponging” between the two return-link processors. The results of the processing delays and throughput volumes developed in models like this can be fed back into the previous COMNET model to give better end-to-end performance estimates.

**PROGRAM PLAN**

The work of ATP³ is just beginning in earnest. The major near-term goals for the program are as follows:

a) simulate configurations specifically developed for GSFC by Control Data Corporation to verify methodology of using the simulation packages,

b) develop models for the ground-segment data processing components, especially, the Data Interface Facility (DIF) and the Data Handling Service (DHS),

c) develop models for parallel architectures presently available commercially and in the NMSU research laboratories and integrate them into the DIF and DHS configurations, and

d) model various data transport configurations to simulate the operation of the parallel processing configurations in the DIF and DHS under various operational scenarios (equipment failovers, various data rates and volumes, etc.).

**SUMMARY**

The facilities at NMSU are presently being used to provide performance estimates for the planned ground-segment, real-time data processing to be used in the Space Station program. We have found the use of commercially-available discrete-event simulation packages useful in developing the modeling for this program. The overall program is just
Figure 5. A baseline DIF architecture (illustration produced with the CACI NETWORK simulation package).
beginning and we are expecting the results over the next two years to be useful in planning the architecture necessary to support the real-time data processing needs.

REFERENCES

