The practice of architecture is in the midst of significant change and an increasingly uncertain future. Socio-economic factors external to the profession are forcing firms to develop new strategies for delivering design services. Overlaying these external changes is the uncertainty resulting from the inevitable introduction of information technology, which is only beginning to have an impact on the profession. Some advocates see the emergence of a new form of design firm—the computerized design firm—as an intelligent organization structured around electronic work groups with powerful computation and communications tools (Catalano 1990). On the other hand, many practitioners still see CADD as an expensive technology whose primary result leads to an increase in overhead costs. But some PRACTITIONERS and researchers (Coyne, 1991) recognize both the potential and problems that computer-aided design presents to the profession.

This research presents a framework for understanding how changing information technology might be appropriately integrated into the design firm. It argues that design is an increasingly diverse enterprise, and that this diversity must be understood in order to effectively integrate information technology. The study is divided into three sections. The first section develops an overview of major social, economic, and structural changes within the profession. The second section discusses two alternative approaches that have been utilized to integrate information technology into firms. The third part presents a framework for understanding how information technology may have an impact on strategies for structuring and organizing architectural firms.

The methodology used in this study is based primarily upon qualitative research approaches originally introduced by Glaser and Strauss (1967), and is similar to the methodology used by other researchers whose research has studied the impact of computers on society (Turkle 1984 and Zuboff 1988). This research is based on in depth interviews conducted with architects, programmers, and executives in selected architectural and engineering firms. The main criterion for selecting these firms was their use of CAD systems in the design process, especially in the early stages of the design process.

Changing Context of Architectural Practice.

In order to understand how information technology may impact architecture, it is important to understand the larger socio-economic context of the architectural profession. As suggested by Robert Gutman (1989) the profession faces a number of socio-economic changes outlined in Figure 1.

The first change has to do with the increased complexity and competition associated with architecture practice. Buildings have become increasingly complex, projects have become increasingly larger, and recent anti-trust legislation has contributed to an increasingly competitive environment for professional design firms. As a result, the generalized practice is increasingly rare, at least for the larger design firms. Firms are becoming more specialized in order to develop an expertise that is required to deal with their increasingly complex problems.

This move toward specialization has been reinforced by the appearance of a more sophisticated client, who is increasingly demanding specialized expertise to deal with specialized problems. Specialization is having an impact on both the organization of firms as well as the organization
of projects. Cuff (1991) has suggested that the profession is moving towards a "split-team" organizational strategy in response to this changing situation. Thus, for example, the architect for the new science and engineering building at the University of Cincinnati is actually a team of three specialized firms: the design architect, the laboratory architect, and the executive (or production) architect.

These major trends seem to be at odds with the third issue: the culture of the recently graduated design professional. A recent survey of graduate architecture students at the University of Michigan indicated that over 60 percent of the students were interested in a generalist practice. This is in direct opposition to the increase in specialization that is occurring in medium and large size firms.

Overlaying all of these issues is the impact of a key component: information technology, which is the focus of this research. Given different firm strategies, what are the appropriate means by which firms might adopt this new technology? What types of problems might result from an inappropriate adoption of computer-aided design? Is there one "best" strategy for adopting information technology in the design firm? Or should information technology be adapted to the specific needs of different types of firms? In developing an answer to these questions, it is first important to investigate two key issues that should be considered in adapting information technology: automate and informate.

The Automation Strategy for Implementing CAD.

Automation is currently the dominant philosophy that is used in the design, implementation and purchase of CAD systems. Automation has been defined by Zohoff (1988) as the implementation of computer technology in a way that emphasizes standardization, specialization, and centralization. In architectural firms, automation results in the implementation of CAD systems in order to achieve productivity gains by substituting automated procedures for traditional, manual approaches. As an example, it is not unusual for some firms who use the "assembly-line" approach in developing working drawings to replace draftsmen with CAD technicians. These firms may also implement shift-work in their CAD department in order to maximize the use of the relatively expensive CAD technology.

Although automation is currently a popular approach, it also can generate a number of problems (Table 1). Some of these problems are associated with the basic assumptions of the approach, some with the software development process, and others are due to an inadequate integration of CAD technology with the structure, organization, and culture of the firm.
Table 1: Problems with Automation

1. Over emphasis on structured design processes
2. Under emphasis of the social and organizational aspects of design
3. Over emphasis of explicit vs. tacit design knowledge
4. Narrow definition of productivity
5. Marketing and image
6. Under emphasis on the culture of the firm

Over Emphasis on Structured Design Processes.

Most CAD systems developers have ignored unstructured design approaches (approaches that rely on tacit knowledge) at the expense of focusing on the more easily programmable, structured aspects of design. CAD systems tend to be designed around explicit knowledge that can be easily represented as a set of abstract rules, facts, or algorithms (Cross 1977; Ehn 1988). However, this view is generally recognized as inadequate for developing design systems. As one expert suggests, "very few systems can support design development, unless you're doing a very structured design/development process" (CADD Roundtable 1984, 14). Another author indicates that while facts and rules are helpful in the design process, other forms of knowledge such as experience and precedent are also part of designing (Winograd and Flores 1987, 188). A standardized definition of design is assumed: one approach fits all. Instead of integrating the whole process, each system tends to emphasize specialization in a distinct part of the design process. As a result, many CAD systems are designed around a single function, such as drafting, structural analysis, or lighting analysis.

Under Emphasis of the Social and Organizational Aspects of Design.

Most CAD systems emphasize the rational, "systems approach" to design and ignore the reality that, "the built environment is socially produced. It is made by people acting within a larger social context of institutions, public policy, economic structures, political power and a cultural framework" (Cuff 1989, 306). The systems design approach shares the same philosophical assumptions and epistemology found in rationalistic reasoning (Husserl 1970; Winograd and Flores 1987). These assumptions have been the driving force behind specialization in architecture as well as behind the development of CAD systems (Cross 1977; Ehn 1988; Winograd and Flores 1987; Flores-Gomez 1985), and have been used without any critical examination of their role and influence on the design process (Brown 1967). The rational, "Cartesian" approach to systems design has been summarized by Winograd and Flores (1987, 15) as follows:

- Characterize the situation in terms of identifiable objects with well defined properties.
- Find general rules that apply to situations in terms of these objects and properties.
- Apply the rules logically to the situation of concern, drawing conclusions about what should be done.
- Apply the rules logically to the situation of concern, drawing conclusions about what should be done.

Over Emphasis of Explicit Design Knowledge.

A third problem associated with automating CAD systems is the attempt by computer programmers and systems designers to explicate design knowledge in order to develop CAD systems. This problem with design knowledge is that it is "too layered and subtle to be fully explicated... [it] has always been learned through experience (on-the-job-training, apprenticeship, sports practice, and so forth)" (Zuboff 1988, 188). In other words, it relies on implicit knowledge that is obtained largely through education and apprenticeship. Thus, the architect can do certain things without being able to explain how it was done. Polanyi (1966) called this phenomenon tacit knowledge. Tacit knowledge is know-how that cannot verbalized. Another example of tacit knowledge is our ability to recognize a human's face among thousands without being able to clearly explain or even understand how this was done. This explains, in part, why it is so difficult to explain or teach...
young architects how to design. Design, in a traditional sense, has both the know-how and know-what; yet the know-what prevails. The attempt to explicate design knowledge results in the development of CAD systems that are isolated from the real world of the architect; a world where the social, technical, and individual characteristics of design are intertwined.

Narrow Definition of Productivity.

The principle justification usually given for the large capital expenditure required to purchase a CAD system is the productivity benefit that will result. Productivity is usually defined in the very narrow sense of output per man hour. In some firms, productivity goals are achieved by organizing the design process as an assembly line procedure, reducing the architects' role to that of a mere functionary (Berger, Berger and Kellner, 1974). This misplaced concept of efficiency is reminiscent of productivity approaches that have been dominant in the manufacturing sector of the economy, where "many industrial engineers feel that gains in productivity will come about mainly through the introduction of new technology. They feel that tapping the latent productivity of workers is a relatively unimportant part of the whole question of productivity" (Work in America, 19).

Automating to Enhance Image.

Another problem is caused by the desire to automate in order to project the image of a progressive design firm. For example, at HK "the initiative (to use computers) came right from the top-the office of the chairman. One of Kassabaum's wishes before he retired was that the firm would be using computer-aided drafting" (CADD Roundtable 1984, 26). The decision to introduce CAD for this reason usually results in unexpected problems. Problems often occur when computers are introduced for purposes of competition without considering their role or influence on the design process. One architect expressed this concern in the following manner: "Architects who are buying CADD systems in order to compete with other architects who have them may not be convinced that a CADD system is a good thing. They're going to have one so that they can say they have one. And they are going to struggle with it to make it work."

Under Emphasis on the Culture of the Firm.

Another unanticipated problem caused by automation relates to the decision by management concerning how CAD should be used within the firm. Managers and owners are usually an older generation who are not familiar with computer usage and terminologies. The existence of a CAD system can alienate them from the design process. Toffler (1980, 1970) called this alienation process culture shock. Culture shock usually denotes moving from one's familiar culture to another unfamiliar culture where different language, signs, and gestures are being used. However, in the case of computers, culture shock emerges as a result of not being able to understand and to cope with the signs and underlying meanings of this new computer culture (Turkle, 1984). To avoid culture shock, managers as well as owners sometimes reject or limit the usage of computers within the firm.

This situation can occur when the managers or owners decide to buy a CAD package primarily to satisfy the clients' demands. Because the integration of the CAD system and the design/production process has not been considered, its role within the design process is often limited. In this situation, the managers' view often reflects a total rejection of using computers in the design process. The computer's potential as a new medium for design is ignored and the traditional design approach is imposed without considering in any meaningful way its potential to improve the design process.

The architect's view, on the other hand, is sometimes in opposition to that of the manager and owner. While some architects believe that the traditional pencil and paper approach is more creative than the use of CAD, other architects believe that computers can enhance the design process. However, they must frequently confront and deal with managerial opposition. For example, one architect said:

"Computers open many possibilities for the designer. It is the only tool that provides architects with real 3D im-
Design and the Manipulation of Information.

Taking advantage of the ability of information technology to generate, store, analyze, and communicate information is the first requirement for the effective implementation of CAD.

I. Increased Role for Information in Design.

Architectural firms provide design services to clients. Traditionally, construction documents have been the primary mechanism for communicating the results of this design service. Hard copy drawings and text are the media used for conveying these building instructions to the contractor. Most design professionals have recognized that CAD has the potential for significantly changing the nature of these contract documents. One architect has described how information technology has changed the nature of design services in the following manner:

"We are not manufacturing glass, steel, or anything of that sort. We are describing environment that is not there, we are in the business of describing things, we are in the business of generating information. So, the product or the direct approach to apply technology to architectural practice has to do the same thing and produce the same thing, which is information."

He also added,

"The whole process of design is building on information (that you have), keep working on it. You describe the site relations, you add that to the building, you relate that to the program, and at some point you will get to final part of design when you have something called construction documents... You actually know more about the nature of the building by the end of the design process."

In this sense, design not only creates a new building, but also generates new knowledge about this building. Knowledge that is embodied in a computerized information database that
describes the designed building has been characterized as "the firm's real asset," and is likely to become an increasingly important factor in the evolution of architectural practice. This is a recognition that the object of design is less important than the information that describes the building.

There are two types of this knowledge that have been generated by the end of the design process. First, there is information that can be used later and added to the firm's general stock of knowledge about design and building. Examples of this information include descriptions about the nature of a product and how the building was put together. Second, there is information that cannot be used later, such as the information that describes elements with specific relevance to a certain project. The first type of information can be stored for further use whereas the latter is of less "generic" value because it is too specific to the project.

Thus, information is becoming an important, proprietary commodity and the increasing focus of the architecture and engineering business. Information about design must be generated, collected, and synthesized. This information is stored, maintained, and embellished for future use. As one architect said, "the cheapest information is the information that you don't have to input." The more the architect uses computer technology in the design process, the more generic information can be recycled and the more efficient will be the design process. Thus,

Integration means you get information from different sources within the design context, for instance, you get a structural engineer laying out where the columns location are; and the architect who picks those locations try different symbols to match where those locations are with the floor plans. The mechanical engineer who takes all this information and work on the ducts provided by the architect, for example, does not have to input this information. He gets it free because he gets the work that somebody already did. This only works if all these disciplines are integrated within the same environment... So, the key issue if we want to do that, we need a standard

user interface that is flexible and organized, and we need a common data format, in other words we need a standard database management system.

2. Increased Need for Intellectual-Centered Skills. When computer-aided design technology is used in designing, the physical tools which were once an extension of the architect's skills become less important. Instead, the locus of the design activity shifts to the manipulation of data. Through this manipulation, data evolves into information that has meaning in relation to the design context (Sanders, 1977; Zuboff, 1988). The architect's role, therefore, becomes that of a data manipulator and information synthesizer in addition to that of an object synthesizer.

The traditional manipulation of geometric objects (action-centered activity) is expanding to include a process of mental synthesis (intellectual-centered activity), a more complete synthesis of many different kinds of information that will constitute the meaning of a building. This information can now be obtained readily from many different and widely dispersed sources. For example, an architect described the importance of information and communication as follows:

We established a link with our New York office because we don't have all the departments in our branch... Architects began using the computer to move information back and forth between the two branches... Of course without the aid of our computer system they would have never been able to do this. After receiving this information designers began evaluating the different types of information, graphics, charts, text, numeric data... After careful analysis they passed this information to the different participants of the design process, and of course this information helped them to develop a total and better image of the project. Our system was the platform that supported the communication of information. Information is a valuable commodity to our firm. As a matter of fact, it is our firm's real asset. However, without a
The role of the architect as information broker was emphasized by an architect who said:

"We'd like to think that we are also business consultants as well as designers... we try to understand everything about the business we design for, so we may go beyond the traditional aspects of design which is concerned with room size or office size, and ask questions like what this business do and what is it going to do in the next ten years? So, we may give recommendations that the business get re-structured as opposed to changing the design... We should not only know about how to design and how walls are built, we should also know about how organizations are structured."

He also added,

"Clients think about architects as somebody who should be brought-in later in the process. What we want to do is to work with our clients from the very beginning of the decisions."

Unlike the action-centered (traditional) design approach, design as intellective-centered skill (research) requires a shift in the designer emphasis: a shift from an objective creation of artifacts to architectural design that is based on understanding and reflecting on the experiential and organisational aspects of the design context as well as the artifact itself. It is also taking advantage of the "stock" of knowledge that has been developed by the firm and encourages communication among all the participants.

Design, according our interpretation of the informants in this research, may becoming an intellective-centered rather than action-centered skill. This intellective-centered skill enables the architect to make decisions beyond the realm of the narrow traditional geometrically-based decisions. The architect's decisions, then, are based on information that is gathered through a vast communication network with all the participants. The architect is becoming a manipulator and synthesizer of information in addition to a manipulator of physical objects.
Design as Communication.

When computer technology is appropriately used, it has the capacity to enhance the different forms of communications that take place within the design process. These forms of communication can be summarized as follows: (1) inter-subjective communication (e.g., communication with oneself), (2) interpersonal communication (e.g., communication with the other participants of the design process, such as the client and other design consultants) and, (3) intra-organisational communication (e.g., communication with outside agencies and with other branches of the same firm).

1. Inter-subjective Communication.

Communication with oneself (inner dialogue) resembles what Schön (1983) has called reflection-in-action. When designers are engaged in a design situation "they will reflect-in-action on the situation's back-talk, shifting stances as they do so from 'what if?' to recognition of implications, from involvement in the unit to consideration of the total, and from exploration to commitment" (Schön 1983, 103). The enhancement of communication or the inner dialogue is twofold. First, it is preceded, as mentioned earlier, by reflection-on-information, and thus, the architect starts the design equipped with more information than is traditionally the case. Accordingly, the architect makes more informed decisions during the process of reflection-in-action and dialogue with the situation. Second, the ability to make in depth studies, to analyse the design, and to represent realistic three dimensional images early in the design process helps the architect improve "back-talk" from the situation (Figure 2). Thus, the architect's reflection-in-action becomes more informed.

2. Interpersonal Communication. There are two types of interpersonal communication: communication with the client and communication with other members of the design team. Communicating with the client often relies on two dimensional drawings. The problem with this form of communication is that most clients, as several architects indicated, "don't understand two dimensional drawings." In later stages of the design process, the communication relies on three dimensional drawings which clients can "relatively" understand. The problem with this form of communication is that it took place later in the design process, and it is a static representation of the building, i.e., they can only show one view of the building. When computers are used, they help the architect to overcome these problems of communicating with the clients. For example, one architect asserted that,

... clients, and this is an interesting issue. don't understand plans. In almost twenty years, I've never seen a client who can understand plans or sections. They are not trained that way, they don't think that way. These guys are bankers, they run factories, they don't understand plans because it is a very funny language that we have developed to communicate with each other. What you need to communicate with is images, a feeling of what is inside the space. So, any system that is going to be useful is going to have a very powerful graphic characteristics, so you can play within the dialogues of design... If you get out to practice and start thinking about how to apply the technology, always think about what
business you are in. And how is it
going to affect you? In our case, it was
the coordination between the different
disciplines.

The computer has also emancipated the architect
from the static form of communication with
clients. For example, the computer enhanced the
communication between an architect and his
client who wanted to see his building with
certain materials and under certain weather
conditions. In addition, the ability to generate a
dynamic walk-through interior (Figure 3) and
exterior perspectives

![Image: Walk-through Exterior Perspective](source: Kemper 1985, 186)

Figure 3: Walk-through Exterior Perspective
(An image showing a computer-generated view of a building from an exterior perspective)

have immensely enhanced the ability to
communicate with clients because the client "can
envisage how his building is going to look like". One architect said,

For the first time I feel that clients understand what I'm saying. You
can't compare the traditional perspective that is drawn in a late stage
of the design process with the kind of
perspectives that we are generating on
the computer. Now, we can show our
clients a realistic images or perspectives
with different color, texture and
lighting conditions. We can rotate the
buildings. We can generate walk-
through perspectives of the building,
whether from the inside or the outside.
I think this is very important because
the clients now can give us a positive
feedback. I mean their feedback is
based on a better understanding of the
design.

Another architect said,

I don't think it is only the dynamic
perspective. In a design project that we
submitted lately, we had to design on
multiple layers. The plan on one layer,
the site on another layer, and the
landscaping on a third layer and so on.
What happened is that we developed
different solutions for the site
landscaping, for example. When the
client came to us, we activated the plan
and the site layers, then we started
turning on and off the layers that have
the landscaping alternatives. We were
also able to show him two different
solutions at the same time to compare
between them by opening a new
window. I'm not talking now about an
expensive system. I'm talking about a
$400 system that is commercially
available. As I told you before, if you
know how to use your tools, and if you can overcome the "mental block," you can benefit from the computer.

Accordingly, the proper design and use of CAD systems can significantly contribute to the communication between the architect and the client and make the client an active participant in the design process.

Communication with other design team participants is the second crucial aspect of the design process that is usually ignored by the rational organizational structures. The use of computers as an environment that integrates and facilitates communication among the different disciplines, coupled with a change in organizational structure (team or matrix structure), enhances this form of communication. For example, in one large firm, architects and other participants were regrouped in teams instead of the traditional pyramid structure (Figure 4).

![Figure 4: Team (studio) Structure](image)

Each team had a different number of workstations (computers) depending on the nature of the project. In addition, the in-house developed CAD system is an integrated system, i.e., it allows the communication between the different disciplines. One architect described how the use of computers as an environment helped the process of communication; he said:

I was working on [the project], and I had a structural problem. Before this current arrangement, I used to print the drawings and take them to the civil engineer to ask some questions. The civil engineer used to take the drawings and study them for sometime and make some calculations and then comes back to me. Now, what happens is that I call the civil engineer who is sitting here in the same space and show him the problem on the screen. He takes the drawing, makes a reference file, opens it on the structural module of the system, makes his calculation in a few minutes, and gives me an answer to the problem. I think the computer helped us a lot in terms of communication. Now, I don't have to wait for hours or days. Now, I get the answer in a few minutes, usually. It is amazing how we can work together, despite the traditional problems of communication between the architect and the civil engineer.

Thus, the use of integrated CAD systems coupled with their proper implementation enhances the communication among the design participants. Accordingly, architects get an early and continuous feedback from the other disciplines which enable the architects to make more informed and integrated decisions than the traditional and automated processes.

3. Intra-Organizational Communication. The last form of communication, which is a relatively new form of communication, is communication with other branches, firms, and clients. This form of communication is often known as "telework" (Krote, Robinson, and Steinle 1988). By and large, the term telework "is used to refer to work performed outside of the normal organizational confines of work-space and time, augmented by computer(s) and communication technology" (Olson 1988, 77). The intra-organizational dimension of telework has been discussed earlier. The other facet of telework, the communication between the various organizations involved in the design process, has been applied in isolated cases. For example, in one situation, a large firm decided to establish a communication network with another branch. One architect in the firm described this process as follows:

We used to maintain a connection from office to office, but we found out that it
is a fairly expensive connection to maintain. So, we decided to cancel it and to use things like Federal Express, and package express services to send things overnight, around the country. Most of the offices are self-sufficient, they have enough equipment to do their own things, so we do send information back and forth, but it is on a situational basis, it is not like we log into each other's systems. We have a building services group here that the New York office doesn't, so, sometimes we do the building service aspects of the project here and the architectural and structural engineering in New York. It is a weekly updated process, it is not a minute by minute or hour by hour kind of process, we often have weekly revisions... The New York office has an interior design department, so we send them information and they go through the same process. This saves a lot of money and unnecessary expenses. I think in the future, when prices are reasonable, we may hook all the offices together.

The prospect of having this form of communication can support the form of architectural practice identified earlier as the "split-team" approach. Instead of having all specialists located in one firm, each firm, possibly in geographically dispersed locations, can easily exchange knowledge and design expertise. The difference between applying this form of "cooperation" and the traditional approach of exchanging information is that when computers are used as medium of communication, feedback can be instantaneous. Thus, the architect can maintain the integrated decision making processes that is emphasized by informing the design process. In other words, big firms, as we know them today, may not exist in the future (Reif, 1968; Olson, 1988). However, these predictions rely on assumptions that networking is feasible, and that architects will be comfortable in using this form of communication rather than the face-to-face communication. These assumption have not been validated and some theoreticians expect implementation problems, especially in professional environments (Gordon, 1988).

A Framework for Implementing Computer Technologies.

The preceding section introduced two central concepts associated with implementing information technology in the design office. We now turn to an assessment of how these approaches may be utilized within the current, diverse, and changing nature of architectural practice. This section will develop an understanding of how various types of design firms should approach implementing information technology.

Two issues should be emphasized in this discussion. First, the implementation of information technology does not always result in productivity increases or increases in effectiveness for design firms. Many cases have demonstrated that implementation of information technology can often have unintended, negative consequences. Merely automating manual processes does not always bring anticipated productivity improvements and can yield productivity decreases. The second point is that there is probably no single "best" strategy for implementing CAD systems in the design firm. Firms that are interested in effectively using CAD should think through how the costs and benefits of CAD best fit within the unique culture and organization of their particular firm.

This second point can be illustrated by reviewing several types of firms and exploring the potential impact of computer-aided design strategies on those firms. The professional practice consultant Weld Cox (1988) has classified firms into three basic categories: strong delivery, strong service and strong idea firms. Strong delivery firms tend to provide highly efficient service to clients with whom they may develop a long term relationship. They focus on reliability, quality, technical competence, cost and schedule compliance. Strong service firms provide experience with often highly complex projects. They tend to emphasize a process that is rich in coordination, multi-disciplinary talents and a high level of problem solving capability. Strong idea firms provide singular expertise, innovation, or both on projects that are unique in nature. They often depend on the working style of their leader or "guru" for how they approach a
given project. Although this may be an oversimplification, it provides a mechanism for exploring the impact of integrating computer technology.

Firms can also be classified according to the types of projects that they do. Figure 5 defines a "Three Track Continuum" based on the findings of the 1987 AIA Firm Survey. Further analysis of the data represented in this figure indicated that, in general, strong idea firms tend to focus on projects in Track I; strong service firms' projects are usually centered around projects in Track II; and strong delivery firms usually seek projects in Track III (In Search of Design Excellence 1989, 24-25).

![Three Track Continuum Diagram]

Figure 5: The Three Track Continuum
(Source: In Search of Design Excellence 1989, 25.)
Table 2: Relationships Between Information, Communication and Firm Topologies

<table>
<thead>
<tr>
<th>Project Communication Complexity</th>
<th>Project Information Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Strong idea (Track I)</td>
<td>Strong service (Track II)</td>
</tr>
<tr>
<td>Low</td>
<td>Strong delivery (Track III)</td>
</tr>
</tbody>
</table>

Strong Delivery CAD Strategy.

Table 2 puts together firm topology and project types within the previous discussion of the role of information and communication in design. For example, strong delivery firms have relatively high information complexity and low communication complexity. This is primarily because the types of projects they do are more of a standardized product than is found in the other two types of firms. The types of buildings designed by this type of firm are likely to be facilities in which most of the design decisions are standardized and innovation is not a factor. Industrial facilities, motels, and other repetitive types of buildings are desired projects for this type of firm. Turnkey projects and design/build firms frequently fall into this category. Many decisions are already made because of the repetitive nature of the building that is being designed. Therefore, information technology will be applied to problems that help this type of firm improve their effectiveness in delivering this relatively standard product.

The CAD strategy for this type of firm is likely to differ substantially from the other two types of firms (Table 3). Managers in this type of firm are interested in improving the efficiency of project delivery system, and may investigate the use of expert systems or parameterized design approaches in order to achieve this goal. Because many design decisions are "standardized" a high level of employee expertise is not required; this type of firm may hire paraprofessionals to execute much of the design work. However, the importance of information technology may be such that relatively highly trained computer technicians may be required to operate and maintain both software and hardware.

<table>
<thead>
<tr>
<th>Strategy category</th>
<th>Firm's strategy</th>
<th>CAD strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project structure and decision making</td>
<td>Depts working like assembly line or specialized teams, Most decisions are standardized</td>
<td>Automate the design process to improve efficiency; implement expert systems for standardized design issues.</td>
</tr>
<tr>
<td>Human resource policies</td>
<td>Paraprofessionals</td>
<td>Replace drafters with CAD technicians; hire highly trained computer staff</td>
</tr>
<tr>
<td>Marketing strategy</td>
<td>Selling a tried and true expert product; clients are developers, some sections of gov't and major corporations.</td>
<td>Use CAD to help sell the message of &quot;efficient product delivery.&quot;</td>
</tr>
</tbody>
</table>

Table 3: Strong Delivery CAD Strategy
Strong Service CAD Strategy

The strong service type of firm is more likely to invest heavily in CAD because of high levels of both information and communication complexity. In this type of firm information technology is likely to be an integral part of the firm's long term marketing and organization strategies which seek to be highly responsive to client needs. It is in this type of firm where a full implementation of the informate strategy will prove to be most effective (Table 4). The complex projects that are typical for this type of firm will benefit from the advanced analytical approaches that are available through CAD. In addition, the many specialists involved in these complex projects increase the difficulty of communication and coordination that can be ameliorated by the development and implementation of electronic work groups and collaborative technologies. At least some of the specialists involved in these projects might evolve into "knowledge workers," as they increasingly take advantage of electronic information available from past projects, client databases, and other remote databases.

<table>
<thead>
<tr>
<th>Strategy category</th>
<th>Firm's strategy</th>
<th>CAD strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project structure and</td>
<td>Depts, studios, or teams led by hands-on leader</td>
<td>Informate the design process; use</td>
</tr>
<tr>
<td>decision making</td>
<td>(principal-in-charge or department head)</td>
<td>electronic work groups and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>implement &quot;collaborative technologies&quot;</td>
</tr>
<tr>
<td>Human resource</td>
<td>Train and retain experience</td>
<td>Designers become knowledge workers; hire computer</td>
</tr>
<tr>
<td>policies</td>
<td></td>
<td>staff; train and retain expertise.</td>
</tr>
<tr>
<td>Marketing strategy</td>
<td>Message is: &quot;We've been here before&quot;; clients are</td>
<td>CAD is central to providing solid service; selling</td>
</tr>
<tr>
<td></td>
<td>institutions, public agencies, and major corporations.</td>
<td>information; consider expanding to facility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>management.</td>
</tr>
</tbody>
</table>

Table 4: Strong Service CAD Strategy

Strong Idea CAD Strategy

For strong idea firms, the nature of the projects and the philosophy of these firms suggests that the complexity of information may be relatively low. Communication is in somewhat of a more ambiguous situation. Because the "strong idea" will not normally be developed within a team concept communication may be less complex. However, it will still be essential to communicate to the client what is normally a complex, unique design idea. The strong idea type of firm may decide on a strategy such as that indicated in Table 5. The principal in this type of firm generally makes all of the key design decisions. Strong idea firms work with clients who are interested in "big idea" projects and who are willing to pay for unique design solutions. The CAD strategy adopted by this type of firm will be very much tied to the personal working style of the principal. There have been many cases where CAD has been introduced in this type of firm only to have it fail because of the resistance of the principal.
<table>
<thead>
<tr>
<th>Strategy category</th>
<th>Firm's strategy</th>
<th>CAD strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project structure and decision making</td>
<td>Flexible teams (ateliers) organized around each project, single authority or head &quot;guru&quot; makes all decisions.</td>
<td>Depends on the principal; but low information and communication requirements suggest a low use of CAD.</td>
</tr>
<tr>
<td>Human resource policies</td>
<td>Hire young, bright talent; but don't retain (or train) for long career</td>
<td>Guru's talent is the key in this type of firm. CAD will be less important.</td>
</tr>
<tr>
<td>Marketing strategy</td>
<td>Sales message is innovation and the &quot;big idea&quot;; look for clients who have a unique problem.</td>
<td>Selling a unique product. May use CAD to generate new solutions and/or use CAD for communicating high image design presentations.</td>
</tr>
</tbody>
</table>

Table 5: Strong Idea CAD Strategy

Conclusion.

This research has presented a conceptual framework for better understanding how information technology might be more appropriately introduced into a design profession that is currently undergoing an evolution brought about by changes in its socio-economic context. It has argued that information technology presents unique opportunities and challenges to design firms; and that implementing this technology must take into consideration the larger organizational and cultural framework of the individual design firm. This framework was based on original research which was placed within the context of recent research about professional firms. Two conclusions should be highlighted.

The first conclusion is that automation as a strategy for implementing information technology has created problems that cannot be resolved unless new approaches are used in the design and implementation of CAD systems. Automation imposes the Cartesian, rationalistic systems design approach on the development of CAD as well as architectural practice. The Cartesian systems approach, while effective in helping to automate structured design problems, has also led to the isolation of knowledge within specialized domains. This causes increased communication problems among engineers, architects, clients, and users.

The second conclusion is that the integration of information technology into the design office is most effective when it takes into account the firm's underlying organizational structure and culture. Information technology is most likely to make the most profound changes in those design firms who face an increasing amount of complexity of both information and communication due to the types of projects and clients they work with. For these firms the "electronic design firm" may be a future reality.

Notes.

1. This view, for example, was offered by George Piller, PAIA, Vice-chair, RTKL Associates, Inc., at a recent conference on Emerging Forms of Architectural Practice, organized by the Center for the Study of the Practice of Architecture, University of Cincinnati, April 19-21, 1991.

2. This architect is working in the same firm mentioned earlier where the partner opposes the use of computers in the design process.

3. Two case studies will be used in this section: the first relates to a large firm, and the second refers to a small firm. The common denominator between the two firms is the use of computers throughout the design process, especially the conceptualization process.
4. By and large, the situation's back-talk, according to Schon (1983), is the process or the moment of reflection when the architect reflects on the drawings (design) and gets feedback from it through a process of interpretation.

5. The use of the integrated CAD system and the new team organizational structure of the firm.

6. A well known architectural management consultant recently indicated to one of the authors that, in his opinion, only small firms have consistently been able to make CADD profitable.

Selected Bibliography.


