A Distributed Data Base Management Capability for the Deep Space Network

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This article reports on the Configuration Control and Audit Assembly (CCA), which has been designed to provide a distributed data base management capability for the DSN. The CCA utilizes capabilities provided by the DSN standard minicomputer and the DSN standard nonreal-time high-level management-oriented programming language, MBASIC. The characteristics of the CCA for the first phase of implementation are described.

I. Introduction

A significant cost item in providing operations support services for the DSN is the availability of management and operations information to support the planning, scheduling, and performance of these services. In order to reduce the costs associated with the acquisition, maintenance, and distribution of the management and operations information, the DSN has designed and is planning to implement a distributed data base management capability, identified as the Configuration Control and Audit Assembly (CCA). By direction from the NASA Office of Tracking and Data Acquisition (OTDA), the CCA implementation will proceed on a two-phase basis. The first phase of implementation will culminate with a 6-month demonstration (2 January, 1977–2 July, 1977) of the basic hardware, software, and data base design of the CCA. The primary objectives of the demonstration will be to establish economic feasibility and technical design. The second phase will provide a full implementation of CCAs and data base for the DSN, but will be contingent upon a successful CCA demonstration and approval by OTDA.

II. Criteria and Justification for a Data Base Management Capability

The provision of a data base management capability for the DSN is based on the following criteria:

(1) Provide an easily accessible source of valid information to support DSN management activities.

(2) Provide a more cost-effective method of acquiring, maintaining, and retrieving management information.

The DSN has determined that a distributed data base design, utilizing standard DSN minicomputers, will meet

the above criteria. This design was selected as an optimum approach for the following reasons:

(1) The provision of a master data base and user terminals at each DSN operations center (Jet Propulsion Laboratory, Goldstone Deep Space Communications Complex (DSCC), Australia DSCC, and Spain DSCC) reduces data entry costs, and minimizes the errors and loss of data in transit to the DSN data base.

(2) The DSN is able to utilize identical peripherals and basic computers for both control of the DSN deep space communication equipment and performance of the data base management task. This reduces overall DSN costs by the cross-utilization of spares, maintenance equipment, and personnel.

(3) The distributed system approach enables the utilization of relatively low-cost equipment, while at the same time increasing data throughput by the performance of independent real-time data handling functions in parallel.

(4) The distributed system approach insulates the DSN from a major disruption due to a single computer failure. A computer malfunction would result in the loss of only a portion of the total DSN data base handling capability.

III. Functional Design

The major functions to be performed by each CCA are:

(1) Acquisition of data and maintenance of a current data base

(2) Provision of communications between CCAs

(3) Provision for access to the data base and retrieval of data

The following is a brief description of the functional design of the DSN distributed data base and the data base management functions performed by each CCA.

A. The DSN Distributed Data Base

The distributed data base concept to be implemented for the DSN is based upon the separation of the total collection of DSN data into parts, and each part being maintained and utilized at a DSN operations center. Portions of the DSN data base will be maintained and utilized at JPL, Australia DSCC, Spain DSCC, and Goldstone DSCC. The portion of the DSN data base at a complex is a "master data base" for that complex. The structure of each master data base is identical and under configuration control by the DSN.

The data base being implemented for the DSN is a hierarchical (inverted tree) information structure, divided into seven top-level categories with various subcategories and files within each subcategory. Each major category is a collection of files in a data base organized to support a particular activity.

References to data within one major category are performed by starting with the name of the category and successively narrowing the specification to the file, file record, or file record element of interest.

Cross-reference between categories (or any two files in the data base) is effected by the use of cross-reference keys. The major cross-reference keys for the DSN data base are a specified small set of common elements such that any record in the data base is accessible starting from at least one of the major cross-reference keys.

A detailed discussion of the DSN data base design will be the subject of another DSN Progress Report.

B. Acquisition of Data and Maintenance of a Current Data Base

The CCA provides a means by which the data base is updated by a transaction input process. A transaction is defined to be any data which would add to, delete from, or alter the contents of the data base.

Transactions are accommodated and controlled via standard DSN software to ensure that the integrity of the data base is maintained. The transaction software provides an interactive interface to the user, and allows the user to input data according to a standard format at an on-line terminal. The CCA will also accommodate the entry of transactions via a batch input process. For entry of transaction data, the user is assisted via prompting, and each transaction is checked for correct syntax and displayed for validation before being recorded (stored) by the CCA.

Recording of transactions is performed immediately upon validation, but the data base is not updated by the transaction data at this time. Instead, the transactions are placed on temporary disk storage until a scheduled periodic data base update is performed. Data base updates are performed on a periodic basis at intervals not to exceed 1 week. The actual update interval will be determined by the number of transactions being handled at a location. Data base updates will be performed by a

designated operator, utilizing standard DSN-supplied software. This software will provide for (1) eliminating old data base files, (2) establishing new data base files, (3) deletion of obsolete file records, (4) insertion of new file records, (5) sorting and merging of file records, and (6) editing of file records.

C. Data Communications Between JPL And The DSCC CCAs

As shown in Fig. 1, the implementation of the data communications function is based upon local reporting of exceptions to files containing plans data. Plans files (e.g., the "As Designed" configurations of DSN equipment at DSS 11, DSS 12, DSS 14) are maintained at both a DSCC and the JPL CCAs. The current master files at a DSCC (e.g., the "As Built" configurations of DSN equipment at DSS 11, DSS 12, DSS 14), which represent the actual state of a DSCC after being updated by transactions, are compared to the plans data, and a file of exception data is generated. The exception file is updated each time the data base is updated. The exception file is made available to local DSCC management for local reporting and is also transmitted via high-speed data (HSD) lines to JPL on a periodic basis (at least once per week) to enable Network status to be determined from the JPL copy of the plans file and the exception data. Data communications between JPL and the DSCC CCAs utilizes the Ground Communications Facility High-Speed Data System. Undetected errors in data communications are specified at less than or equal to 1 block error in 10^9 blocks (1200 bits per HSD block).

D. Access To The DSN Data Base And Retrieval of Data

Access to and retrieval of data from the DSN data base are provided by the DSN standard programming language MBASIC (Ref. 1). MBASIC (Management-oriented BASIC) is a high-level interactive programming language (an advanced version of the BASIC language developed at Dartmouth College) which contains language elements that are designed to place emphasis on management information processing applications support.

Information retrieval from the data base is accomplished by user applications programs written in MBASIC. MBASIC provides the means whereby the authorized user, operating from a remote terminal device, may access any DSN file to any sub-level, read the data into the user's working storage, extract and operate on data, format the data for a report, and output a hard-copy report from the selected data base contents. For very generalized reporting, normally all that is required is an MBASIC "COPY" statement to display selected DSN data base contents in a human-readable format at the user's terminal.

IV. Phase I Implementation of CCAs

Phase I implementation of the CCAs will culminate with a demonstration study to establish economic feasibility and the technical design of the distributed data base management capability.

To perform the demonstration study, one complete CCA will be installed at the Goldstone DSCC (DSS 12, Bldg. G26-101), and supplemental hardware will be added to an existing Telemetry Processor Assembly of the DSS Telemetry Subsystem located at JPL (Compatibility Test Area 21, Bldg. 125-B17) to make up a CCA. The configuration of CCAs for the demonstration is shown in Fig. 2.

A. CCA Demonstration Hardware

The hardware portion of each CCA will consist of a Modcomp (Model II-25) minicomputer with 65 536 words (16 bits per word) of core memory, two magnetic tape transports, a moving head disk unit, an operator's keyboard-printer device, a high-speed printer, and user terminal devices.

B. CCA Demonstration Software

The software provided with the Phase I implementation of the CCA will operate within the confines of the standard Modcomp operating system (Max III), allowing multiperipheral communication under a real-time operating system. The user will communicate with the CCA through the MBASIC processor and an established collection of service routines. The following is a general description of the software elements comprising the distributed data base management capability for the first phase of implementation.

(1) *System monitor.* The system monitor software acts as an executive between the operating system and the user. It allows remote application users to access the MBASIC processor.

(2) *HSD communications interface.* The HSD communications system software module provides the capability to transmit data between the DSCC CCAs and the central (JPL) CCA. This is a nonresident software module, which is loaded into core and activated on a scheduled basis by the CCA operator.

(3) *Checkpoint and recovery.* The checkpoint and recovery functions provided by the CCA system software will detect and report computer failures due to power failure on memory parity error. Upon restart after such computer failures, a message will be output to each on-line user, stating that the CCA system has been restarted and the approximate time of the computer failure.

(4) *Self-test and maintenance.* Self-test and maintenance routines are included as part of the CCA system software. These routines will check the integrity of the assembly hardware and will aid in localizing a hardware malfunction.

(5) *Transactions.* On-line transactions will be accommodated by the CCA software. The user will be provided with prompting to achieve error-free and efficient entry of data.

(6) *Updates.* A service routine to provide updating of the master data base will be included. Its design will accommodate the periodic updating of the master data base files by transaction data.

(7) *Compare.* A service routine to provide exception data will be included. Its design will provide the capability to produce an exception report from a comparison of the master data base and the plan base files.

(8) *Maintenance utilities.* Utility programs provided by the Modcomp system will give the user the capabilities to prepare and debug programs.

(9) *Record access routines.* A collection of record access routines will be provided to establish access into the data base by key parameter.

C. CCA Demonstration Data Base

The data base to be utilized for the data base management capability demonstration study will consist of edited files taken from the existing operational Configuration Audit Data Base for Deep Space Station 12. The demonstration data base will include the As Designed Equipment Configuration files, the As Built Equipment Configuration files, and the Master Property Index of Equipment files. Throughout the demonstration period, the demonstration data base will be maintained and periodically updated by transactions. The demonstration data base is an integral portion (a major category, "Physical Plant and Tagged Equipment Data") of the total DSN data base and as such, can be directly transferred to operations if Phase II of the CCA implementation is effected.

V. Conclusion

The distributed data base management capability will improve the overall operating efficiency of the DSN and will reduce operations costs by providing valid operations support data at each DSN Deep Space Communications Complex. Data errors will be reduced by the provision of a data base near the source of data inputs, and data base integrity will be achieved by the utilization of standard DSN software for the data management task.

The distributed system design is now technically and economically feasible as a result of

(1) The availability of a minicomputer with data handling capabilities approaching those found only on much more expensive computers a few years ago.

(2) Cross-utilization of a low-cost standard DSN minicomputer.

(3) The availability of reliable and almost error-free communications links between CCAs.

The implementation of the distributed data base management capability will be effected in two phases. Following the completion of the first phase, a six-month (January 1977–July 1977) demonstration study will be done in order to establish the economic feasibility and the technical design of the distributed data base management capability. Based on the results of the demonstration study and approval by OTDA, the second phase of implementation will provide the total distributed data base management capability at each DSN operations center.

Reference

1. *Fundamentals of MBASIC, Vol. I and II*, Jet Propulsion Laboratory, Pasadena, California, March and October 1973 (JPL internal document).

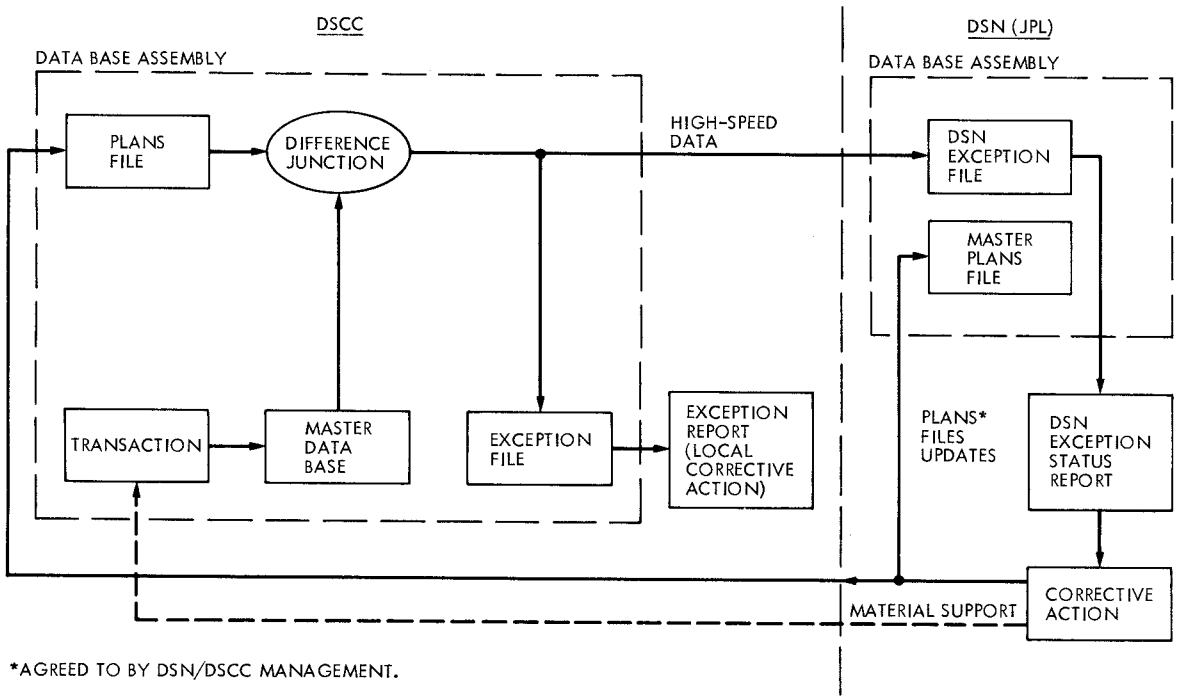

Fig. 1. Communications between JPL and the DSCC CCAs; generation and utilization of exception data

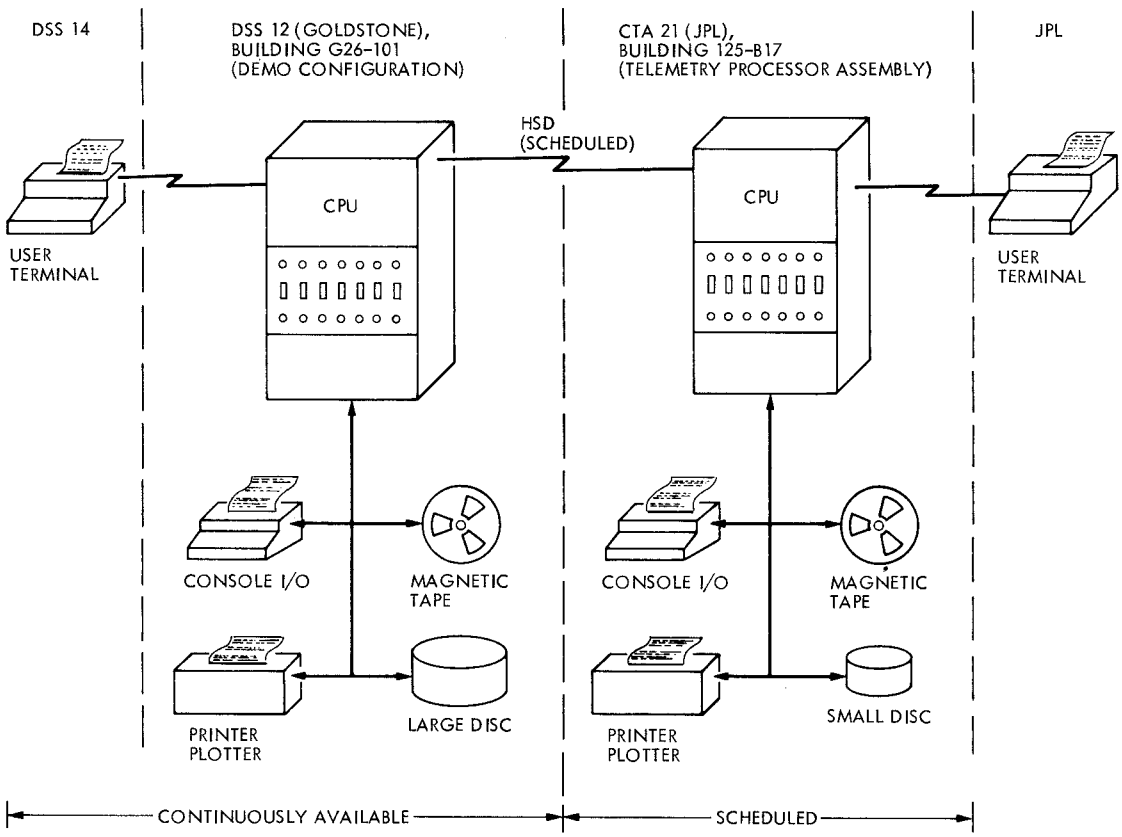

Fig. 2. General configuration of the CCA demonstration equipment