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The Evolution of Information Systems Architecture

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ABSTRACT

Information systems architecture is an emerging discipline directed towards the planning and control of information systems resources throughout an organization. It is seen as a vehicle for assisting managers in the task of dealing with the need for integration in a complex technological environment, and coming to grips with issues concerning the role of information systems in supporting the organization's business needs.

One of the most important applications of architecture for some companies may well be in the area of competitive strategy. Architecture can provide the vision and structure that will enable a company to utilize its information systems resources to gain strategic advantage over its competitors.

Thirteen companies facing architectural problems were organized in a consortium to exchange ideas on common issues and to work on developing architectural frameworks, guidelines and methodologies. This article presents the results of an exploratory research study which examined the state of architectural activities at each of these companies.

Introduction

The job of managing information system (IS) resources is becoming increasingly complex. There are marked differences in the IS environment of the 1980's in comparison to the 1970's. In the 1970's, the IS environment was technology-focused with an emphasis on centralized data processing (DP) organizations running traditional administrative systems on large mainframes. Although technologies such as database management systems (DBMS), and decision support systems (DSS) were being introduced, they were immature and less well understood than the standard DP technology. As we enter the mid 1980's, the widespread growth in end user computing, and the maturity and proliferation of diverse application technologies such as computer assisted design and manufacturing (CAD/CAM), robotics, office automation, and fourth generation languages, requires a new approach to the planning and control of IS resources. Some of the major forces driving this new approach are listed below.

DIVERSE TECHNOLOGIES

The decreasing cost and increasing power of microprocessors has fueled a proliferation of specialized and diverse technologies. It is not uncommon to find overlapping, but incompatible applications in different organizational groups of the same company. A typical example was found in a large, decentralized company where ten business units had started to develop a customer support application on a personal computer in ten different ways. As a result of an architectural effort, a common approach and technology was agreed upon.

DECENTRALIZATION

The trend in large companies towards decentralizing IS resources has caused a dispersal of technically competent personnel. The result is that some business units do not have a critical mass of such people. Systems analysts have become a critical resource that needs to be leveraged.

END USERS

The broad base of non-traditional users who lack formal training in application design and development are placing different demands on IS resources and IS management. As one IS planning manager commented wryly:

> "The biggest disadvantage of fourth generation languages is that user expectations far exceed the languages capabilities."

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COMPETITIVE STRATEGY

An important development in some industries has been the recognition that the computer itself can provide a competitive advantage in the market place. For example, Merrill Lynch, in introducing its cash management account (CMA) providing customers with integrated financial services, gained so much market share that competitors were forced to produce similar products in order to regain clients. Another example is provided by Deere and Co.'s investment in a flexible manufacturing system (FMS) that allowed it to reduce inventories by as much as 50% and to build a variety of heavy equipment products on its flexible automated lines. As a consequence, it can consider much broader and more aggressive business strategies than its competitors. As these examples illustrate, a company that hesitates in using computer-based technology may find itself pre-empted by a competitor and forced to invest in the technology just to stay in business.

SHARING OF DATA

New business opportunities often require the integration of data which are fragmented across multiple systems, departments and geographic areas. As an IS manager commented:

> "There is an enormous unarticulated demand for applications and systems development. But many systems are a mishmash of data and applications."

PRODUCTIVITY DRIVE

In contrast to the fast moving financial industry, the petroleum industry is facing a shrinking market and shrinking margins. Here the computer is seen as a means for reducing cost and improving productivity.

In response to many of these pressures, some companies have started to examine and formulate an information systems architecture. They are developing an overall design or plan that provides direction and guidance for the future deployment and management of all IS resources throughout their company. As noted by a corporate IS planner:

> "Architecture started as a means of bringing together internal and external DP groups, of merging data processing, office automation and telecommunications. I regard it as an agreement of where we're going."

A manager of application developments commented:

> "From my perspective, there was no relationship between the database systems and application systems being developed. I needed a tactical architectural plan to understand the applications coming down the pike."

These companies found an architectural effort helpful in meeting their needs. Since there are many ways of approaching these issues, a research study was conducted that examined companies architectural activities in order to gain some guidance as to common architectural problems and possible solutions.

The Research Study

In April of 1983, a consortium of thirteen companies was formed to address common architectural issues.* Each company nominated one individual with major responsibilities for architectural activities as its primary representative to the group. Over a period of one year, the group members met on a bimonthly basis in 2-day sessions where information on common problems and experiences was exchanged, and architectural frameworks and methodologies were examined. At each of these meetings, a second individual, usually a specialist in some technical or planning area associated with architecture, accompanied each primary member.

The author conducted one-day site visits at the participating companies and gathered information on the current state of the practice of information systems architecture. Data were collected through a series of structured interviews with the primary architect and other individuals involved in architectural activities. Eight of the interview sessions were conducted on-site, and two were conducted at the bimonthly meetings. The remaining three were conducted through extensive telephone discussions supplemented with information available at Nolan, Norton & Company. After each interview session a summary of the interview data was sent to the primary architect who checked it for correctness. Correlations between selected variables from the interviews were computed.

Architecture Definitions

At the beginning of the study there was some disagreement as to the difference between an architecture, a design, a plan or a strategy. A search of the professional and trade literature produced several uses of the term but none appropriate to information systems architecture. The term "architecture" is clearly attractive because of its association with structure and integration.

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*The consortium was organized and managed by Nolan, Norton & Company, Lexington, Massachusetts.

As a means of providing input to the definition process, a chronological list of uses of the work in IS-related areas was compiled. The starting point was the original use of the term in building design and construction:

> Architecture: The special method or "style" in accordance with which the details of the structure and ornamentation of a building are arranged."
> —Oxford English Dictionary

As we track architecture through the computer field, we see a consistent use of the word to describe how a computer system is constructed and how its components inter-relate. For example, a hardware engineer's definition is:

> Computer Architecture: "The organization and interconection of components of computer systems" (Stone, 1975).

The next step is to combine several components, each component possessing its own architecture, and then to define an overall architecture of the resulting system. An example in the computer science field is the combination of hardware and software with the resulting computer systems architecture:

> Computer Systems Architecture: "The design of an integrated hardware and software system as seen by the programmer" (Baer, 1980).

Following a similar procedure in the information systems area, we can identify individual components such as data resource management and communications that have already embarked on activities that are architectural in nature. For example, in the communications field, network architectures have been defined for some time. Because of the specialized requirements of this architectural work, the function responsible for designing and implementing network architectures is usually separate and distinct from, say, the database design function of the systems development function. Consequently architecture-like activities have usually been fragmented in different technical groups and there is often little integration between these activities.

The final step is to define a broad-based overall information systems architecture which combines all of the IS components, and defines the relationships between these component and between the components and the business environment. Note that this process of defining an information systems architecture is bottom-up in nature. An alternative top-down process will be described later.

THE COMPANIES DEFINITION OF ARCHITECTURE

In the thirteen companies being studied there were many different activities being undertaken under the name "architecture". However, two broad viewpoints were identified:

- Technology-driven definitions
- Business-driven definitions

A selection of the companies architecture definitions illustrating these two viewpoints is presented in Table 1.

The first type of architectural definition placed emphasis on producing guidelines and standards for the selection and use of hardware and software technologies. For example, an architect defined a systems architecture as: "What operating systems should be running on what hardware." This architect commented:

> "Having grown up through technology, I look at architecture from a low level. How do we put together a computer system in a heirarchy with standardization, application planning, connectivity, and data direction?"

Another architect in this same category was building credibility in her new function by demonstrating cost savings through an improved technology strategy. She noted:

> "Architecture can provide guidelines and standards to avoid problems caused by mis-use of technology."

The second type of architectural definition articulated a framework which linked the architecture to the company's business requirements. This framework was then used to drive the architectural planning process. There was less concern about technology per se and more concern about business accountability. A corporate staff member of a financial institution established the following principle:

> "The primary purpose of a systems architecture is to provide business managers effective control over their future employment of technology to achieve strategic business objectives."

The technology-driven architects were approaching architecture in a tactical and bottom-up manner, by addressing technological issues first and then driving towards the business direction. By contrast, the business-driven architects were approaching architecture in a more strategic and top-down manner, by first ascertaining the business needs and then driving down to the technology level.

Table 1

A Selection of Architecture Definitions

Technology Driven

The distribution of hardware, software and processing responsibilities, and the management of data

The strategic technological decisions that should be taken today in light of where we see ourselves in 1990, and the interrelationships of these decisions.

The blueprints of where the company would like to be in regard to technology 3-4 years from now.

Business Driven

A representation of the business that allows the orderly integration of applications, data and communications for the development of stable information systems.

A framework for orchestrating effective integration of a set of systems applications, data resources, systems environments and communications facilities to achieve the business objectives of the corporation.

An overall process for managing information resource (IR) assets which provides for an ongoing assessment of the IR environment, the vision or direction for supporting business requirements, and the development of appropriate linkages between all architectural components.

The Companies

Because the need for architectural planning is most evident when the IS environment reaches a high degree of complexity, the types and sizes of companies joining the architecture group were quite varied. They were drawn from both the industrial and service sectors, see Tables 2 and 3.

The companies studied were very large, with the smallest spending about $5 million per year on DP/IS. However, there was considerable variation in the size of the companies' annual DP/IS expenditures, as illustrated in Table 4. The expenditure figures include software development, maintenance and enhancement, operations, data communications and technology depreciation. One or two companies were unable to separate out their expenditures in areas such as voice communications and office automation, however the ranges are representative of the scale of expenditures.

All of the companies studied are of the Fortune 200 size with annual 1982 revenues exceeding $1.5 billion or assets exceeding $9 billion. Therefore, the conclusions resulting from the study are primarily relevant to large companies.

IS Organization

Since architecture is concerned with all IS resources in a company, a reorganization affecting the IS function is likely to affect the architectural activities too. As the

Table 2

Industrial Classification of the Companies

Industry	# Companies
Petroleum	4
Bank	2
Retailer	2
Aerospace	1
Conglomerate	1
Diversified Financial	1
Petro-Chemical Manufacturer	1
Utility	1

Table 3

Size of the Companies in 1982

Industrial Companies Revenue Range	#	Financial Companies Assets Range	#
$1 billion-$5 billion	5	$5 billion-$10 billion	1
over $5 billion	5	over $30 billion	2

following narrative shows, the companies studied exhibited a striking volatility in their IS environments.

There were seven enterprise-wide reorganizations and nine internal IS reorganizations within the group between 1979 and 1983; all thirteen companies were affected. There was no pattern to the types of reorganizations other than their frequency. As a corporate IS staff member described:

> "There were regroupings as a consequence of mergers then regroupings as a consequence of the decentralization. We can't keep track of what's in the organization. The geographic locations keep shifting, the situation is changing continually."

Three companies had experienced recent changes in top management. The ensuing effect on the IS organization was different in each company:

> "A new CEO came in. The DP people are struggling because they don't know where the company is going."

> "The new CEO is pro-IS, although not an avid fan. He was the driving force behind the executive information system."

> "The new chairman has a strong commitment to team play. He told the department heads that systems were their responsibility."

The internal IS reorganizations were also quite varied in nature. Several companies centralized control over some IS activities, typically by making common systems development and telecommunications a central responsibility. In contrast, other companies decentralized applications development and distributed DP personnel to user groups.

Another type of internal IS reorganization was the establishment of a new IS group whose charter included architecture. In some instances this action was precipitated by an enterprise-wide reorganization; in other cases in impetus came from a systems or planning group that perceived a need for a broader perspective on IS planning.

As these descriptions illustrate, the architects have a difficult and demanding job. They have to produce architectures that will survive a changing and dynamic environment.

Companies' Maturity in DP/IS

It has already been noted that the need for an architectural effort becomes apparent when the degree of IS complexity is high. In order to determine whether a company's level of sophistication in the DP/IS area correlated with other architectural variables, each company's level of maturity in this area was estimated using Nolan's "Stages of Growth" hypotheses (Gibson and Nolan, 1974; Nolan, 1979).

In the early 1970's, Gibson and Nolan hypothesized that an organization progresses through four different stages of learning in assimilating traditional DP technology, and that these stages could be represented by the familiar S-shaped curve, see Figure 1. By the late 1970's, Nolan had increased the number of stages to six and had proposed that there was a discontinuity in the S-curve,

Table 4

DP/IS Expenditures in 1982

DP/IS Expenditures Range	# Companies
$ 5 million-$ 50 million	4
$50 million-$150 million	6
over $150 million	3

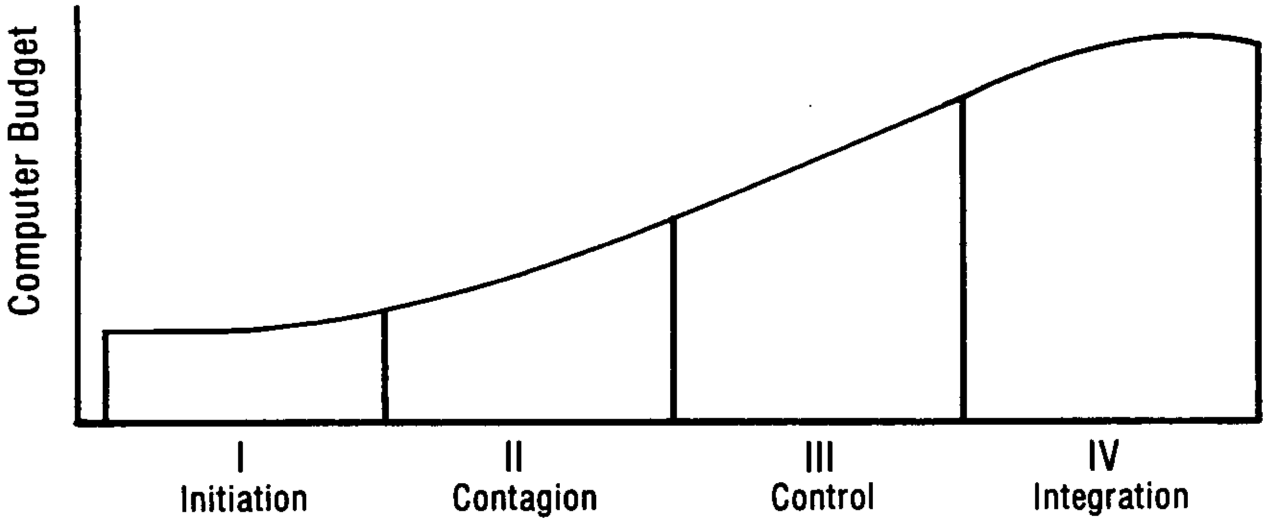

Figure 1. Four Stages of DP Growth[3]

in Stage III, reflecting a shift in management orientation from the management of computers to the management of data resources and new technologies.

In studies concerning the displacement in the market-place of one product by another of superior technology, the same S-curve is produced when the market share of the new product is plotted against time (Mansfield, 1968). Girifalco (1982) showed that there is a sharp break or discontinuity between the old technology's S-curve and the new technology's S-curve, and that the major problem for a company or industry lies in learning how to cross these discontinuities (see Figure 2).

Consider the IS situation in the 1980's where there are multiple computer-based technologies being assimilated

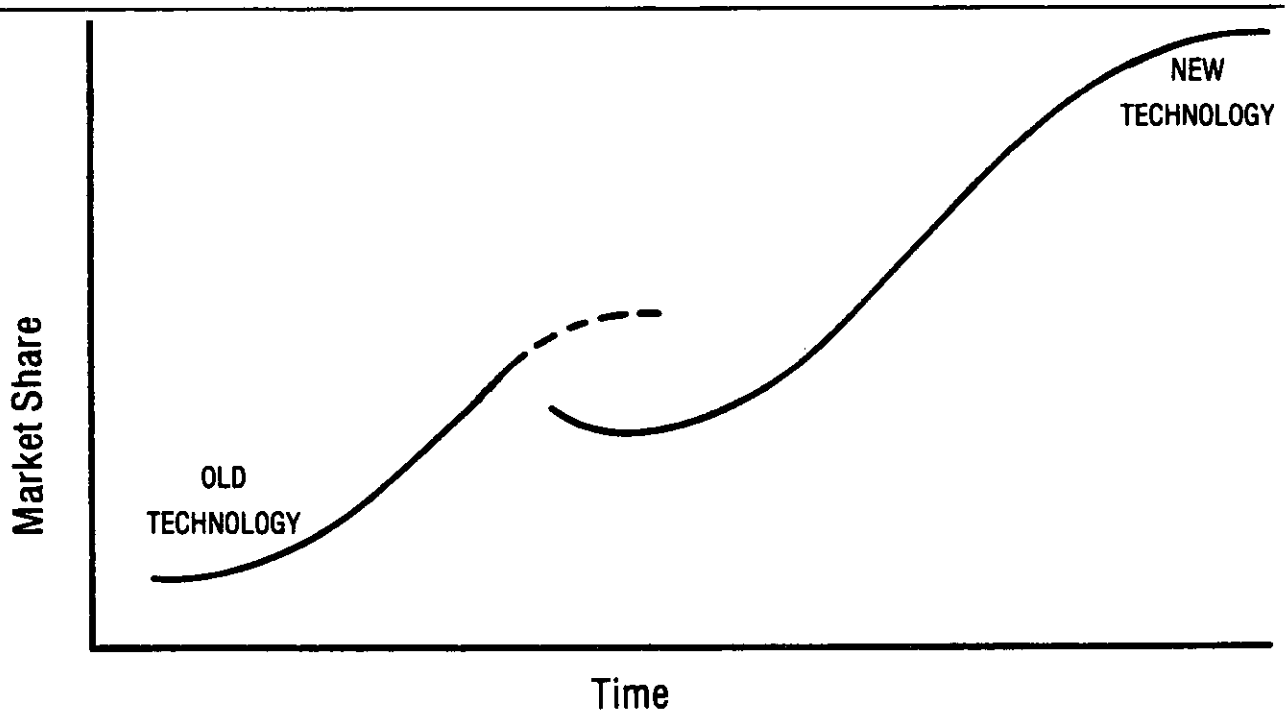

Figure 2. Discontinuity in the Technology S – Curve[4]

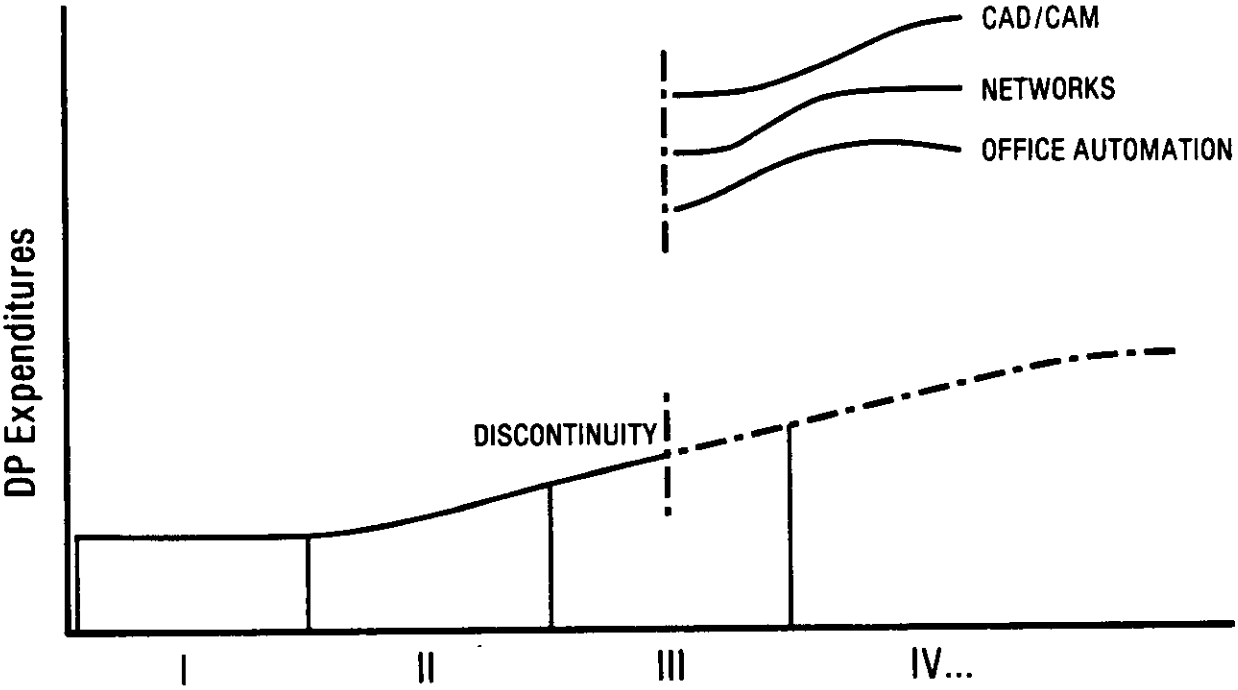

Figure 3. Advanced Stages of Growth

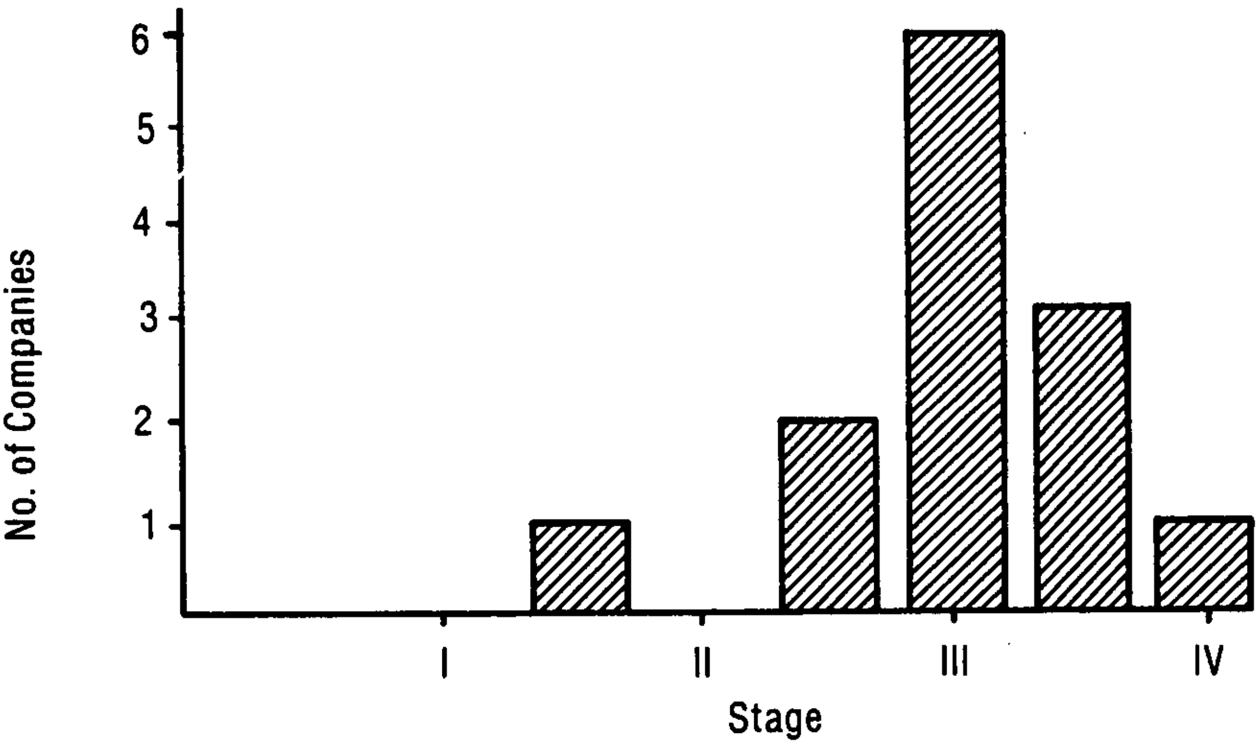

Figure 4. Companies' Stages of DP/IS Growth

by organizations. The stages hypothesis can be extended once more to reflect the discontinuities between traditional DP mainframe technology and the many new microprocessor-based technologies. Thus Figure 3 more truly represents the current situation.

Returning to the architecture study, the most commonly stated reason for starting architectural activities was the necessity for dealing with the proliferation of diverse technologies. Thus one would expect the companies studied to be around stage III, where the discontinuity appears. This was the case, as is demonstrated by Figure 4 which shows most of the companies clustering around stage III.

Architectural Model

Since information systems architecture is a new and emerging discipline, a general model is desirable to provide a structure within which issues and experiences can be compared and categorized. Because of the varying interpretations of the term architecture, there are many different models that can be used. However, for the purpose of the study the companies agreed on a separation of information systems architecture into four subarchitectures:

- Data Architecture: Addresses the classification and organization of internal and external data resources employed by the company.
- Application Architecture: Addresses the structure and relationships of current and future applications both vertically and horizontally in the company.
- Communications Architecture: Deals with the flows of data within an organization, and between the organization and the outside world.
- Technology Architecture: Addresses the structure and relationship of the hardware devices and systems software forming the technological infrastructure.

To illustrate how the architectural effort is used, consider the more traditional use of the term in designing buildings:

The first two phases of the building architect's responsibilities prior to construction are the schematic design phase, and the design development phase (AIA, 1972). In the schematic design phase, the architect first confers with the owner, analyzes the requirements, and prepares a schematic design illustrating the scale and relationship of the project components. This design is conceptual in

	Data	Applications	Communications	Technology
Conceptual				
Logical				
Design Guidelines & Boundaries				

Figure 5. Subarchitectural Model

character. Upon approval of this, he or she then proceeds to the second phase which includes the preparation of detailed drawings and other data relating to the building appearance, structure, mechanical and electrical systems, construction material and finishes. Of course, in both of these phases the architectural design must conform to any standards such as building codes or zoning ordinances.

Relating this process to the information systems area, three "levels" of architecture were established:

- Conceptual level: Presents a conceptual picture of the architecture showing its links to the company's business environment.
- Logical level: Defines the data, applications, communications, and technology subcomponents and their inter-relationships.
- Design guidelines and boundaries level: Specifies the standards to which the architecture implementation must adhere.

The model is illustrated in Figure 5. Note that following the building architect analogy results in a top-down process for defining an information systems architecture. In many situations this is the preferred direction.

Findings

THE ARCHITECTS

An indication of the immaturity of information systems architecture in the companies was illustrated by the fact that only two individuals' titles referred to architecture. There was a group manager of information systems architecture and a manager of architectural planning. Most of the other individuals carried a job title similar to manager of IS planning or manager of information services while performing architectural activities. All of these individuals will be referred to as architects. Eleven of the architects were either one or two levels below senior IS management, one was the highest ranking computer executive in his company, and one was three levels below the senior IS manager.

Architectural activities were all a part time effort in the sample of companies studies The amount of time spent by the architects on architectural responsibilities ranged from 5% to 75% with a mean of 21%. The most common organizational unit hosting the architect was an IS planning group where the architect's primary responsibilities included other activities such as applications planning, capacity planning, and database planning. Several architects provided support in applications development,

Table 5

A Selection of Mission and Goals of the Architecture Functions

Tangible End-Product

To create a set of solution for IS development so that decentralized product development will look as though it came from a central group.

To make better decisions on acquisitions of new technology and to improve the management of technological resources.

To exploit technology so as to provide the company with advanced information services at least cost.

To ensure that the tools, methodologies, and organizational structures are in place.

To develop an architectural model and sell it to the executives of the sytems groups.

Learning About and Developing Leadership in Architecture

To learn about architecture and to decide how and when it will be applicable to the company.

To develop leadership in architecture.

To understand architecture.

office automation, and telecommunications. An architect in a corporate data resource management group was involved in data resource planning studies, getting the data dictionary in place, and evaluating fourth generation languages.

In examining the styles that the architects adopted in their architectural role, they placed an emphasis on being a leader and facilitator. In many of the companies this was necessitated by the autonomy of the operating units or the internal culture which mandated management by consensus rather than by edict. Because of the newness of the architectural functions, many of the architects had started with the facilitator role and were working on establishing credibility for the leadership role.

MISSION AND GOALS

Despite the immaturity of the architecture function in many of the companies studied, all of the architects except one had formal mission and goals. Because of the variety of activities being undertaken under the designation architecture, the mission and goals statements ranged quite widely. However the statements fell into two broad categories of activities or tasks:

- Activities that would lead to a tangible end result.
- The task of learning about, and developing leadership in architecture.

Table 5 presents a selection of the companies mission and goals statements illustrating these two viewpoints.

It would seem intuitively plausible that companies experienced in dealing with a variety of computer technologies would be likely to have the necessary sophistication to direct their architectural efforts at clearly defined, tangible end results. Using the stage of DP/IS growth to measure a company's degree of assimilation of these technologies, it was found that a higher stage did correlate with a company's having tangible mission and goals (Pearson correlation coefficient of 0.55, $p = 0.05$).

The individual who indicated that his architectural function was too new to be able to define a mission and goals statement, was a technology-driven architect in a stage I-II company. His company was anticipating large future expenditures on technology, and architecture was viewed as a means of validating the company's current technology and applications planning.

Data from the thirteen companies demonstrated a direct relationship between the architects having tangible mission and goals and the companies being decentralized (Pearson correlation coefficient of 0.64, $p = 0.02$). This can probably be attributed to architects in decentralized companies experiencing a greater sense of urgency to produce something valuable quickly. The corporate architects in these companies had to establish credibility with the operating units, not merely with a central organization.

Architectural Activities

While it is true that separate and fragmented architectural activities had been carried out previously, most of the companies studied had started architectural activities since 1982. One company's "architect" maintained that he had not yet started architectural work as an organized activity since he was doing the same things then as he had for many years. This individual had joined the group in order to learn about architecture and to determine when and how it would be applicable to his company. However, his company was expecting only incremental change it its business and was in sharp contrast to many of the other companies.

Two companies had started work in data architecture in the mid 1970's and had both embarked on large business modeling projects. The first company's data resource management group had succumbed to a hard sell by a vendor and had embraced that particular methodology over a period of about six years. The group was unable to produce the expected database implementations, which resulted in a backlash within the company against architectural planning. The second company had also developed business models over a period of five to six years but had used a variety of methodologies. It too fell into the trap of attempting multiple large projects without reaching a successful production stage. Both companies have now scaled down their projects in this area and are starting to experience some successes.

A third and very decentralized company had started a technology architectural effort in the late 1970's, primarily at the design guidelines and boundaries level. At this company independent plant sites traditionally had managed their own computing systems facilities. Although they used the same vendor, many sites did not upgrade the operating systems or take advantage of new programming tools. The initial thrust of the architectural effort was the standardization of systems software and the identification of common applications in order to leverage the scarce resource of systems analysts.

Another company with some longevity in architectural activities had developed an application architecture for a customer support system in 1980. The architecture addressed issues such as centralization versus decentralization, subject databases* versus application databases. A couple of years after this effort, the company reorganized IS and established a formal architecture group responsible for designing, building, and supporting a network architecture for internal use. To achieve this goal, the group first defined a short-term "transition" architecture concerned with a backbone network, then an intermediate architecture directed towards data integration, and finally a fully distributed architecture. By the end of the research study, the transition architecture had been successfully implemented.

Given the newness of the function, it was not surprising to find the group's progress at a very preliminary stage. Referring to the 12-cell model of Figure 5, the architects reported which cells were covered by architectural activities in their companies. In many cases these activities were fragmented and distributed throughout the company so Figure 6, which illustrates which subarchitectures and levels had been addressed, does not indicate the depth or extent of these activities.

Taking the group as a whole, less attention was reported at the conceptual level of all four subarchitectures than at the logical level, and design guidelines and boundaries level. The reporting of conceptual-level activities correlated with companies having decentralized control over data or applications activities (Pearson correlation coefficient of 0.60, $p = 0.03$). All the companies had distributed IS resources to some extent. Telecommunications resources were usually centrally controlled but data and applications were handled in a variety of ways. All of the decentralized companies that had distributed control over either data or applications, reported starting work at the coceptual level in at least one subarchitectural area.

The reporting of conceptual-level activities also correlated with the size of the company (Pearson correlation coefficient of 0.55, $p = 0.05$); all the companies with annual sales exceeding $3 billion reported starting work at this level. (For the financial institutions, an equivalent sales figure was calculated by determining the amount of sales necessary to produce the institution's annual net income. The Fortune 500 median return on sales for 1982 was used in this calculation.)

Since most architects indicated that the links between architecture and business planning were either nonexistent or weak at best, the claims to conceptual level architectural activities need to be regarded with caution. It is likely that these activities were closer to the logical level and with a tactical flavor.

*Subject databases, sometimes called data classes, relate to organizational subjects rather than to conventional computer applications (Martin, 1982).

	Data	Applications	Communications	Technology
Conceptual	7	9	6	6
Logical	10	10	9	9
Design Guidelines & Boundaries	10	11	11	10

Figure 6. The Total Number of Companies who Reported Having Done Work in the Various Cells (maximum of 12 companies per cell)

STANDARDS

The orchestration of technical standards was one of t first activities undertaken by several of the architects typical scenario was for the architect to obtain a conse.. sus on standards and then to set policies and enforce them. Companies often chose to enforce standards by indirect means. In several cases only the standardized technologies were supported by the IS organization and errant users choosing non-standard technology were on their own. One company required all requests for non-standard systems to be accompanied by a justification of the additional cost necessary for migrating to the standard at a later time if the original request turned out to be a mistake. Some examples in the four subarchitectural areas of data, applications, communications and technology follow.

Data: The thrust in the data area was away from application databases and towards subject databases. Several of the data architects were involved in evaluating and promoting various business modeling methodologies, but there did not seem to be sufficient maturity in this field to be able to talk about standards.

In contrast, in the database management sytems arena about half of the companies had standardized to one specific vendor's product, with the remaining companies using a variety of vendors and systems.

Applications: A strong driving force behind many architectural efforts was the need to improve productivity in applications development. Some architects were preparing guidelines for the use of prototyping and fourth generation languages. They were also examining the architectural issues concerning the purchase of commercial packages. As one architect described:

> "There is a large movement towards packages. They can provide an infinite productivity ratio if the users are willing to compromise to the facilities of the package."

Communications: There was less diversity of technologies in this area than in other areas, primarily because of AT&T's setting of industry standards. But a consequence of this historical vendor dominance was a scarcity of technical expertise in-house to handle the current deregulated environment.

Several architectural efforts were directed towards the design and installation of a high-capacity backbone network. One architect described the situation in her company as follows:

> "We have a spider web of leased lines. We're getting rid of the applications-oriented networks and getting in a few pipes that everyone will share."

Another problem that had been addressed by most of the architects was whether to support one or several logical network architectures. All but one of the companies studied supported SNA, but four also supported X.25, and one also supported DECNET.

Technology: In the mainframe area for all the companies studied, business computing was standardized to a specific vendor's machines (or compatible machines). However, for scientific or engineering computing the companies had a variety of vendor standards. In the minicomputer arena there was no dominant vendor standard and several companies standards specified more than one acceptable vendor.

There was a variety of approaches to managing the influx of personal computers (PC). At one end of the spectrum was the company with a single vendor standard that enforced a strict acquisition policy requiring the signature of one of several vice presidents before a PC could be purchased. At the other end of the spectrum was the company with a three vendor standard that sponsored PC seminars, had requested approval for a retail PC store, and was studying the feasibility of arranging vendor discounts for its employees personal PC purchases.

ARCHITECTURAL PRIORITIES

In rank ordering the four subarchitectures of data, applications, communications and technology in terms of priority, three quarters of the group chose communications architecture as one of their top two priorities, and about half chose either data architecture or applications architecture as the other high priority. The near-term architectural goals in these areas covered a broad set of issues.

Communications: A common theme echoed by many of the architects was the need to integrate communications facilities and make them more cost effective. One communications architect had faced a company situation of over twenty specialized data networks, none of which could communicate with each other.

Some companies were perceiving connectivity as a business need, as demonstrated by a financial institution which found that its customers were unwilling to deal with public network problems.

Data: In the data area, the common initial problems occurring in the use of data planning methodologies were described earlier in this section. Data architects who were involved in major projects which had failed now placed a high premium on educating people in architectural planning and obtaining company buy-on for data resource management studies. Other near-term goals were the implementation of subject databases and the selection of a database management system for microcomputers that was compatible with the overall IS technology direction.

Application: The high priority placed on applications architecture by about half of the companies was surprising since a noticeable aspect of the site visits was the apparent lack of urgency in the applications area. Although companies readily produced data architects and telecommunications architects, few produced an applications architect. Perhaps this confidence in the application area can be attributed to the general familiarity with the applications planning process.

Conclusions

Information systems architecture is in an early stage of development in the companies studied. The field of architecture is immature and few tools or methodologies are available. An IS manager commented:

> "We don't seem to have IEEE-like forums or functions in architecture. There is a lack of professionalism in the field."

There was a divergence in viewpoint in defining an architectural focus. Two thirds of the architects saw architecture as a business-driven discipline that would allow the IS organization to support more effectively the company's business needs. Senior management commitment and involvement were key in this case. The remaining architects saw architecture as a means of planning proactively for the assimilation of technology in their company, and improving efficiency and effectiveness. In this case, architecture was driving IS planning towards a more strategic approach.

Although there was no single definition of architecture in the group, the function that architecture was to perform was more clear cut. It was seen as a vehicle for more effective management and planning of diverse technologies and for dealing with integration issues of these technologies. Accompanying the purely technical issues, were human resource issues of how to handle a variety of users ranging from specialized system developers to technically naive end users. A corporate architect described how the increasing emphasis on fully distributed end user computing would change the IS manager's job:

> "In the future, the IS manager will be responsible for the IS architecture infrastructure rather than for computers."

One of the most important applications of architecture for some companies may well be in the area of competitive strategy. There have been several spectacular strategic successes in industries such as the financial services industry and the airline industry, where computer-based products have been used to gain market share. Architecture can provide the vision and structure that will enable a company to utilize its IS resources to position itself for optimal competitive advantage.

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