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COMMON FRONT END SYSTEMS FOR SPACE SHUTTLE AND SPACE STATION CONTROL CENTERS AT JOHNSON SPACE CENTER

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ABSTRACT

In the beginning of the fiscal year 1992, the development organizations of Johnson Space Center (JSC) were poised to begin two major projects: the Space Station Control Center and the refurbishment of the telemetry processing area of the Space Shuttle Mission Control Center. A study team established that a common front end concept could be used and could reduce development costs for both projects. A standard processor was defined to support most of the front end functions of both control centers and supports a consolidation of control positions which effectively reduces operations cost. This paper defines that common concept and describes the progress that has been made in development of the Consolidated Communications Facility (CCF) during the past year.

mission control, ground control, telemetry processing, space station, space shuttle

1 BACKGROUND

In preparation for ground support of the upcoming space station, Johnson Space Center had begun to plan a construct a Space Station Control Center (SSCC). A building adjacent to the Mission Control Center (MCC) was in construction and requirements had been written. At the same time, development efforts in the MCC had been refocused to replacement of the oldest and least reliable machines, those of the front end. A study team was established to determine if there was merit in a joint development effort of a common design. It was hoped that such an effort would reduce both development and recurring costs.

1.1 Three-Layer Model

The study began by defining a model of the front end functions. A three layer view of the processing was produced and is diagrammed below.

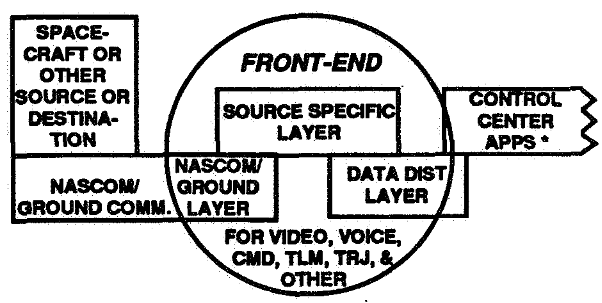

Figure 1. Three layer view of the front end.

Layer 1 is that processing which terminated the ground-to-ground protocol and interfaced with the external world. The Goddard Space Flight Center (GSFC) communications network protocol is handled in this layer, thereby isolating the remainder of the control center from any changes in ground network.

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Layer 2 provides the source specific processing for the front end. This layer does the specific format manipulation based on variations in spacecraft communications. It, in turn, isolates any changes in spacecraft telemetry from any other areas of the control center.

The final layer, layer 3, formats the data so that it can be distributed to the remainder of the control center. Ideally, the format is identical despite the spacecraft. This allows common applications, such as display building programs, to use and understand the data independent of source.

Each processing layer removes data formatting variation such that the entire front end produces a set of data which is identical despite its source. An application can use the data from any spacecraft without modification to its processing code. This provides an excellent opportunity for duplication of several applications downstream of the front-end processing. Additionally, future support for additional spacecraft becomes easier.

1.2 Layers vs. Requirements

This model provided an excellent framework against which to map the requirements of the shuttle and space station programs. In the mapping of these functions, layer 1 was designated the institutional layer. It contained the demultiplexers and modems that receive the data from external world. It also included the recording, switching and routing functions. It included the processing to handle the ground network data which included data from other NASA sites, network scheduling and network status data processing. The requirements for the space station and shuttle data processing revealed that the layer 1 functions were identical for both programs.

Layer 2 isolated most of the differences between the spacecraft telemetry. The space station telemetry consists of CCSDS packets using Reed-Solomon encoding. Its telemetry object lists are nonperiodic. The shuttle telemetry could require decryption, and utilizes Inter-Range Instrumentation Group (IRIG) standards. It's periodic nature is key to validating and decommutating the data. It became clear in mapping the requirements for this layer that the two programs were completely different. However, if the unique processing could be isolated, it appeared that a synergistic approach to the front end could be achieved. Spacecraft unique processing of the data could be performed on a single type of machine. Using a single platform, even with a different configuration of boards, would allow a synergistic approach to the maintenance and operations of the machines.

Once the data has been extracted from its down link format, layer 3 provides distribution of that data to the other areas of the control center. Development of a common data format provides the potential that the data acquisition functions used to receive the data throughout the control center can be identical and additional synergistic savings can be created. The code to perform layer 3 functions for the shuttle telemetry differ somewhat from that of the space station program, but both sets of code can easily run on the same platform.

The diagrams below illustrate the allocation of the control center requirements to the three-layer model.

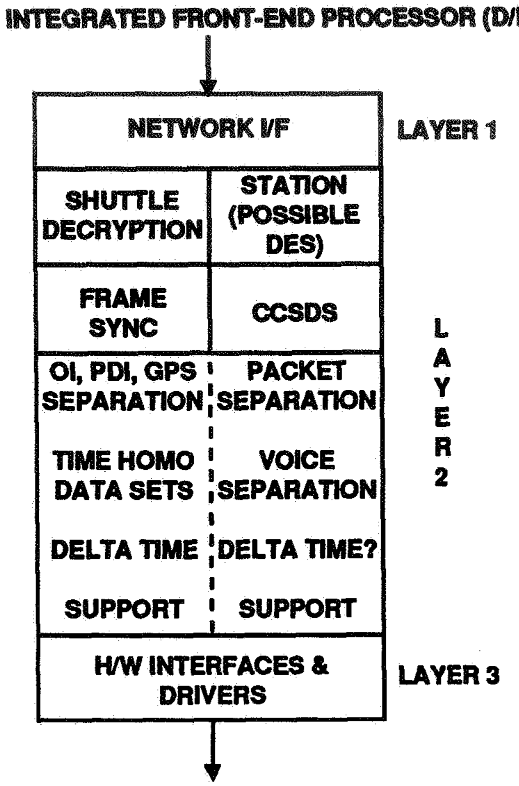

Figure 2. Mapping of downlink front end processing.

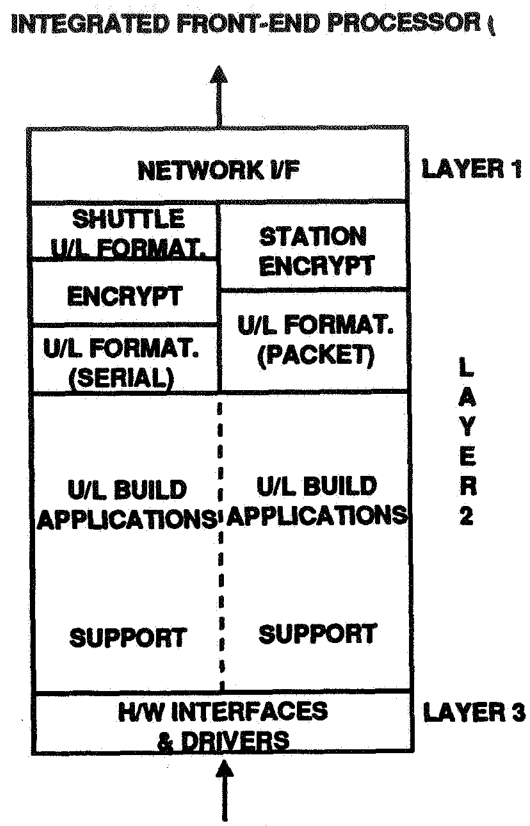

Figure 3. Mapping of uplink front end processing.

Correspondingly, the uplink function was mapped in reverse--building outbound commands in a layered fashion. The basic elements of these layers are given in the Figure 3. Once again, it is apparent that the functions are parallel and that the programs could benefit from synergism.

1.3 Considering the Marketplace

The study team evaluated the requirements and did an initial survey of the marketplace. A straw-man architecture in which the front-end processor was a VME-based machine was proposed. Specialized boards to do the spacecraft-unique processing were found to be available that would run on such a platform. An estimate for a common front end for both control centers at JSC determined that NASA could save 15% of the estimated development costs and reduce the maintenance staff by 30. Some savings result from the use of a single piece of hardware for both programs. Some savings is due to the single development effort on common platforms customized for each program. The results of this study were used to launch the Consolidated Communications Facility (CCF) project. This was approximately one year ago.

2. CURRENT STATUS

Since that time, the requirements for the consolidated system have been written and the project has been divided into 5 subsystems. These were: the Consolidated Data Select Switch (CDSS), the Consolidated Data Recording Subsystem (CDRS), the

Front End Processor Subsystem (FEPS), the Consolidated Distribution Subsystem (CDS) and the Test and Checkout Subsystem (TCS). Each of these subsystems has been designed and procurements are in progress. A mapping of the subsystems to the layered concept is shown below.

2.1 Consolidated Data Select Switch (CDSS)

The CDSS consists of high-rate and low-rate data switching, accepting multiple data lines from external sites and routing data to external sites. The low rate data switch

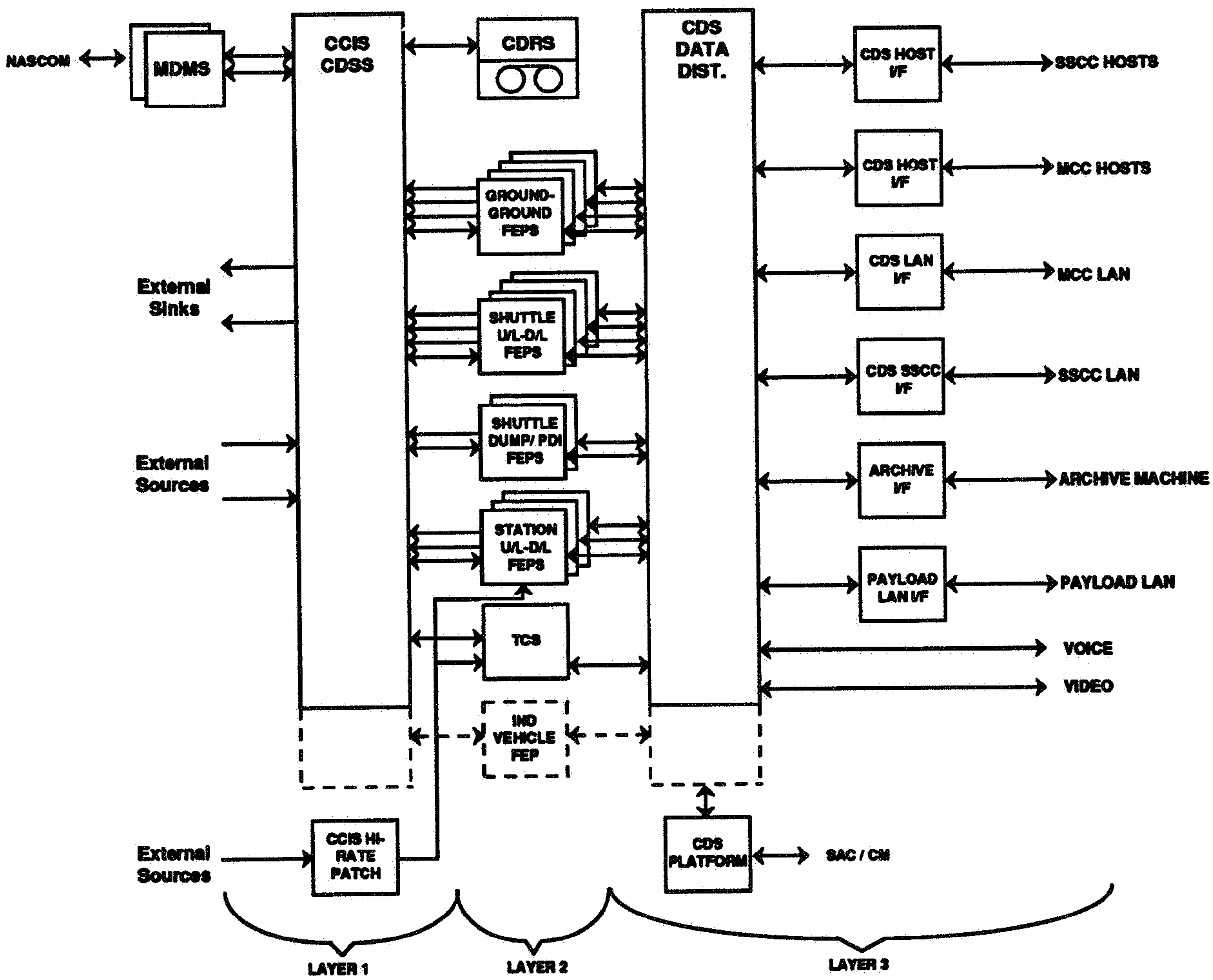

Figure 4. A mapping of the CCF components to the three-layer model.

handles the majority of this work--it is currently specified as a 600x500 port switch. The Request For Proposal (RFP) for this switch is being developed. The high rate data has few lines and will be patched rather than switched.

2.2 Consolidated Data Recording Subsystem (CDRS)

The planned CDRS technology is borrowed from the television industry which keeps commercials on cassettes. A robot then queues the tapes automatically and plays them as scripted. The control center taping system is envisioned as two sets of robotically operated tape silos. Since recorders do not operate efficiently at the slow data rates of the control center, data will be buffered and sent to the recorders in bursts. The recording system is expected to be run with minimal operator intervention. The operator will be needed only to remove any tapes for permanent storage or to arbitrate playback capability. This approach will reduce operations costs--a strong theme in the development of the CCF.

2.3 Front End Processing Subsystem (FEPS)

The FEPS contains the bulk of the processing in the CCF. The current design of the Mission Control Center contains several specialized hardware devices designed in the sixties and seventies. Over the years, other systems based on more modern COTS technologies have partially replaced the front end processing capabilities, but never were able to completely do so. The result is that the Mission Control Center now has four different design approaches to the telemetry processing. All will be replaced with the CCF.
The design of the CCF FEPS is based on a single VME-based machine. The machines will be tailored to suit the specifics of the spacecraft data for which it is used with special processing boards and software. The FEPS do all of the layer 2 processing. This isolation of the layer 2 to a single processor means that the CCF could be expanded to handle future vehicles with change only in the FEP processing. Additionally, the FEPS provide the processing platform to create the common data format discussed in layer 3. The procurement for the FEPS is currently in progress; replies to the RFP are due in January.

2.4 Test and Checkout Subsystem (TCS)

The TCS will run on the FEPS platform and will provide the ability to run test data streams through the system and score the output to assure proper processing. The TCS will be run routinely to validate the hardware and software is ready. It will also be used by maintenance personnel to locate problems.

2.5 Consolidated Distribution Subsystem

The CDS provides distribution of the data to the computation and display systems throughout the control center complex, including the older IBM mainframes and the newer UNIX workstations. Because the format of the data is common in nature for both programs, a single display processor can be used for either shuttle or space station data. This basis for the front end output simplifies the consolidation of the remainder of the control centers for each program.

3 SUMMARY

By looking at ground support for a joint space station and shuttle project, NASA has found a better and cheaper way of providing a telemetry processing area. The definition of a front end concept and mapping the functions required by both the shuttle and space station programs clarified the needs of each program. From this, NASA was able to determine what common hardware and software could support both. The subsystems were defined and designs done to accommodate the needs of both programs, as well as expand to future. The procurement of much of the CCF is currently in progress and the entire project is expected to be complete in 1996.