NOVEMBER 197[illegible]

HEWLETT-PACKARD JOURNAL

Distributed Computer Systems

As multiple minicomputers collect data, control processes, and run tests, a central computer system supports them all, gathering data, generating management reports, and performing other tasks at the same time.

by Shane Dickey

A SINGLE LARGE-SCALE COMPUTER or a network of smaller, less costly computers? In this era of multiplying minicomputer applications and increasing minicomputer efficiency, the answers to this question are changing. There are, of course, computer applications for which the network solution is clearly not appropriate, and there are others in which a decision must be based upon a detailed comparison of the alternatives. But there are more and more applications that can benefit greatly from a network solution.

A not-uncommon situation that typifies problems amenable to solution by a computer network, or a "distributed" computer system, is that of a manufacturer producing and testing a product in several discrete steps. Each step in the process takes place in a different area of the manufacturer's facility, and several could be completed better, faster, and more economically if they were automated (examples might be incoming parts inspection, subassembly manufacturing, subassembly testing, and final testing). However, funds for computer automation are limited. Also, any computer solution must provide for a large, unified data base to coordinate all the manufacturing and testing areas and to provide management information.

Hewlett-Packard 9700-Series Distributed Systems represent a new approach to solving these problems and many others. These systems give the user a powerful minicomputer-based central system and one or more smaller satellite minicomputer systems, each dedicated to a specific task such as data collection, laboratory automation, process control, production monitoring, or automatic testing (see Fig. 1). Special distributed system software makes the systems much more than simple interconnections of computers.

Programs for the satellites are developed and stored at the central system and loaded into the proper satellite on request via a communications link. This assures centralized quality control for applications programs and affects considerable savings through centralization of major peripherals and programming manpower. Upon execution, the satellite programs can manipulate the central station's mass storage devices to build a centralized data base. User programs in different computers can communicate directly with each other via a transparent communi-

Cover: *In this distributed computer system, a 9700A Distributed System Central Station collects data from two satellite automatic test systems dedicated to measurement tasks. Test programs for the satellites are developed at the central station as a background activity. Communication is over hard-wired cable when the systems are as close as these or as much as two miles apart. Common-carrier facilities are used for more widespread networks.*

In this Issue:

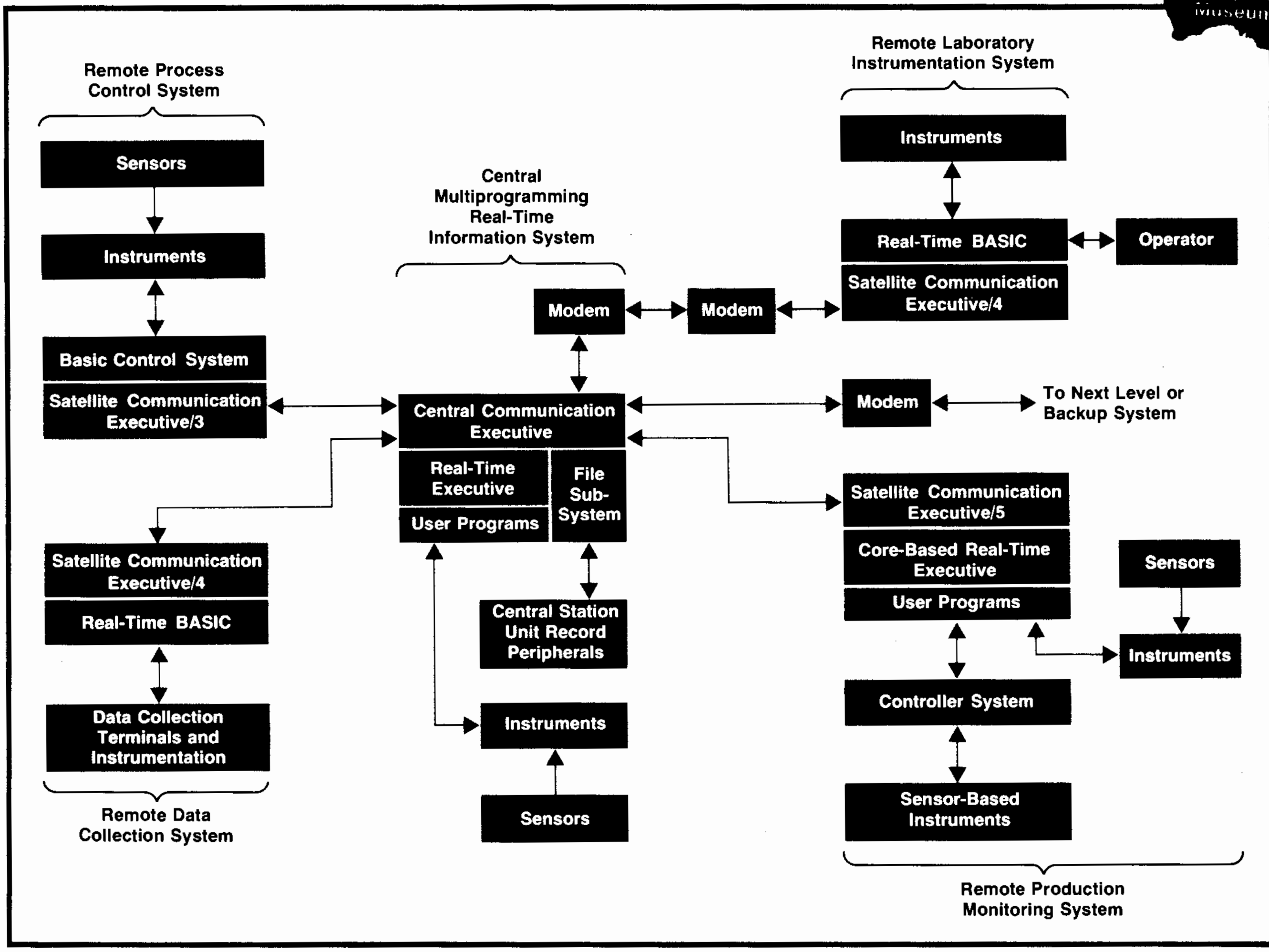

Fig. 1. *HP 9700 Series Distributed Systems are hardware/software systems that allow a central real-time executive (RTE) system to communicate with multiple satellite computer systems. Three satellite operating systems are available: basic control system (BCS), real-time BASIC (RTE-B), and core-based real-time executive (RTE-C).*

cations interface. Because the systems are modular, a user who has limited resources can begin with a minimum system and later expand as much as desired.

A companion package, the Remote Data Transmission Subsystem (RDTS), provides for communication between the central station and the IBM 360/370 series of computers. Thus a direct link can be established between working automatic test systems and a management-level information system. Central station communication with the HP 3000 is also possible via an HP 30300A Programmable Controller.

Integrated Hardware/Software Systems

An HP 9700-Series Distributed System is an integrated hardware/software system. Fig. 1 illustrates a four-satellite arrangement. At the central station is an HP 2100-Series Computer with 24K or 32K words of core memory and various peripherals, including one or more disc drives, a paper tape reader, and a system console. To these may be added one or more magnetic tape drives, a line printer, a card reader, a paper tape punch, a digital plotter, and various measurement instruments. Central station software consists of the multiprogramming real-time executive (RTE), a file management package, and the central station communication executive (CCE).

Each satellite consists of an HP 2100 Computer with 4K or more of core memory and whatever peripherals and console are required. For simple applications a 64-word remote communications loader provides for down-link loading of user-written applications programs from the central station. However, most applications will probably require some form of satellite operating system. The three satellite operating systems available are the basic control system (BCS), the core-based real-time executive (RTE-C), and the real-time BASIC system (RTE-B). Fig. 2 compares their features and capabilities. The operating system is combined with a satellite communication

A Working Distributed System

At HP's Advanced Products Division in Cupertino, California, a 9700 Distributed System helps produce the HP-35, HP-45, HP-70, HP-80, and HP-65 Pocket Calculators.

RTE Central System is a 32K distributed system central station. It has two swapping partitions and a full complement of peripherals including disc drive, card reader, magnetic tape, line printer, and paper tape reader and punch. It is used as the central file system as well as for program preparation, data analysis, and report generation. Applications programs for the satellites are stored here and loaded into the satellites as needed—for example, when changing from HP-80 testing to HP-65 testing.

RTE-C Manufacturing Support Satellite supports all of the automatic equipment on the manufacturing line: four logic board welders, three logic board testers, and a battery charger/tester.

RTE-C Incoming Inspection Support Satellite has a 16K computer controlling a ROM tester, a continuity tester, a component tester, and a data entry station. This satellite is on a Bell 103 modem link to its location in a warehouse five miles from the main facility.

BCS Magnetic Card Recorder Satellite does all of the program recording for the library of prerecorded HP-65 program cards.

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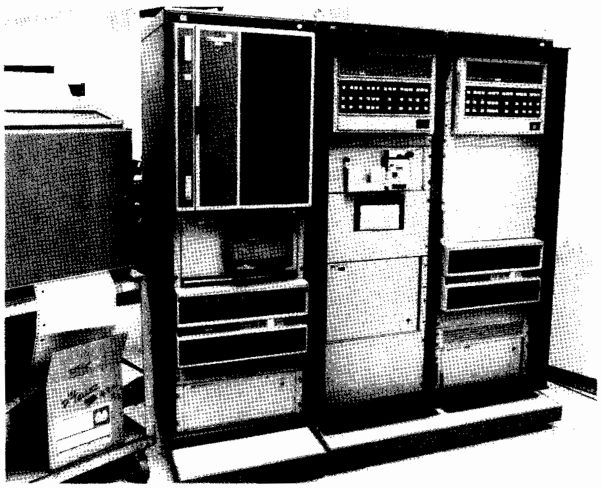
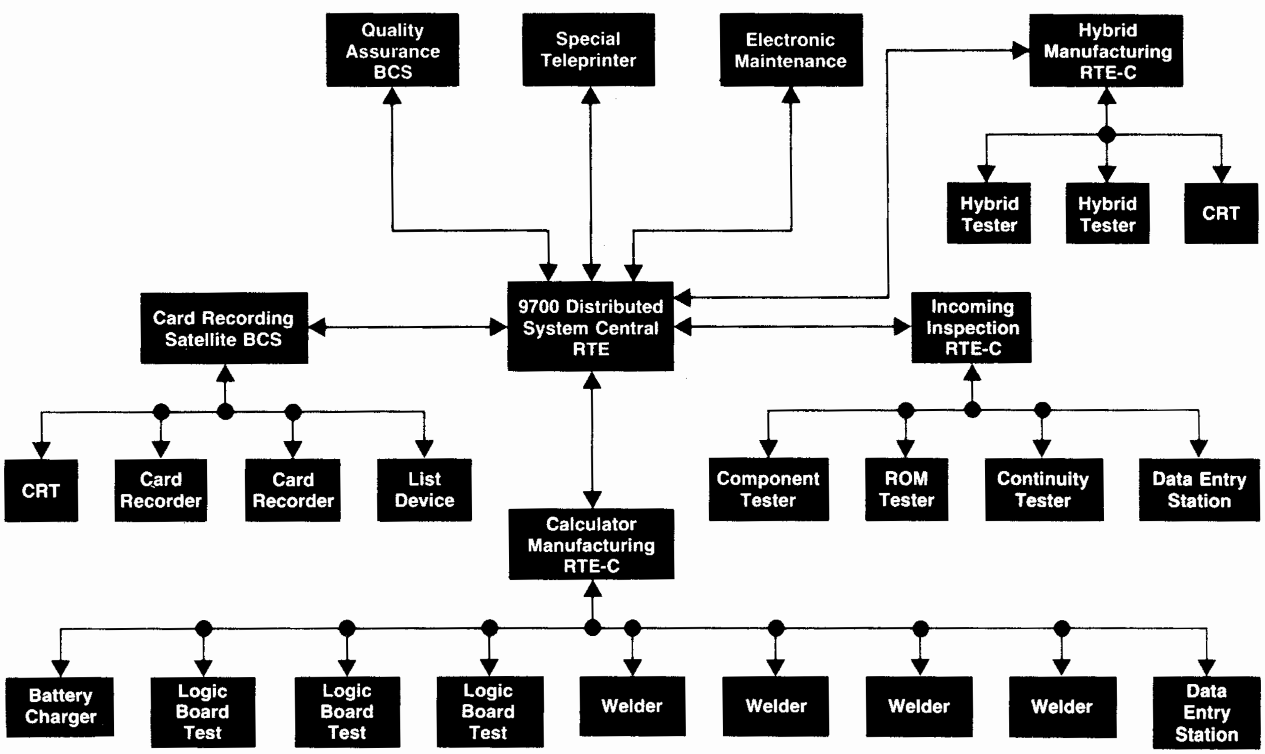
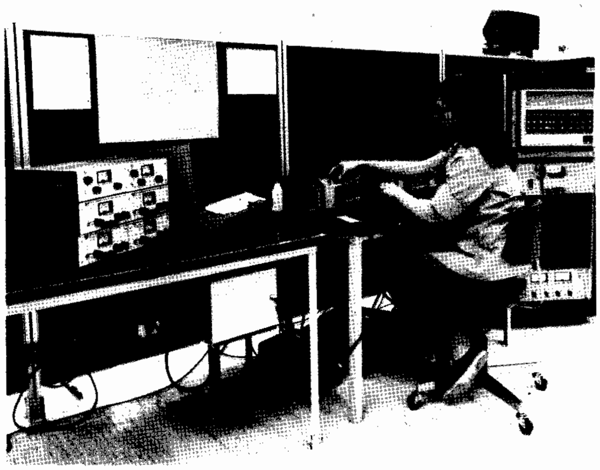


Distributed System Central

Card Recording Satellite



BCS Quality Assurance Satellite may be used as a calculator simulator with access to the central file system.
RTE-C Hybrid Manufacturing Support Satellite is a 16K computer supporting two hybrid testers and a data entry station.



Hybrid Manufacturing Satellite

Electronic Maintenance Satellite is used for peripheral testing. It has access to various diagnostic programs stored in the central file system.
Special Teleprinter has an HP-65 card reader installed. It is used to generate program listings for the HP-65 user's library.

executive (SCE) to complete the link to the CCE.

Connecting the central station with the satellites are serial communication interface cards and either twisted-pair cables for hardwired interconnections or user-supplied modems for communication over common-carrier facilities. Distributed system packages consisting of just the communication hardware and software are available as separate entities for users who already have the computer systems.

The BCS Satellite

The basic control system (BCS) is the least complex of the three satellite operating systems. It provides a starter-set capability to the measurement satellite programmer. Satellite communication executive SCE/3 connects BCS with the central station.

BCS handles execution and input/output interrupt processing of FORTRAN, ALGOL, and assembly-language test programs by means of a complete set of measurement-instrument I/O drivers and library subroutines. Because of its simplicity, BCS has the fastest I/O interrupt service time of all the satellite types, and it is well suited to the dedicated high-speed collection, concentration, and remote storage of test data.

BCS satellites are usually dedicated to their measurement tasks and therefore are not available for preparation of the measurement software that they execute. For this reason all satellite software for these terminals is compiled or assembled as a background activity at the central system while the satellites' ongoing distributed-system needs are being serviced by the foreground distributed-system modules of CCE. The object code thus produced is relocated by a system cross loader and stored on the central station disc to be sent to the satellite on request (see Fig. 3). The BCS satellite operating systems and programs can be generated from files in a batch mode or interactively from the central station console.

Distributed System Capabilities	RTE-C	RTE-B	BCS
Satellite System Generation at Central	•	•	•
Program Development at Central	•		•
Remote Program Test (Satellite program test-executed at Central).	•		
Program Storage on Central Disc	•	•	•
Shared Peripherals	•	•	•
Remote Access to Data Files	•	•	•
Remote Task Scheduling (Satellite-to-Central)	•	•	•
Remote Task Scheduling (Central-to-Satellite)	•	•	
Cooperative Real-Time Multi-processing	•	•	
Dynamic Master-Slave Switching	•	•	
Remote Program Loading	•	•	•
Linking of Program Segments	•	•	•
Forced Program Loading	•		

Fig. 2. *Capabilities of the three types of satellite operating systems and the central real-time executive system.*

Remote File Access and Remote System Services

Once the test program has been loaded into the satellite and begins acquiring measurement data, remote file access (Fig. 4) makes available to the satellite programmer all of the power of the central station's file management package (see box, page 10).

When a request for remote file access is issued by a satellite user program, control is transferred to a remote file access interface subroutine, which assembles all calling parameters and data, if any, into a transmission buffer. This buffer is shipped to the central computer by SCE/3 via a serial-communication I/O driver. Upon arrival at the central station, the request is queued up by CCE for execution. Upon execution, the processing of the request is a two-step procedure. The initial step is accomplished by a remote file access monitor, which determines whether the request is for a new or existing file. If the request is for a new file, a data control block (DCB) is created for use by the file. If the request is for an existing file, the previously created control block is used.

The central station distributed software maintains a data control block for each file currently open in a

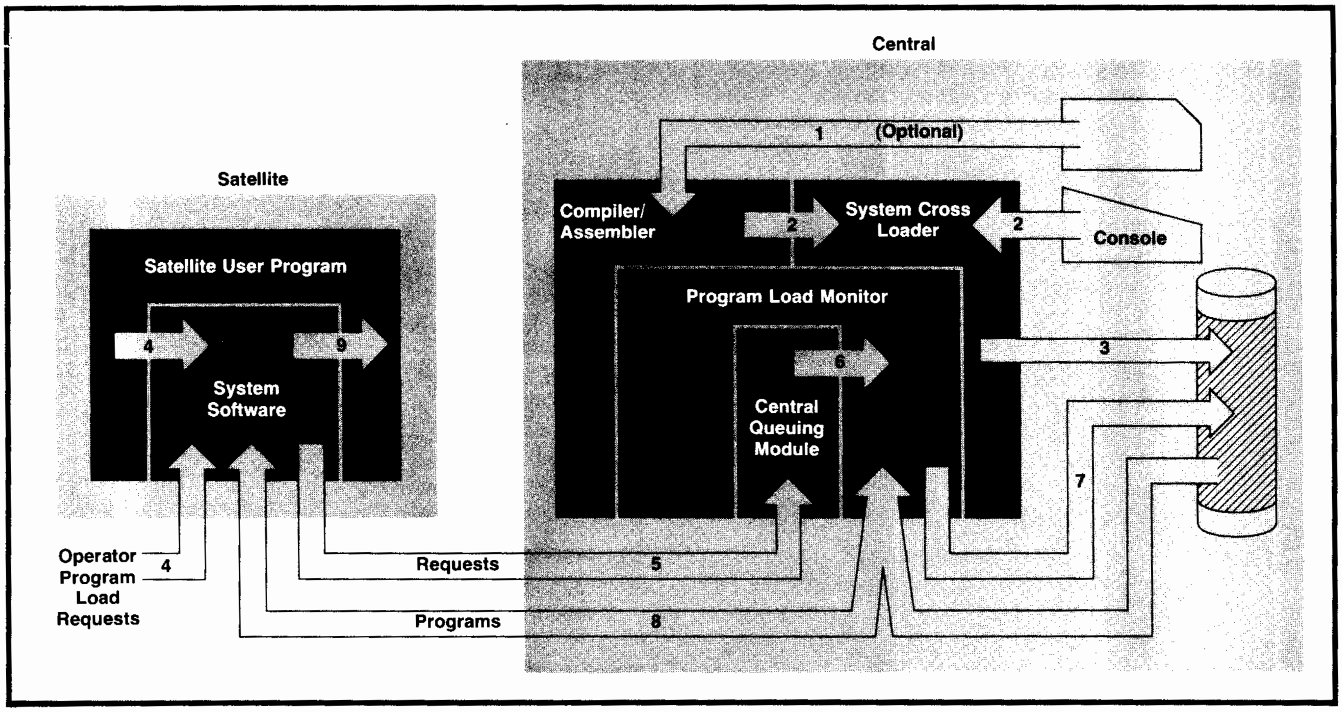


Fig. 3. *Satellite systems are freed from program development and storage problems by central program preparation and automatic down link loading: 1. Satellite applications source program is compiled or assembled (optional) 2. System cross loader builds satellite operating system from operator interaction or file input and relocates the object program for the target satellite 3. Relocated program or system is stored on central disc. Then: 4. Program or system is requested by satellite user program or operator (not shown: central station operator or programmer may issue request for RTE-C satellite, which may be unattended) 5. Satellite system sends request to central queuing module 6. Request is passed to program load monitor 7. Program or system is recalled from disc 8. Program or system is loaded into satellite 9. Completion reply is returned to requester.*

satellite. The data control block is required by the file management package for file-specific information and for a packing buffer. The system will allow up to 256 of these data control blocks concurrently, one for each of the maximum number of satellite files.

System access time to these data control blocks will be minimized if they are maintained in a core-resident table. However, the core consumed in an active system can be excessive. Core can be conserved if the data control blocks are maintained on disc, but this slows down control-block access. 9700 Distributed Systems solve this dilemma by dynamically maintaining only data control blocks for recently referenced files in core. If a file goes unused for an extended period of time, its data control block is "aged" as new requests are received. When a data control block is older than all other core-resident data control blocks, the next request for a new file will cause it to be transferred to an overflow disc file for later recall. The user can control the relative sizes of the core- and disc-resident portions of the data control block table at system generation time.

After the data control block has been assigned and all pre-execution conditions have been satisfied by the monitor, control is passed to the execution module. This module reassembles the original request and data from the transmission buffer, performs preliminary error checking, and executes the request under file subsystem control. The success or failure of the transaction is then transmitted back to the satellite system and then to the user program, thus completing the service of the request.

Besides the remote file access calls, the BCS satellite programmer has access to many of the requests for central system services (RTE EXEC calls) that are available to the central station programmer. The service requests are designed to aid in the synchronization of network times, events, and program control, and include a clock-time request, a program schedule request, and unit-record and instrument I/O requests.

The clock-time request returns the contents of the central station real-time clock to the satellite. The schedule request causes a central station program to be scheduled for immediate or time-delayed execution. Thus, for example, a central data reduction program can be scheduled to process data gathered by the satellite and stored at central. The unit record

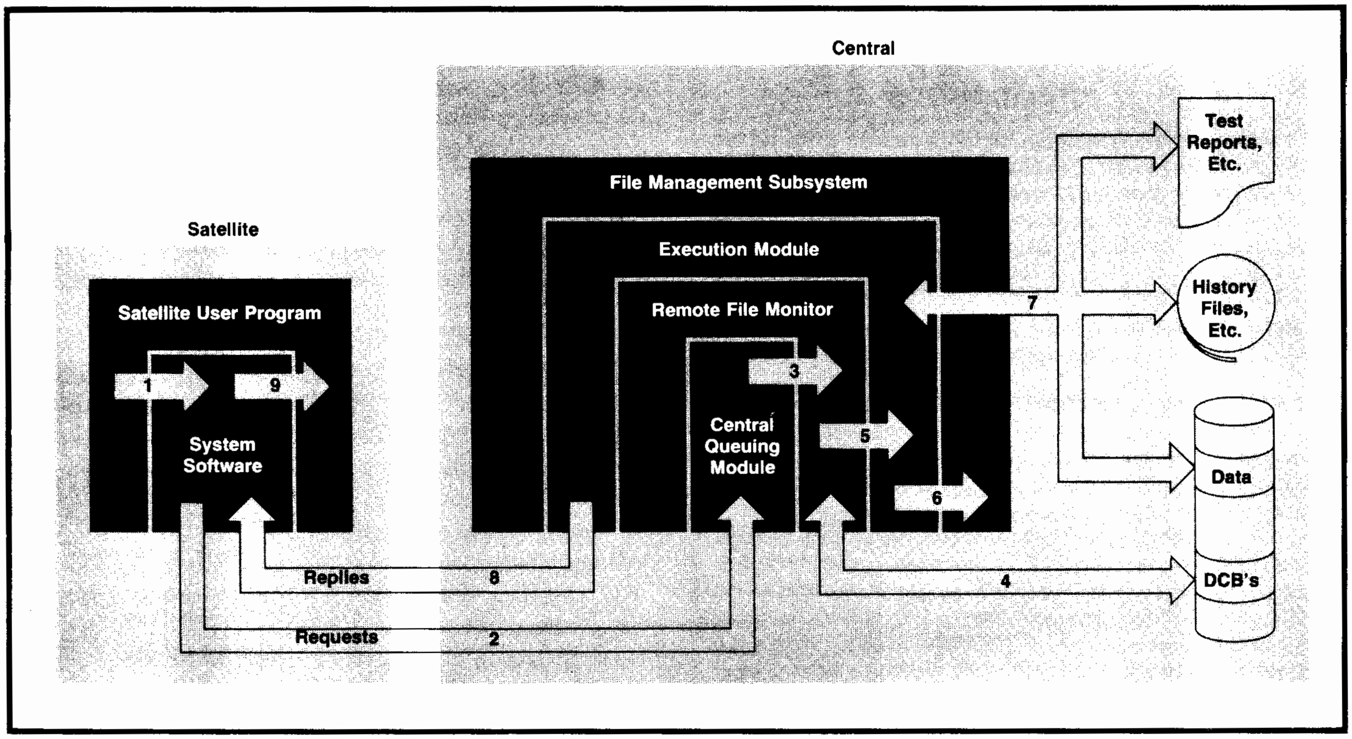


Fig. 4. *Central station data storage and file management capabilities are made available to the satellite programmer by remote file access: 1. Satellite user issues request to satellite system 2. Request is sent to central queuing module 3. Request is passed to remote file monitor 4. Monitor sets up "aged" data control block (DCB) 5. Monitor passes request to execution module to be formatted 6. Formatted request is passed to file management subsystem for execution 7. Data is read (written) from (to) the desired central peripheral 8. Request status and data are returned to satellite system 9. Status and data are returned to the requester.*

requests cause I/O control, status and read/write commands to be issued to central station devices or instruments. These requests are handled by the system in a manner analogous to that of the remote file access calls, except that data control blocks are not needed.

System Operator Interaction

Interactive operator commands provide file control and further enhance network program control. Satellite operator control of central files is accomplished by implementation of an operator interface for the commands to create, close, purge, and rename files. Program control is enhanced by providing an operator interface to the central station service requests already discussed. Also, the satellite operator can at any time cause the executing satellite test program to be terminated and, optionally, cause a new test program to be loaded into the satellite and executed.

Besides these interactive operator commands the software includes utility calls to allow the transmission of system messages from the satellite operator console to the central station console, to cause the central station real-time clock setting to be printed on the satellite console, and to list directories of program and data files on the satellite console.

The directory list feature is an operator utility request of particular interest. The satellite operator can request a local listing of all program and data files currently being maintained by the central station file manager. A partial listing may also be obtained.

A complete listing is obtained by entering the command "DLIST" on the SCE/3 satellite console. If the command is followed by a "filter" word of up to six ASCII characters, only those files whose names contain characters that match the filter characters are listed. Any number of characters up to six may be input; character positions to be ignored are specified by an asterisk. For example,

:DL[IST]	List all programs stored by the central system for the requesting terminal.
:DL[IST], *AB***	List only programs stored by the central system that contain "AB" in the specified position (e.g., CAB, IABLE, etc.).

While simple in concept, this feature provides broad flexibility when used with user-defined file naming conventions.

Satellites for Specific Applications

Distributed systems are a logical extension of computer-based measurement equipment designed for specific applications. HP offers such systems for a variety of applications. Those for automatic instrument testing and microwave network and spectrum analysis, now available as stand-alone systems, will soon be available as distributed system satellites. As satellites, 9500-Series and 8500-Series systems facilitate the preparation and coordination of programs and data for quality control, test and calibration histories, and related activities.

9500 Systems as Satellites

The 9500-Series Test Oriented Disc Systems (TODS) are designed for a variety of automatic test environments. As stand-alone systems, 9500 systems provide FORTRAN and Assembly Language programming capability in addition to the ATS-BASIC programming language and a flexible disc file management scheme. As satellites in a distributed system, 9500 systems attain even greater flexibility by gaining access to the RTE central's file structure, peripherals, and real-time operating system. Programs running in TODS share central station peripherals, schedule programs in the real-time environment of the central, transfer files between the file managers of the two operating systems, and create files on either disc from the measurement data obtained at the satellite. An interactive operator command package provides the satellite operator with capabilities similar to those offered to the satellite user program. In addition, message transactions between the operators at the RTE central and the TODS operator allow a manual hierarchy to be established in operator-governed distributed systems.

8500 Systems as Satellites

These microwave network analysis and spectrum analysis systems have been optimized for specific tests and are furnished with test programs that minimize user programming. Operated as stand-alone systems, their application programs use only the local computer peripherals. Data interchange between stations is possible, but only by transferring information on magnetic tape. In a distributed system, both of these limitations are removed. The central system disc file is now available for convenient loading of program and calibration data into the satellite. Measurement data can be stored on the central disc so that a summary of test results from several test stations is easily prepared.

RTE-C and RTE-B Satellites

Distributed system software has also been designed and implemented to couple satellites using the core-based real-time executive (RTE-C) and the real-time BASIC system (RTE-B) to a central RTE system. A major feature is a powerful capability for direct intercomputer program-to-program communication, which allows coordination of distributed processes without the need to rely on a file system. The satellite communication executives for the RTE-C and RTE-B satellites are SCE/5 and SCE/4, respectively.

Two different hardware systems support either the RTE-C or the RTE-B software. The 9601 is an integrated measurement and control system consisting of an HP 2100 Computer, unit record peripherals, and analog and digital input/output subsystems. This system is especially useful in laboratories, research and development environments, and similar smaller-scale applications. The 9610 is a larger industrial measurement and control system that provides expanded I/O capabilities and standard termination panels for data acquisition and alarming, data logging, manufacturing testing, and supervisory control applications.

Under the RTE-C operating system, FORTRAN, ALGOL, and assembly language user test programs can be executed. The ISA FORTRAN extensions for simplified digital and analog I/O and system scheduling functions are also supported.

The RTE-C operating system is a core-based subset of the powerful disc based real-time executive operating system used at the central station. RTE-C handles multiple user tasks in a multiprogramming and hardware-protected environment. With its incorporation into the distributed system network these features are retained and a host of others are offered. The SCE/5 satellite has remote file access to source programs stored on the central computer disc. An interactive command package is available to the satellite operator.

Equipped with the RTE-B operating system, stand-alone 9601 and 9610 systems provide the BASIC programmer with analog measurement, digital I/O, bit manipulation, plotting, and magnetic tape I/O. Incorporated into a distributed system, they gain many significant new features.

The SCE/4 satellite is unique in that BASIC test programs are prepared at the satellite and the results of the interactive sessions are stored by satellite operator command on the central station disc for later retrieval. These source files can be purged from the system, merged with additional BASIC program statements and loaded into the satellite for interpretation and execution, all by satellite operator commands that have been added to the real-time BASIC system. Once completed, the satellite programs can use the remote file access and program-to-program features of the system.

The SCE/5 and SCE/4 satellites retain all of the operator capabilities provided for the SCE/3 satellite. In addition, the central station operator has been given the ability to send a message to SCE/5 and SCE/4 satellite operator consoles, request the current real-time clock setting from RTE-C satellites, and schedule RTE-C programs for down-link loading and immediate or time-delayed execution. The central station can also invoke control and read/write operations on RTE-C and RTE-B satellite peripherals and request status information on these devices.

A feature of particular interest for factory automa-

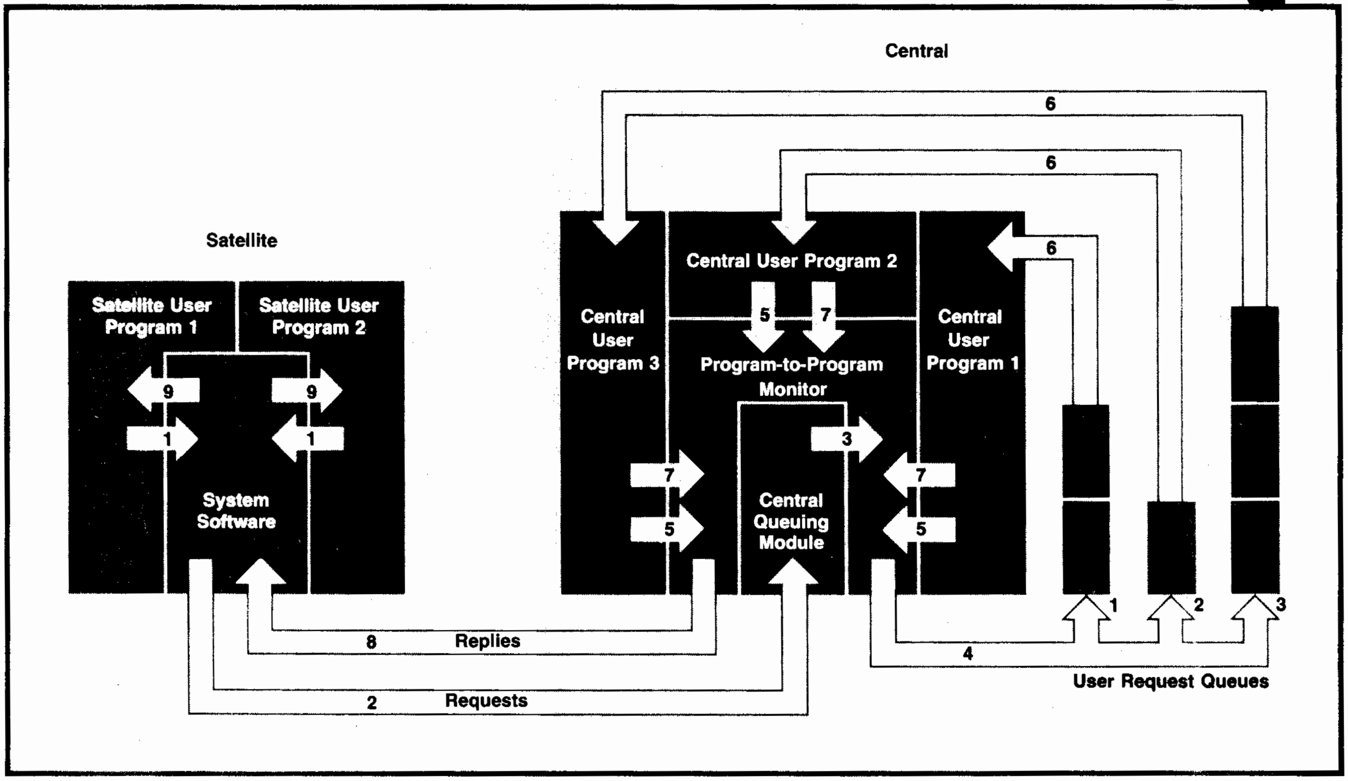


Fig. 5. *High-level-language programs in different computers communicate interactively via a transparent program-to-program communication interface: 1. Master satellite user issues request to satellite system 2. Request is sent to central queuing module 3. Request is passed to program-to-program communication monitor 4. Monitor schedules the receiving central user program if not active and queues requests for the specified central user program (three are shown) 5. Central user asks for its next request 6. Monitor passes next request to user for acceptance or rejection 7. Central user accepts or rejects requests 8. Monitor concludes request and sends reply to satellite system 9. Satellite system returns reply to user.*

tion and other applications that call for unattended satellites is forced down-link loading, offered with the SCE/5 satellite. This feature allows the central station operator or programmer to cause an application program to be sent to an unattended SCE/5 satellite and executed.

Program-to-Program Communication and Transportability

The remote file access capabilities previously described, expanded to include the RTE-C and RTE-B satellite types, manage a centralized data base quite well. However, to pass data from one executing program to another using remote file access, an intermediate file structure is required. The direct program-to-program communication capability, Fig. 5, eliminates this intermediate step and also allows the coordination of many programs executing in various network computers simultaneously.

A feature of primary importance in both remote file access and program-to-program communication is that of transportability. Our goal here was the standardization of the user/system interface so that central station user programs could be executed without modification in a satellite environment (that is, transported) and vice versa, when dictated by network needs.

The program-to-program facility was designed to permit the FORTRAN, ALGOL, and BASIC programmer to send and receive data to or from another program executing in another computer by means of simple library subroutines. All coordination of program execution and data transfer is handled by the system, leaving the application programmer free to concentrate on the design of the data collection and measurement tasks specific to his installation. The system is designed so a program executing in the central computer can communicate with several programs executing under RTE-C and RTE-B satellite operating systems simultaneously.

To further ease the burden on the application programmer the system provides a "tag field" as part of each system call. This tag field is constructed by the request originator and shipped by the system to the receiver, who may interrogate and modify it before it is returned to the originator as part of the request-completion information. The decision to use the tag field as well as its specific contents remains with

RTE File Management Package

The remote file access commands provide the satellite programmer with the facilities of the real-time executive file management package. The highlights of this powerful package are as follows.

Multiprogramming and File Integrity

Of key importance in a distributed multiprogramming RTE system is avoidance of file conflicts. The RTE file manager provides a variety of options that permit file access and file security to be optimized file-by-file to satisfy requirements. Up to seven different programs can have the same file open simultaneously, or a file may be opened exclusively to just one program. Simple, easy-to-use security codes restrict files to designated programs and users and control the nature of their access (read only or read and write). It is also possible to leave access to files unrestricted.

Often the security of the filing system is just as important as its integrity. Data in certain files may be of a confidential nature, making it necessary to restrict read as well as write access. It may be necessary to assure that data in other files comes from only one source, so only that source can be given write access to those files. The same security codes that can be used to safeguard file integrity also form the basis of a file security scheme that can be as comprehensive as desired.

The file manager provides for calling programs and data files by name. This spares the programmer the inconvenience and time required for detailed track and sector addressing.

File Manager Calls

Remote Program Calls		Purpose
remote file	create	Creates a central station file; does not store data.
remote file	absolute position	Positions a central station file to a known record address.
remote file	open	Opens a desired central station file.
remote file	control	Sends RTE control request to central station file.
remote file	read	Transfers one record from central station file to satellite user buffer.
remote file	write	Transfers one record from satellite user buffer to central station file.
remote file	position	Directs next read write to a specified record.
remote file	rewind	Resets central station file to first record.
remote file	rename	Renames specified central station file.
remote file	disc directory access	Returns 125 words of central disc directory.
remote file	status	Returns central station file status, including position of record pointer.
remote file	close	Closes a central station file.
remote file	purge	Purges central station file and directory entry.

All requests are callable from FORTRAN, ALGOL, BASIC, or HP Assembly Language.

Peripheral Device Control

An optional feature of the file manager, one offering real convenience to the user, is peripheral device control by means of file manager commands. This is established by a file directory entry for the magnetic tape unit, photoreader, punch, line printer, or other peripheral device that is to be controlled. After this directory entry has been established, the device can be controlled by the file commands. One important benefit of peripheral control via the file manager is that a program can obtain undivided access to a peripheral in the multiprogramming environment. For example, a satellite program can issue an exclusive open to a file that is designated as a line printer, locking out other network programs until a needed listing is completed.

the application programmer using the system.

The program-to-program facility also provides for communication between CCEs (central communication executives) in different central computers. This makes it possible to interconnect several distributed system networks to form a "supernetwork."

Using Program-to-Program Communication

Program-to-program communication is implemented by means of eight subroutine calls. These are divided into two types. The first type, the master requests, consists of the calls: POPEN, PREAD, PWRIT, and PCONT (program-to-program open, read, write, and control). These calls treat the other program as a slave input/output device and have logical counterparts in the RTE file system. The second type of call, the slave request, includes the calls: GET, ACEPT, REJCT, and FINIS (get next request, accept last request, reject last request, terminate communication). These calls are used to receive the master calls from the system and, after examination of the tag field, to instruct the system to return the tag field to the requester and to complete or terminate any pending data transfer. The FINIS call removes the slave program from active communication with its master requesters.

When a master program-to-program communication request is issued by a satellite user program, control is passed to an interface subroutine that assembles calling parameters, system information, the user's tag field, and optional data into a transmission buffer. The system then causes the buffer to be shipped to the central station via the communication driver.

A master POPEN request received at the central station causes the system to schedule the required central station program (if not already scheduled) and to pass the POPEN request to that program upon execution. If after examination of the tag field the program accepts the POPEN request, a queue is created by the system for the PREAD, PWRIT and PCONT requests to follow, and the updated tag field is returned to the originator. Subsequent POPEN requests for this same program will be passed through to the executing program and the existing queue used.

The ensuing PREAD/PWRIT requests received at the central station cause the tag field to be passed to the executing program. If the request is accepted by the central program, the system causes the associated data field to be written to or read from the queue previously created for the program in question. At completion the updated tag field is returned to the requester. Rejected PREAD/PWRIT requests cause the data to be purged from the system. PCONT requests are passed through the system to the executing program for tag examination. Thus the PCONT request allows the exchange of small data fields without the overhead required to process PREAD and PWRIT requests.

Acknowledgments

I am indebted to project engineer Larry Pomatto for his help in evolving many of the concepts discussed here, for programming support on the RTE-B and central software, and for his consistent willingness to "go the extra mile." I would also like to thank project engineer Jim Hartsell for the BCS and RTE-C satellite software, which he thoughtfully prepared and executed; project engineers Prem Kapoor and Barbara Packard for 9500 and 8500 satellite software; George Anzinger, group leader for operating systems, for his many system tools that helped make the project possible; Andy Danver and Dave Borton, for product marketing support; Joe Bailey, Bob Shatzer, and Hal Sindler, for encouragement, enthusiasm, and project, field, and training support; and finally, many allied project members.

SPECIFICATIONS

Distributed Systems

These specifications are for distributed system hardware and software only. Specifications for central and satellite systems available on request.

91700A
Central-to-Satellite Distributed System

CENTRAL COMMUNICATES WITH: BCS, RTE-B, and RTE-C satellite systems

SOFTWARE: Central Communications Executive, including data communications driver

HARDWARE: Serial Data Communications Interface, hardwired or modem version

HARDWIRED CABLE:

LENGTHS (feet)	1 to 600	601 to 1200	1201 to 2000	2001 to 3000	3001 to 4000	4001 to 5400	5401 to 7300	7301 to 10,000
LINE SPEED (kbps)	1000	500	250	125	250	125	62.5	31.25

MODEM CONNECTION: Distance is limited only by telephone network; line speed is determined by choice of line and modem and can range up to 20,000 bits per second.

MEMORY REQUIRED:

CPU-RESIDENT: 500 words plus user-defined system buffer area for use by all RTE central modules and the system.

DISC-RESIDENT: 3300 words of real-time disc-resident area and 6080 words of background disc-resident area.

MINIMUM CENTRAL SYSTEM MEMORY: 24K words.

Satellite Systems

	BCS Satellite			RTE-B Satellite		RTE-C Satellite	
Uses Satellite Communication Executive	SCE1	SCE2	SCE3	SCE1	SCE4	SCE1	SCE5
Memory Required (words) for Operating System (including BASIC interpreter in RTE-B system), SCE, and Data Communication and System Console Drivers	2150	2,860	4,590	11,620	14,890	6,710	10,000
Additional Memory (words) for REMAC (RTE-C Operator Communications Interface)							1,660
Minimum Recommended System Memory Size	4K	4K	8K	16K	16K	8K	16K
I/O Channels Used for Data Communication Interface		1		1		1	
Languages: FORTRAN, ALGOL, HP Assembly		×				×	
Real-Time BASIC				×			

91703A

SOFTWARE: Satellite Communications Executives 1, 2, and 3 including data communication driver for use on BCS based computer systems.

HARDWARE: Two Serial Data Communications Interfaces, Hardwired or Modem.

91704A

SOFTWARE: Satellite Communications Executives 1 and 4 including data communications driver for use on RTE-B based computer systems.

HARDWARE: Two Serial Data Communications Interfaces, Hardwired or Modem.

91705A

SOFTWARE: Satellite Communications Executives 1 and 5 including data communications driver for use on RTE-C based computer systems.

HARDWARE: Two Serial Data Communications Interfaces, Hardwired or Modem.

PRICES IN U.S.A.:

91700A, $3500.

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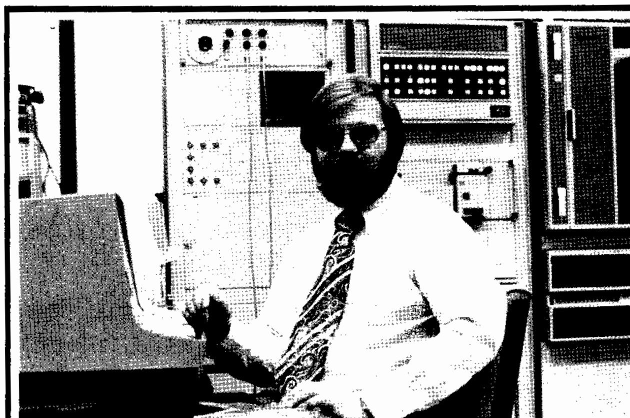

Shane Dickey

Before coming to HP in 1972, Nebraskan Shane Dickey specialized for five years in real-time minicomputer systems design and implementation for process and supervisory control. As project manager for HP 9700 Distributed Systems, he has guided that project from inception to production. He's a member of ACM and author of a pair of professional papers on distributed systems. A 1966 graduate of California State University at Long Beach, Shane holds a BA degree in mathematics. He lives in Sunnyvale, California, but is building a new house in the nearby Santa Cruz mountains with a solar heating system that he designed. Other interests include sailing, woodcarving, scrimshaw, and stained glass. Shane and his wife, a systems programmer, have just welcomed their first child, a boy.