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DYMAC COMPUTER SYSTEM

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Abstract

The DYnamic Materials ACcountability program (DYMAC) has been monitoring nuclear material at the Los Alamos Scientific Laboratory plutonium processing facility since January 1978. This paper presents DYMAC's features and philosophy, especially as reflected in its computer system design. Early decisions and tradeoffs are evaluated through the benefit of a year's operating experience.

Introduction

A computer-based system for dynamic materials accountability has been in operation at the Los Alamos Scientific Laboratory's new plutonium processing facility since January 1978. Called DYMAC, for DYnamic Materials ACcountability, it provides near-real-time information about every inventory item in the facility. The DYMAC system was designed to meet the plutonium facility's record-keeping requirements and to incorporate safeguards tools. In this paper we discuss our approach to implementing those safeguards tools into the DYMAC system. We also briefly familiarize the reader with the record-keeping aspect of DYMAC.

Processing in the plutonium facility varies from plutonium-metal fabrication and advanced carbide fuel preparation to ion-exchange and leaching recycle operations. In designing the DYMAC computer system, we had to build in the flexibility to accommodate the diverse processing and adapt to changes as they occur. We designed the computer system so that the process technicians themselves enter data into the system. This entails two other design considerations: to reduce data entry errors and to have data entry occur in near real time.

A process technician makes a transaction at an interactive video terminal.

Description of the Computer System and Its Use

Our design requirements for the DYMAC computer system specified a dedicated computer that could handle confidential data. The system had to be portable in the sense that it could be installed on a similar machine in another facility. Moreover, it had to be implemented at a nonprohibitive cost, using standard computer hardware available to the general public. Because of the portability requirement, the operating system had to support high-level, machine-independent languages. The operating system had to provide some multiprogramming capability to simultaneously handle more than one activity while providing quick response time. One further requirement was that the computer come provisioned with a software package for data base management.

The foregoing specifications led to the acquisition of a powerful minicomputer, the Data General Eclipse C330. The Eclipse computer currently operates with 163,840 16-bit words of core memory, and 20 million bytes of disk storage capacity. The Eclipse is controlled from two system consoles. Peripherals include a 600-line-per-minute printer for generating overnight reports and two magnetic tape drives, which are used to back up daily transaction activity and to make backup copies of the facility's data base and the DYMAC software programs. A multiplexor allows data transmission over 128 communication lines. The lines connect the Eclipse with interactive video terminals and NDA instrumentation located in the plutonium facility. Electronic balances are the only NDA instruments connected directly to the Eclipse at the present time. In the next few months, the Eclipse will be able to communicate directly with thermal-neutron coincidence counters, segmented gamma scanners, and solution assay instruments.

The software supported by the Eclipse consists of three packages: RDOS, the operating system; INFOS, the data base management system; and DYSS, the application programs. RDOS is a real-time, interrupt-driven operating system.

It economically allocates and schedules computer resources (such as processor time, memory, and peripheral devices) among user requests. The RDOS software is supplied by the Data General Corporation. Also provided by Data General is INFOS, a file-oriented data base management system. INFOS has the ability to create a file, order it, search it, insert whole records, delete whole records, and alter a part of a record. Information in a file may be simultaneously ordered in many different ways. To allow the computer to interact with users at terminals, and with NDA instruments, we have designed and implemented an application code that uses INFOS to maintain a dynamic data base. We call the application code DYSS, for DYMAC Software System.

When the status of an inventory item changes, the technician who is working with the item uses a nearby video terminal to make a transaction that informs DYSS of the change. During the transaction-making process, DYSS queries the technician through a series of prompts and responses. It asks him to identify the process step he has just completed, and the item he is processing. Depending on the process step he chooses, DYSS will ask him to identify the instrument he used to assay or verify the item's plutonium content. DYSS then reads the assayed value from the instrument, performs the appropriate calculations, and immediately updates the inventory and transaction history files to reflect the new inventory status.

DYSS collects data, by means of transactions, to maintain a current data base and then provides that current inventory information to process personnel in the form of reports displayed on their video terminals. A requestor can display lists of which items should be in a specific glovebox, or in an entire material balance area. He can inquire about recent activity related to any item in a given process area. Many video terminals are paired with hard-copy units, so that reports may be printed instead of displayed.

The precision and accuracy of every NDA instrument in the facility is checked and the daily results of such checks entered into DYSS from the interactive terminals. DYSS uses these results to determine each instrument's status, that is, whether it is performing sufficiently well to be used for accountability measurements. DYSS checks this performance data each time an instrument is used as part of a transaction.

DYMAC Design Approach

Our basic design approach for the DYMAC system requires the process technicians to enter information into the computer as they do their work. This is a fundamental change from having a supervisor enter the information and has two major design implications: how to ensure the quality and timeliness of data entry. We must reduce data entry errors to have a reliable data base and we must encourage the technicians to enter processing information into the system in as near real time as possible. The DYMAC system is built on these precepts.

DYMAC depends on the process technicians to maintain an up-to-date computer inventory rather than depending on their supervisors or designated accountability personnel. We delegated this responsibility to the process technicians to increase their sense of custodianship of the nuclear material that they handle. Process supervisors, who historically have been responsible for inventory record-keeping, now will have time to supervise, evaluate, and improve processing. We made data-entry terminals accessible to the technicians by locating one in almost every processing room in the facility. Hence, DYSS handles intermittant activity from many different terminals, instead of constant activity from a few terminals. By requiring the process technician to enter information each time he completes a processing step, we reduce some data-entry errors because the information is firsthand and avoids the possibility of personnel communication errors. On the other hand, the technician may not fully understand the accountability procedures, and then we must protect the data base against his entering incorrect information.

The effectiveness of any accountability system is ultimately limited by the quality of data it collects. To reduce data-entry errors, we designed DYSS to:

- o perform extensive diagnostics on user input and
- o minimize the input required of personnel by using on-line instruments and drawing on standardized information precoded into computer data files.

DYSS performs diagnostic checks on all input data. Each response typed in by the user is checked syntactically, that is, for correct number of characters and for proper alphabetic, numeric, or alphanumeric format. Many entries are then compared with files of valid field contents. For example, a technician may respond with 'G253' for glovebox 253 when asked for an item's new location. Although the response is syntactically correct, DYSS determines its validity by searching a file of the facility's location designators.

A further level of diagnostics involves searching the inventory file. As soon as an item is identified during transaction entry, DYSS searches the inventory file to determine if another item of that name exists. If it does not find that item, it will not allow the user to continue. The possibility always exists that the user made a typing error when entering the item's name. Another possibility is that the item is mislabeled or an improper transaction has previously been made. By immediately searching the inventory file, DYSS can detect these entry errors. Similarly, it searches the instrument file to validate the identifier whenever an instrument is used in a transaction. It also searches the standards file to validate standards used in the daily precision and accuracy checks of the NDA instruments.

The numerous searches made during the course of a transaction are possible because the "intelligence" of the DYMAC computer system is centralized in the Eclipse. A different approach, one we rejected, was to distribute the intelligence of the computer system by using relatively expensive remote terminals that include some processor and memory, or to use remote minicomputer concentrators to drive the interactive terminals. Typically, in systems where the intelligence is so distributed, elementary diagnostics such as syntactical checks are done at the remote processor, then the complete set of transaction data is transmitted to the central computer to update the data base files. Unfortunately, if the item involved in the transaction is <u>not</u> found in the inventory file, the entire transaction must be rejected. Using on-line data base searches made possible by the centralized intelligence of the DYMAC system, we can detect many entry errors as soon as they occur. On-line file searches also mean that information retrieved from the data base can be displayed to the technician and used to furnish part of the transaction data.

To reduce data-entry errors, we tried to require relatively little input from users in comparison to the input from instruments and standardized information in computer data files. The on-line instruments allow the system to read measurement data directly instead of relying on a technician to manually enter it where he may transpose digits or even forget them. Diagnostics are performed on directly transmitted instrument data to ensure its integrity and guarantee that the transmission has been error-free.

Input required from the user is minimized by individualizing transaction options for processes. We have analyzed each process in the facility to determine material flow and measurement points. For each step in a process, we have coded DYSS to specify the type of material involved, its form, and its old and new locations. We have precoded DYSS to know whether an item's name is changing, whether it is to be divided to form new items, or combined with another item. DYSS knows what type of measurement or verification is needed, and what calculations to perform on the measurement data. It knows if seals are applied, verified, or broken. It knows whether completion of a process step indicates that a material balance can be drawn.

All this standardized information is stored in computer data files. There is a set of related files for each process in the facility. When a technician at a terminal identifies the process step he has just completed, DYSS accesses the appropriate files to furnish a large part of the transaction data. It only asks the technician for the information that could not be precoded into the file. The organization, use, and maintenance of these precoded data files for the entire plutonium facility has greatly influenced the structure of DYSS.

The effectiveness of the DYMAC system depends on the timeliness of input as well as its quality. We encourage technicians to make transactions immediately following the completion of a process step. The computer system, instruments, and interactive terminal network are available to the process personnel during normal facility working hours.

One incentive for timely data entry is that it gives the supervisor added control over processing. He can tell how much material has been processed and what remains to be processed. He can use on-line inventory listings to take an immediate physical inventory. To reduce discrepancies that he may find, the supervisor can require his technicians to make transactions in a more timely fashion.

The use of on-line measurements promotes the timely entry of transaction data. When an item is weighed on an electronic balance, its weight is locked in the balance readout unit for transmission to the Eclipse computer. The technician must make a transaction concerning the item and its new weight while the electronic balance retains the value. During the course of the transaction, the Eclipse computer reads the contents of the electronics register directly without going through the data-entry terminal. When the transaction is complete, DYSS updates the inventory and transaction history files. The balance cannot retain the results of several measurements, hence a transaction must be made before the on-line instrument can be used to measure the next item.

Another part of the DYSS design that encourages timely transaction input is the two-part transaction. Transactions involving a change of process or custodian are made at two different times, one by the sender of the material and one by the receiver. Verification measurements may be required at send and receive times. Data base records for inventory items sent are marked by the DYSS code as being in-transit inventory. DYSS monitors the in-transit file to ensure that items are received in a timely fashion. It sends messages to the facility's lead accountability person, the nuclear materials officer (NMO), when an item has been in transit longer than the allowed time. The NMO then investigates the cause of the delay.

<u>Conclusion</u>

The DYMAC system at the Los Alamos plutonium processing facility has kept excellent records in the 16 months of its operation. Process personnel rely on these records to run their processes smoothly. Accountability personnel draw on the same records for safeguards purposes. The key to maintaining these timely records has been the willingness of the facility technicians to make transactions as part of their processing requirements.

We had intended that the DYMAC system be completely portable. Although some functions are unfortunately dependent on the Eclipse computer's multi-user capability and its data base management system, DYMAC's concepts are certainly applicable in other facilities. Such concepts as data entry by process technicians, precoded data files for each process, on-line file searches, the in-transit inventory file, and the data base structure are indeed portable. These concepts are coded in a high-level computer language that can be reused at other facilities with some modification for operating system peculiarities.