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WIPP Conceptual Design Report

Addendum M: Computer System and Data Processing Requirements
for Waste Isolation Pilot Plant (WIPP)
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Computer System and Data Processing Requirements for the Waste Isolation Pilot Plant (WIPP)

General Description

Data-processing requirements for the Waste Isolation Pilot Plant (WIPP) dictate a computing system that can provide a wide spectrum of data-processing needs on a 24-hour-day basis over an indeterminate time. A computer system is defined as a computer or computers complete with all peripheral equipment and extensive software and communications capabilities, including an operating system, compilers, assemblers, loaders, etc, all applicable to real-world problems. The computing system must be extremely reliable and easily expandable in both hardware and software to provide for future capabilities with a minimum impact on the existing applications software and operating system. The computer manufacturer or WIPP operating contractor must provide continuous on-site computer maintenance (maintain an adequate inventory of spare components and parts to guarantee a minimum mean-time-to-repair of any portion of the computer system). The computer operating system or monitor must process a wide mix of application programs and languages, yet be readily changeable to obtain maximum computer usage.

The WIPP computing system must handle three general types of data processing requirements: batch, interactive, and real-time.

Batch Processing. Has limited or no response-time requirements. When punched cards were the major source of input/output (I/O) to a computer, batch processing was the best way to use the computer; all of the same kinds of jobs could be run serially in one batch without taking the time to switch from one system to another. However, this method was inconvenient and time-consuming; any errors made in the data of the program required punching new cards and rerunning that particular job, with a corresponding loss of data-processing time. Batch processing is still highly efficient for tested and debugged routine jobs. Typical batch-processing jobs require no programmer or outside intervention; they can have business (payroll or report generation) or scientific (heat transfer or numerical analysis) applications. Both applications can require large amounts of computer memory and time, but require low-priority processing during nonprime-time.

Interactive Processing. Requires service at frequent but intermittent intervals. For example, a person typing commands at a remote terminal interacts with the computing system; the system program controlling the terminal responds to each command within one-tenth of a second. Interactive terminal usage is the most efficient and rapid method to develop and test computer programs. When complete, they can be submitted as a batch job from the remote terminal.

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Time-sharing permits many people (each at their own terminal) to interact with the same computer through small-time intervals, to create and run their individual programs, and at the same time share the same computer resources. Everyone uses the same high-speed printer for large computer printout or the same large storage disks for data storage.

The heart of a time-sharing computer system is the executive system program that dictates the size of the time-slice for each time-sharing user. Different users can place different demands on the computer system. For example, one user program may require more central processing time of the computer, while another user may require much I/O processing, such as during highly interactive text editing or when entering new data, and very little central-processing time.

A good time-sharing scheduler can distinguish the various demands of each time-sharing user by maintaining queue levels by priorities. The queue at the highest level is devoted to highly interactive user tasks that receive a very short time-slice, but at very frequent intervals. The queue at the lowest level is devoted to tasks that are primarily central-processing timebound. These tasks are allocated longer time-slices but at much less frequent intervals than are the higher level interactive tasks. The time-sharing scheduler also varies the priority level of each user task; that is, CPU-bound tasks are moved to lower priority levels, and tasks that become I/O bound are moved to higher priority levels. The result is an operating system that can handle widely different types of jobs in a time-sharing environment, yet efficiently share the resources of the computing system among many users.

Real-Time Processing. Requires immediate response and therefore top priority from the computer system. For example, a real-time event in the form of an interrupt from a high-speed communications device is a signal to the computer system that it is ready to send data. If the computer system fails to respond quickly, (typically in the microseconds range), and starts to process incoming data, then data transmission could be lost. Real-time events can also be clock-driven; that is, the computing system can activate a task that reads and records the temperature from a remote sensor every 10 minutes. This real-time event would be less time critical than the first example, and would be assigned a lower software priority and a slower response time. In either case, real-time events require rapid response to a request for service and are always assigned higher priorities than are interactive or batch-processing tasks.

Using a single, massive central computer to process all of the WIPP facility's computing needs would be too wasteful of both money and computer resources. Large mainframe computers traditionally have been more expensive in terms of units of computing power and more rigid in their hardware structure than a group of smaller minicomputers that can accomplish the same computing requirements. A computing system composed of several minicomputers and micro-processors (a computer processing unit contained in a single plug-in semiconductor chip) is much less expensive than a single computer. Greater hardware and programming flexibility is achieved by distributing the data-processing loads among several small computers, with each computer processing a specialized task; i. e., a distributed processing network.

The WIPP computing requirements can best be resolved by a distributed network system in which a large central supervisory minicomputer interfaces with several smaller minicomputers and microprocessors. The large central computer, located in the WIPP administration building, will be linked by high-speed communication lines with the other minicomputers, microprocessors, and terminals at the WIPP site, both aboveshaft and downshaft. The smaller minicomputers in the system will monitor most of the real-time events: in-situ experiments and stored wastes, loop-badge systems, meteorological data, ventilation parameters, radiation levels, alarm and control systems, etc.

Several smaller computers are needed to process most real-time events for the following reasons.

- (1) A small number of real-time processing tasks do not usually require much computer processing time and, therefore, do not substantially degrade overall computer performance. However, a computer heavily burdened with real-time processing tasks, as would be the case at the WIPP facility, cannot handle the other necessary interactive or batch-processing tasks.
- (2) A single computer has a finite number of real-time sensors that can be interfaced to the I/O processing unit of the computer. The smaller computers in the network monitor the real-time tasks and also format, error check, edit, compress, buffer, and store the real-time data on a small but inexpensive mass-storage device (a floppy disk or cassette) for later transmission to the larger computer in the administration building. The large-capacity storage devices of the central computer will provide permanent storage of data. Intermediate storage of real-time data permits more efficient use of the communication links to the central computer and provides continuous processing in case the central computer is down.
- (3) Most of the data communications load can be handled by the small computers, leaving the central computer free to coordinate operations for the entire computer network, process interactive jobs from the various remote terminals, and do batch-processing jobs.
- (4) It is imperative that, when the central computer becomes inoperative, the smaller computers in the distributed network can still perform their critical real-time monitoring and processing functions until the central computer is again operational. The impact on the distributed computer network will be negligible when one of the small minicomputers or microprocessors is down for either scheduled maintenance or hardware failure. Usually, the functions of the inoperative small computer can be switched to another computer in the network.

A necessary feature of the computer system will be the capability to easily modify the system parameters that determine the portion of computer time each of the three general data-processing types receives from the central computer. Thus, during the prime daytime shift, the computing system could be structured to give better response to the increased interactive terminal requirements while decreasing or eliminating the amount of time given to batch-processing demands. During the second and third shifts, when interactive demands have decreased drastically, the computing system could be changed to allow the batch-processing jobs much more of the computing system resources. All batch-processing tasks could thus be completed before the beginning of the next day's prime shift. **Of course, any real-time monitoring tasks assigned to the central computer would continue to receive the highest priority during all three shifts.**

Data Bases

Typical real-time data bases will include:

- Time-based parameter data (temperature and strain-gage values, etc) from the large thermal field experiments

- Time-based parameters from the TRU and RH horizons

- HEPA filter parameters

- Meteorological parameters

- Radiation measurements from the HVAC system

- Radiation history for WIPP/waste handling personnel

- Payroll

- Plant engineering inventory

- Loop-badge data bases

As radioactive material is received, unloaded, and stored, inventory data bases will be produced. These inventory data bases will include type, identification number, radioactive and nuclide data, shipping data, etc, plus storage location at the WIPP facility. Data bases subjected to regular analysis that are not too large will be allowed permanent storage on the mass-storage devices of the central computer. The very large data bases will require permanent storage on magnetic tapes and will be copied into a temporary disk storage area whenever a computer analysis is required. All data bases will be updated at regular intervals and then copied to magnetic tape(s) to provide a permanent data library; this will prevent the mass-storage devices from becoming saturated.

Data Collection Systems

As mentioned in the general description section, most data-processing requirements for the WIPP facility will be to monitor and collect real-time data events by the various minicomputers and microprocessors. Each computer system will include a local terminal to permit system and application program loading, execution, and restart capabilities.

A computer system may also interface to one or more process I/O subsystems. A process I/O subsystem may contain several different types of I/O modules that provide the hardware interface to a field sensor. A signal line conditioner may be placed between the I/O module and sensor to amplify or filter the sensor signal. Typical I/O modules include I/O counters, analog-to-digital convertors, digital-to-analog convertors, solid-state isolated and nonisolated sense and interrupt inputs, and solid-state and relay outputs. Common analog sensor types include thermocouples, resistor temperature detectors, and pressure gages.

The need to monitor real-time events over a wide physical area, particularly belowground where experiments will be run in both the transuranic (TRU) and remote-handling (RH) horizons, requires the use of remote-process I/O subsystems. The I/O subsystems can physically be separated from the computer by distances of up to a mile, with a single coaxial cable providing the high-speed interface link. The field signals can be concentrated and connected to the I/O modules in each remote I/O subsystem near their source instead of requiring lengthy and costly cabling to the distant computer for every sensor. Remote I/O subsystems also can be engineered and packaged to operate in the harsher elements usually encountered in a noncomputer environment. Another very important capability of a remote I/O subsystem is the ability to switch a remote subsystem from an inoperative computer to another computer. The switching costs are more than offset by the gain in overall reliability of the real-time monitoring data collection systems.

A small minicomputer or microprocessor system with remote I/O subsystems may be required to provide real-time monitoring and collection of data for the early experiments to be conducted in areas off the construction vent shaft. The computer system should have the capability to filter and perform initial data compression techniques to minimize the amount of real-time data stored on a peripheral mass storage device (magnetic tape, floppy disk, etc) that will be used for later analysis on the central computer or on a computer system at another facility. The central computer in the WIPP administration facility may not be available for use for the early experimental effort due to the construction schedule.

An additional minicomputer or microprocessor system with remote I/O subsystems will be needed to provide real-time monitoring and collection of data from the various in-situ experiments conducted at the RH and TRU horizons. The expected large number of sensors (up to 5000) will require two minicomputer or microprocessor systems with several remote I/O subsystems. Two small computer systems can better process the large number of sensor readings and provide continuous real-time monitoring in the event one computer is inoperative. Some experiments on this horizon must run for many years to obtain meaningful data.

Additional minicomputer or microprocessor systems will be required for the meteorological station(s), radiation lab system, the central monitor and control system, the HVAC monitoring system, and the central supervisory computer system at the administration facility.

Scientific and Business Systems

The WIPP computing system will be subjected to real-time, interactive, and batch data-processing demands. Interactive processing will be available to users via the various remote terminals and will provide a wide spectrum of interactive applications. Typical interactive processing will include entering new TRU waste inventory data, editing and error correction of the new data, merging the existing data with the data base, and dumping the new data base from mass storage disk to magnetic tape(s) for backup. Similar processes will be provided for the high- and intermediate-level waste inventory data, radiation history of WIPP personnel, etc. **Interactive processing can also include the entering, editing, and compilation of new computer programs with storage on the central computers disks.** Following preliminary debugging and checkout, the new computer programs can be loaded and executed from a remote terminal. Many computer programs will involve analysis of the data bases residing on the central computer's mass storage disks, with a user varying the type of analysis desired from a remote terminal. For example, the total volume and location of a certain type of radioactive TRU material received from a particular location may be desired.

Batch-processing jobs will be entered via a remote terminal or submitted through the central computer systems card reader in the administration facility. Batch-processing jobs will usually require more computer memory and time to obtain a solution than will an interactive job. Typical batch-processing jobs include statistical analyses of geological and meteorological data, analyses of ventilation systems, fault-tree analyses, rock-mechanics analyses, modeling for the movement of radionuclides in the biosphere, risk assessments for repository conversion decisions, etc. Additional interactive and batch-processing requirements will be business oriented. Typical business-processing jobs will include payroll for the WIPP facility personnel, report-generation capability, inventory analysis, system charges and accounting, etc. Completion of large batch computer programs will usually be during second and third shifts when interactive processing is at a minimum.

The WIPP computing system will require network software, data communication protocols and software, software security and accounting protocols, industry-standard high-level languages for both scientific applications (BASIC, FORTRAN) and business applications (COBOL and report generation), compilers for high-level languages, assemblers for machine-level languages, and loaders to link and convert both high-level and machine-level programs into an executable format. Utility routines should include a test editor, on-line program debugger, file-maintenance capabilities, libraries for commonly used mathematical and I/O subroutines, etc.

Adequate documentation and training courses for the computer operating system at the user level should be readily available. System software update support from the computer manufacturer should be reliable and responsive, with system consultants available when needed.

Building and Facilities

The central supervisory computer system will be located in a computer room in the administration facility. The computer room (tentatively 60'ft x 40' ft) should be large enough to allow at least 3 ft of space behind all computer equipment for easy service access. A separate storage space should be provided for computer supplies including magnetic tapes, disk packs, line-printer and terminal paper. A tape library room should also be available to store library and backup tapes and disk packs. Air-conditioning systems for both areas must provide a year-round temperature- and humidity-controlled environment similar to that of the computer room and adequate for future needs. **A static-free raised floor is required in the computer room to avoid potential static electricity and to allow easy installation of computer cables and power lines.**

Electrical power mains should allow for future system expansion and must conform to applicable national, state, and local codes. A UPS system will be required to guarantee reliable and continuous electrical power to the computer system. The computer room should be shielded and communication lines routed in conduit if any potential electric-noise sources will be in the immediate area.

A halon fire-extinguishing system should be installed in the computer room, the tape library room, and the computer supplies area to avoid any serious damage to the computer system or the loss of data on magnetic tapes and disk packs.

Remote Terminals and Locations

The central supervisory computer system in the administration facility will provide interactive processing via remote terminals located both above- and belowground. Remote terminals will be available in the TRU waste facility, the RH waste facility, in the computer areas for the experiments at the TRU and RH horizons, in the central monitor control room, and at the access control area and computer room in the administration facility. Additional remote terminals may easily be added. The remote terminals can be linked to the central computer in the administration facility by either shielded hardwired lines or acoustic couplers and telephone lines. The latter method allows remote mobility for the terminal, which can then be moved to any location having access to a telephone line.

Cables

The communication links between a computer system and its associated remote I/O subsystems require one coaxial cable for each subsystem, as do the communication links between the various minicomputer and microprocessor systems with the central computer system in the administration facility. All cabling used to provide communication links for the WIPP computing system should be installed in conduit for protection from electrical noises, temperature, and moisture. Communication conductors should also be adequately separated from conductors for light and power in raceways, compartments, junction boxes, etc. Although the remote I/O subsystems have hardwire provisions for error detection and software correction, proper cable

selection, cable installation, grounding and noise suppression will greatly reduce the number of line errors with a greater percentage of good data transfers. High error rates tend to load the system down with error recovery procedures.