**Proceedings**

# DISTRIBUTED COMPUTING

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distributed computing

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THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

# GENERAL CHAIRPERSON'S MESSAGE



It has been a pleasure to head the team which has brought you Compcon 80 Fall. I think this has turned out to be an outstanding conference, with thirty nine technical sessions plus the plenary session and evening panel debate. I would expect these proceedings to be well thumbed in the years to come.

I must tell you that everything went smoothly, even through changes of employment and conference committee membership. Everyone carried his/her share of the load, but no one was overtaxed. Based on previous years' experience, we established a realistic schedule and followed it. Problems arose and were dealt with. My point is to suggest that if you've never participated in Computer Society committee work, you might consider working on a conference.

I'm especially pleased with the program balance. There is good treatment of each of several levels of involvement with distributed processing: casual interest, beginning involvement, and highly experienced (two years, perhaps ?). The pre-conference tutorials continue this multi-level presentation, including entry level as well as specialized presentations. My only regret is that there are too many simultaneous sessions I want to attend—and I haven't felt that way about a conference in years.

Of course this was a team effort. I salute the conference and program committees. Special tribute is due David Nelson, program chair, who organized an outstanding group of people, who in turn produced this outstanding program.

The subject of this year's conference, Distributed Computing, has been selected because of its emerging importance. It is sufficiently broad to encompass most of computer-land's specialities, while at the same time being sufficiently focused to promise specific benefit to attendees.

I trust that interactions at the conference will be as much a benefit as these proceedings. Your suggestions for, and participation in, future conferences is invited.

Marshall D. Abrams
General Chair
COMPCON FALL '80

# PREFACE

Man's desire to interconnect—railroads, highways, telephones, and now computer systems—is resulting in significant advances in distributed computer systems. These advances are as significant for the 1980s as timesharing was to the 1970s and batch processing was to the 1960s. Just as batch processing yielded to timesharing, so will the latter yield, in many respects, to distributed designs, as their advantages become understood and verified through experience.

We are entering a new phase in distributed processing. We finally have actual experience with several systems, and one gets a feeling similar to when a computer program becomes too large and complex—a desire for simpler solutions, a desire to discard unworthy ideas, and a desire to reimplement the good ones. Through all of this, we see the emergence of ideas which are more elegant, integrative, and in better compliance with both application and technological requirements.

This year's conference reaches a very broad set of topics, all of which directly bear on the design of distributed systems. The Program Committee is equally broad with respect to member's interests, affiliations, and backgrounds. We hope you find the program valuable and interesting.

David L. Nelson
Program Chair
COMPCON FALL '80

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# SESSION 1: MANAGEMENT ISSUES

W. Kerns
U.S. Air Force

# KEY DECISIONS IN DISTRIBUTED PROCESSING

Harold Lorin

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The establishment of "distributed processing" involves a number of key decisions. These decisions address the dispersion of responsibility, hardware, and software across various operational units. This paper comments on the relationship between organizational decisions and systems structures.

## PLACEMENT OF APPLICATION DEVELOPMENT SKILLS

The development of computer applications requires the skills to recognize an application opportunity, to conceptualize a solution consistent with the characteristics of information processing devices, to develop a computer oriented design, to create programs, to debug and test programs, to maintain and evolve programs in view of evolving business needs.

The life-cycle of application development contains some reasonably well defined points of transition from conception to production. In the most rigorously centralized organizations the perception of an application possibility may lie with the data processing department which then imposes applications upon business units or staffs. However, it is at least equally usual for a business unit or staff unit to recognize the potential for the "computerization" of some procedure and approach the data processing department with a proposal. This proposal is then subjected to a benefits/cost analysis which may result in its being undertaken as a project. The role of the business unit at this point becomes the role of a purchaser of professional services from the data processing department.

The vesting of design and implementation skills in a data processing department is justified for a number of reasons. Important among them are:

1. The professional management expertise of the data processing department that gives it the methodologies to exert controls on the development process.

2. The economies of scale that may accrue from an ability to manage populations of expensive professional people more flexibly and to share certain general systems skills which may be needed to develop an application of any complexity.

3. The ability to provide career paths, co-ordinate education, and maintain technological competence.

4. The ability to coordinate applications proposals in order to reduce redundancy or insure proper communication between applications which may be related.

There are alternate views of the degree to which these benefits may be obtained in various situations in various business environments.

The movement of skills from the data processing department to business units may or may not constitute an extreme form of decentralization and it may or may not be complete. It is possible, for example, to put systems justification and design skills into a business unit while maintaining the approval rights and the implementation skills in the data processing department. There are various levels of assistance or enforcement rights which may remain residual within a data processing department even when the skills of a business unit to recognize applications is enhanced.

The actual "exportation" of professional computer talent in the form of applications programmers is an important step that will have major impact on the data-processing styles of an enterprise. It provides a business unit with an independent resource which it can use to generate needs for computational power. It is a key decision in data processing. The decision may be made independently, as we will see, from decisions about the physical placement of computing devices or decisions about the extent to which identified sets of hardware units are dedicated to a particular business unit's applications.

The application development talent which we address here is beyond the level of personal computing or the

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use of canned application packages. The image is one of professional programmers who are employed by a business unit and who are primarily concerned with the development and maintenance of computer applications software. A closely related skill, naturally, is the evaluation and selection of available applications packages for use by the business unit.

This export is an important decision for at least three reasons. It implies new management and organizational responsibilities for the business unit, it implies possible new structures within which business units can coordinate and cooperate with each other, and it lays the basis for some hard questions about the relationship between applications development and systems planning. These questions are often difficult to answer because there is commonly a fuzzy intersection between systems development and applications development efforts.

Before determining to vest professional programming talent in a business unit the following questions must be considered:

1. Is the set of applications associated with business units clearly partitionable so that analysts and designers associated with an applications area can be assigned in such a way that their current skills are directly applicable?

2. Is there a corresponding specialization within the programmers and, if not, will some benefit in programmer productivity or program quality be achieved by dedicating subsets of programmers to the applications of a particular business unit?

3. How much additional structure must be built within the business unit to provide the management skills associated with successful programming projects? How much incremental expenditure may be necessary to replicate necessary management skills in each business unit?

4. Is there some specialized systems environment associated with the applications of the business unit? Will the business unit then find it necessary to take over some systems software responsbilities as well? Will the applications developers coming on board have these skills?

5. Should the business unit undertake to act as a kind of mini-data processing department within its own structure, providing a relationship between "end users" much like the relationship between the business unit and the data processing department, or should the programmers be integrated with end users on a project basis? To what extent will the relationship between end users and programming staffs truly be made easier?

6. Can the business unit offer career paths to its computer people? Would there be a clear line of advancement within the department, or a clear line of advancement out of the department into systems management areas which may be residual in the data processing department?

7. Is the decision to export programmers really being made on its own merits or is the decision entangled in ways that may not be necessary with issues of where machines are placed, how systems are chosen, etc.?

## CONTROL OF DATA

Data may be looked upon as a corporate resource and responsibility for data management planning, database organization, data structure, data security, integrity, accessability, vested in a centralized data management organization. At the other extreme data may be considered an application or a program resource and the definition of new data files, structures, etc., left to application development projects.

In planning for distributed processing a policy about data control must be formulated. Between a pure central control approach and the approach that considers data a convenient adjunct to processing, there are a number of operative points of view.

One approach is to vest control of business unit data with business unit management. Each entreprenurial function of the organization has responsibility and authority to decide what data is to be kept, how data is to be structured, how it is to be protected, etc. Some external standards for integrity, security, recoverability may be imposed by a central data processing standards function, and some requirements for external reporting may be imposed, but the decision about what data to keep and how to keep it is left essentially to the business unit. The concept of corporate wide data management and control is not formed in such a context. The positions of Database Administrator, Database planner, Database designer do not exist at a corporate function level. Attempts to form highly integrated data structures and minimize replication at an enterprise level

are not undertaken. This decision has potentially very wide impact both on application development style and on the relationship between operational units and a data processing staff.

The reasons commonly given to define a corporate wide data management function are:

1. Data is a valuable corporate resource whose definition and integrity, timeliness, quality, accessibility, lies at the center of both tactical and strategic management. It is a unique and valuable resource and must be managed at a level which has an enterprise wide point of view.

2. Software packages which provide appropriate functions of data description, integrity, recoverability are commonly rather complex to use and install. As a consequence advanced systems skills are required to achieve the benefits of such software and these skills are appropriately placed in a professional staff.

3. The use of such software packages is desirable not only from a data control point of view but because of their potential impact on program preparation productivity. Advancing technology in program preparation methodologies holds out the promise that program preparation effort can be reduced by the use of data management facilities associated with highly structured program development language interfaces.

The decision to vest data control with business units need not be total. As with application development skills, partitionings of responsibility and authority may be undertaken. Classes of data may be defined which may or may not need enterprise wide control, and levels of authority over data may be defined.

In determining what policy should be formed for data control the following factors must be considered:

1. Does the distribution of authority over data suggest a change in the software systems which are used to provide data residence and access?

2. Does the distribution of authority suggest a fundamental change in the hardware structure of systems which will be used to house the data? A physical model of centralized control data with some amount of distribution of processing involves dependent applications processors communicating with a data utility. A dispersed data control physical model involves cooperating peer processors with local data and mechanisms for data shipment from one to another.

3. Are there facilities for enhanced program development in the context of systems whose use would be implied by the decision to disperse data control?

4. Is there an implication that the physical placement of hardware systems will change as a result of the decision? Does control over data imply where the data is physically placed, or whether specific machine systems will be dedicated to the business unit data?

5. What is the nature of additional data management skill which will be necessary to achieve standards of integrity, etc., by employees of the business unit?

6. To what extent may patterns of business unit cross-referencing emerge so that there is important data referencing across functional business units? If this develops who is responsible for developing such a capability, who is responsible for controlling it? Does the data-processing department undertake to implement and support cross-referencing capability or can each functional unit develop systems which can refer to the data of other units?

The above list of factors suggests that the data control decision is closely related to systems structure design, application autonomy, and physical location of equipment. This is an area where special effort is necessary to discover the implications of various approaches to data control.

## PHYSICAL PLACEMENT OF EQUIPMENT

Evolution in data-processing may involve the interconnection of computer systems which are already in place. In such situations a determination about where to physically locate equipment is not necessary. It is possible, however, that because of changes in organization, business style, and technology, a decision about where to locate equipment must be made. It is important to realize that this decision is a separate and distinct decision. It must not be confused with the decisions regarding the degrees of dedication of specific systems with specific departments or applications.

Frequently the idea of distribution is closely associated with the presence of computer equipment physically within a business unit. It is not necessarily true, however, that this dispersion of equipment is

necessary in order to achieve the benefits that application or workload partitioning will bring. An interesting exercise, well worth undertaking, is for business unit management to gather in a meeting with data-processing management in order to discuss what benefits might accrue with various forms of distribution of function and equipment.

A list of what is expected from dedicating equipment to business units may be formed. This list will contain such items as increased availability, increased stability of performance, increased flexibility, faster response time, etc. The next step is to determine exactly what kind of difference in benefits will occur if the computer equipment is not located with the functional unit but is retained in a data center. Often it will become obvious that the equipment should be placed in the business unit. Sometimes it will be recognized that the benefits which are sought may be achieved by paritioning and dedication without a physical dispersion of equipment.

A next phase is for data-processing personnel to explain in some detail what is involved in the "ownership" of computing equipment of various kinds. The need for professional staffs with various skills, etc. and the nature of systems management may discourage some whose desire for equipment is only a surrogate for a desire for more responsive service from a data center.

The factors which should be considered in determining whether and to what degree computing equipment should be physically dispersed are:

1. Which of the benefits of dedication of equipment require that the equipment be physcially placed in the business unit? Stability of performance, local programmability, no systems sharing may be accomplished without physical dispersal of the system. Non-dependence on communications equipment and absolute physical security require local siting.

2. How much equipment should be placed in the local facility? Is enough equipment to support some failsoft status sufficient or need the entire applications area operate in the local facility?

3. Are there operational costs which will be different in important ways depending on the physical location of the equipment? Will systems programming or operational costs go up or down? Will local professional staff be needed or will certain aspects of systems control be retained in the data center even if

the equipment is dispersed?

4. Are communications costs going to be a serious factor indicating where equipment should be actually physically placed?

5. Will back-up systems cost and design effort be greater or less if the equipment is dispersed?

## ORGANIZATIONAL LEVEL OF DISPERSION

An important decision is to what depth in the organization computing equipment and associated function may be dispersed. Within a functional area there may be some number of organizational levels and each may have a reasonable separable set of applications. At what level in the organizational chart should equipment be dispersed, what will be the equipment/application ratios, at how many discrete sites should equipment be placed?

In considering what levels of functional management constitute an appropriate level of dispersion, the following things should be considered:

1. What is the level at which the organization is prepared to take responsbility for enforcing standards in data control, programming project control, operational control?

2. To what extent is there intensive and continuing interaction between organizational structures within the same functional grouping.

3. To what extent does systems design, communications design, applications design become more complex as a function of more granular partitioning?

4. To what extent has management at lower levels expressed an interest in having dedicated and/or locally sited equipment?

5. At what level of structure is the organization stable so that dispersion of hardware will not reduce the flexibility of subsequent re-organization.

## DETERMINATION OF SYSTEMS EDGES

This is an issue that must be carefully worked out between data-processing professionals and functional units who are acquiring a voice in the direction of applications development, systems development and communications design.

The decision to disperse applications programming, for

example, must necessarily involve some questions about what the intersection is between applications development and systems development. Does the capability of developing an application involve the capability to choose what operating system or data manager the application will use? Does local control of data formatting and design imply the right to choose what data manager system will be used to support the data?

In different systems software environments the functional edges between applications programs and systems programs differs widely. Some systems provide functions that must be programmed into the application when other systems are used. A clear understanding of who is responsible for determining systems environments must be achieved before distribution decisions can be put into place.

Similarly, the edges of the network must be defined and discovered. It is good practice for a professional staff to maintain control of a "backbone" network. This backbone network is designed to allow the computer systems of various functional units to interact with each other or with higher level management systems. The design of logical and physcial networks to do this, the establishment of standards and protocols is often considered an important professional activity even when computer power is dispersed. Avoiding the proliferation of applications specific networks, achieving efficient network usage, the flexibility of cross-application access from sets of terminals is seen as a major advantage.

The definition, however, of just what is the "backbone network" is something to which explicit attention must be paid. One approach is to have a centralized staff define the business unit computer to business unit computer network, but leave the definition of subnetworks of terminals or satellite processors which talk to business unit systems to the operational departments. Thus the department A system talks to the department B system across the enterprise network, but terminals talking to A use an isolated network which may be defined by department A.

In considering how much global responsibility the backbone network staff should have, the following factors are important:

1. How much cross system access is expected from any particular terminal? Now? Within Five Years?

2. How much terminal specialization is involved in supporting particular applications? Will the nature of the terminals suggest interest in communicating only with one system or will general purpose terminals which may grow in functional use be more common?

3. To what extent will back-up and failsoft situations involve the use of the backbone network ?

4. How stable is the functional organization which is used as the basis for distribution? Will it tend to change so that access to systems not currently needed become a requirement?

5. Is there a real possibility that more and more local function will be placed in local units as the intelligence of local units increase? Will this tend to change the systems access patterns of local units?

6. To what extent does technology suggest that distinctions between large capacity, long haul, or low capacity short haul (or various combinations of speed, capacity and distance) will fade in the future and a single technology will be chosen for all unit to unit interaction?

## CONCLUSION

We have proposed that the decisions to disperse programming power, data control and physical equipment are key issues in distributed processing. Some organizational decisions have little impact on systems structure. Some, like the decision about data control, seem to imply a great deal about how the computing systems of an enterprise will be shaped.

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