

**INTEGRATING THE REAL ESTATE DEVELOPMENT ENVIRONMENT:
COMPUTERS AND AN OBJECT ORIENTED APPROACH**

by

Nicholas Tsapatsaris

B.S., Civil Engineering,
Worcester Polytechnic Institute, 1986

M.S., Structural Engineering,
Worcester Polytechnic Institute, 1987

Submitted to the Department of Urban Studies and Planning
in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE
in Real Estate Development
at the

Massachusetts Institute of Technology

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Signature of the author _____
Department of Urban Studies and Planning

Certified by _____
Gloria Schuck, Lecturer
Department of Urban Studies and Planning
Center for Real Estate

Accepted by _____
Lawrence S. Bacow, Chairman
Interdepartmental Degree Program in Real Estate Development

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Submitted to the Department of Urban Studies and Planning
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ABSTRACT

The real estate process is a collaborative effort involving a diverse group of organizations such as development, architectural, brokerage and many others all working together in transforming a market need into useable space. Typically, each member of the real estate team uses computers and operates in an isolated environment. This research conceptualizes an integrated and distributed computer environment for collaborative real estate development.

In this research, Object Oriented Technology (OOT) is applied to the real estate process. OOT is chosen for its: (1) usefulness in navigating through discrete and complex databases, (2) ability to cope with project management and resource allocation; (3) applicability to the richness and complexity of real estate; and (4) potential for utilizing existing computer infrastructures.

To illustrate the effectiveness of Object Oriented Technology in management situations, an integrated and distributed environment for real estate development project scheduling has been conceptualized.

The four major points that are discussed in the conclusions of this work are: (1) modelling the real estate process, (2) how to intelligently apply the technology, (3) the importance of integrating computer technology within real estate, and (4) how real estate organizations should change with new technological developments.

Thesis Supervisor: Dr. Gloria Schuck,

Title: Lecturer,
Department of Urban Studies and Planning,
Center for Real Estate

Biographical Note

Prior to attending MIT, the author was a registered professional engineer with Rohde & Soyka Consulting Engineers and also Chazen Engineering and Land Surveying in the Mid-Hudson Valley area of Upstate New York. As part of a real estate development team, his responsibilities included the structural analysis and design of buildings and all aspects of site development projects.

This work is part of ongoing research in the application of computer technology to the building process. Prior research includes a knowledge based expert system for the preliminary selection of structural systems for tall buildings [Jayachandran, and Tsapatsaris, 1989]

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CHAPTER ONE

Introduction

Statement of Problem

In the prosperous 80's, costly inefficiencies in the development process were outweighed by a bullish market. For example, developers could afford prolonged approval processes because real estate values were increasing. The 1992 real estate market is not as forgiving. We can no longer afford problems such as lack of communication between the architect and contractor. Jeffrey Russell of the University of Wisconsin states that fragmentation is a problem which faces the real estate industry. *"The specialized nature of construction has created islands of automation and a project environment that is an ad-hoc combination of owners, designers, contractors and suppliers"*, [Tarricone, 1992, p. 44]. John D. Macomber [1989, p.1] supports this and adds: *"Software vendors are racing to consolidate all of these development project applications into one neat package that will communicate all of the necessary information to whoever needs to use it"*.

Computer applications in real estate are fragmented and non-inform. Incompatibilities in both software and hardware stifle collaboration amongst the various organizations in the process. *"Each phase of the development process now has its own computer software. A single project lives multiple lives in the multiple computers used by specialists in the real property chain"* [Macomber, 1989, p.1]. This problem is amplified by the fact that some applications are more complicated than others,

leading to varying levels of technological sophistication within real estate. For example, some engineering firms routinely use Artificial Intelligence techniques and Computer Aided Design, while only 39% of owners use Computer Aided Design-based facility management systems [Veale, 1989, p.9].

The following research hypothesizes that Object Oriented Technology (OOT), a computer programming methodology based on "objects" rather than procedures, can be used to help integrate the fragmented real estate development process. This will in turn lead to increased and more efficient collaboration, which will result in a leaner, and hopefully more effective development process. These efficiencies may be a key to revitalizing the large vacancies that exist today and saving both human and physical resources.

This research is intended for two audiences: real estate professionals who are responsible for strategic and resource allocation decisions, and managers of information systems and/or computer scientists. Chapter two is directed toward real estate professionals and provides a summary of existing computer technology in real estate. It also serves as an introduction to OOT. Chapter three can be skimmed by real estate professionals but has been written primarily for those who have very little, if any, knowledge of real estate. It provides a general description of the real estate process for computer scientists and is used to conceptualize an integrated and collaborative computer environment for the real estate process. This system is

presented in Chapter four and is intended for those with an understanding of OOT. Chapter five illustrates an application of OOT to scheduling of a development project. The bulk of this chapter has been written for computer scientists and those who would like to learn more about OOT. The section on implementation in chapter five is, however, strongly recommended to real estate professionals. It presents the reasons for creating the scheduling environment along with the major issues that must be addressed before the system is put into use. Chapter six presents the four most important conclusions of this research. It is intended for both real estate professionals and computer scientists.

A survey published by the Laboratory of Architecture and Planning at MIT shows that the real estate decision-making process is increasingly supported by computer technology [Veale, 1987, p.18]. Applications include Computer Aided Design/Drafting (CAD), project management, and investment analysis programs. The survey also points out that the presence of these systems does not correlate with more effective management. When asked how the real property process can be improved, many organizations responded that what may be needed is not yet another computer package, but a solid grounding in sound management principles.

The MIT survey indicates that computers have not lived up to their expectations. Some executives expected a substantial reduction in staff, while others sought high monetary returns from their investments in technology. Few concerned themselves

with the organizational impacts which may be one of the most important contributors to the problem. This is illustrated in those executives who claimed they had successfully made the transition into the high-tech environment, yet full acceptance of computer technology into the culture of real estate organizations was far from being accomplished.

One difficulty in the application of computers to real estate is the way in which technology progresses. According to Thomas Kuhn, science does not progress continuously, by gradually extending an established paradigm. Instead, it proceeds as a series of revolutionary upheavals. Software development proceeds in similar fashion with few attempts to utilize existing software in new developments. Some software developers argue that starting from scratch is more efficient than augmenting existing systems. This argument depends upon how widespread the use of the existing software packages is, and whether or not it is worth re-training employees to use another package.

OOT may be a useful tool in increasing software re-use¹ thereby minimizing the magnitude of shock that comes with new technological developments. Madnick [1988, p.2] supports this and states: "*integration must be accomplished through software that 'surrounds' these existing systems rather than replacing them.*" This is an enduring dream that continues to elude the grasp of software developers, but OOT may have

¹ software re-use is the utilization of existing computer software in new technological developments.

brought us a step closer to achieving what Cox [1990, p.25] calls "*well-stocked catalogs of reusable software components*".

Methodology

In order to apply OOT to real estate, key components of the process have been summarized and documented in chapter three in a series of flow charts and descriptions. The sources of knowledge for this work include: interviews with selected students and faculty at the MIT Center for Real Estate, industry experts and literature review. A detailed description of the real estate process is a monumental task that would take experts from every discipline many years to complete. Instead, this research summarizes the behavior and structure of the primary constituents in the industry. Further complicating the compilation of a complete map is the fact that real estate is not a static or linear process. Market needs and technologies are constantly changing thereby requiring the model to be flexible and open to change.

Processes including the following domains, or areas of real estate have been compiled: tenant/user, public groups, public agencies, developers, architects, planners, engineers, contractors, brokers, owners/investors (private, government, corporations, investment banks, etc), financial advisors, lawyers, asset managers, portfolio managers, mediators/dispute resolution specialists, appraisers and others. Using these domains (areas of real estate), a conceptual framework for the real estate process in an object oriented environment is presented in chapter four. The

existing stock of software packages currently being used by the industry will play an important role in this environment. They are briefly described in the next chapter.

CHAPTER TWO

Computers Applications in Real Estate

Introduction

This chapter presents an inventory of computer applications in real estate and a description of OOT. Some of the packages described in these sections have become industry standards thereby increasing the chances that they will be "re-used" in future software developments. This collection of software will ultimately serve as a foundation for the object oriented environment that is conceptualized in chapter four.

Most computer applications in real estate are CAD-facility management and design, lease analysis, building maintenance, space and inventory, and capital investment analysis [Veale, 1987, p.2]. Industry surveys have shown that 75% of real estate firms use computers in a decision making capacity; approximately three out of every four computer users employ this capability for investment analysis and two out of three firms for internal administration. About 50% of users use their computers for property management and investor reporting. Some two out of five use it for development feasibility, and one in five for negotiation and deal structuring. Of those firms that do not use computers, more than half are currently investigating automation [Roulac, 1987, p.79]. The next five sections summarize current computer applications in real estate.

Algorithmic Programs, Geographic Information Systems and Computer Aided Design

Computer programs which do not in any way attempt to model the human cognitive process can be called algorithmic programs. Examples include spreadsheets which can compute the net present value of an investment, and programs used in estimating construction costs. Specifically, some developers use spreadsheet based software such as LP MODEL (Limited Partner Model) and shareware templates for Lotus 1-2-3. Alvernaz [1985, pp. 259-262] discusses several possible software packages for the IBM PC. He notes that the following applications are most common: lease-by-lease analysis of income and expenses; projection of financial performance in the future; and valuation or return-on-investment analysis of individual properties. Software packages that perform these functions include PRO-JECT, DYNAMIS, and DYNARELEASE.

Property management software such as Sigma Research Associates' RealPlan, analyzes office and shopping center complexes. Different investment options can be compared when minimum equity hurdle rates are provided. The package is especially useful for long term optimization problems and managing large real estate investment portfolios [Trippi, 1990, p. 55].

As financial specialists perform analyses described above, architects and planners are designing the project. Geographic Information Systems (GIS) have become a valuable tool in the physical planning of a site. Research at the MIT School of

Architecture and Urban Planning is at the forefront of the technology², and has developed a computer based project planning environment. The system is implemented on a large screen and acts as a central source of information for the planning process. The user can access maps, soils information, demographic data and even video tapes of specified locations. This expands the amount of information available in a planning meeting exponentially, however, users are currently limited to pre-programmed data. In other words, it is not an "on-line" system. To be successful in a collaborative environment, the system must have the ability to import and sort information from outside sources as the planning process progresses. In the future, an architect may be able to have CAD drawings electronically mailed through a central network to a planning board meeting upon request. This prediction is based on the assumption that CAD will continue to spread across all sectors of the industry, including the owners of real estate.

From an owner's perspective, CAD has become an important tool in asset management [Garrison, 1987, pp. 24-41]. Computer generated drawings can be submitted by the architect to the owner in the form of "layers" (layers are templates of specific information that can be superimposed on drawings) which include HVAC, partitions, structural, etc. The owner is then free to add layers which specify types of tenants, lease rollovers, and expenses. The result of this combination is an ability to track space, maintain as-builts, make presentations to prospective tenants, and

² Michael J. Shiffer, Phd., Postdoctoral Associate, Department of Urban Studies and Planning, MIT.

create tenant fit out estimates. In down markets, this system provides a competitive edge in leasing. The fluidity of electronic information reduces leasing time and makes renovations much easier. Instead of weeks of design for tenant fit out, the owner electronically mails overlays to the architect who can then complete the design in only a few hours. The total cost to purchase a CAD system complete with software is approximately \$35,000.

Decision Support and Expert Systems

Decision Support Systems (DSS) are computer software systems that allow managers to access and transform data in a manner that is not pre-specified. Commercial applications include development, acquisition, expansion, and renovation. One of the earliest DSS was the Decisionex system, offered by Decisionex Inc. of Westport Connecticut. Its primary function was to provide a "what-if" facility for well capitalized investing organizations. The system made detailed projections of tenant space, income, expenses, and other investment criteria allowing properties to be compared. Typical monthly cost to the consumer ranged from \$10,000 to \$50,000. It was eventually replaced by smaller, less sophisticated, and cheaper systems. Some of the more modern packages include: FIN/SIM, MicroREAM, Realdata and REALDEX [Trippi, 1990, p. 55]. Although these programs serve basic computational needs, they cannot provide "intelligent" information such as heuristics to the user. Incorporation with expert systems can assist the decision maker by providing more intelligent information.

Knowledge Based Expert Systems are interactive computer programs incorporating judgement, rules of thumb, experience, intuition and other expertise to provide knowledgeable advice about a variety of tasks [Kostem, 1986]. In 1987, over 40% of the largest banks, brokers and investment companies were using or developing expert systems [Marquina, 1989, p. 129]. One of the first application of expert systems in business was in investment banking deal structuring. The data involved in putting a deal together had become too timely and complex for human beings. Intelligent processing of large databases was made easier by expert systems. This computational power then spread to portfolio review and strategic planning where the possibilities for portfolio mixes are equally complex and numerous. Expert systems search knowledge bases for portfolio allocations that match the investor's objectives. The programs use a process called "backtracking" which is similar to the way humans think when retracting information from their memory. Although helpful, attempting to model the human thought process alone is not sufficient for the success of expert systems in real estate. Financial institutions have found that expert systems must be connected to corporate real estate databases in order for them to be useful. In addition, the knowledge bases must be continuously updated. This can be accomplished by using "Automated Knowledge Acquisition Systems". As data is collected from asset managers, it is intelligently and automatically placed in the appropriate section of the database library.

In the near future, expert systems will serve as pre-processors in the implementation of diversification strategies such as Markowitz-type risk aversion [Trippi, 1990, p. 53]. They will also enable managers to intelligently sift through large databases. For example, an expert system could be created to search the Resolution Trust Corporation's (RTC) database. The program would match investor criteria with properties considering capitalization rates, location, building types, and amount of renovation required. Expert systems are excellent tools for the processing of the heuristic aspects of acquiring a portfolio. Another application of expert systems to real estate portfolio management includes the RESRA appraisal system by Security Pacific. This program is used for valuating large commercial portfolios and is particularly useful for organizations that prefer to perform their own valuations [Eliot, 1988, pp. 48-59]. Similar systems have also been created for property appraisals [Dreyer, 1989, 51-56] and taxation.

The advantages of expert systems include the ability to review a much larger number of properties than humanly possible in a short period of time. This enhances the portfolio manager's decision making process; it does not replace it. One disadvantage is that expert systems are best suited for narrow domains of expert knowledge. This has caused the proliferation of isolated expert modules that work well alone, but can not interact with each other. As a result, research in the 1990's will focus on integrating our existing computer infrastructure using networks.

So far, expert systems have not lived up to their expectations [Coats, 1988, pp. 77-86]. They have been misapplied to algorithmic problems and have not been sensitive to the needs of the user. Many have focused on the replacement of experts which has been a source of resentment. Those who try to sell artificial intelligence seem to promise more than they can deliver and thereby create a feeling of hype that surrounds the technology [Blumenthal, 1989, p.202].

Networks

Integration of the real estate industry through networks is not a new concept. In 1983, the National Association of Realtors created the Real Estate Information Network (REINET). It operates on a satellite-connected computer system which can be accessed through property manager's phone lines and provides instantaneous electronic communications, a library of diverse computer programs and a marketing network for property exchange [McGeehan, 1983, p.20] REINET is similar to Colliers International and Oncor. These are brokerage firms which emphasize electronic linkage.

One of the most popular research areas of information technology will be "integration". Substantial research is currently under way at the MIT Center for Information Systems Research [Madnick, et al., 1988]. This work includes a study of methods of achieving integration while maintaining autonomy using evolutionary architectures. "Composite Information Systems", a methodology which incorporates

database management and artificial intelligence techniques has already been applied to the banking industry [Frank, et al., 1987]. Additional research is being conducted in "Logical Connectivity", the connection between information technologies [Wang et al., 1988]. Applications of these concepts to real estate could help satisfy the increasing need for integration of multiple databases within the industry.

Databases

A key component of any portfolio management strategy is a good database. Some sources of real estate information include: statistics from the American Council of Life Insurance; publicly reported information on syndicated partnerships; reported returns on Commingled Real Estate Funds (CREF) and many others. Information in the databases includes: lease term, age, tenant industry, tenant size, renewal dates, building quality, and many others [Louargand, 1991, p.5]. Besides accuracy, *"a common problem with available databases is that they attempt to treat real estate as a homogeneous asset class. In fact real estate ownership is represented by a 'bundle of rights' (that can be separated and divided in a number of ways)"* [Hartzell, et al., 1986, p. 231]. These databases must therefore be manipulated and dissected as illustrated by Ziering and Mueller [1990]. Their work proposes the development of property attractiveness indices in order to bridge the gap between portfolio and property level analyses. Demand, supply and performance characteristics from databases are linked. OOT can satisfy this need by virtue of its ability to navigate through discrete and complex databases. A description of OOT technology follows.

Object Oriented Technology

The central ideas for OOT emerged in the late 1960's with the introduction of programming languages designed for writing simulation. However, it was not until the late 1980's that OOT became widespread. The recent proliferation of applications coincides with new developments in hardware which make it possible to implement demanding object oriented environments cost effectively. OOT is therefore having a profound impact on programming languages, databases and artificial intelligence. This section will describe the technology and provide a basis for its application to real estate.

What is Object Oriented Technology?

OOT has formed in an ad-hoc way not allowing for a uniform definition of terminology. In fact, there are a number of different perspectives on what "object oriented" is. The research indicates that OOT is a computer programming methodology that differs from conventional programming in that the fundamental building blocks are "objects" and not procedures. This contrasts with conventional programming in which data structure and behavior are only loosely connected [Rumbaugh, 1991, p. 1].

An object is an encapsulation of a set of operations with structure and behavior. An example of an "object" in the real estate process is a loan. A loan has a structure which consists of interest rate, maturity, loan to value, type of loan, term, principal,

and effective rate. The behavior of the object is illustrated when it is queried. A request to "compute interests rate" would activate the behavior of the object producing a result. The object can also interact with other objects in the real estate process. There are three major elements in OOT [Blair, et. al., 1990, p. 25]:

1. **Objects:** are an encapsulation of a set of operations with structure and behavior that can respond to messages.
2. **Class and Instances:** A class is a template defining behavior in terms of implementation and interface, from which objects can be created by a new operation. An "instance" is an object which cannot be broken down any further. For example, if mortgages are a class of objects, a specific person's loan on a house is an instance of the object.
3. **Inheritance:** is the ability to create sub-classes from existing classes, hence establishing a class lattice. For example, the structure and behavior of a mortgage object can be used to create different types of mortgages such as graduated payment mortgages, adjustable rate mortgages, buydown, and many others.

The key benefits of OOT are namely modularity, data abstraction, code re-use, encapsulation, classification, and polymorphism. These terms are defined below:

1. **Modularity:** This allows a program to be broken down into smaller self sufficient fragments. If one makes a change in a small part of the code, the whole system is not affected. This allows for easy updating and flexibility.
2. **Data abstraction:** is the ability to create a model of a system in terms of the data and operators which are most suited to the needs of the problem.
3. **Code re-use** of commonly used object classes can be employed, thereby minimizing redundancy of programming efforts.
4. **Encapsulation:** Encapsulation is defined as the grouping together of various properties associated with an object. Access to information within the object can be public, protected, or private. For example, most people have an understanding of what a tax return is, however, each return "encapsulates" certain forms and procedures which are private to the individual taxpayer. A general goal in object oriented programming is to maximize the private information within objects.
5. **Classification:** Classification is the ability to group associated objects according to common properties. If a human being is classified as an object, Massachusetts residents are a class of this object.
6. **Polymorphism:** This implies that objects can belong to more than one classification. Classifications can therefore overlap and intersect allowing one message to provoke different responses from objects. Interpretation is defined as the ability for a particular item to have several different meanings depending on its context.

An exciting application of OOT is currently being developed in the Civil Engineering Department at MIT for building design [Sriram, 1991]. Like real estate, the building design process is collaborative. The purpose of this research is to improve the way diverse disciplines cooperate to specify, design, manufacture, test, market, and maintain a product. *"One of the major problems facing the U.S. industry is the lack of communication between various participants involved in the engineering process"* [Sriram, 1991, page iii]. Computer aided tools collectively called DICE (Distributed and Integrated Environment for Computer-Aided Engineering) are being developed to address this lack of communication. An object oriented approach is being used to manage the database system.

Why Object Oriented Technology?

The choice of computer technology is an important step in the development of software. The software engineer must have a clear understanding of what is being modelled. One of the goals of this research is to better understand the human thought process in the context of real estate development. Do developers think in terms of tables, charts, algorithms and databases, or do they think in terms of objects? Thinking in terms of objects seems to resemble the human thought process more accurately. When developers need engineering services, they think of the engineering firm as an object with structure, behavior, encapsulated knowledge and many other OOT characteristics described in the previous section. OOT is, therefore, a logical way of modelling human thought and ad-hoc processes.

The second major reason for choosing an object oriented approach is its ability to adapt to change. The most successful organizations of the future will be those that are able to learn and change with technological advances. By organizing a computer model in terms of objects, specific objects can be altered without shocking the overall computer system and organization. This is in contrast to functionally oriented programming languages that were applied to static processes.

The application of OOT to real estate may include the following: (1) navigating through discrete and complex databases; (2) project management and resource allocation; (3) complex deal structuring. Before applying OOT, a thorough model of the process must be created. A complete and detailed model of the real estate process is beyond the scope of this work, however, an overview is presented in the next chapter.

CHAPTER THREE

The Real Estate Process

The purpose of this chapter is to provide the computer applications expert with a fundamental understanding of real estate. At times, this chapter may seem too simplistic to the real estate professional, however, it is a necessary and important step in the modelling process. Hopefully, this initial simplicity will help bridge the gap between the domain expert (real estate professional) and the applications expert (computer scientist).

Although a complete model for the real estate process does not exist, several processes which have been modelled in depth are engineering, architecture and construction. These are well documented in the DICE research in the Civil Engineering Department at MIT [Sriram, 1991]. They will not, therefore, be covered in this work to avoid duplication of effort. Instead, other aspects of the real estate process are shown. The sources for the information presented in this chapter include interviews with selected students and faculty at the MIT Center for Real Estate, industry experts, and real estate literature reviews.

This chapter documents a general perspective of the process without focusing on any one area in particular. As software development proceeds, the degree of detail in the model also increases. This approach minimizes the complexity of the model and provides for a clearer understanding of how OOT can be applied to real estate.

The Organizational Structure of Real Estate

Real estate development companies vary in size, organizational structure, and by the type of projects they build. Mintzberg [1981, pp. 103-116] classifies organizations in five categories:

- 1. Simple structure:** These organizations are not standardized or formalized, and use minimal planning, training and liaison devices. Few middle line managers are needed because coordination is achieved at the strategic apex by direct supervision. The chief executive, who is usually the owner, retains highly centralized control.
- 2. Machine bureaucracy:** These organizations emphasize the standardization of work for coordination. Labor is characterized as low skilled, and highly specialized. The resulting power structure is horizontal and decentralized.
- 3. Professional bureaucracy:** Hospitals, universities and accounting firms are examples of this organizational structure. Labor is generally skilled and can take control of their own work. The result is a decentralized power structure which flows down the hierarchy to the professional of the operating core.
- 4. Divisionalized form:** This form differs from a professional bureaucracy in that the organization is partitioned to accommodate diversified product lines. This structure is typical of many Fortune 500 companies.

5. **Ad-hocracy:** This is a tremendously fluid structure, in which power is constantly shifting. Coordination and control are by mutual adjustment through informal communication. This is the most futuristic organizational structure because of its effectiveness in an information rich environment. The "cubby holes" of production have been brought closer to the strategic line apex through information technology. The middle managers who once transferred information between production and upper management have become obsolete in ad-hoc organization. The few middle managers that exist do not merely transfer but transform information by adding value to it.

Historically, real estate organizations have been characterized by a simple structure. They are generally one unit consisting of one or a few top managers and a group of operators. The key means of coordination is direct supervision of functional groups from a strategic apex. This apex is often the owner.

The organizational structure of the real estate industry as a whole, is difficult to classify. The development process entangles a mixture of organizations. For example, large consulting engineering firms (professional bureaucracies) and large construction firms (machine bureaucracies) are coordinated by small real estate firms (simple structures). The real estate firms are usually flexible, and fast while the large construction firms tend to be slower and bureaucratic. This combination of firms is difficult to synchronize thereby resulting in delays in construction and in the

preparation of plans.

A solution to the inefficient lack of compatibility between organizations is not foreseeable in the near future. We can however begin to dampen the differences in organizational structure by a more efficient use of computer technology. This concept will be discussed further in Chapter five where an object oriented model of project scheduling has been conceptualized. Chapter three describe the real estate model beginning with the "team" members and the process, followed by a section on each of the "team" members.

Members of the Real Estate Team

The real estate process is not standardized. Each project requires a different composition of expertise and knowledge. The process is comprised of the following: developers (residential, hotel, industrial, office or mixed use), tenant/user, lawyers, public groups (neighborhood, environmental), public agencies, planning boards, architects (design, construction and detailing), planners (regional, site specific), land owner, engineers (geotechnical, foundation, soils, structural, HVAC, hydrology, site, architectural), contractors (classified according to the "Construction Specifications Institute, (CSI)), brokers (residential, commercial, industrial, office), financial (private investors, pension funds, government, corporations), asset managers, financial advisors, portfolio managers, mediators/dispute resolution specialists, and appraisers. Figure 1 illustrates a traditional real estate development team. The developer is

usually responsible for coordination and is located at the center of the process. (This structure is slowly being replaced by a newer, "ad-hoc" structure as will be shown later in this work. In the new structure, the developer may not continue to be at the center of the organizational chart. Instead, an "intelligent process" will connect the organizations.)

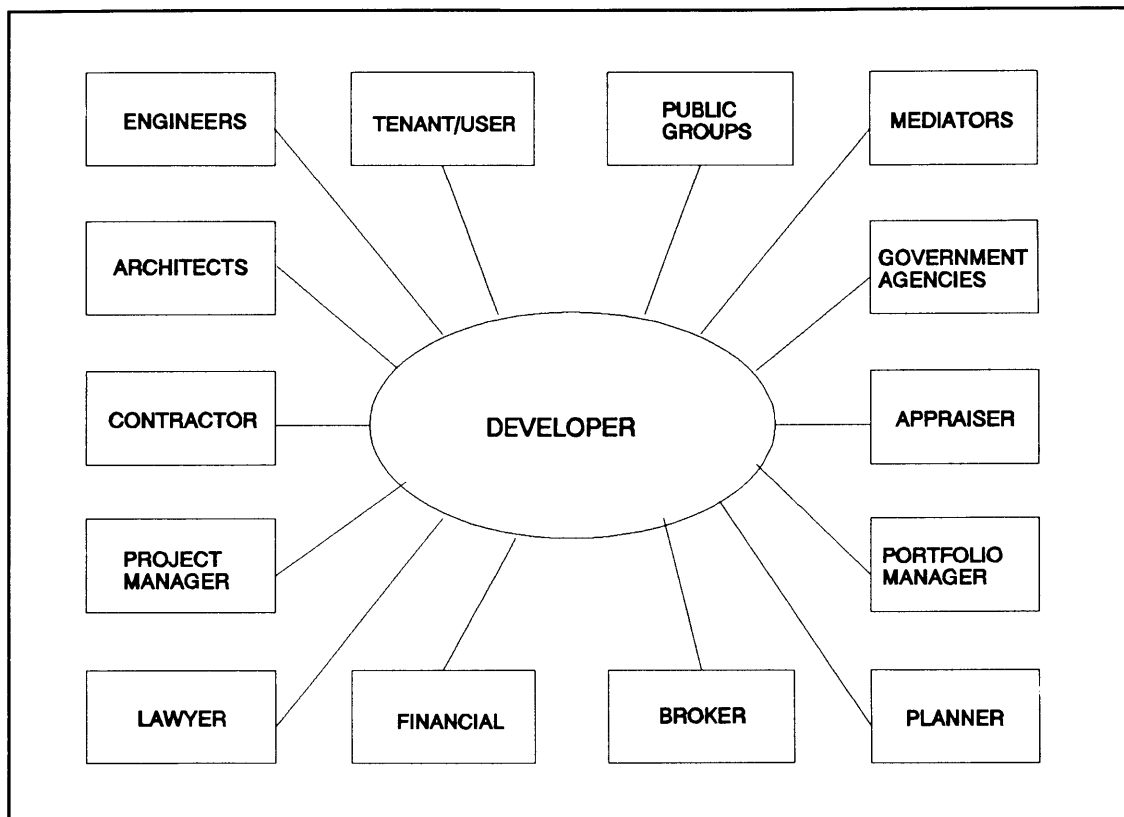


Figure 1. The Traditional Real Estate Development Structure

A Description of the Real Estate Process

Figure 2 is a simplistic description of the schedule of events in a real estate project. It is broken down into four basic categories: (1) market analysis and feasibility study; (2) approvals and design; (3) construction; and (4) occupancy and operation.

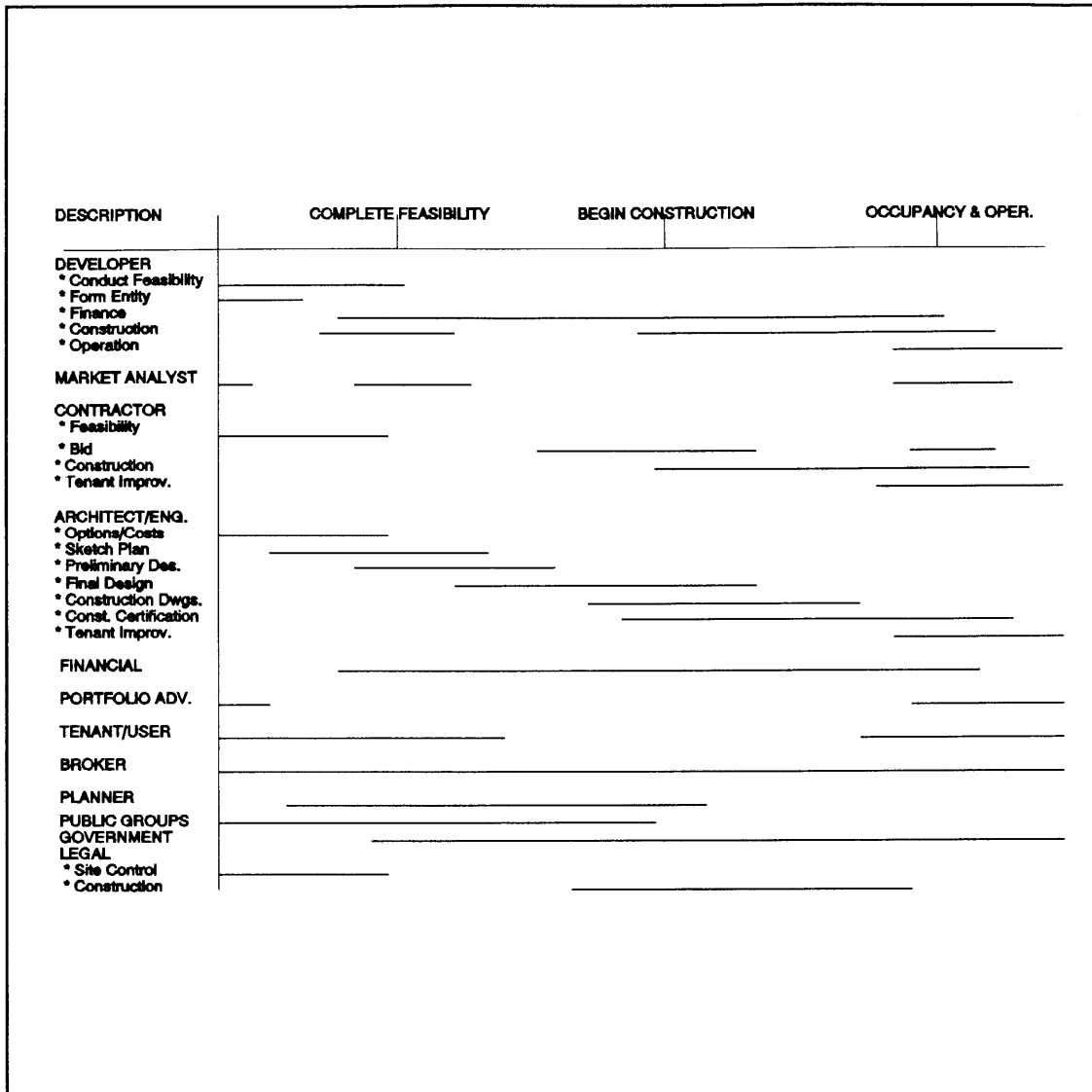


Figure 2 The Real Estate Development Schedule.

To assist the computer application expert in understanding the domain, several different views of the process are presented. Figure 3 illustrates an alternative view of the development process in the form a flow chart. This differs from Figure 2 in that key dependencies such as: "bid phase precedes construction and preliminary approvals precede final approvals", can be more clearly visualized.

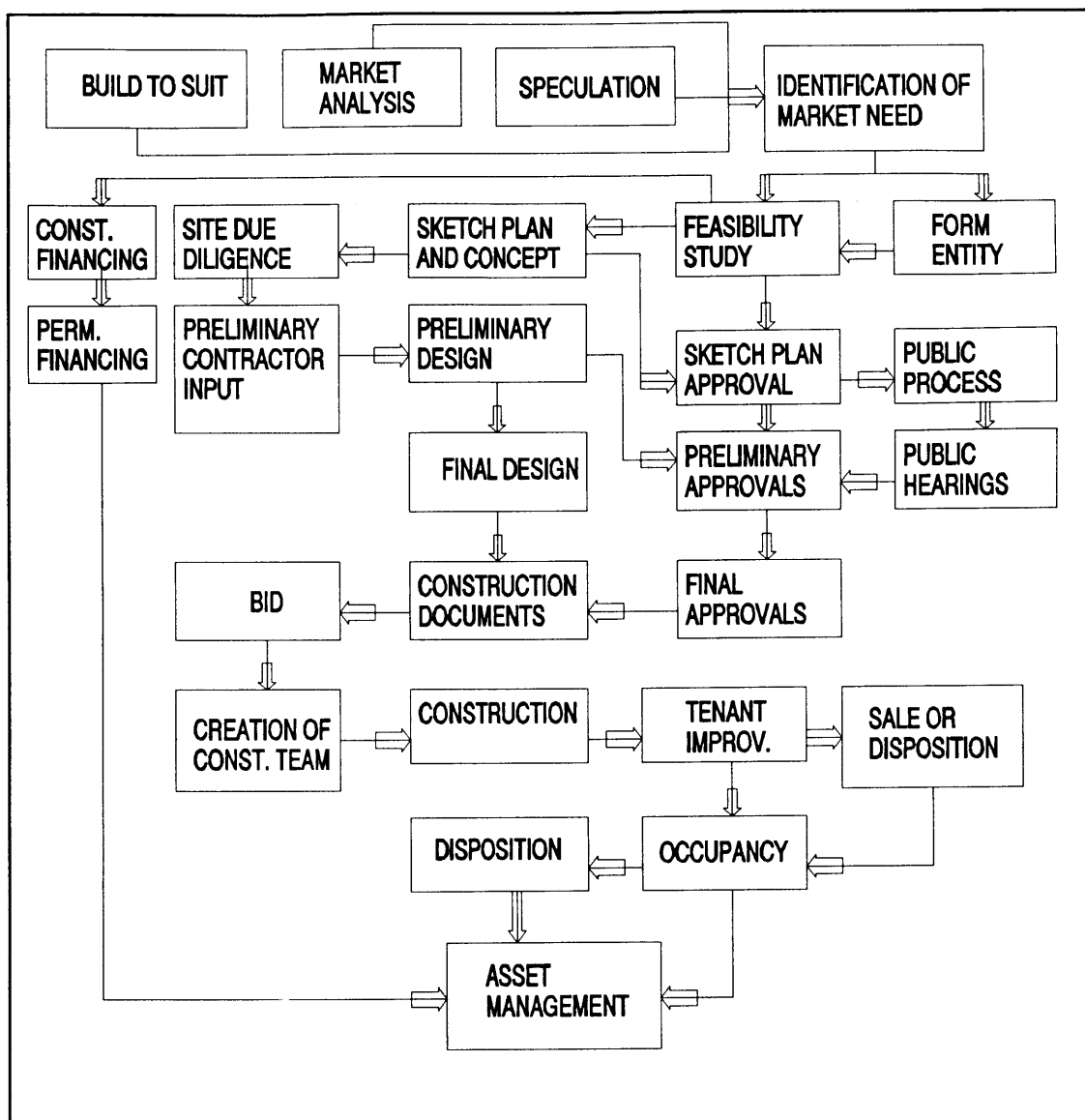


Figure 3. The Real Estate Process

The process begins with the identification of a market need. The idea to develop can originate in a variety of ways including a build to suit contract, a market analysis, and speculation. The developer then conducts a feasibility study and forms the entity which will develop the project. In many cases, a developer forms a new entity for

each new project in order to minimize financial liability. Many lenders are no longer comfortable with this and are requiring that the developer disclose other assets as collateral.

The depth of due diligence varies with the experience of the developer. However, essential ingredients in a thorough due diligence include the review of environmental, legal, and governmental issues. A contractor and design team are often consulted at this stage regarding the feasibility of the proposed project. This preliminary technical analysis produces sketch plans and preliminary designs which can then be used to initiate the approvals process.

The approvals stage requires the collaboration of many different entities and is often the most time consuming part of the process. Most municipalities require sketch plan, preliminary and final approvals along with lengthy and rigorous environmental reviews. The public is given the opportunity to voice their opinion and contribute to the development. Once approvals are complete, construction can begin. The final stage in the development is occupancy and management of the asset.

Beginning with portfolio management, the remainder of chapter three describes the real estate process by illustrating the behavior of each "team" member individually. The sections include a description of entity relationships and information flow between organizations.

Portfolio Management³: Owners of large real estate portfolios must look at how a *portfolio* of deals works together. In some cases, the impetus behind an acquisition or disposition is to achieve diversification within a portfolio. The portfolio manager is, therefore, involved early and late in the development process. In the beginning, it is in the capacity of selecting the asset and at the end by managing it to meet the investors criteria. A common tool used in portfolio management is "Modern Portfolio Theory" (MPT). *"MPT is a collection of ideas about how markets work and how assets should be priced."* [Louargand, 1992]. Figure 4 illustrates the process. The four major categories of data that a portfolio manager uses in MPT are property specific, systematic, local and regional markets, and economic and geographic location. When analyzed by a portfolio manager, this information produces a plan for a diversified portfolio.

Appraisals⁴: These services are required by lending institutions, developers, and buyers. The appraisal must provide an accurate valuation of the asset given market conditions, construction costs, type of property, lease characteristics, purpose of appraisal, comparables and physical attributes as shown in Figure 5. The three approaches for valuation are market comparables, replacement cost, and discounted cash flow.

³ The knowledge about real estate portfolio management was adapted from a graduate course titled "Real Estate Portfolio Management", taught at the MIT Center for Real Estate by Marc Louargand. The information in this research regarding portfolio management was reviewed by Marc Louargand.

⁴ The knowledge about appraisals was adapted from graduate courses at the MIT Center for Real Estate and an interview with Brad McMillan, formerly a Project Manager with American Appraisal Associates.

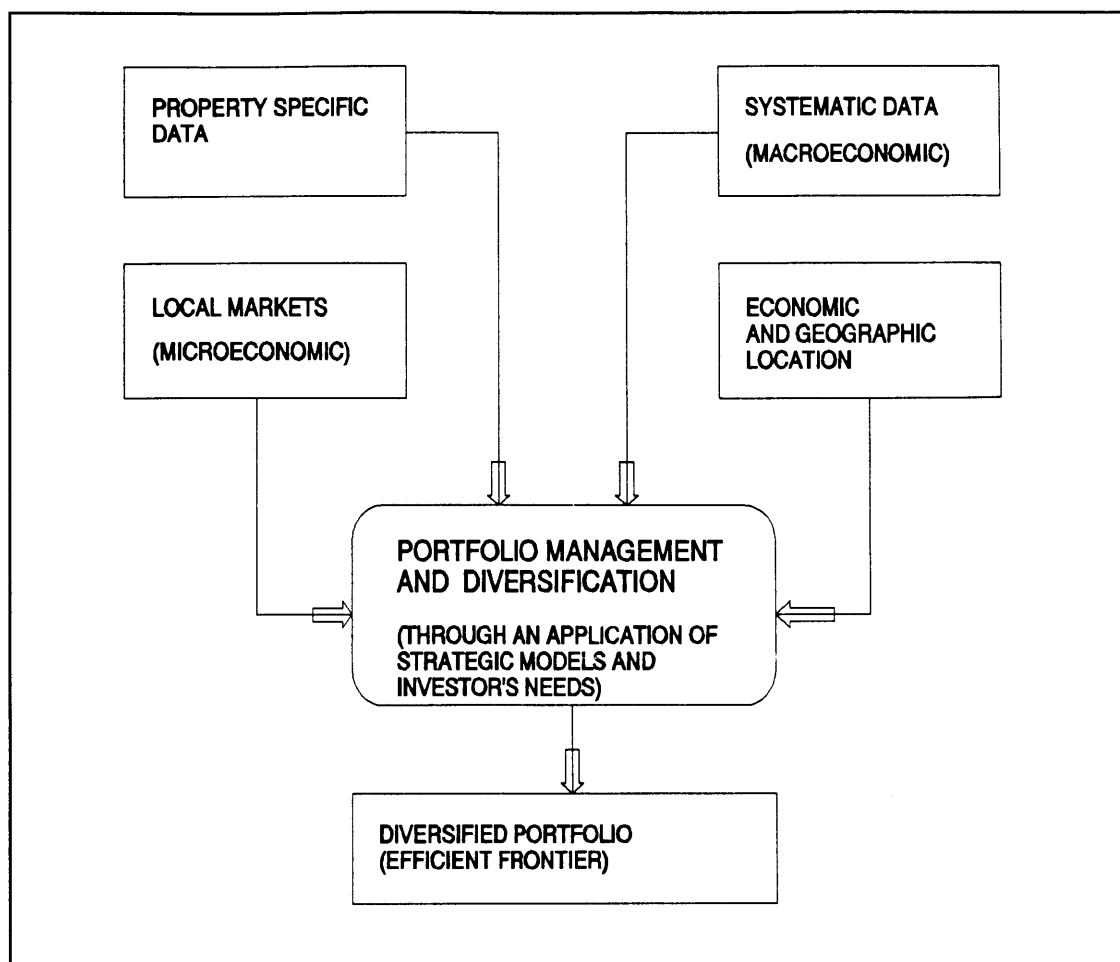


Figure 4 The portfolio management process

The appraiser uses judgement and expertise in arriving at a logical combination of the three approaches in a valuation.

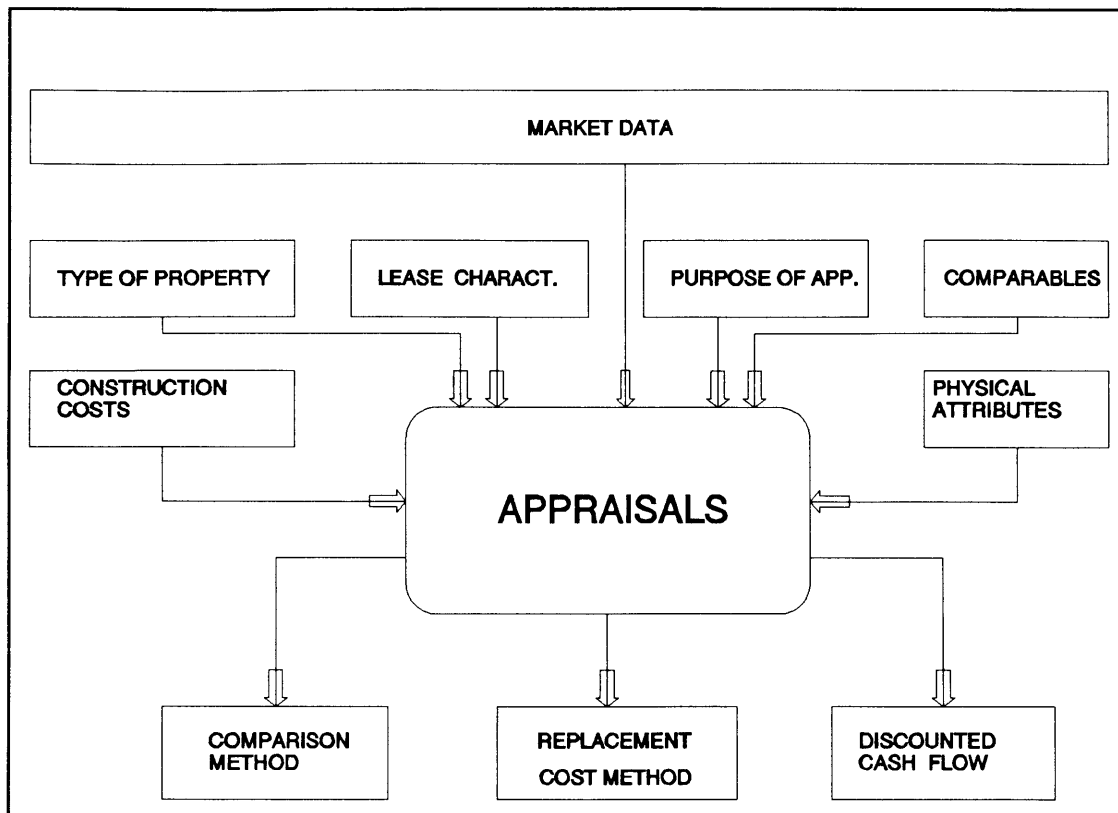


Figure 5. The Appraisal Process

Brokerage⁵: Traditionally the primary function of brokerage has been to transfer information and make connections between prospective occupants and developers. A new trend has been for brokers to act as tenant representatives. As shown in Figure 6, the broker must interact with tenants, developers, and other brokers. Tenants define the need, often with the assistance of their own space planner. The

⁵ The sources of knowledge for the brokerage industry were interviews with students and faculty at the MIT Center for Real Estate.

developer provides access to the project contractor, space planner and architect to assist in defining the available space. An understanding of the market and collaboration with other brokers help the project broker to efficiently lease the asset. The final stages of the leasing process require legal advice from the developer's, and tenant's attorneys.

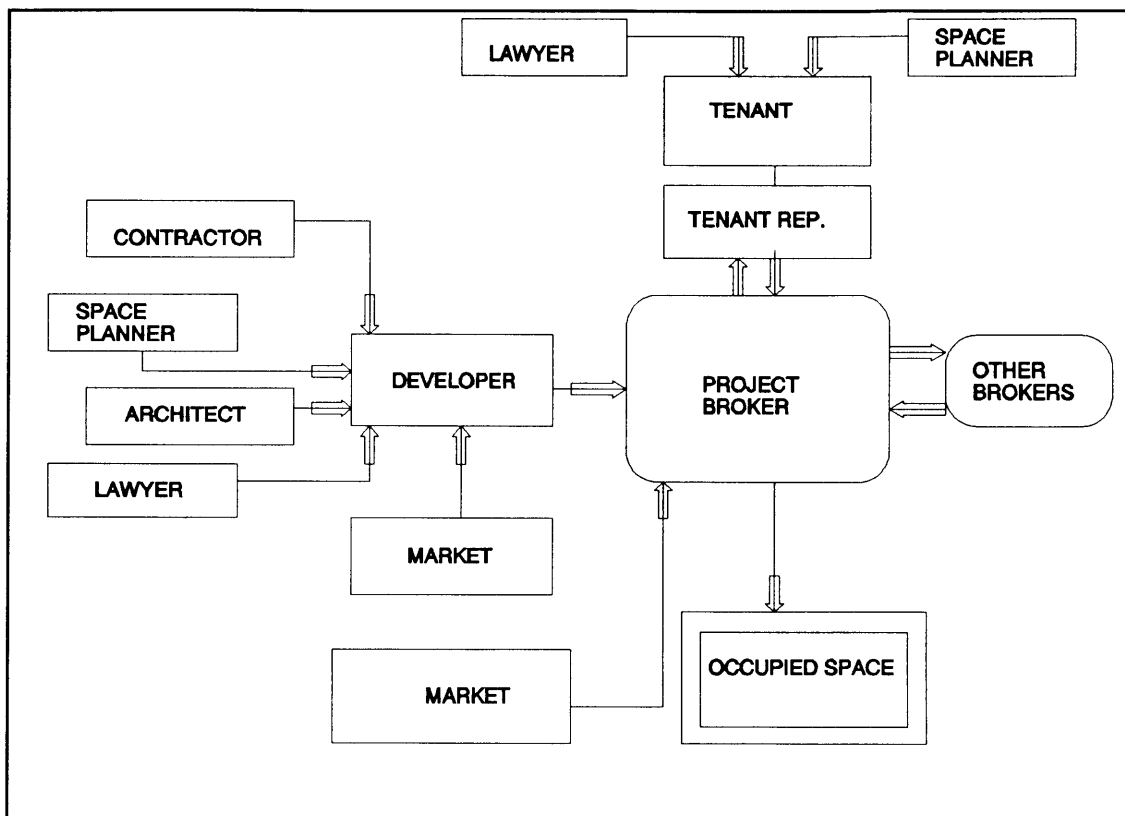


Figure 6. The Brokerage Process

Legal⁶: Figure 7 illustrates the legal process. The four major tasks of the developer's lawyer are to provide advice on the following: (1) form of development entity (e.g., sole proprietor, or general partnership with limited partnerships); (2) deal structure; (3) general conditions of construction documents; and (4) financial contracts, lease structures, and title insurance. In this process, the lawyer must interact with an environmental and land use consultant, tenants, property owners, and partners (can be limited partners, (LP)) and/or primary developer (general partner, (GP)).

Developers and risk⁷: The majority of risk in a development project falls with the developer and the financial partner. Development risks can be characterized as company specific, project specific, or systematic and financial. Examples of systematic risk are economic activity, capital availability, inflation and tax policy. An example of a project specific risk is a first time developer.

The management of risk is one of the areas where an experienced developer can add significant value to the project. Figure 8 illustrates the risk management process which begins by identifying the broad concepts that cause actual returns to deviate

⁶ The knowledge source regarding legal issues was an interview with Lawrence Bacow, Esq., Chairman of the MIT Center for Real Estate and professor for a graduate course titled "Legal Issues in the Development Process". Additional detail was obtained from course notes on the subject.

⁷ The knowledge source regarding risk in real estate was an interview with Tom Steel, director of the MIT Center for Real Estate. Additional information was extracted from a graduate course in real estate finance taken by the author at MIT.

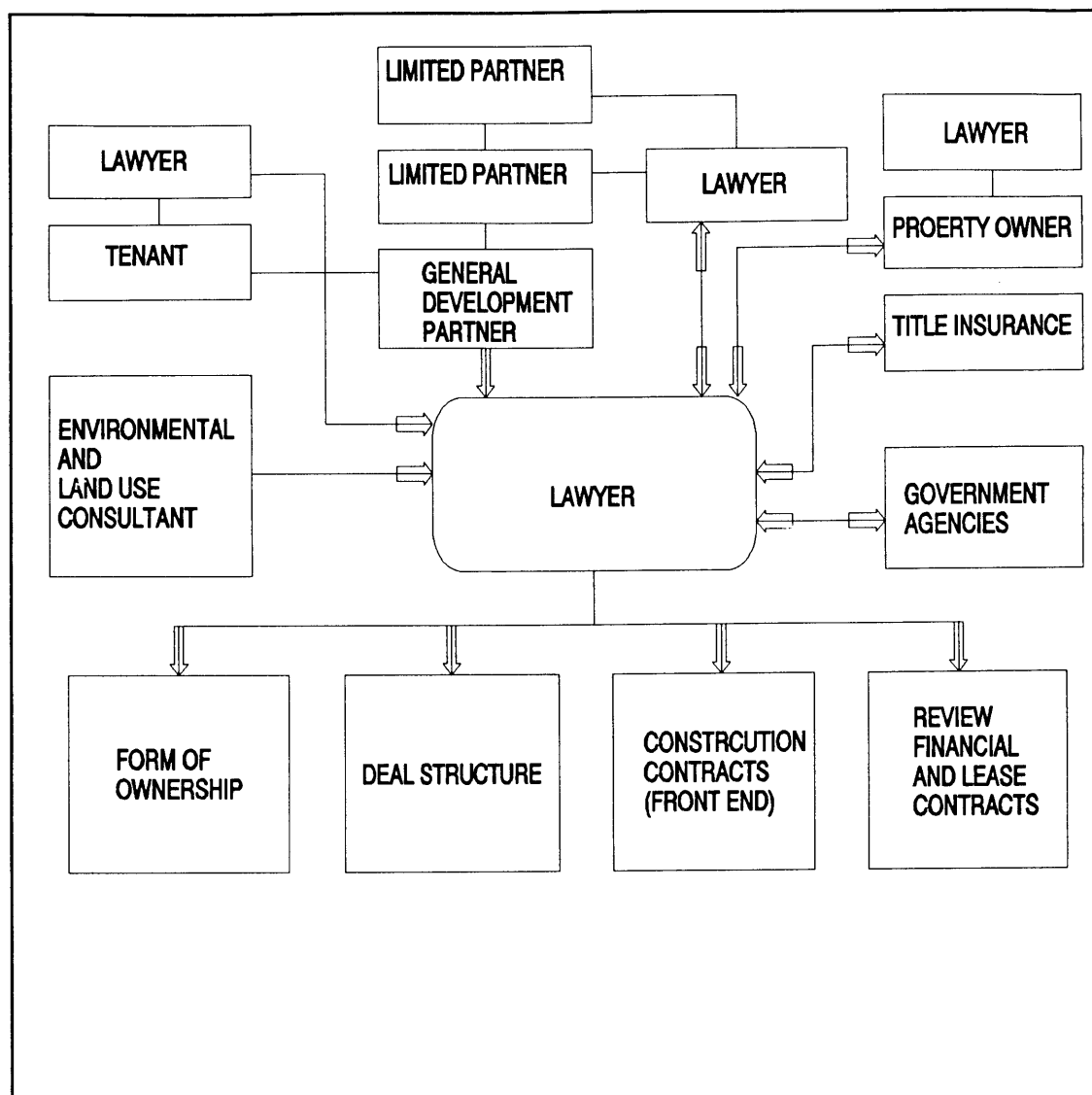


Figure 7. The Legal Process

from expected returns. The developer can then set the minimum hurdle rates required for a desired return. To mitigate project specific risk, the developer can: (1) acquire a better understanding of the risk through due diligence; (2) buy insurance; and/or (3) use MPT in portfolio diversification. The final stage in the risk management process is the ability to realize the calculated risk. Unfortunately, many recent real estate developers have grossly underestimated the potential risks.

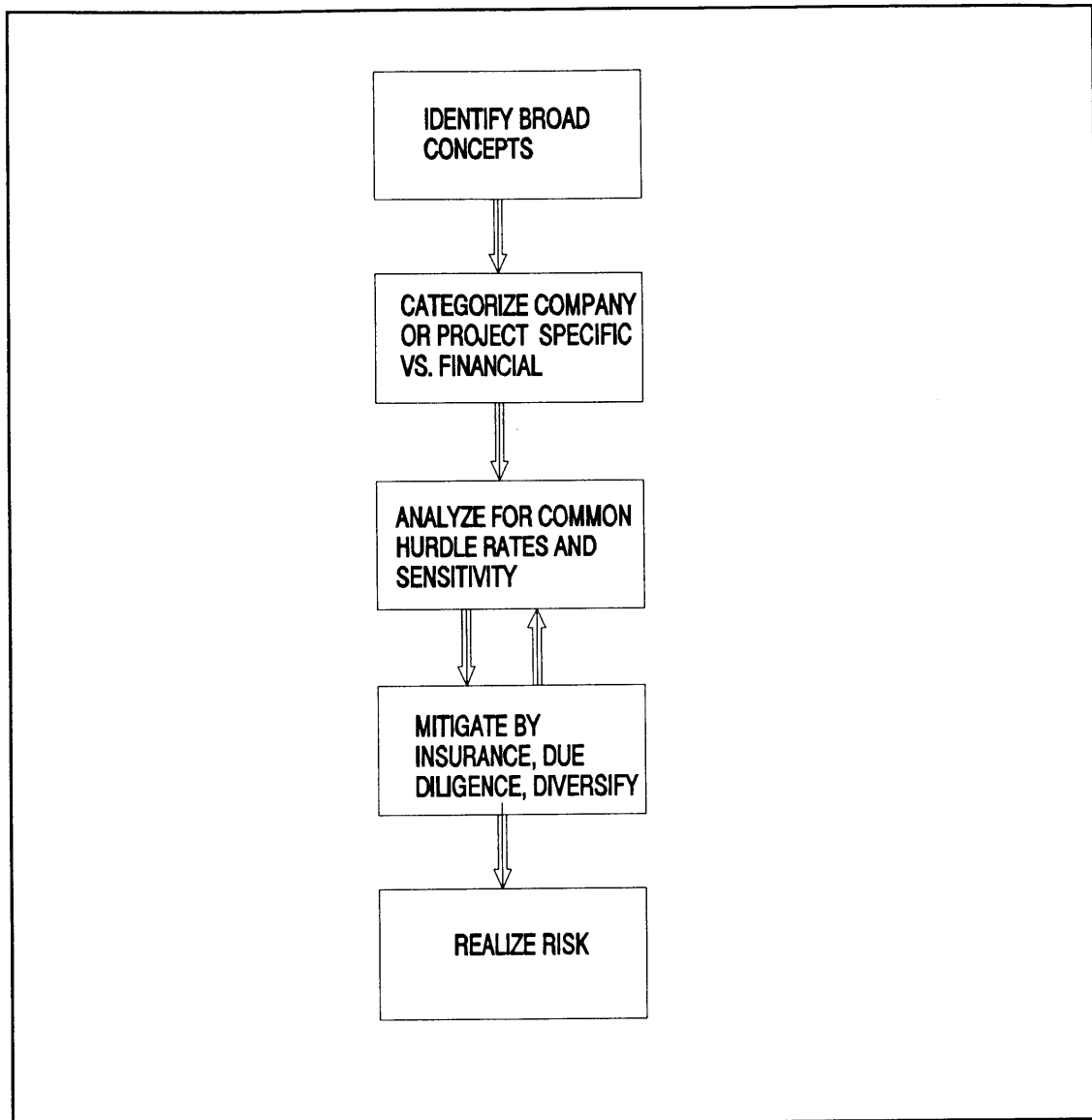


Figure 8. The Risk Management Process

Real Estate Development Financing⁸: All development projects require some method of financing. Figure 9 illustrates the real estate lending process. Sources of capital vary and include commercial lenders, government and private investors. Early in the development process, a financial institution determines whether a project is worthy of financing. Factors considered by the lender include the financial strength of the borrower; background such as years in business and references; payment records; market potential; and the geographic location of the project. If the loan is approved, the amount, interest rate, and type of loan are determined. The final stage is the loan monitoring process.

The lending process can also be further refined into three analyses: the primary analysis considers the actual financial performance of the asset; the secondary analysis examines the underlying value of the collateral; and the tertiary repayment examines the guarantor support or additional collateral value. This refinement in the lending process allows the lender to be better prepared in case the borrower defaults.

⁸ The knowledge about real estate finance was adapted from a graduate course at the MIT Center for Real Estate titled "Real Estate Finance", fall 1991. Additional information was obtained from an interview with Tom Steel, formerly CEO of Perini Land and Development Company.

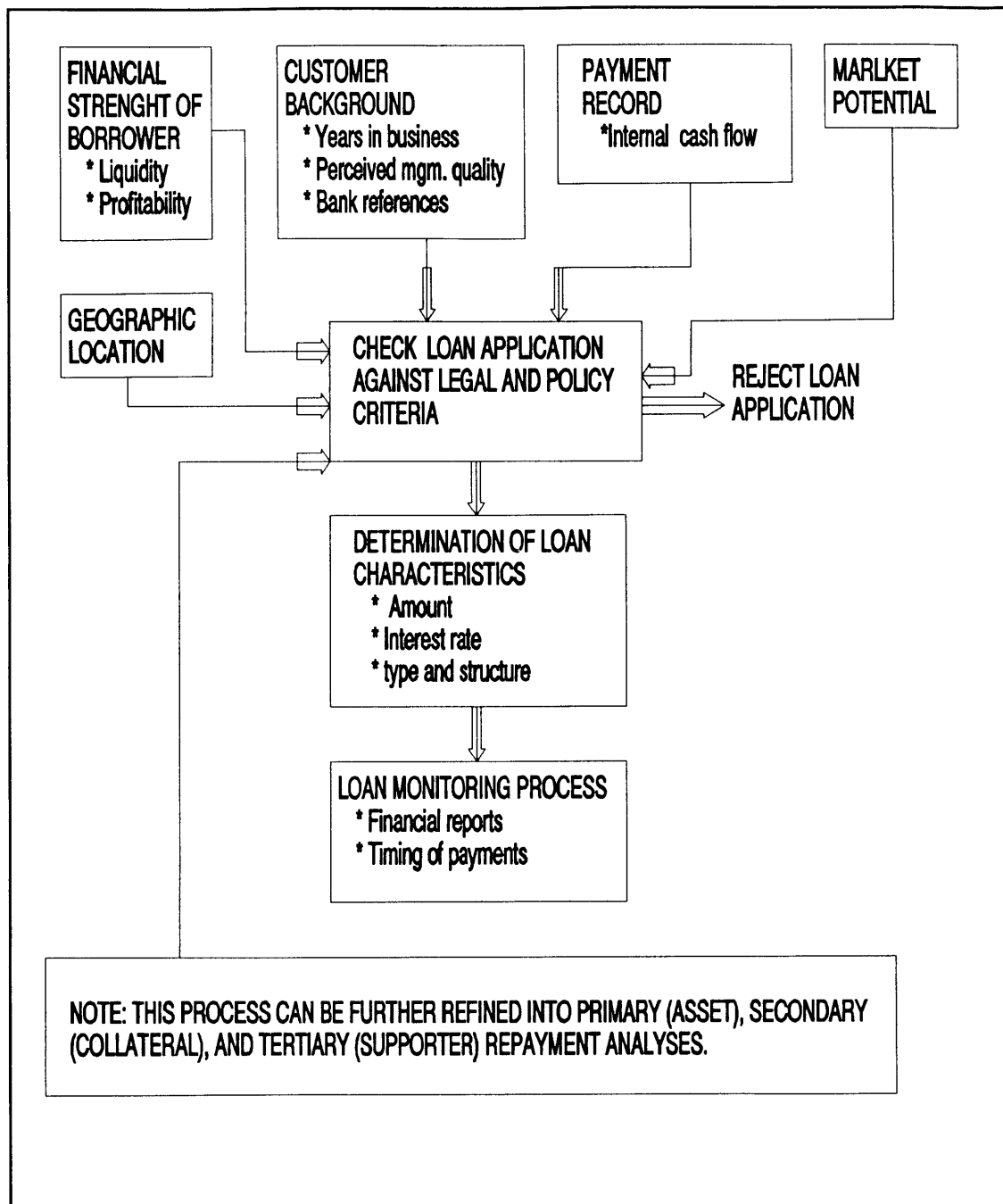


Figure 9. Real Estate Lending

The Approvals Process⁹: Perhaps the most varying of all components of the development process is the approvals process. Each state has different laws, procedures and requirements for land use development; however, local governments use four common tools to regulate developers [Ellickson, 1981, p. 36]: (1) zoning ordinances; (2) subdivision regulations; (3) general regulations; and (4) building and related codes.

Rather than attempt to describe the entire approval process, this section will illustrate the mechanics of the process using a zoning change as an example (see Figure 10).

A large variety of entities can initiate a zoning change. These include but are not limited to: city council, planning board, regional planning agency, board of development, board of appeals, registered voters, and land owners. The initial request is submitted to the city council along with all supporting documents such as plans and reports. The city council then refers the application to the planning board which in many cases acts as lead agency coordinating the process. Advice is sought from experts as required in making the decision of whether to amend the current zoning, reject the application, or adapt a new laws.

⁹ Information source: "The Law and Politics of Development", graduate course, MIT Center for Real Estate taught by M. Wheeler, Esq., spring 1992.

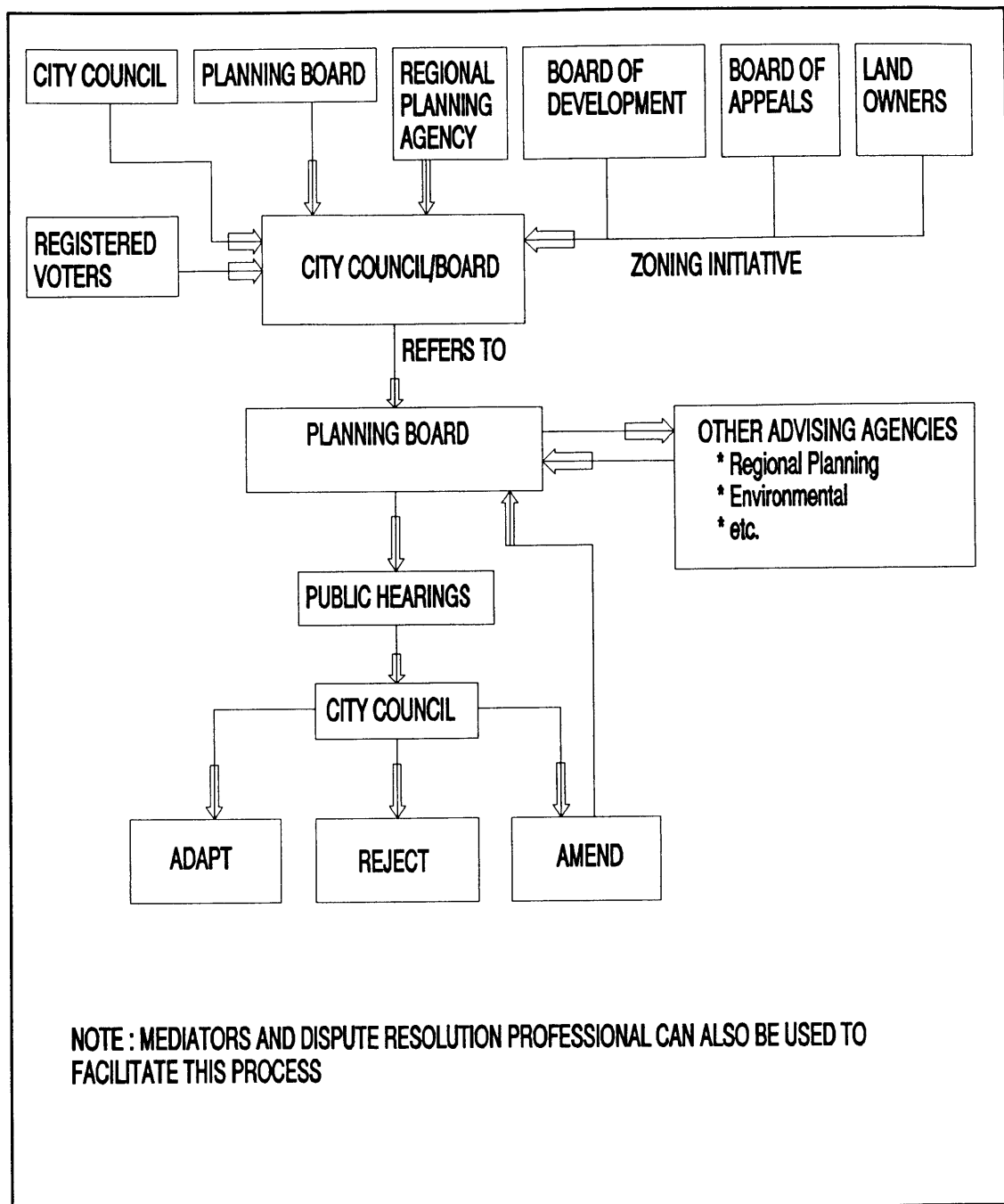


Figure 10. An example of a zoning change

A recent trend in the approval process has been the increasing involvement of public groups. Developers are beginning to realize that neighborhood and environmental groups can make important contributions to the process. To facilitate the interaction between the developer, government, and public groups, a mediator or dispute resolution expert is often hired. Although helpful, the increasing volume of information in the approval process has made it impossible for a mediator to incorporate the opinions of all individuals who may want to contribute. In the long term future, computer technology may advance to the point where information can be collected by a central "approvals system" in a network. An example of this application would be that each and every resident in an area could electronically submit comments regarding proposed developments. The system would then intelligently sort comments and provide summaries as to the public opinion. This tool would not replace, but facilitate the public approval process by intelligently managing information.

This chapter has provided a brief overview of the real estate development process. Further refinement would include in-depth interviews with a diverse cross section of domain experts from each component of the process. Once a knowledge base is accumulated, the task of knowledge maintenance begins. The model of the real estate process is dynamic, and as such must be updated continuously. An intelligent computer environment which can be used to model the real estate process is presented in Chapter four.

CHAPTER FOUR

An Object Oriented Model of the Real Estate Process

This chapter is a vision of the future of technology in real estate where computers will play an important role in enhancing collaboration and integration between the team members in the process. This Chapter is intended for those real estate professionals who are technically inclined and also for computer scientists. A conceptual architecture for an object oriented computer environment for the real estate process presented herein.

Chapter three is the basis for the application of OOT to real estate. For some computer scientists, entity relationship diagrams and flow charts are adequate descriptions for codification. However, as the use of OOT becomes more widespread, software developers are using structured modelling methodologies. The following should be identified when creating an object oriented environment: key objects and relationships; attributes (structure); internal operations (behavior); and external operations (interface behavior). Once the objects have been identified, class hierarchies can then be developed followed by implementation of each object. The objects specified in this section represent an initial attempt in an iterative process.

The first step in creating the object oriented model of real estate was the selection of objects. *Objects should be "tightly cohesive and loosely coupled"* Figure 11

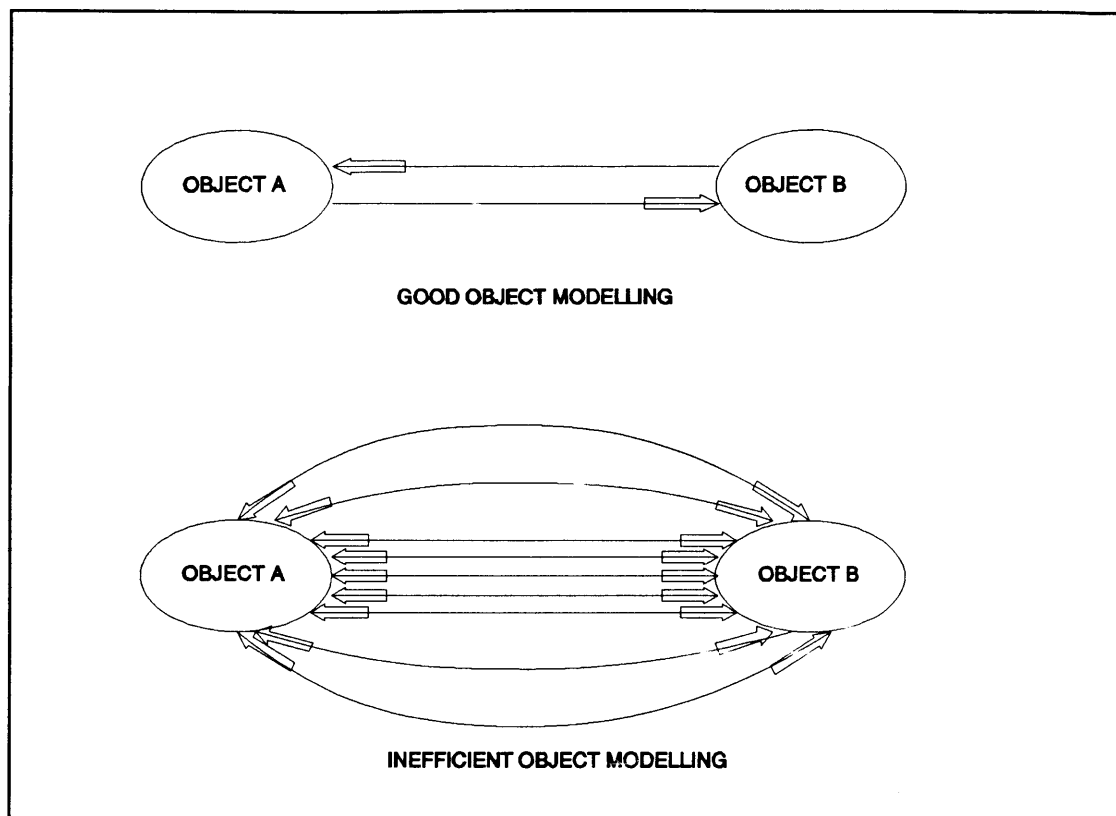


Figure 11. Object modelling

illustrates this point graphically. Good object modelling minimizes the information flow between objects A and B. A large flow of information between objects A and B is inefficient as shown in the lower part of Figure 11. In addition, all functions within an object should have some sensible relationship with each other, i.e., "tightly cohesive"¹⁰.

¹⁰ Adam Pease, B.S., computer science, Worcester Polytechnic Institute, M.S., artificial intelligence, Worcester Polytechnic Institute. Mr. Pease is currently applying artificial intelligence techniques in industry.

The following section outlines methodology used in the creation of the objects for the computer environment. Certain objects are specified and then decomposed into smaller classes.

Object Specification

There is no one correct way to decompose a problem into objects. The goal of this work has been to model "real life" objects as closely as possible and to make each object lightly dependent upon others for information. This approach maximizes the system's adaptability to change by creating a functionally modular environment. Each component of the real estate process shown in Figure 1 has, therefore, been chosen as an object. This decomposition of the process has the advantage of resembling the way developers think. For example, when a developer requires architectural services, an "architecture" object comes to mind.

Another design goal was to create objects such as the "law" instead of the "lawyer". The "law" encompasses a larger domain of knowledge than the individualistic "lawyer" object. This broadness of expertise is accomplished by including the expertise of a large number of lawyers in the "law" knowledge base. The product is a "collective" rather than an isolated legal opinion.

Another reason for specifying a "law" object rather than a "lawyer" object is to reduce the influence of ego and irrational human behavior on the decision making process.

Although the legal object will indirectly encapsulate some human characteristics, it is an inanimate and fairly rational object.

In addition to specifying the objects, their "states" must also be specified. A state is the form that an object maintains when performing a certain function. An example of this is the law object which may have three distinct states; site control, contract documents, and leasing. These states are illustrated graphically in Figure 12.

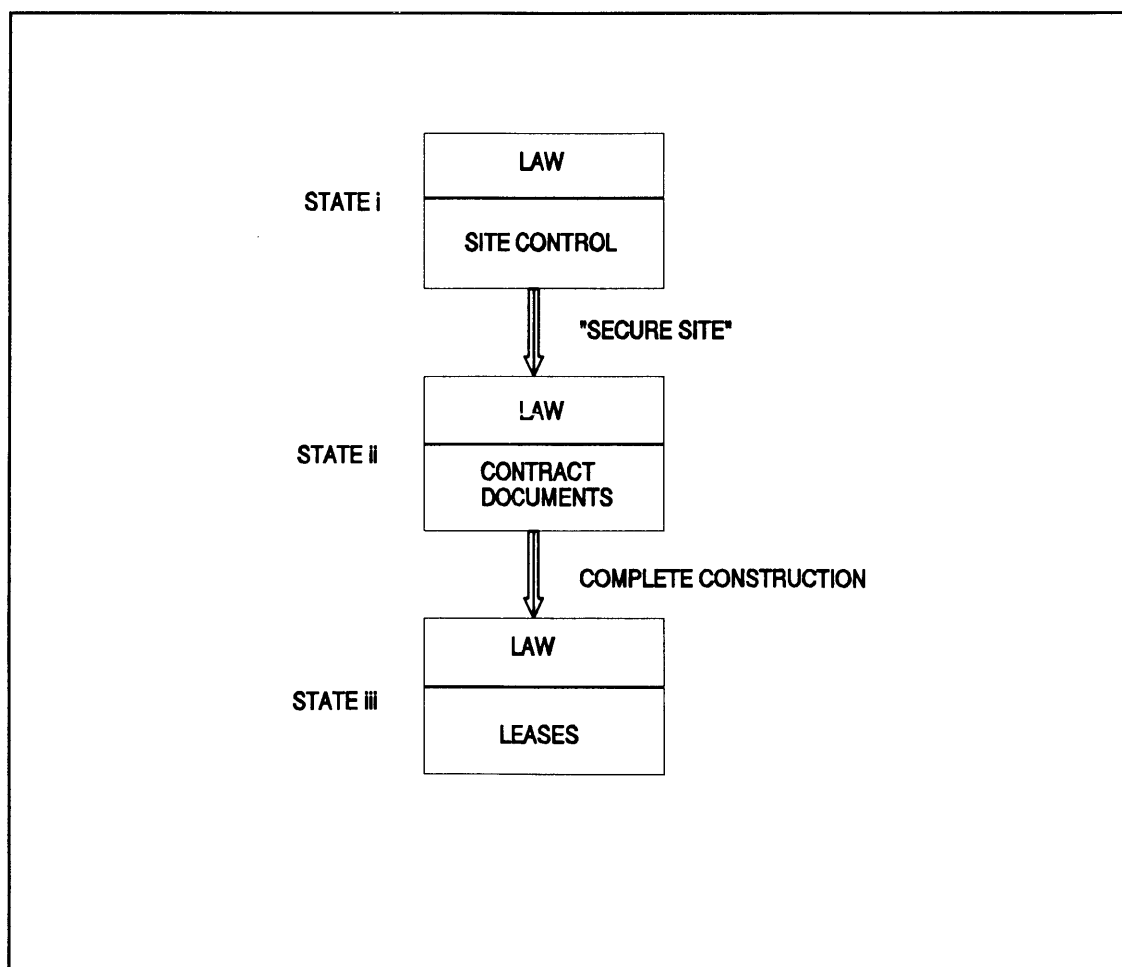


Figure 12. Law state diagram.

To assist the applications expert in the codification process, each object is briefly described in the next section. These descriptions may have been extracted by the applications expert from the information provided in chapter three. However, the simplicity and concise nature of a list format is recommended to avoid errors and misinterpretations of the domain. A list of objects follows:

object: real estate law

description: The real estate law object contains the appropriate knowledge and expertise necessary to obtain control of the site, structure deals, review financing and other contracts, examine the legal implications of environmental issues, and aid in the approvals process. Each of the above categories can also be classified as an object within the legal object.

objects: engineering, architecture and construction.

description: Rather than attempt to describe these objects in this work, the DICE research is recommended for a more thorough description [Sriram, 1991].

object: government

description: The basic functions of the government object are to regulate and set standards for development. The complexity, variety and size of the knowledge base required for this module warrant substantial decomposition. Initially this will be achieved by several layers of functional decomposition. For example, it can be

broken down into: environmental approvals, building department, architectural review boards, etc. Then the decomposition will proceed with more procedural decompositions such as "application to subdivide" and "building permit".

object: planning

description: The planning object parallels the government object by contributing to the regional and local urban planning efforts of the process.

object: brokerage

description: The brokerage object matches potential users of space with vacant properties. In addition, it provides valuable advice about the operation of real estate and local markets to a variety of other objects.

object: user

description: The user object refers to the occupant of a completed space. It ultimately specifies the location, demise, and character of the space, thereby making it a very important element in the process. The object can function in a variety of states by owning or leasing the space it occupies.

object: portfolio\asset management

description: This object provides advice for the composition of numerous assets in forming a "diversified". It also is the entity responsible for the operation of assets.

object: appraisal

description: The appraisal object provides the value of assets. It is further decomposed into the following objects: lease characteristics, purpose of appraisal, comparables, physical attributes, construction costs, and market data.

object: finance

description: The finance object analyzes the "credit-worthiness" of the development object. It is a key object in deciding the amount, method and terms of financing.

* * *

Although the description of the objects above is not exhaustive, it provides a basis for the applications expert in codifying higher level objects. The working computer environment will require a much more specific description of the structure and behavior of each object including interaction patterns with other objects.

A global view of the integrated computer environment for real estate is shown in Figure 13. This figure shows that each of the "team" members in the real estate process will utilize its own individual computer system to communicate with the central system and database. Specific functional processes will be confined to local systems while those that are more general and affect other objects will be open to the central system. An example of a local process is the final structural analysis of

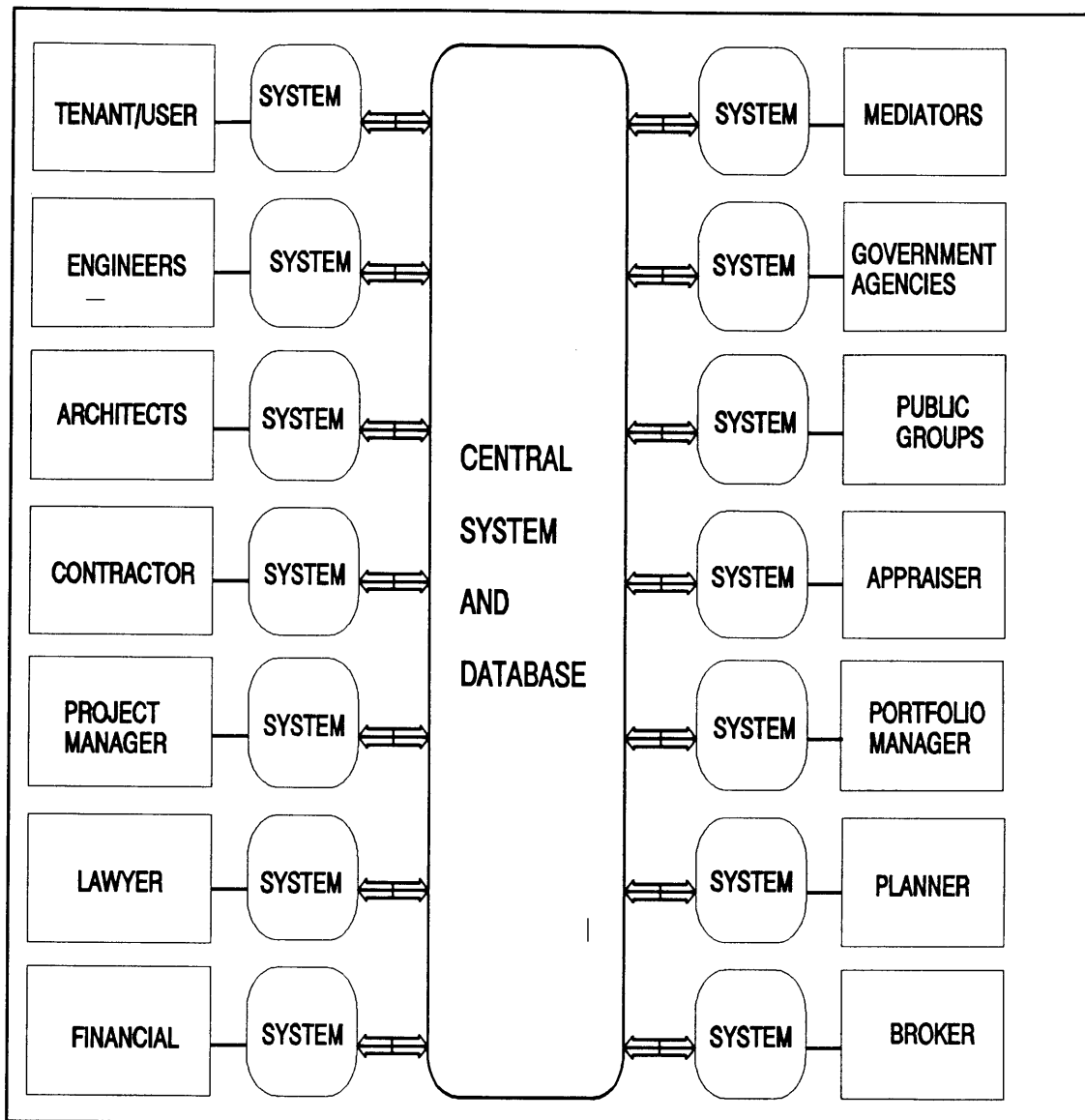


Figure 13. An integrated computer environment for real estate

a building. Examples of general processes are public approvals and project planning. The intent of this approach is to increase the modularity of the overall system so that changes in a specific domain will not require communication with the central system.

The following section is the next step in the normal progression of events in the evolution of an object oriented system. It is a summary of the flow of data from one object to another, or the object's *behavior* and includes: the identification of its data requirements and their origins; the output that the object produces and the direction in which it flows; and a description of relationships between all objects. The only object that is analyzed to this level of detail in this research is the appraisal object. A complete analysis of each object is extremely time consuming and beyond the scope of this work.

Data flow specification.

The first task regarding the appraisal object was to identify communication patterns with other objects. The following is a short list of objects that interact with the appraisal object and a brief description of why they require property values:

- * Engineering, architecture and construction objects need appraisals of assets for value engineering studies, especially in the conceptual design stage.
- * Tenant and user objects communicate with the appraisal object to anticipate and confirm their space costs.
- * The government object will not necessarily require appraisals, but will need cost figures in assessing taxes and establishing development fees.
- * The portfolio management object interacts with the appraisal object on a regular basis. Real estate portfolios are appraised at least once every year in

order to assess whether or not the portfolio is meeting the investor's criteria.

- * The brokerage object may use an appraisal to establish an asking price for an asset.
- * The financial object usually requires several different appraisals of an asset prior to approving a loan.

As shown, appraisals are required by a variety of objects for different reasons. By modelling this process using OOT, the advantages of polymorphism can be applied. This occurs when the same message means roughly the same thing to different objects. For example, the financial object interacts with the appraisal object for a different reason than the engineering object. The same appraisal object can, however, be used in both cases.

A second layer of knowledge in modelling the appraisal process is identifying the actual information that is passed between objects. The following information has been extracted from a "client request sheet" prepared by the American Appraisal Associates, Real Estate Advisory Group:

General information required for the appraisal includes: valuation date, investment name, property type, address, new or update appraisal, portfolio manager, developer/partner/owner, property manager, in-house leasing agent, and outside broker/leasing agent.

Appraisal methodology can be one or all of three approaches: income, market, and/or cost.

Physical characteristics are shown on electronic copies of site plans and/or plats that include floor-to-area ratio (FAR), gross and net acres or square feet, and location maps from a GIS network. In addition, information as to whether the property is operating, under construction, being leased, vacant, or to be developed is required.

Financial and investment data includes joint-venture agreement(s), a summary of the business and development plan, projected 3rd party debt balance(s), and PRO-JECT or financial analysis package diskette. The following information is also helpful:

- * **Income statements** that have an itemized breakdown of all operating expense accounts and balance sheet data. This information should include previous and current years (if applicable).
- * **Stabilized budget statements** which refer to the budget of projected expenses when the property has reached stabilized occupancy should be submitted. These are used to set operating expenses stops. For properties in lease-up, the difference between a budget and a stabilized budget is the impact of lease-up on variable expenses.

- * **Rent roll & lease abstracts** for multi-tenant properties are preferred over actual leases. It is very important that rent rolls include all changes from addendum.
- * **Tax statements** including past returns and tax strategy should be submitted.
- * **Legal description & title report** (included in the joint venture agreement) should be submitted. A title report is needed to identify any easements and/or restrictions.
- * **Leasing status report** (asking rental & concessions) including a summary of any current leasing (negotiating, pending) activity including rental rates and concessions that are being offered should be submitted.
- * **Recent building sale/escrow** data must include information regarding recent building sale transactions in the area.
- * **A description of significant capital improvements** made or planned and a cost estimate should be submitted.
- * **Competitive supply/demand data** either externally or internally produced on both the overall and property specific competitive market for the property should be submitted. Information that typically summarizes historical construction and absorption activity, as well as projected future activity is especially useful.
- * **Status of development plans** should also be submitted.

It is often helpful to summarize the information presented above in graphical form by using object tables. Figure 14 summarizes the structure and behavior of the appraisal object.

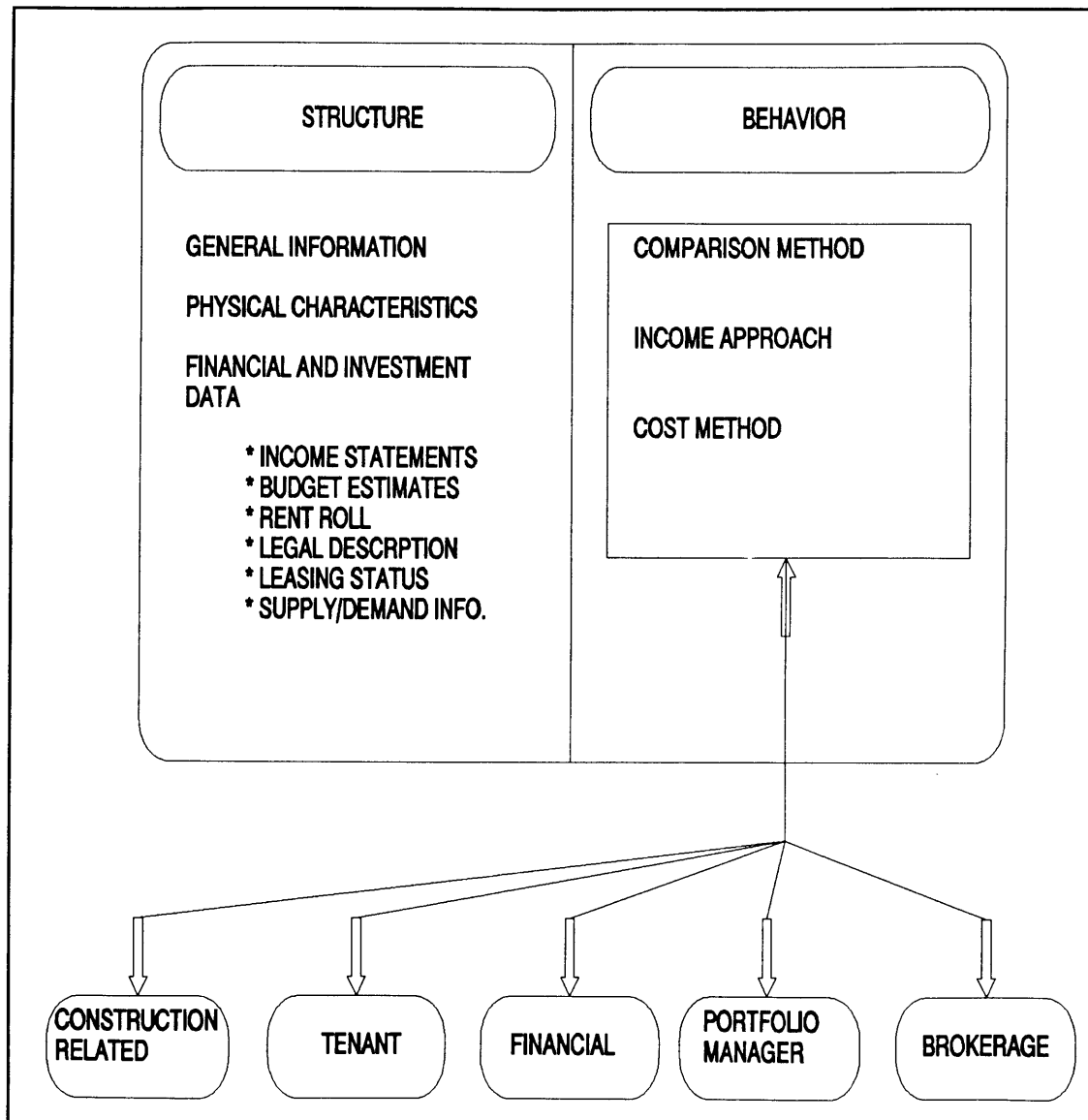


Figure 14 The structure and behavior of the appraisal object.

Its structure includes all general information, physical characteristics, and financial data. Its behavior is outlined by the three appraisal methodologies and the other objects with which it interacts. Some of these objects are construction related, tenant, financial, portfolio management and brokerage.

One quality of this model is the ability to experiment with it prior to implementation. This can be done by substituting objects and rearranging the structure of the program to examine alternative scenarios.

Chapter four has described a very long term vision of an integrated computer environment for real estate. There are many software and hardware issues as well as organizational issues that must be resolved before such a system can be implemented. These issues will be discussed in chapter six. However, chapter five describes a more tangible application of computer technology that can be implemented in the very near future - **an intelligent and distributed real estate project scheduling environment.**

CHAPTER FIVE

An Application of Object Oriented Technology to Real Estate Project Scheduling

The intelligent and distributed real estate project scheduling environment is a tool that can be used from the conceptualization of a project to occupancy. The need for such a tool is exemplified in costly mis-communications and misunderstandings in the scheduling process. Even experienced developers cannot keep track of what their consultants are doing each day. The system described in this chapter is targeted at real estate developers and the organizations that surround them with the intent of increasing the efficiency of the project scheduling process. Chapter five consists of a technical description of the computer system followed by a section on implementation. The implementation section is recommended to both real estate professionals and managers of technology.

The function of the system would be to electronically merge and process work schedules from the various constituents in the real estate process. For example, the lawyer's schedule is checked against the engineer's schedule to determine if there are any conflicts. The results are posted in a revised global schedule. The system includes start and finish times for all events that would occur in a development project beginning with detailed schedules for the feasibility stage through occupancy. The process that is being modelled is illustrated in Figure 15.

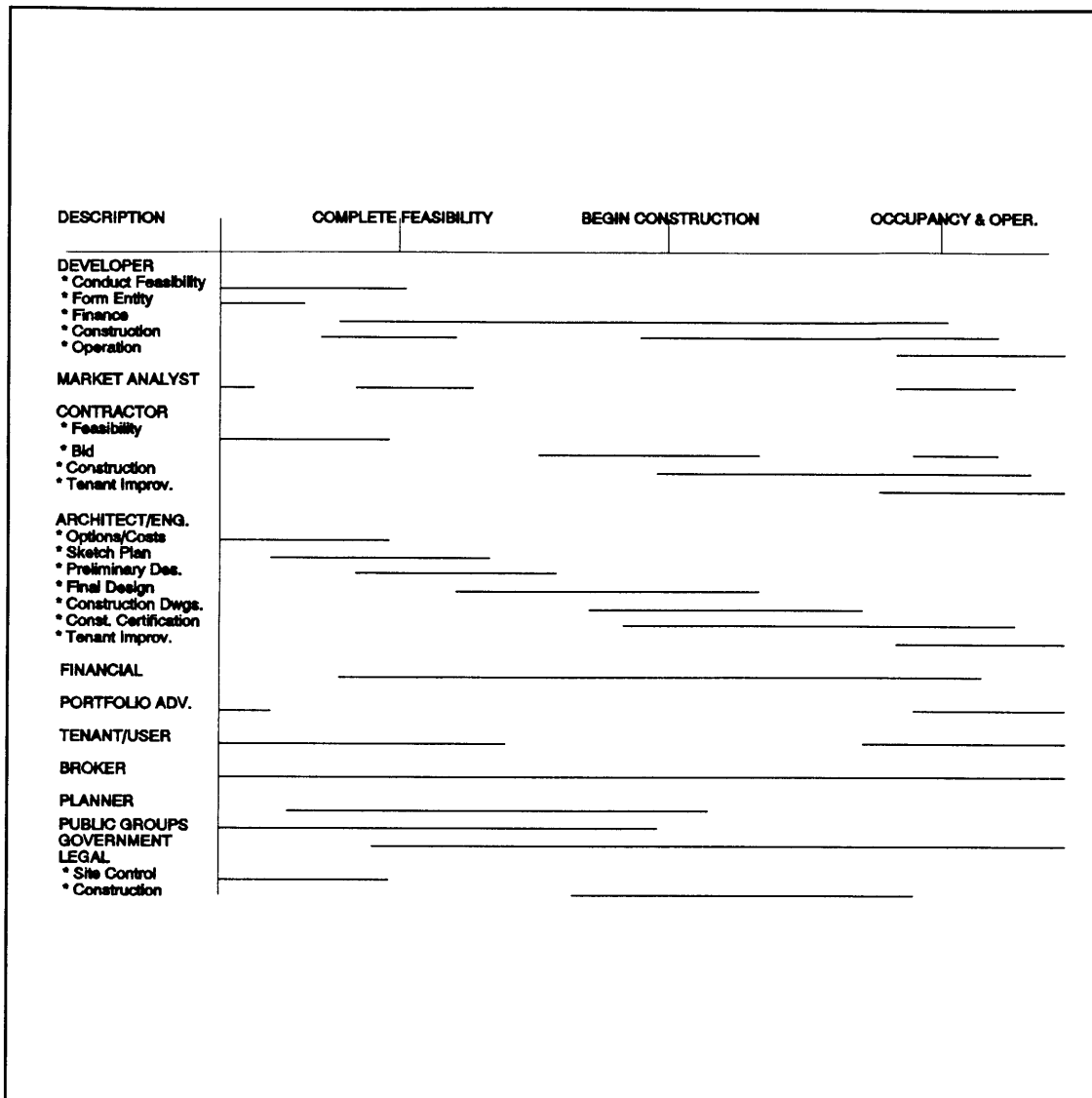


Figure 15 The Real Estate Development Schedule.

A key advantage of this system is that it does not merely transport and merge schedules, but adds value through the intelligent processing of them. The system will have a central rule base which will contain expert information from experienced developers about the scheduling process. For example, *"IF the environmental study*

is at the due diligence stage, **THEN** the engineering drainage study should be no further than in the preliminary stage". Although this rule is basic common sense, some developers have made this mistake, and, therefore, incurred additional and unnecessary engineering fees. If this rule is broken, the system will make the developer aware of this and provide an opinion. The developer will have the option of overriding the warning and proceeding with the schedule at hand, or making the required changes.

Unlike the many existing software packages¹¹ for project scheduling, **the system proposed in this work will not be an isolated computer package but an integrated and distributed, "on-line" environment that will assist the developer in coordinating the entire process.** This system is a component of the global environment described in chapter four. Higher level objects such as the "law" have not yet been incorporated. Instead, human interface with the system is required to enter changes in the schedule. The system can be envisioned as a network of distributed micro-computers with a central control mechanism that coordinates and allows communication for all of the different schedules that must be combined.

The software and hardware required can be implemented on IBM compatible personal computers - machines that are available in almost all offices. Communication will be achieved through modems thereby creating a "virtual

¹¹ Primavera is an example of project scheduling software that is commonly used in the construction industry.

network" (i.e., a virtual network is a system consisting of modems and computers that resembles an on line network.) that is cost efficient and flexible. From a technical perspective, a user would only need to purchase a modem, software and an IBM Personal Computer. (Implementation is discussed later in this chapter.)

The scheduling system would be distributed and contain a central database. As a result of interaction with other objects, this database will receive updated schedules, resolve and report conflicts, and distribute updates.

Each site will be equipped with a local system. The reason for having redundant localized systems instead of sharing one global system is to maximize modularity. Each site has its own local items and dependencies that it may need to change. By localizing, each producer of a schedule can make changes to a localized system without communicating with the central system. This brings the system much closer to being a truly distributed system with decentralized control and centralized processing. Additional functions that can be performed locally are: the addition of constraints; the reporting of constraints; and the retrieval of updates. When the distributed schedule is merged with the central site, all items and dependencies are transposed to produce a globally updated database.

The most important characteristic of the system is its "intelligence". This distinguishes it from existing packages by the ability to schedule dependencies and

activate relaxation and conflict resolution rules. For example, the start time of the final architectural design process does not necessarily have to begin after the preliminary design is complete. There may be an overlap of approximately 0-20% in these events. The scheduling system will contain the rules (intelligence) to realize this and act accordingly by either flagging excessive overlaps or dismissing small ones as normal.

Object Specification

The objects specified for the scheduling system are: schedule, schedule item, constraint resolver, dependency list, rule base, user interface, file interface, modem interface, dependency editor, rule editor, and report generator. These objects are briefly described below:

object: schedule

description: This is the entire schedule including all line items. The class definition of "schedule" includes: item list, global project number, current date, user ID, user type, etc.

object: schedule line item

description: This is an individual line item such as the preliminary design time of an architect. The class definition of "schedule line item" includes: start date, end date, name, entered by, comments, calculated/actual start, calculated/actual end.

object: constraint resolution

description: This object is responsible for the combination of individual schedules from the higher level objects described in chapter four. This can be done in two ways: by merging two schedules; or by merging one line item at a time. The method of merging can be decided later in the software development process.

object: dependency list

description: This object contains the knowledge required to establish the flow of events. For example, *"IF appraiser has not submitted the property appraisal, THEN financier can not approve the construction loan"*. The development of the dependency list evolves in stages. In the first stage, dependencies which do not have any slack are identified. In later stages, more "fuzzy" dependencies are identified. For example; *"construction of foundations can begin before a building permit is issued, if a conditional permit is issued"*.

object: rule base

description: The rules contained in the rule base object are not the same as those in the dependency object. They have been separated in order to facilitate a more efficient representation of the knowledge. Conceptually, separating the dependency rules is a more efficient design, especially since it makes updating the rules easier. An example rule in the rule object is: *"IF certificates and applications for payment have not been signed by the engineer, THEN do not apply for certificate of occupancy"*.

object: user interface

description: The user interface is an especially critical component of the system. It will be simple enough so that it can be used with little, if any, knowledge of the system. Hopefully this will reduce the "fear" associated with new computer systems. The user interface will consist of a user friendly menu that contains all of the commands necessary to run the system.

object: file interface

description: This object implements and manipulates the transfer and maintenance of schedule rules and dependencies on the disk drive.

object: modem Interface

description: The modem interface will facilitate communication between the user and the central system.

object: dependency editor

description: The dependency first translates information entered by users into code, then translates the various schedule from one form to another if necessary. A lawyer, for example may prefer to use a flow chart; the contractor many prefer to use a horizontal bar chart. The dependency editor will translate from one form to another.

object: rule editor

description: This is a syntactic, not semantic, translator. It translates rules that are entered by the application expert into code. To ensure that the appropriate individuals will enter rules, certain rule editors will be restricted to outsiders. For example, a developer will not be able to alter a registered architect's rule base.

In the future, the rule editor may be able to translate the meaning of a rule. To a lawyer a rule may look like "*IF final approval is procured, THEN review the front end of the construction documents*". To an engineer, the same rule may look like "*IF final design is approved, THEN prepare the front end documents*". Since the rule sparks the same event to two different entities, the rule editor will translate so that the other can understand.

object: report generator

description: Although most communication can be accomplished electronically, the industry is not yet ready to abandon paper copies. An essential component of the system will be a report generator which will provide graphical illustrations of updated schedules, a summary of changes, who they were made by and why.

* * *

Each individual system is very similar to the central system. The architecture of a typical user system is shown in Figure 16. Use of the system begins with a user entering a schedule of activities into the system. This information is then electronically mailed to the central system once every day or as necessary. The user interface is central to each individual system. It is linked to the schedule, schedule line item, file interface, report generation, rule editor, dependency editor, constraint resolver, modem interface, and of course, the user.

Each user communicates with the central system using his/her own individual microcomputer system as shown in Figure 17.

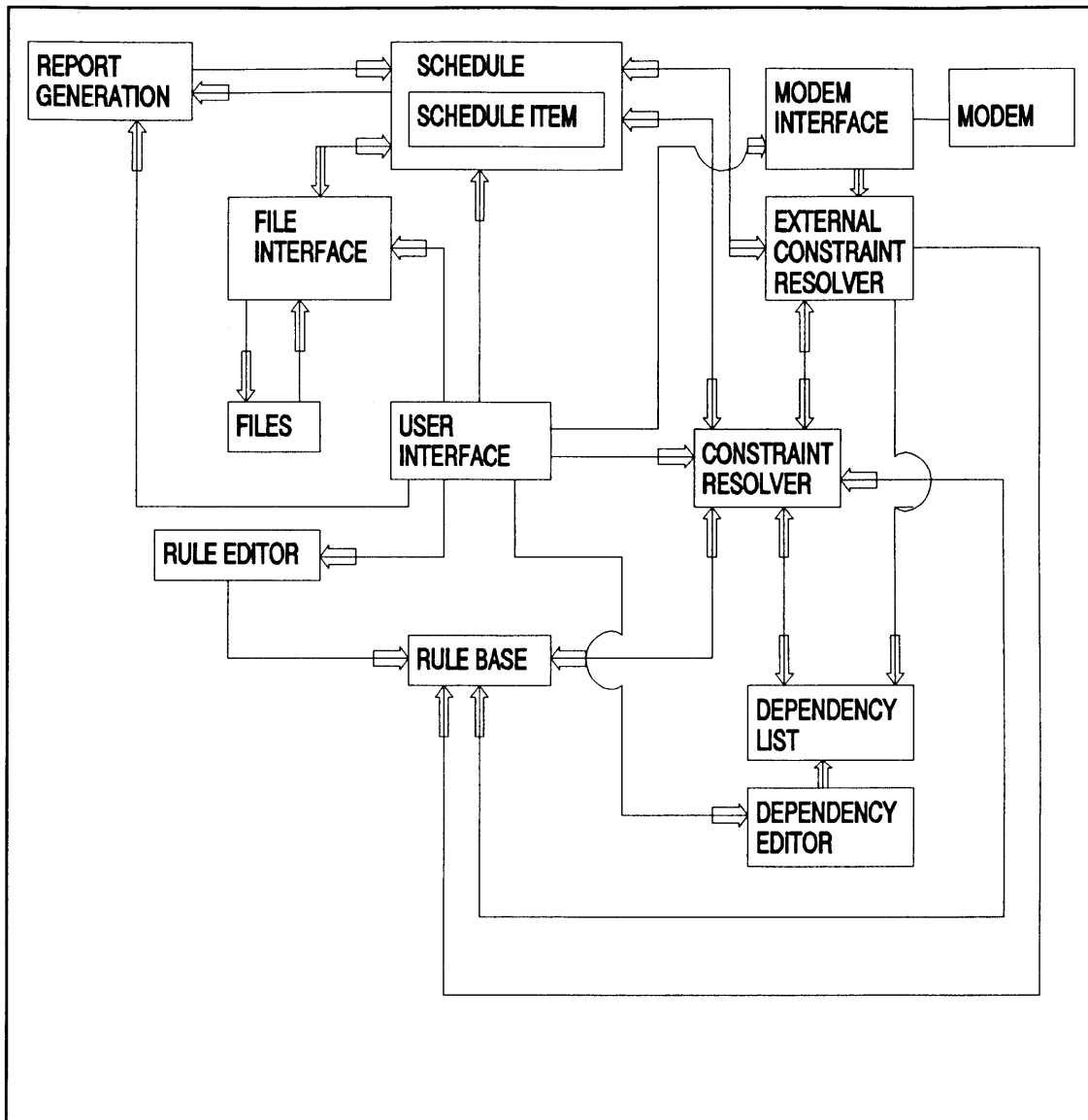


Figure 16. System architecture

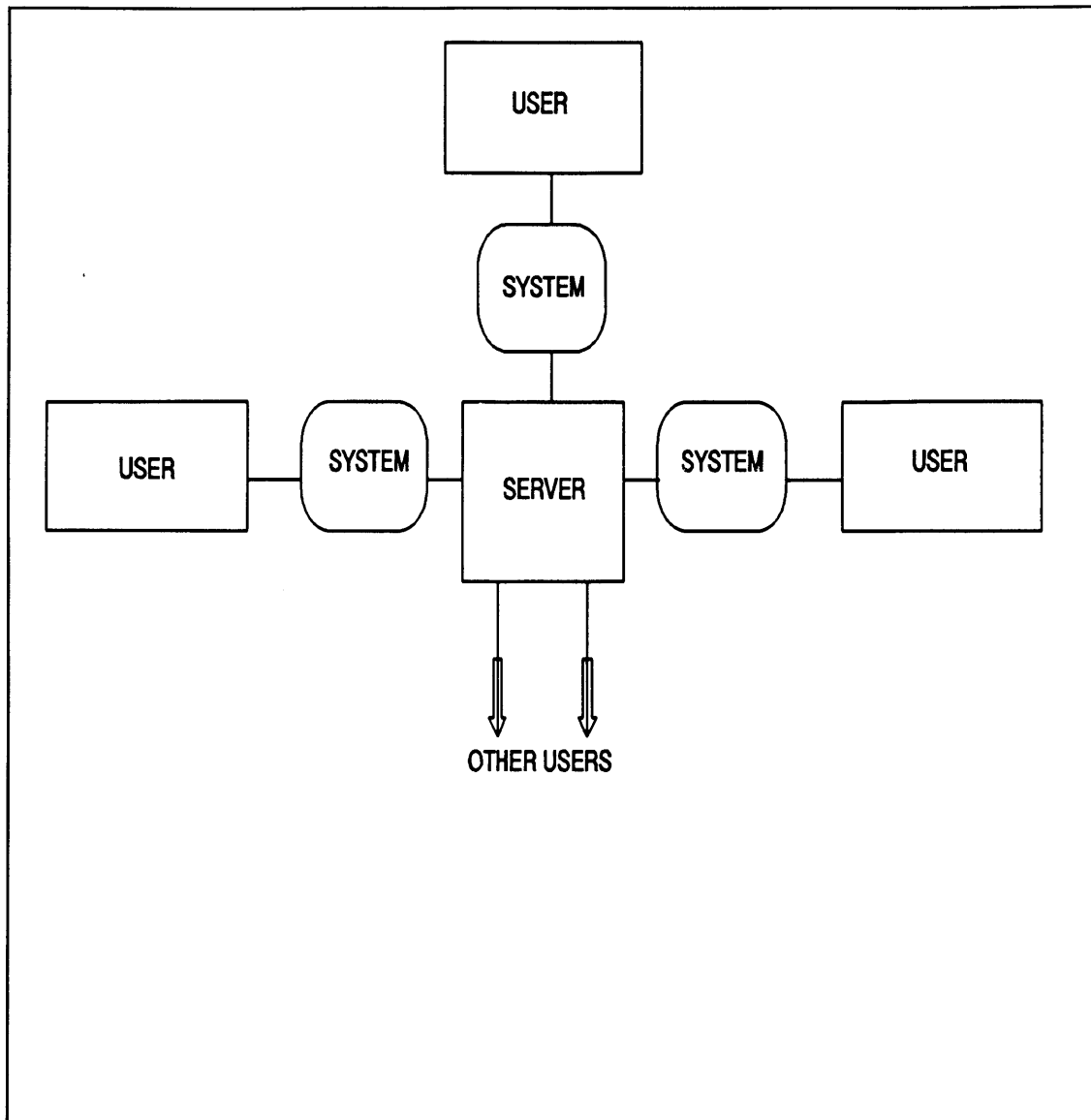


Figure 17. Scheduling system configuration

Implementation

In our present real estate market, funds for new product development are scarce. Unfortunately, research and development are among the first items to be struck off an operating budget in difficult times. The research that continues to be funded must show promise for high, short term returns. Although the visionary environment presented in chapter four does not fall in the category of a short term project, the scheduling system in chapter five does. A reason for beginning with the implementation of a scheduling environment is that it is an excellent prelude to the implementation of the global environment (described in chapter four). The scheduling system will be the first step in a series of developments that will lead to totally integrated and collaborative system. Once the scheduler is successful, development can then proceed to the implementation of collaborative and concurrent analysis and design of real estate projects. Beginning with the scheduling environment is advantageous in that it allows all of the "team members" to become involved in the project from the beginning. Therefore, later in the development of the system, certain team members will feel they helped lay the foundation of the environment. Participation by all team members from day one is, therefore, an important goal of implementation.

Before soliciting partners in the implementation of the scheduling system, two basic questions must be answered: (1) What is the problem and how will this venture address it ?, and (2) How much will it cost in relation to the expected return ?

The problem statement was defined earlier in this chapter, however, an example from my work experience will help clarify the need. In the development of a large shopping mall in New York, a private developer had hired a number of local consultants to design and obtain approvals. The consultants included an environmental firm, a law firm, an engineering firm, and a traffic specialist. Although the developer was experienced, he was not familiar with the local rules and regulations. (This was part of the reason for hiring local consultants who had a working knowledge of the locality). Each consultant knew what they had to do and portrayed this to the developer. There were periodic meetings where all of the consultants could interact and coordinate their schedules, however, they were unsuccessful. There are several reasons for this. Firstly, getting everyone in the same room at the same time was a monumental task. In many cases, meetings were held without a quorum. Another reason was that the cost of holding a meeting was high. It is estimated that the collective hourly billable rate of such a meeting exceeded seven hundred dollars per hour, making this extremely expensive for the developer. The last point is that even if the meeting were held, and accurate minutes were kept, it was difficult for the developer to enforce and monitor the agreed upon tasks. Schedules were often forgotten or changed by consultants without notifying the developer in a timely fashion resulting in wasted time. As an example of this, the engineering firm was completing the final drainage studies while the environmental firm had not yet completed the due diligence.

The project scheduling environment will help alleviate these problems. Firstly, the development team can "electronically" meet every day through the central network. Face to face meetings will be saved for situations that truly warrant an expensive collection of a dozen or so professionals. The scheduling environment will provide a daily "paper trail" or record of each consultant's activities, thereby introducing another dimension of accountability to the process. This will inevitably help keep consultants on time and on target in their obligations.

Gaining acceptance from both the private and government sectors will be one of the most challenging aspects of implementation. The motivation for a private developer to use the system is its potential for increased efficiency. However, the benefits to the developer's consultants are "fuzzier", and even more unclear to government agencies. With government agencies playing an important role in the process, their cooperation is necessary before the system can reach its full potential.

Apart from motivation, user acceptance may be hindered by procedural and political factors. Government agencies (professional bureaucracies) for example, often have a set protocol that is difficult to change. Approvals and application processes usually follow strict guidelines making the flexibility required to implement the scheduler difficult to achieve. One way to "sell" the scheduling environment is to also convince the citizens of its benefits. In difficult economic times, a tool that may ultimately decrease the cost of real estate and local taxes (through more efficient use of

government resources) should be welcomed. Another approach is the funding of installations and training by private developers. Time is of essence in most real estate projects; a small investment in software and training may provide a high return in the form of quicker approvals. The actual return on investment is difficult to quantify and should be estimated by the organizations that fund the implementation.

A critical input in determining the feasibility of the scheduling system is development time and cost. A database of expert rules can be accumulated by interviews with approximately twenty experts from each of the eighteen domains (e.g., lawyer, architect, etc.). Knowledge engineers would conduct these interviews and work closely with the a team of computer scientists. The following is a preliminary cost estimate for the development of the system:

Knowledge Acquisition:

- * 18 domains x 20 experts in each domain = 360 knowledge sources.
- * 360 knowledge sources x 1 day of interviewing per source = 2880 hrs.
- * Four knowledge engineers for six months = \$140,000.
- * Cost of knowledge sources = \$300,000.

Codification:

- * Two computer scientists for one year = \$160,000.
- * Marketing and overhead = \$300,000.

Total product development = \$900,000 in approximately one year.

(A cost for hardware is not included because it is assumed that most users own and operate IBM compatible microcomputers and modems. Software and hardware selection is beyond the scope of this work, however, C++ language and IBM compatible microcomputers are recommended because of their wide use in industry.)

An expenditure of nine hundred thousand dollars is more than most real estate firms will be willing to spend for a scheduling system. Possible strategies for reducing the costs of developing the system include the spreading of development costs over a larger number of developers. For example, fifty developers could form a partnership with a software development firm, thereby reducing the cost to \$18,000 per firm. Another strategy would be for a research center such as the MIT Center for Real Estate to seek grants from the National Science Foundation or the Urban Land Institute for a research project. Finally, another alternative is to solicit funding from large institutional investors or a large holder of corporate real estate such as IBM, or General Electric.

The identifiable development cost are only a small part of the total cost of the system. The most significant costs are those which are most difficult to quantify - organizational impact and costs associated with user acceptance. These intangible costs and their implications will be discussed in chapter six.

CHAPTER SIX

Implications and Conclusions

This chapter has been written for the real estate professional, the manager of technology and/or computer scientists. The four most important points of this research are discussed. These points are:

1. **Modelling real estate:** *Modelling the real estate process requires a thorough and dynamic knowledge acquisition effort.*
2. **Intelligent applications of intelligent technology:** *Object Oriented Technology must be applied to the appropriate parts of the real estate process and used to supplement, not replace, human expertise.*
3. **The importance of integrating the real estate environment and the computer technology within it:** *Real estate development requires collaboration between a variety of entities. Integrating the technology within real estate will help enhance the performance of the real estate "team".*
4. **Old organizations and new technologies:** *The application of object oriented technology to real estate will require a change in organizational structure. The abilities to learn and grow with the knowledge rich future are essential ingredients for success.*

Modelling real estate: *Modelling the real estate process requires a thorough and dynamic knowledge acquisition effort.*

A major pitfall in the application of new modelling technologies is an insufficient understanding of the domain - even by real estate professionals. *It is, therefore, very important for real estate professionals and developers of software to carefully select the knowledge acquisition¹² team.* A working knowledge of both the real estate business and computer science is necessary. Fortunately, object oriented technology has helped to alleviate this problem by bringing the domain experts (real estate professionals) and the applications experts (software developers) closer together. Some object oriented environments even allow domain experts to enter rules directly into a computer system. The working platform is now shared by both the applications and domain experts. This is unlike older programming techniques where the domain experts were far removed from the actual codification process.

The problems associated with a lack of understanding of a domain are exemplified in the application of expert systems. Chapter two summarized the reasons why expert systems did not deliver all they promised. One reason is a lack of understanding of the processes. Application experts were using expert systems to address problems they did not understand. It was assumed that conceptually straightforward processes were easy to model. In fact, the opposite is true, the expansiveness and lack of structure and uniformity in processes such as real estate

¹² Knowledge acquisition is an area of computer science which deals with the collection of information for codification purposes.

make modelling extremely difficult. *Both domain experts and computer scientists must, therefore, not underestimate the complexity of the real estate process.* An example of this is a knowledge acquisition session with a portfolio manager. When queried as to why a certain asset was chosen, the manager's response often is: "because". This answer obviously encapsulates years of experience and judgement and is difficult to dissect and understand, let alone put in a computer program. Additional difficulty arises when decisions are irrational, influenced by ego, or politically motivated. The application of OOT and AI to these types of decisions is discussed in the following section.

Intelligent applications of intelligent technology: *Object Oriented Technology must be applied to the appropriate parts of the real estate process and used to supplement, not replace human expertise.* OOT is an exciting area of computer science which shows great promise for modelling the real estate process. However, not all parts of the real estate process should be modelled. Future work in creating an intelligent object oriented environment must separate those processes which can be modelled from those that should not. Development functions such as using a "gut feeling", creating scenarios, and brainstorming may be among those processes that should always remain within the realm of developers. On the other hand, tedious, repetitive and less enjoyable tasks can benefit from the merging of intelligent technologies with traditional data processing. The project scheduler described in chapter five is an example of this.

The fact that only some parts of the real estate process should be modelled implies that *there is a balance, or an "optimum" level of technological application in real estate.*

The two extremes are: (1) where computers play a fundamental role in most business functions, and (2) very little computer use. The ultimate level of technological application obviously lies somewhere between these two points. Some "players" in the real estate process tend to apply more technology than others. Some engineering firms routinely use artificial intelligence techniques and CAD for design, while only 39% of owners use CAD-based facility management systems [Veale, 1989, p.9].

Further complicating the question of "how much technology is necessary?", is that the optimum technological application is a moving target. Its location depends on type of organization and the degree of comfort that firms have with technological applications. It is ultimately the responsibility of the real estate developer to determine the optimum level of technological application. This can be done by applying and experimenting with technology in the work place and solid long term planning.

Although the decision to implement a new technology is strongly influenced by short term monetary returns, the long term implications must also be examined. This is why chapter four is intently broad and visionary. A key advantage of this work is that the vision of the future of technology in real estate has not been created by computer scientist alone. Instead, the problem statement and application of OOT

to real estate were originated and molded by real estate professionals. *This research offers an opportunity for the real estate industry to take a proactive role in the long term planning of technological developments and applications that affect it.*

Although OOT and AI are promising for the future, real estate professionals should not expect dramatic leaps in the technology. For years, AI experts have promised much more than they could deliver. If certain predictions made during the 1960's had come true, we would now have machines that were identical to the human brain. Instead, the foremost AI research facilities in the United States have only recently begun to model the human walking process. The expectations for real estate must therefore be realistic. Implementation of a functional, intelligent and globally integrated computer environment for real estate is foreseeable only in the very long term.

The importance of integrating the real estate environment and the computer technology within it: *Real estate development requires collaboration between a variety of entities. Integrating the technology within real estate will help enhance the performance of the real estate "team".* "What we have found and what we have observed in putting these systems (AI) in over the last few years is that by and large the systems that are successful are the ones that are integrated into the organizational fabric and information processing environment in which they are operating. The ones that are not successful are the one that are stand alone and not

integrated. We believe therefore that such integration is very important." [Carter, 1989, p.53].

Integration is a computer buzzword of the 1990's. Software use in the real estate industry has reached the point where each "team" member operates in his/her own isolated computing environment thereby limiting collaboration. Before substantial progress is made toward a unified computer environment for real estate, there are many software, hardware and organizational issues that must be addressed. Most of our existing software has been designed without much foresight in compatibility with other packages. One reason for this is an attempt by software developers to create industry standards for their products. Another is simply a lack of a long term vision of an integrated environment. This has resulted in computer packages with incompatible semantics, and input and output files making it difficult to utilize existing software. Some software developers prefer re-writing existing software packages to avoid the use of outdated computer languages and uncertainty as to the performance of existing software. Although starting with a "clean slate" seems to benefit software developers, it may not be the best solution for users who have spent an enormous amount of time and money in education. In order to minimize the shock of new technologies to organizations, existing computer packages that have an established user base must be preferred over new packages. An example of a real estate software package that has wide acceptance in industry is PRO-JECT. It is a lease-by-lease financial analysis package. Although previous versions of have not

been the most user friendly packages on market, PRO-JECT remains industry standard. Most large institutional investors and appraisers use it and are reluctant to change. This research, therefore, supports the re-use of software packages such as PRO-JECT and other packages described in chapter two in creating an object oriented environment for real estate. This will hopefully reduce software development cost (by not having to re-create existing software) and organizational impact. An analysis of the organizational impacts of new technologies to real estate is beyond the scope of this work, however, several major points are outlined in the next section.

Old organizations and new technologies: *The application of object oriented technology to real estate will require a change in organizational structure. The abilities to learn and grow with the knowledge rich future are essential ingredients for success.* Chapter three briefly describes Mintzberg's topology for organizational structure. The ad-hoc organizational structure shows the most promise for success in an object oriented computer environment. It is a structure that brings the "cubby holes" of production closer to the strategic line apex through information technology. The organizational structure is "flatter" as a result of this.

Ad-hoc organizations also have the flexibility to accommodate change. The computer environment conceptualized in this work will require that organizations have the ability to deviate from the norm and be successful under pressure and change. Alvin

Tofler calls this new flexibility in organizational structure: "*the greatest shift of power in business history...., and the first signs of it are evident in the new style organizations fast springing up around us. We can call them the 'flex firms' of the future*" [1990, p.175] Gloria Schuck states: "*Without organizational change, the application of new technologies will only reflect the status quo. Organizational change is not just moving boxes around an organizational chart. Effective utilization of information technology requires comprehensive and systematic changes in skills, roles, rewards, systems and structure*"¹³.

Technological and organizational change also requires that real estate firms become "learning organizations". The most valuable asset of the future firm will be its human resources. Growth will not only mean increases in net operating income and leasable area, but also increases in knowledge. Knowledge will be encapsulated in both the minds of employees and the intelligent computer systems that surround them (e.g., the object oriented environments described in chapters four and five of this work). Real estate firms will, therefore, rely less on the "sweat" of their labor force and more on their minds. Professionals will become more specialized and irreplaceable than their standardized "smokestack" economy counterparts. This is illustrated in the real estate brokerage industry. In the past, brokers were automating by simply transferring information. Now they must digest and improve it before it can be sold. The value is not in the transfer of data, but in the intelligent processing of it.

¹³ Gloria Schuck: Lecturer, Department of Urban Studies and Planning, Center for Real Estate, MIT. Quote from a graduate course titled "Managing the Real Estate Development Effort", spring 1992.

Stewart Forbes of Colliers International, a brokerage firm which uses computer networks extensively, is correct in saying: "*...we have tried to present that information to the group in a way that the sales associate can see it as a promotion of their expertise, not simply a collection and documentation of it.*" [Gladstone, 1990, p. 13]. Zuboff [1985] supports this by stating that information technology has a dual role - one is to automate, the other to "informate". The process of informing goes beyond automation to create meaningful information.

The payoff in terms of organizational change is difficult to quantify. The figures below pertain to a collaborative computer environment for design and construction only [Sriram, 1991]. They are shown to provide a general idea of some of the potential benefits of object oriented technology to the building industry.

Development time - 30-70% less

Engineering Changes - 65-90% fewer

Time to Market - 20-90% less

Overall quality - 200-600% higher

White collar productivity - 20-110% higher

Dollar Sales - 5-50% higher

Return on Assets - 20-130% higher

* * *

This research constitutes a vision of the future of technology in the real estate industry. It is an attempt to: (1) educate the real estate professional about new technologies and their implications, and (2) educate the manager of technology and/or software developers about real estate. It is hoped that this merging of expertise will ultimately lead to efficient and profitable uses of new technologies real estate development.

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