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CENTRALIZE? DECENTRALIZE? DISTRIBUTE?

By Cort Van Rensselaer

Design the information system to match the organization it supports.

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Hewlett-Packard Co. has been extremely successful in using large and small computers to handle its administrative data processing in whatever environment was necessary: centralized, decentralized, or distributed. We think that what we've learned can be useful to other worldwide multidivisional companies with broad product lines, and so we've gone to some effort to share our experience. Describing something as complicated as how a company operates is not an easy task, however, especially given the added confusion that comes from an unsettled data processing vocabulary, so it seems best to trace what we have done with specific examples.

Basically, we have evolved from a purely centralized operation to our present mix by riding on the coattails of advancing technology. Our first computer experience in the late '50s and early '60s was with large standalone processors (and we still have some of those). As the company grew, we developed a central data processing facility at our corporate headquarters in Palo Alto, Calif. This facility served a number of San Francisco Bay area users in a batch environment, in


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Universal numbering conventions were established for non-dp reasons, but proved key to dispersing the processing.

which input and output was transferred by messenger or taxi.

In the early '70s, this center became too cumbersome to manage. It became increasingly difficult to respond adequately to the diverse needs of a large number of users. The short term answer was to go to an RJE environment—while still retaining a centralized computing facility—where control of the operation of application systems would be transferred to the users.

During the same period, we began to use time-sharing for interactive systems requiring geographically dispersed terminals, and to install a worldwide data communication network with local data entry to support our sales and service activities. The time-sharing and remote data entry applications gave us confidence in the effectiveness of minicomputers, and the development of the communications net was to be the groundwork for what has followed.

About five years ago we realized that our standalone installations outside the Bay area were more responsive to local management needs than our common RJE systems were. As a result, we began to decentralize a large portion of our previously centralized data processing.

Finally, our data communications network and decentralized computers together made it possible to experiment with distributed systems, where data storage and processing functions are shared across a mix of computers and lines, and where nontrivial operations are performed at more than one place. This activity has grown very rapidly, and several of our major data processing applications systems now operate in a distributed mode.

Thus far our experience with distributed processing has been positive. Distributed processing has made it possible for us to adapt to a constantly expanding geographic operation, and a constantly changing organizational structure, while maintaining consistent administrative support. It has permitted us to meet the reporting requirements of our own management and those of the governments of the various countries where we operate, in a timely and cost-effective manner. And it has improved the accuracy of administrative data by moving a significant portion of the processing to the source of information.

The most significant lesson we have learned from our experience, however, is that there is no one best way to process data. Information systems must be designed to match the organization they support. Thus our decentralized organization with its strong central management requires both decentralized and centrally managed systems. (See Table 1.) Understanding why this is true requires a short explanation of our business.

THE BASICS OF THE BUSINESS

Hewlett-Packard manufactures more than 4,000 products for wide-ranging markets which are primarily in manufacturing-related industries. We have 38 manufacturing facilities and 172 sales and service offices around the world, and together these employ about 45,000 people. We have experienced a very rapid growth of about 20% per year, culminating in sales of $1.7 billion in 1978.

To support this business, we currently have some 1,400 computers (not including desktop units or handheld calculators). Of these, 85% are used to support engineering and production applications, are usually dedicated to specific tasks, and often are arranged in networks. A number of them are also used in computer-aided design applications as front-end processors for large mainframes.

The remaining 200 computers are used to support business applications. The largest is an Amdahl 470/V6 located in Palo Alto, and there are nine medium-sized IBM systems in other large facilities. Seventy HP 3000s are used in our factories and larger sales offices, and 125 HP 1000s are scattered about for data entry, data retrieval, and data communications work.

Generally speaking, the HP computers are oriented toward on-line applications, and the large mainframes toward batch processing (although three also support on-line applications). In addition, HP uses about 2,500 crt terminals in business applications alone.

The network tying all this together (Fig. 1) consists of 110 data communications facilities located at sales and service offices, at manufacturing plants, and at corporate offices in northern California and Switzerland.

Some long-standing management traditions have contributed to the successful application of all this hardware. For example, for the past 20 years HP has been oriented toward decentralized management responsibility at the operating level with strong central management coordination. Local managers have been accustomed both to making their own decisions and to reporting to management on a frequent and detailed basis.

Another important tradition has been the adoption of companywide coding standards. Universal conventions for product number, account number, part number, entity code, employee number, and others were established to meet business requirements long before computer systems were extensively employed.

But perhaps the most important systems-related management tradition has been the existence of functional advisory councils. These groups were established to resolve common local problems in such areas as order processing, materials management, cost accounting, and quality assurance. Today, these councils provide a forum in which to arrive at a consensus for dp related problems and to achieve user support.

We have found the decentralized management, the companywide standards, and the existence of the councils all to be invaluable in building and managing our complex, dispersed systems.

TEN BIG PROBLEMS

Yet, for all our built-in advantages, progress hasn't always come easily. As our use of computers has evolved, we have faced a number of continuing challenges, some of the most important of which are:

1. Establishing a central planning and management program for company-

CENTRALIZED	DECENTRALIZED	DISTRIBUTED
Material Services	General Accounting	Product Information
Vendor Contracting	Cost Accounting	Customer Information
Consolidated Shipments	Customer Service	Order Processing
Legal Reporting	Production Planning	Accounts Receivable
Employee Benefits	Materials Management	Product Assurance
	Purchasing	Payroll & Personnel (85%)
	Payroll & Personnel (15%)	

Table 1. After nearly 20 years of evolution, HP has come to the conclusion that there is no one best way to process data, and the company does some processing in each kind of environment.

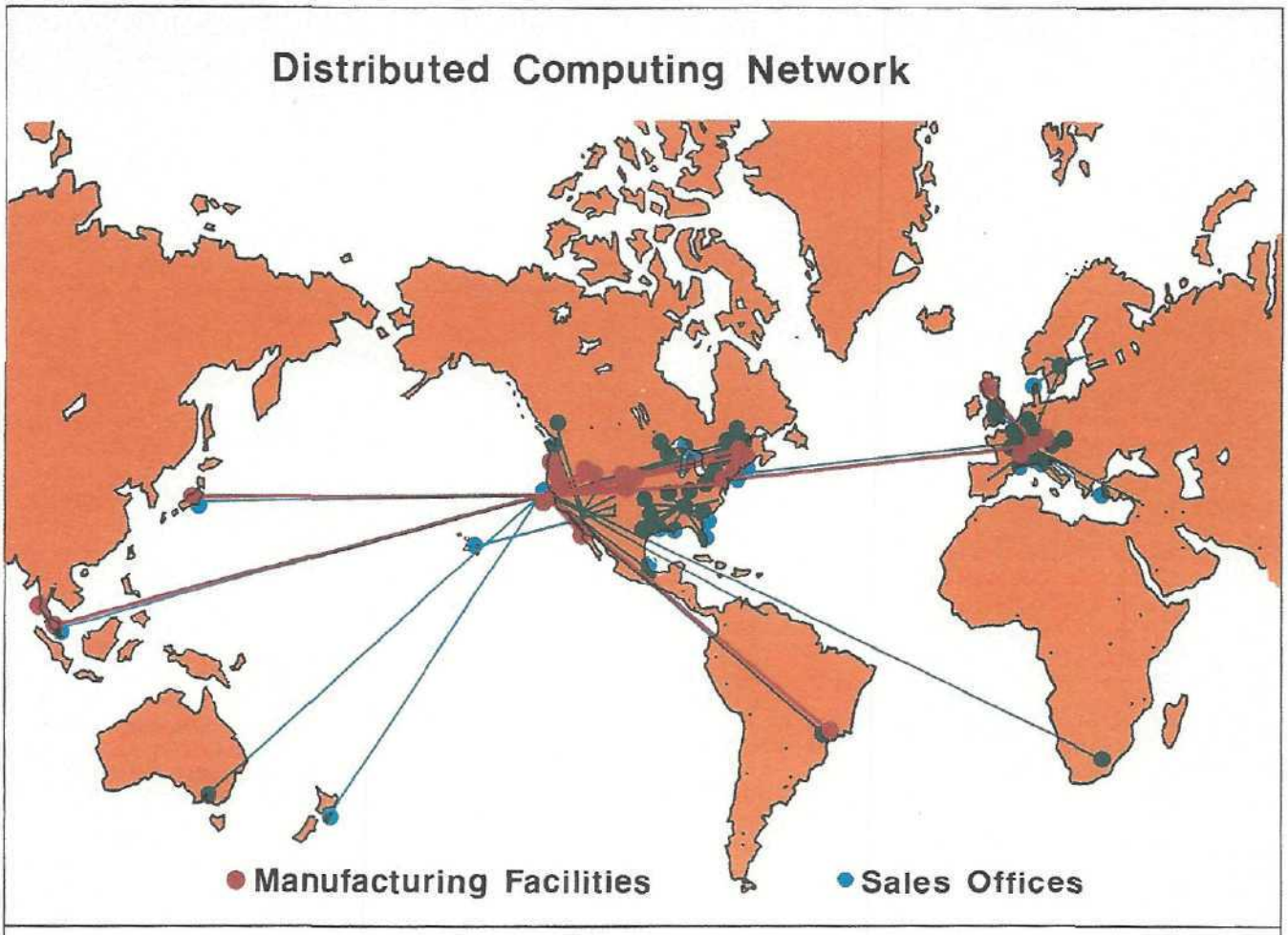

Fig. 1. HP's internal communications network has 110 nodes linking manufacturing plants and sales offices to corporate centers in Palo Alto and Geneva. Most lines are dial-up facilities, and so communications line costs are held under $50,000 per month even though message volume averages 140 million characters per day.

wide information systems activities so that decentralized development work could be coordinated.

2. Designing systems which could respond easily to constant geographic expansion, organizational change, and the addition of new operating units.

3. Coping with ever-increasing needs for detailed and accurate information to meet management and government reporting requirements while controlling administrative costs.

4. Designing systems which could be adapted to respond to specific local needs while maintaining companywide compatibility.

5. Getting user-managers to accept responsibility for the specification and operation of their systems.

6. Convincing users in different functional areas that data is an organizational resource to be shared by all, and that individual transactions should simultaneously update the records of all functions.

7. Avoiding unnecessary duplication of effort in designing and supporting systems.

8. Developing the skills of data processing staff members to meet the needs of a growing organization, and assigning priorities to their activities.

9. Establishing, maintaining, and promoting the use of standards for hardware, software, documentation, project management, data, and auditability and control as a foundation for well-coordinated worldwide applications systems.

10. Controlling security and privacy in an on-line, decentralized, and distributed multinational environment.

Although we have made a great deal of progress in solving many of these problems, candidly, a number of them are still unresolved.

We began to seriously address the first and most important challenge— establishing management control over companywide systems developments—about two years ago. We saw then that a large amount of data processing hardware had been installed in decentralized locations and that many potentially incompatible systems were being designed. Furthermore, we realized that the plans for hardware installation were not well-coordinated with the needs of systems being developed centrally. In an attempt to deal with these matters we established an Information Systems Planning Office. This in turn led to the creation of an Information Systems Planning Task Force (similar to the advisory councils discussed earlier), which was assigned responsibility for defining how HP's information systems activities should be managed.

The task force first identified three organizational areas which required different approaches to system design and operation: sales and service, manufacturing, and corporate administration.

HP's fundamental organizational unit is the manufacturing division profit center. There are 38 of these. Each occupies a single plant location, and performs a full range of business functions (including research and development, manufacturing, and marketing) as well as support functions (financial control, personnel administration, and product assurance). In many respects, each division resembles an independent company.

We practice management by objectives and attempt to have decisions made by the people who are closest to the problems. From an organizational viewpoint, this means that manufacturing support systems must be *decentralized*. The exceptions are centrally managed distributed systems such as those for payroll and personnel.

With such decentralization, there is an unfortunate tendency for redundan-

HP has 172 sales and service offices around the world, about 70 of which are directly connected to the firm's communications network. Most offices maintain their own customer, order status, and product data files on-line, and are involved in some form of distributed processing for each.

cy in system design. To minimize this, HP has established a sharing policy for common programs, which has been quite successful.

HP's worldwide sales and service organization employs a different type of system. Customers are served by a single organization which just happens to be geographically dispersed. Sales and service activities related to specific product lines are performed by specialists; and these specialists are supported by a *distributed* marketing administration system which ties the sales and services offices to the company headquarters and to the factories.

The third entity, corporate, provides those services such as product assurance, payroll, and employee benefits, financial and legal reporting, which are best handled in a *centralized* manner.

The planning team studied how existing information systems supported these various company operations. During this analysis, it became clear that our most successful systems were those which matched the company's organization and management philosophy. This led to the conclusion that systems should be centralized, decentralized, or distributed depending on management needs.

The following four examples describe specific HP information systems or facilitates and show how they match our organization. The first deals with the communication system, which is the heart of our minicomputer network. The second and third examples are of two systems having distributed data bases, one with central master files (at two locations) and the other with both central and dispersed masters. The final example deals with decentralized systems which interface some distributed systems.

Most of the processing done at the 38 manufacturing sites is performed in a purely decentralized manner. Exceptions are for payroll and personnel data processing, and for functions performed in coordination with the sales offices.

110-NODE NETWORK

The communications system which supports our computing network employs minicomputers at 110 worldwide locations. These minis take care of a number of data communication functions. They handle data entry, format data for transmission, automatically detect and correct errors, and adapt transmission protocols to meet the requirements of various countries. In addition, the minis support on-line access to local data bases.

We started to build this network in the late '60s when we were using paper tape, which was slow, very expensive and —even more important— extremely error-prone. In 1968, HP introduced a minicomputer oriented primarily toward scientific applications. To see if we could use this machine in business applications, we started using it to support a communications network with intelligent terminals. The network was successful right from the start, and we've been continuously adding to the locations served. Five years ago we began to install display terminals on the network. More recently we've been adding distributed data bases and an inquiry capability.

The network operates in a store and forward mode. In Europe, for instance, we transmit everything to Geneva (Fig. 2) and concentrate the data there for more efficient use of the overseas lines to Palo Alto. The communications system uses the standard dial-up worldwide telephone network over most routes. This greatly reduces the cost, since we pay only for the actual time used. For example, it takes about one minute a day to transmit all the information back and forth to New Zealand. A single dial-up call to New Zealand is clearly a lot less costly than having a dedicated line.

The average worldwide data volume is about 140 million characters per day. This translates into about 100,000 messages. Still the line cost runs under $50,000 per month, which is very economical compared with the communication costs of other companies using on-line systems at similar data volumes.

The largest communication system applications are for marketing (60% of the traffic), accounting (15%), employee information (10%), and administrative messages (15%). We transmit about a million orders per year over the network,

almost 50% of which originate outside the U.S., and about three million invoices. The network is also used extensively for file transmission.

The system has provided an excellent means for transmitting administrative messages (electronic mail) and has been particularly effective for overseas communication, where the telephone is costly and inconvenient because of time zone differences. Using the system, the cost of transmitting a letter-size message overseas is typically 30¢. This low cost, coupled with the system's speed and convenience, has resulted in a large increase in day to day communication between people at the operations level in our U.S. and overseas offices.

As the largest user of the communications system, the marketing administration group is responsible for planning and implementing systems enhancements, which are developed by a small central team of programmer analysts. New releases are transmitted as data to the remote locations and put into operation at a prearranged time. The installation of these periodic system enhancements normally goes smoothly, but a fair amount of expertise is required at the remote locations to cope with unexpected bugs which occur due to slight hardware differences, special local modems, and other incompatibilities.

MARKETING ADMINISTRATION SYSTEM

The second application system example is the distributed marketing administration system, which supports the sales and service organization. The primary objective of the marketing system is to provide accurate and consistent information to support our customers on a worldwide basis. To do this requires a centrally managed distributed system.

The marketing administration system (Fig. 3) suggests how centralized, decentralized, and distributed processing all go on simultaneously.

Decentralized processing is used for production planning, product configuring, and shipment scheduling at the manufacturing sites, and for order entry and service scheduling at the sales and service offices.

Centralized processing comes in for such functions as financial and legal reporting and administration of the employee benefits program at corporate.

Some forms of distributed processing are employed for maintaining and accessing distributed data bases. The data for customer records all originates at the sales offices, for example, and slices of the customer data base are kept in each sales office, but a complete customer data base is simultaneously maintained at corporate and slices of the data base also exist at the manufacturing plants.

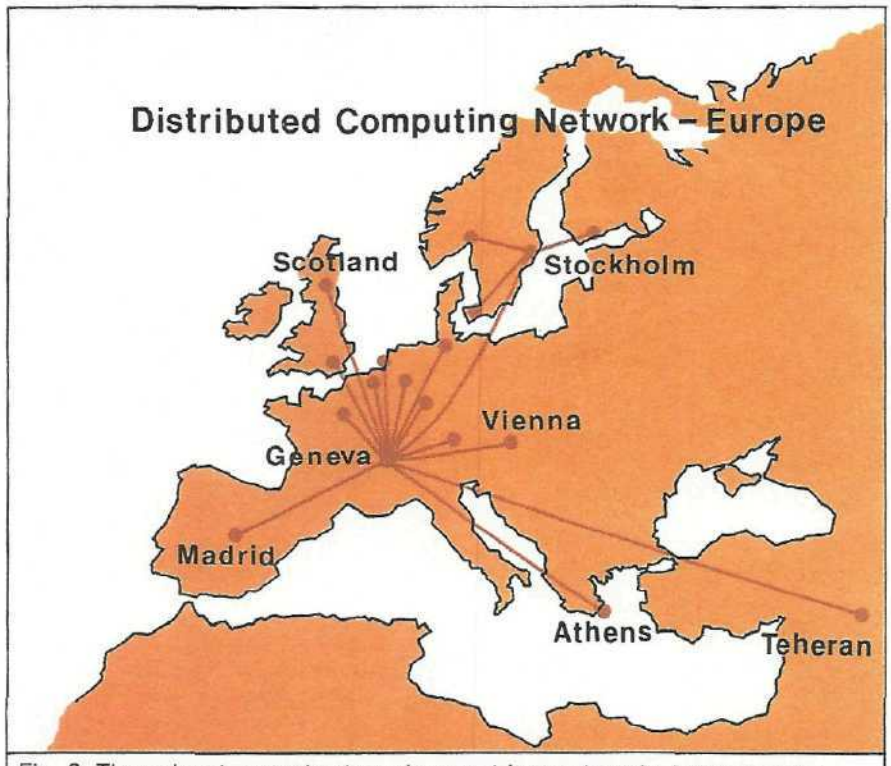

Fig. 2. The network operates in a store and forward mode. In Europe, for example, local sites may perform data base inquiry and update their own files, but must batch all data for files maintained in Geneva. Similarly, Geneva batches data bound for Palo Alto files.

The Geneva office handles both sales and manufacturing orders for products produced in Europe, sending only summary information to Palo Alto. For products manufactured outside of Europe, Geneva ships orders directly to Palo Alto; order status files for those sales are maintained simultaneously in Palo Alto and Geneva.

The data for product records all originates at the sales offices, for another example, and slices of the product data base are kept at each plant, but complete product data bases are simultaneously maintained at corporate and at each sales office.

Orders and changes are entered at the sales and service offices, transmitted to headquarters where they are entered on central files, and then sent on to the factories for acceptance and delivery acknowledgement. Company order, shipment, and backlog status is maintained centrally to provide information to top management. Delivery information is transmitted from the manufacturing divisions back to the sales offices where orders are acknowledged.

Invoices are centrally processed in Palo Alto and Geneva. The credit and collection functions are decentralized to the sales offices, with central reporting of receivables status to provide financial control.

Files of European open orders are maintained in both Geneva and Palo Alto. An order from a European sales office containing items to be supplied from a European factory and a U.S. factory is processed in Geneva. Complete detail pertaining to the U.S.-supplied items is transmitted to Palo Alto; however, only order statistics are sent to Palo Alto for the European-supplied items. Order status information is transmitted back and forth daily to keep the two files in sync, and a monthly audit procedure insures that nothing has been overlooked in the daily updates.

Up to date order status change information is transmitted daily from the Palo Alto headquarters to the larger U.S. sales offices to provide on-line access for response to customer inquiries. The remote files are kept in sync with the master files by computer control. That is, the update program requires each batch update to be performed in the right order. (The Jan. 17 update cannot be performed before the Jan. 16 update.) Local files can be recreated from the central files should recovery be necessary.

Although data communication is handled in a batch mode, the system operates in the same manner as an on-line distributed system in which a significant portion of the data processing is done at more than one location. Data is batch communicated because this is the most economical method to employ with currently available communication facilities.

The use of display terminals in the sales offices to access order status infor-

mation produces a labor saving of close to 20% over the former methods. In the past, HP used microfiche reports, produced once a week and mailed to the sales offices. Data retrieval was awkward and time consuming. In addition, reports were usually received late, so we had to transmit printed information daily to update the microfiche. Now, having this information directly available also cuts costs, since fewer telephone calls to the factories are necessary for order status inquiries.

Managing the marketing administration system is a continual challenge. Because of its wide geographic and applications scope, changes must be made slowly and carefully to avoid upsetting existing features. Individual HP organizations and functions have a continuing need for enhancements and want these to be installed quickly. Functional councils, such as the Information Systems Task Force, the Order Processing Council and the Customer Service Council, have played important roles in prioritizing these needs and obtaining support for overall system development plans. Needless to say, differences of opinion are strongly expressed in meetings of these councils.

Another management challenge is the coordination of international dp system activities. Europe, in particular, has important and unique system needs which are best developed and supported locally. These needs, however, must be closely coordinated with the main system because of the close interrelationship of transactions and files. A great deal of overseas travel, along with rotation of knowledgeable personnel, is needed to keep these efforts properly coordinated. To accomplish this coordination, three U.S. systems people are currently assigned in Europe, and two Europeans in the United States.

PERSONNEL/PAYROLL SYSTEM

In order to comply with local laws and customs, an independent personnel/payroll system is maintained by HP in each country in which we have operations. In the United States we have a distributed system which pays about 25,000 employees. The pay information is entered on display terminals at about 30 remote locations, each with its own daily updated disk file. The data is transmitted to Palo Alto monthly, where the payroll is processed. The pay checks are either transmitted back to the orginating locations for printing or they may be directly deposited in the employee's bank account.

Why do we process our payroll in Palo Alto, rather than at the remote locations? We do this for two main reasons. First, to help administer overall HP benefits. For example, we have a nationwide insurance plan, a retirement program, cash profit sharing, and a stock purchase plan; all of these must be administered out of a central file.

Second, many government reports must be made on a centralized basis: retirement legislation reports, equal opportunity reports, withholding taxes, etc. By producing the information needed for benefit administration and government reporting a by-product of the payroll system, the information need only be entered into the computer system once.

The distributed data base which supports the payroll/personnel system operates in a different mode from that which is used for the sales and service system. Each division is responsible for the accuracy of the data relating to its employees. The data is kept on local HP 3000 disk files updated daily. Changes made to these files are transmitted to Palo Alto several times a month, where they are used to update the central file prior to payroll processing.

The audit and control procedure which ensures that the central and remote files are in sync works in the following manner. After the central file is updated, the modified records are transmitted back to the local entity for comparison. Any discrepancies are then reported.

Discrepancies can arise from two causes. First, somewhat more stringent edit routines can be applied centrally, so an unedited error is occasionally detected. Second, certain changes to employees' records can be made centrally and these are sometimes not recorded in the local files. A small, but significant number of errors are detected by this audit and control procedure.

The payroll/personnel system serves a number of departments: finance, accounting, personnel, and tax. An advisory board consisting of members of each of those departments reviews and approves changes to the system's programs, which number several hundred per year.

Eighty-five percent of HP's U.S.

Approximately 2,500 crt's (and 200 computers) are used for business dp alone, including these at the Sunnyvale installation's receiving dock.

CHARACTERISTICS OF APPLICATION SYSTEMS

Activity	Factory Management System	Marketing Administration System	Payroll/Personnel System
Development	Joint effort between divisions and corporate on modular basis	Various operational units working under centrally coordinated plan	Corporate
Operation	Decentralized (use is optional)	Distributed	Distributed
Data Base	Locally maintained, serves all manufacturing facility departments	Centrally and locally maintained, local sales office data bases updated daily	Locally and centrally maintained, central data base updated before each payroll run
Support	Sharable systems centrally supported	Central support of basic systems, local support of alterations	Central support

Periodic enhancements to the communications system demand a fair amount of expertise at remote sites.

employees are paid by this system. The other 15% are located in manufacturing divisions which have elected to run their payrolls locally. Personnel data for this 15% must still be maintained in the central file to take care of the centrally administered benefit programs. Keeping this independently prepared data accurate and consistent with that prepared centrally is a significant challenge. This experience has dramatized the advantage of sharing common data used by different functions. The discipline of the payroll system has proven to be invaluable in keeping central personnel records up to date and accurate.

The remote personnel files of both kinds permit local entities to produce reports on their employees. In addition, they provide a timely interface to local systems such as cost accounting. The remotely used software is centrally supported, and changes are released periodically.

FACTORY MANAGEMENT SYSTEM

The last application system to be described is the factory management system, which is implemented on HP 3000 hardware. This decentralized system supports the functions of order processing, materials management and purchasing, production planning, product assurance, service support and accounting.

The factory management system consists of a group of functional modules which access a central data base which serves as an information resource for the division. As mentioned earlier, most systems used by our manufacturing divisions are decentralized and locally managed. Although each HP division has unique requirements which must be satisfied by its local support systems, there is a remarkable similarity between the needs of the different divisions. Most HP divisions are oriented largely toward assembly operations, so manufacturing support systems are designed around a bill of materials processor. As a general rule, 80% of a division's needs can be satisfied with the basic system. We developed the factory management system to multiply the return on development and support costs by sharing systems between these decentralized locations.

The factory management system has been developed over the last five years, one module at a time. (An example of a system module would be materials management, production planning, or cost accounting.) The development has been done by joint development teams consisting of division personnel responsible for providing the specifications and ensuring that the system meets their functional needs, and of central data processing specialists who make sure that the modules operate efficiently and properly interface other system modules. On completion each module can be shared by other divisions on a voluntary basis.

We have not attempted to solve all system problems in each module. We have followed the 80-20 rule, taking care of major requirements that are common to a number of divisions. In fact, we have encouraged sharing divisions to add unique features required to meet their local needs. Quite often these unique features are of value to other divisions and later get incorporated into the "standard" modules.

This approach to sharable system design has been very successful. We find that the shared modules save up to 75% over the cost of local development and that they can be implemented in a fraction of the time. So far, over half of HP's 38 divisions have elected to participate in this program, and nearly all have plans eventually to use some parts of the system.

The factory management system has been especially useful to new divisions (which are being added at a rate of about three per year). It has permitted managers in these divisions to have a high level of systems support capability early in their growth cycle. On the other hand, the system has been much less useful to older, established divisions with mature systems. These entities have found it difficult to justify the cost of change (especially retraining people), even though on-line operation and other enhancements would be desirable.

The factory management system architecture permits divisions to utilize either the complete system or individual modules to support specific functions. Many divisions have installed modules to automate activities which previously were handled manually. Often these modules are interfaced with existing systems implemented on IBM (or IBM-compatible) hardware.

With the large number of divisions using the factory management system, we have found it profitable to establish a central support facility. This group installs enhancements to the system on an on-going basis, makes modifications as required to match changes in interfacing systems (such as companywide distributed systems), and helps the divisions install modules. Several functional advisory boards have been established to facilitate priority setting and to keep the central group tuned in to user needs. One of the important problems considered by the advisory boards is whether to enhance existing systems to achieve short-term benefits, or to put the effort on additional systems capability to satisfy future needs.

The factory management system provides an interesting management challenge. Since it uses within one facility a data base supporting all using functions, managers must rely on the accuracy of one another's data. This can be difficult to implement in an organization accustomed to individual departmental control of systems resources, but it pays off by providing consistent information and eliminating the classic argument over whose numbers are right.

For access to those numbers, HP is making wide use of display terminals in factory applications, as well as in sales and service work. The primary advantage

The largest mainframe in use is an Amdahl 470/V6. Others include nine medium-size IBM cpu's and 70 HP 3000s.

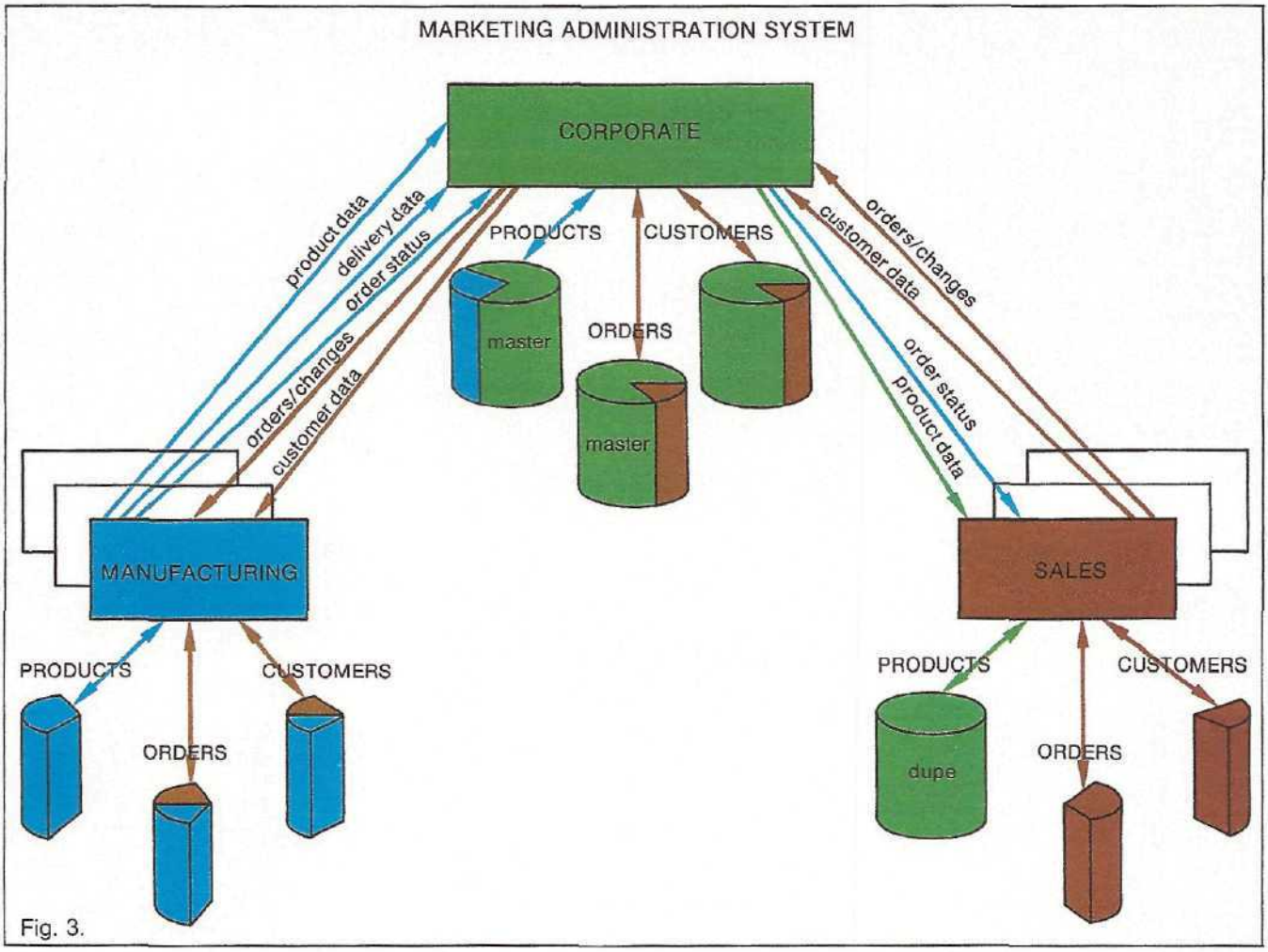

Fig. 3.

of these on-line terminals is usually thought to be that access to data, but there is an important secondary justification: paper saving. Terminal availability greatly reduces the number of printed reports required. In one study (involving another manufacturer's hardware), we found that half the cost of installing on-line displays was justified by a direct reduction in printed reports which the users agreed to give up in return for on-line access to data.

FOUR STRINGS TO TIE IT TOGETHER

An important activity of managing systems in a large worldwide company is the central systems support which ties the whole process together. Four main functions or aspects are involved at HP: (1) long-range planning, (2) "visibility and leverage," (3) personnel, and (4) standards and guidelines.

The preparation and maintenace of *an overall plan* for systems evolution and development is essential. This involves the combined efforts of manufacturing, sales and service, and company-wide personnel. To accomplish this, we've established three planning teams. The manufacturing planning team is headed by the vice president of corporate services and his staff. The marketing team consists of members of the staff of the vice president of marketing. Companywide planning is handled by the office of the controller. The central management job is to consolidate the results of the planning efforts by these three teams and then communicate these plans throughout the company and to upper level management for approval or for suggested modification.

The aspect we call *"visibility and leverage"* has played an important role in the success of our systems. We believe that good managers will make good decisions if they have the right information. A great deal of needless duplication of effort has been avoided by communicating information about information system activities taking place throughout the company. For one thing, this has highlighted existing sharing opportunities.

Information systems *personnel* are very important in this scheme, and growth of the number of people in this function parallels that of the company's dollar growth: 20% per year. Most of the hiring and development of these people is decentralized, but the central activity provides an overall framework to improve consistency.

Another important function of Central Information Systems Services is user management education. Training programs are conducted regularly covering the role of users in system design and operation.

The final area, *standards and guidelines*, is essential to the success of all our systems. As mentioned earlier, we have some well-established, company-wide coding standards which arose out of non-dp activities. In addition, the dp systems themselves have helped create and maintain standards. For example, our worldwide order processing system imposes a strong data standards discipline. Factories and sales offices must follow the rules in order to communicate with one another and to ensure that orders are processed.

We have put a lot of effort into standardizing our documentation procedures as well. Documentation is of great importance as a project management tool during system design. It is also a key ingredient of our systems sharing program, as it helps a prospective user evaluate the utility of systems under consideration.

In contrast, hardware and software standards have probably been of less importance to HP. Nearly all of our computers are manufactured by HP or IBM, and have compatible communication protocols at the hardware interface level. Magnetic tapes can be readily interchanged, for one thing. Then too, HP minis emulate HASP workstations for IBM mainframes. Data is transmitted using

Order status information is transmitted back and forth to Europe daily, to keep files in sync.

standard protocols. We have adopted COBOL as the standard language for application programs, and we use the HP Image data base management system extensively in our HP 3000 applications. There aren't too many pieces to coordinate.

In summary, our minicomputer systems have helped us find workable solutions to the 10 challenges listed earlier. These systems have helped us provide consistent support for our administrative activities under conditions of rapid growth and change. They have kept our sales organization supplied with the up to date information necessary to provide full service to our customers in all of our worldwide sales and service offices. They have helped our management keep score by providing key information when needed. And they have helped us cope with ever-increasing government reporting requirements.

HP's internal business systems are continually being improved to meet changing requirements. As this goes on, and as we evaluate the results, it seems that several characteristics emerge over and over again as the most significant:

Successful systems put the control of the data close to the source of the information and the control of processing close to the manager responsible for the function being performed. In an organization like Hewlett-Packard, this will frequently imply distributing the processing, but not always. When distributed processing is called for, there are additional criteria for success. Among these are an existing set of standards and coding conventions, some mechanism whereby disagreements among users and developers can be resolved, and some facility for sharing programs and procedures among the participants.

When all of these things can be combined, as they have at Hewlett-Packard, user managers are satisfied, corporate managers have the data they need when they need it, and administrative productivity is increased—and those have been the goals all along, haven't they?

*

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Mr. Van Rensselaer has been Hewlett-Packard's manager of corporate information systems since 1966. He has worked for HP since 1942, beginning with a position as development engineer, then production control manager, assistant sales manager, and U.S. sales manager. He has been the general manager of three divisions: the Colorado Springs Div., the Oscilloscope Div., and the Dymec Div. (now part of the Computer Products Group), and has also been manager of HP corporate planning.