

SURVEYS IN COMPUTER SCIENCE

C.A. Ellis N. Naffah

**Design of
Office Information
Systems**



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With 36 Figures



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PREFACE

The goal of this book is to present a framework within which the myriad of office technologies and office systems design techniques can be better understood. There are a number of office books which deal with the social/organizational aspects of office automation or with office equipment introduction strategies. This book differs from those in that it is written by technical computer people for technical computer people. As such, it assumes a general computer literacy and contains a technical emphasis with a social fiber woven in. Besides the framework, we also present the current state of office primitives, office tools, and office technology. We cover relevant work on-going by international standards bodies, and we discuss the concepts that are emerging (or which we feel will be emerging) from universities and industrial research laboratories. Office technologies and techniques are classified as *personal environment aids* versus *communal environment aids*.

We now fully realize how difficult it is to write a coherent book within this fuzzy, interdisciplinary, rapidly changing field. Concepts have been stressed wherever possible; there are some sub-areas where the generalizing concepts have not yet emerged. We also realize the potential danger of obsolescence. We have tried to combat this somewhat by the presentation of concepts, generic tool design, and emphasizing our framework. This book is not a substitute for reading of the current periodical literature – that is where the most timely information lies. We sincerely hope that this book does help to provide a base and perspective for understanding that literature, and gives some useful future direction indicators. We will provide updates to this book if demand warrants.

The choice of what topics to cover in how much detail is a compromise. We humbly apologize to those who find their favorite topic missing. We stress within many chapters that we are presenting concepts and *a few* examples; not a comprehensive compendium of all items of importance. In many cases, we briefly introduce ideas and indicate where they fit into the framework. In these cases, we provide references to the literature for further reading.

Much experience and benefit has been acquired by Najah Naffah at INRIA (the French government's Institut National de Recherche en Informatique et Automatique) in his previous position as head of the KAYAK office research project. Much experience and benefit has been

acquired by Clarence A. Ellis at Xerox PARC (the Xerox Palo Alto Research Center in California) in his previous position as head of the office research group. We would like to thank numerous colleagues who have stimulated and informed us. Pioneers such as Doug Engelbart in the area of personal environment aids, and Louis Pouzin in communal environment aids have performed much of the research upon which this book is based; we thank them. Particular appreciation is extended to Gunter Schlageter and to Peter Cook whose careful reading and critical review has improved this book enormously. Thanks are extended to students in our courses who helped us develop and debug this material – at Stanford University (Computer Science Department) in California, and at the AMK Berlin Technical School BECEEP (Continuing Education Department) in Germany. We would also like to thank our family members for their tolerance and for their warm support. Our employing companies are also due a round of thanks – Bull Corporation (Paris, France) employing Dr. Najah Naffah and MCC (Austin, Texas) employing Dr. Clarence A. Ellis. We have relied heavily upon their support and wonderful equipment on which we composed, edited, and output the text and diagrams of this book in camera ready form. This book was literally put together from two sides of the Atlantic Ocean. We relied heavily upon electronic information transfer via international interconnected computer networks which provided rapid turn-around times. It is an example that sizeable work tasks can be cooperatively performed in a distributed manner over long distances.

Clarence A. Ellis
Najah Naffah

TABLE OF CONTENTS

1. Office Prelude	1
2. Workstation Technology	20
3. Communication Technology	51
4. Networks	72
5. Office Systems Tools	105
6. User Interfaces	134
7. Office Documents	150
8. Office Application Systems	173
9. Office Postlude	210
Bibliography	221

1. OFFICE PRELUDE

This book is a treatise on the technical aspects of office information systems. Before discussing these aspects, we need to provide motivation. Somehow one needs to have some understanding of the typical structures and problems in the modern office, and some feeling for what is really happening in the office today. We devote the greater part of this chapter to the development of this understanding and feeling.

In the first section we discuss structured versus unstructured work, and clerical versus knowledge workers. Sections 1 and 2 are quite concerned with people, the most important element in the office, at both the individual level, and at the organizational level. Section 3 lists some properties of office systems which distinguish them from other (e.g. data processing) systems. This leads to a discussion of models of offices in section 4, and a presentation of one particular model of office information systems in section 5. This model will act as a framework for discussion throughout the other chapters of the book.

1.1 The Office Today

Today's office is a changing environment. Offices containing manual typewriters, adding machines, and hand sorting, copying, and mailing are being replaced by integrated electronic office systems containing mixed media document editors, electronic mail systems, electronic files, and numerous personal electronic aids such as electronic spreadsheets and tickler files. Studies have shown that well over half of today's office workers use some form of information processing or telecommunications workstation on the job. The need for these systems is apparent: increasing administrative overhead and costs, coupled with increasing need for information and information processing are causing many organizations to search for methods to increase *efficiency* (amount of work getting done per dollar expended), and *effectiveness* (extent to which work done actually meets goals and needs of the organization). Organizations are finding that careful design and implementation of office information systems, taking into account important human factors of organizational design and office psychology and sociology, meet these needs, and can make some aspects of office work more pleasant and convenient.

In the 1970s, office automation was concerned with clerical work and structured tasks such as repetitive forms fillout. A prime example of technological assistance for this class of work is the word processor, a computer based office aid which embodies the "typewriter with memory" notion with features to make the composition and editing of documents easy. The primary target of this machine was the secretary-typist. Only 6% of the office dollars are spent on secretary-typist salaries, and only 20% of these people's time is consumed by typing [Tap82]. The word processing market is nevertheless a huge market. Two other categories are identified within the office work force. These are the "professional and technical workers" and the "managers and administrators". The combination of these two occupational categories is designated as "knowledge workers." These people typically spend a lot of their time performing work classified as unstructured tasks.

An example of unstructured work is useful for clarification. A sales manager, when confronted with a threat of resignation because of discrimination by the company's best sales person, may avert this catastrophe by a combination of investigation, critical bargaining, and persuasive communications. Note that this involves creative problem solving for a one time exceptional situation rather than following a routine procedure. Henry Mintzberg, who conducted one of the most thorough investigations of managerial work, found that managers spend 66-80% of their time in oral communications [Min73]. Other studies have verified this. One study reported that knowledge workers, on the average, spend their time approximately as follows:

formal meetings – 20% to 30%

writing – 10%

phone conversations – 5% to 15%

reading – 8%

analysis – 8%

travel – 10%

The remaining time, classified as miscellaneous and idle includes activities such as informal meetings, expediting, scheduling, waiting in airports, seeking people or information, copying, filing, and transcribing. Given this mix of structured and unstructured work, it seems that the emphasis within office information systems for this latter category of

workers should be on using the system as an augments and assistant rather than as a replacement for people doing repetitive procedures.

Today's advanced workstations have gone a long way toward making the office environment more productive, and the computer interface more friendly. Although advanced workstations are currently used by a small percentage of knowledge workers, the added value of these workstations, properly introduced and integrated, is quite high in adopting organizations. A misspelled word in a document can be automatically detected and easily replaced without retyping the entire page or document. A user interface consisting of pictorial (iconic) objects such as pictures of file cabinets and mail boxes, displayed on a high resolution screen, and voice input / output is easy to learn, use and remember [Smi82]. All of this is augmentation for the individual.

It appears that the next big productivity breakthrough may occur when we can achieve community augmentation which works as well as systems being introduced today work to augment the individual. A prerequisite for this to occur is an advanced workstation on every office worker's desk. In the sales manager example mentioned above, note that many of the resources needed to solve the problem were non-local, such as access to shared historical information; ability to quickly communicate with many people; shared problem solving capability; knowledge concerning default procedures which typically are outside this manager's domain; and knowledge of formal and informal organizational structures. Later in this book, we will further discuss this important notion of communal office augmentation. Proponents of this view also stress the need for links between the augmented office and external systems, including the paper based operations, including telephones and databases, and including management information systems and decision support systems. Certainly, a prerequisite for the emergence of this type of augmentation is the integration of the electronic components of the office to allow them to function together smoothly and effectively. We believe that artificial intelligence and knowledge based systems are an important ingredient in this next big step.

As previously mentioned, *office automation* was primarily concerned with automating the clerical functions within the office. On the other hand, *management information systems* have traditionally been concerned with data processing aids for managers, where data access systems or data monitoring systems would periodically generate reports. For top executives and senior managers, *decision support systems* were developed as interactive real-time systems to provide the top decision makers with rapid access to data and to models which would summarize and

extrapolate from the raw data. These tools range from simple cross tabulation to online models which estimate the cash flow of an organization under varying business strategies or varying economic climate assumptions. Recently there has been a realization that there is a large need for diverse information access and problem solving aids at all levels of the office. This is true because the office handles those aspects of the business which were not amenable to easy automation within the data processing department. Thus, office information systems try to integrate and share information between all three of the segments (clerical worker, professional, and manager) in a manner which benefits problem solvers at all levels of the corporate structure.

There are two primary technological innovations which form the basis for this change in the office. One is *advanced workstations*, e.g. personal computers and word processors driven by the inexpensive microprocessor boom; and the other is *advanced communications systems*, e.g. new technological developments in the areas of PBX, local area networks, and satellites. In the next three chapters, we will discuss these technologies. In the subsequent chapters, we will discuss the office tools and applications in both hardware and software which are built upon these technologies. Throughout those discussions, it will be assumed that readers have a basic understanding of computer hardware and software, but not necessarily of specialized sub-areas.

Lets explore the example of unstructured problem solving mentioned previously to see what technology might be useful. For illustrative purposes, we now introduce Anna Ying, a hypothetical modern day office worker who works for the Widgets Company. As such she performs administrative and technical work. She fulfills several roles in her office, one of which is sales manager. At various stages of our exposition throughout this book, we will present scenarios of Anna Ying working on typical office tasks and problems using office technology which is advanced, but feasible today.

Anna Ying is sitting at her personal workstation (see figure 1.1) in her office preparing graphs and a list of important items for an upcoming meeting when an important electronic mail message appears in a window on her screen. It indicates that the company's best sales person, Maria, is threatening to resign today and move to New York. Although Maria is travelling today, Anna knows that she can still place a suggestion of dinner tonight onto Maria's electronic calendar. Then Anna uses her mouse to open a spreadsheet icon on her screen, and calculates the financial alternatives of various monetary incentives to Maria. This does not seem to be a feasible solution, so Anna chats with Maria's office

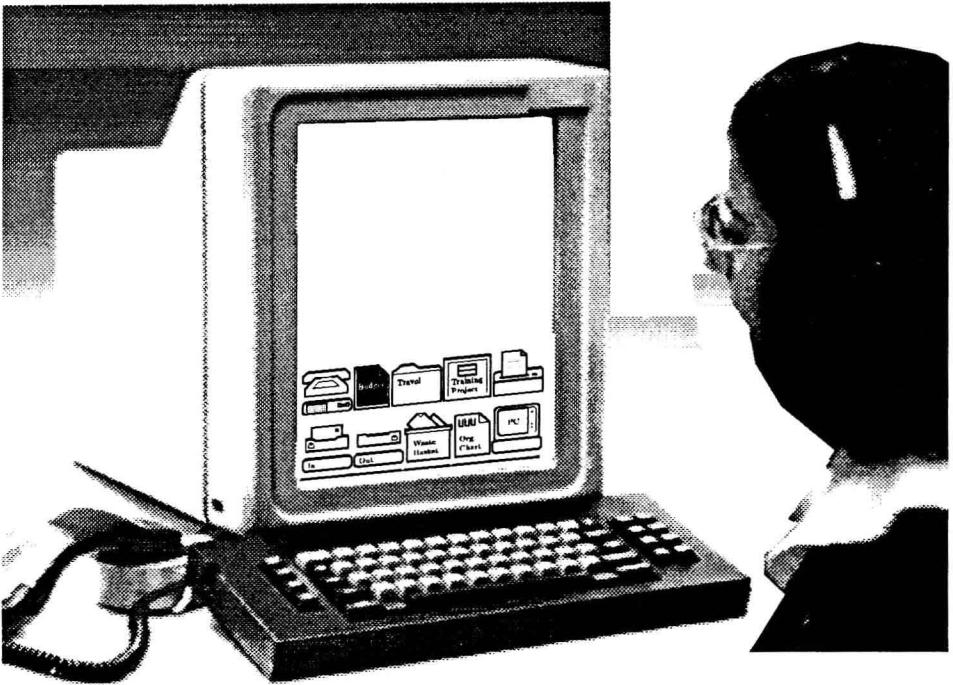


Fig. 1.1 Anna Ying at her Workstation

friends. She goes to the offices of those who are local, uses the continuous video link to talk with those in New York, and sends electronic mail to the others.

When Anna's workstation indicates that it is time for her meeting, Anna pushes a button to send over the local area network a copy of her electronic folder, containing the graphs and lists, to the color laser printer. The high quality printer has output the documents by the time that Anna walks past the printer room on her way to the video conferencing room for her meeting. She presents these using the overhead camera projection system to her boss and colleagues who are physically remote during the meeting.

After the meeting, she reads her electronic mail and listens to her voice mail. It seems that Maria is considering moving to New York because her spouse may be able to find an engineering job there easier, and Maria

may find a job with more growth potential. Anna consults her electronic diary, gathers more information about Maria's situation, about local engineering job possibilities from her local CD-ROM database, and contacts an engineer friend of hers. She also gathers non-local statistical information about New York from her satellite videotext connection. The evening dinner results in a satisfying resolution of problems due to Anna's sincere concern for Maria, Anna's persuasive communication, and Anna's thorough, rapid access to individuals and information.

1.2 People in Offices

We define the office as that part of the organization which has information processing responsibility. This is a very encompassing definition; the office is not so much a place as a locus of common activity. Some people are following trends of making their home their office, utilizing the many available modes of electronic communication. Many office tasks are routinely performed in remote locations (by salespersons on airplanes for example) not at all resembling the stereotypical room with office desks and furniture. For these modes of work to be feasible, the social and organizational structures of the work place must be explicitly recognized and nurtured. Potential social conflict can arise in the division of time between family and work when working at home. Potential organizational conflict can arise when a manager cannot accurately calibrate and evaluate the effectiveness of subordinates because they are not continuously in sight.

The office can be viewed as an intersection of people, information sources, and information manipulation tools drawn together by common goals. We must recognize the presence and the importance of social and organizational structures in the office, and be sure that introduction of automated aids does not put these factors into negative imbalance.

At the level of individual and social needs, work within the field of social psychology provides useful information for office design. Work by Maslow has become famous because it identifies layers of need within people [Mas54]. This theory holds that there are five such layers. At layer 1 are some very basic *physiological needs* such as the need for food. One will inevitably observe the hunger drive which results if this need is not fulfilled. Above this layer, there are *safety needs*. Even in prehistoric times, the caveman represented an example of this in their relentless striving for a shelter safe from the animals of the wild. A third layer is called the *belonging need*. Because man is innately a social creature, there is a drive to find a group to which the individual can, at least to

some extent, belong. This may be a family, an ethnic group or an organization. Above these layers, which are called *hygienic*, are two further layers called *motivators*. They pinpoint the need for *self esteem* (layer 4) and the need for *self actualization* (layer 5). In our modern western society, office workers tend to be above the threshold level for the *hygienic* layers, so Herzberg found in his studies that an increase in these had no noticeable effect on the worker's productivity or effectiveness. On the other hand, his studies found that increase or decrease in *motivators* had significant effects.

At the organizational level, Professor Ouchi and others have shown that successful organizations have organizational control structures which fit the size, style, and needs of the organization [Ouc81]. One prevalent structure is the *organizational hierarchy*, also referred to as the *bureaucracy*. In this structure, there are levels of management, and rules concerning what employees should do and how employees at each level should interact with the levels above and below them. For a large organization this allows delegation of work via standard channels. However, this structure can have a large amount of overhead from middle level managers, and from the amount of time and energy expended to get information from the top level to the actual workers at the bottom.

Another organizational structure which is associated with Japanese business structure is the *clan*. Within this structure, employees within an organization feel that they are part of a family, and the employer is looked upon as the benevolent parent. There is a lot of company loyalty, and a lot of behavior is determined by peer group pressure. This has the advantage of a lot of devoted work being done without the need for a large bureaucratic overhead of managers to oversee or to pressure workers to get the work done. It has disadvantages of stifling individuality and not encouraging creative inventiveness.

A third organizational structure is called the *marketplace*. In the marketplace the workers interact according to resource needs and resource availability. Clients or buyers search in the marketplace for contractors or sellers to perform the tasks or to provide the goods that are needed. If I need paper supplies, I would get them from the supplier which can provide them to me at the lowest price within the time frame I need. Similarly, if I must deal with one of the accountants in the organization, I will choose to deal with the one who will charge the lowest price for services, but who will give me good service in a short waiting time. The market structure tends to be fair in its evaluation and rewards provided that the notions of cost of information can be concretely

established. Although clients have some prior knowledge of the various contractors and capabilities, they must generally communicate with a number of potential contractors in order to determine the specific capabilities and current availability of the contractors. This tends to add a great deal of overhead. Notice that a pure market structure for a corporation is not practical, but the availability of specially tailored electronic communication facilities makes some aspects, like the cost of bargaining and keeping informed, more feasible [Tur83]. Thus this organizational structure and the two preceding ones illustrate the pure ideals whereas any actual organization would utilize a mixture of the above.

Given these observations concerning social and organizational structures, we next present a view of the office derived from the literature and from personal involvement in numerous office studies. Afterwards, we can then put these ingredients together to suggest how technologies can and should fit into office structures.

1.3 A View of the Office

Our view of the office is grounded in the considerations discussed in sections 1.1 and 1.2. Many of the repetitive, highly structured procedures and tasks have, over time, migrated from the office to the data processing department. Thus, today in offices we find that a large portion of the work (even at the clerical level!) is exception handling and problem solving. For example, clerks in a billing office handle the exceptional cases rejected by the data processing computer. They spend vast amounts of time answering phone inquiries from customers who are frequently angry about incorrect bills or misunderstandings. In this office it is necessary that these customers be handled courteously, quickly, and skillfully to retain their business. This suggests that offices, when viewed as information communication and processing systems have some rather unique aspects and emphases. Some prominent features of offices and office systems which distinguish them from other (e.g. data processing) systems are:

- **People Systems** – An office is a social environment to which any introduction of procedural changes, goal changes, or automated equipment causes perturbations. If people who need to exchange information are moved so that they are no longer close to the coffee machine, then needed information which used to get transferred informally may no longer get exchanged. Explicit consideration should be given beforehand to analyzing likely effects of changes. Many

technologically successful systems have failed due to ignorance of human and social factors. For example, the mass movement of secretaries away from individual managers to word processing pools violated social maxims. The managers tended to feel a loss of a most valued resource, and the secretary lost self esteem, and tended to feel less directed and less motivated. This change broke important social ties which had helped to keep many office organizations healthy.

- **Dynamic Systems** – Change is frequent and expected in most domains of the office. An employee's vacation days, for instance, force others to change their routines accordingly. Change also results from promotions, employee turnover, competition's changes, sickness, changing government regulations, etc.

- **Concurrent Systems** – The office is a highly parallel, highly asynchronous system. In many cases, this structure has grown from years of experiential learning by doing. There is much to be learned by systematically observing the informational and social checks and balances of a smoothly working organization. But also, one may observe habits and impediments which are unnecessary relics of a past way of doing business. Thus, some of our mathematical office analyses which automatically detect potential parallelism have produced extremely useful results. Inherent in the media of the electronic office is the much greater potential for parallel processing than the previous age of unautomated offices. As a word of caution, we have observed that it is not always easy to discern whether an activity falls into the category of unnecessary relic or necessary redundant checks and balances.

- **Ill-Structured Systems** – In terms of monetary investment, we have mentioned that most of the people resource is within the "knowledge worker" category. These are the professionals, the managers, and the executives who are highly paid, and therefore are a prime set of candidates for office augmentation aids. Much of the work performed by this group is unstructured or ill-structured. These workers need augmenters and aids rather than the structured data processing systems which are prevalent in more structured parts of a business. For example, a sales manager in a typical company may need to search diverse data, read between the lines of a report, and have a confidential lunch meeting with a colleague in order to track down the information necessary to salvage the account of a big customer. The ultimate office information system would be able to assist this person in all of these aspects of work.

- **Open-Ended Systems** – Another important group of people is the "clerical/secretarial" category. One might assume that the work of people

in this category is all structured, but office studies have shown that even within this category, the amount of problem solving, exception handling, and customer interfacing (all three are unstructured activities) are high. Just the activity of interpreting a customer's handwriting may involve significant problem solving. Thus systems and models must be capable of handling a diverse spectrum of activities with high proportions of semi-structured and unstructured activities. We must insist that systems be inherently open-ended with escape hatches to handle unanticipated exceptions and emergencies, and with ability to interface with many disparate other systems. This is much more tenable than aiming toward notions of total automation of procedures, total removal of paper from the office, or totally peopleless offices.

1.4 Office Models

Office models can be used by many different persons in many different ways. We cannot avoid the use of models; each worker in the office carries an informal model of his/her activities. Furthermore, there is high utility in explicitly devising and recognizing models within the office domain. Formal models, which tend to be mathematical and explicit, are useful for analysis and design; informal models, which tend to be implicit and ad hoc, are useful for capturing social and behavioral aspects. Before presenting an office information systems model in section 1.5 which will be our framework for discussion throughout this book, we will first attempt to answer some fundamental questions of what is modeling and why build models.

1.4.1 What is a Model

Models are limited abstractions of reality. The limitation is expressed by focusing upon a subset of the attributes and structures. Informal models can help workers to decide upon appropriate actions when they encounter unforeseen or exceptional situations, [Suc83]. Explicit awareness of user models can help to improve upon the acceptance and error-free use of office systems. For example, whereas a computer person has a computer model of disk storage which implies that retrieval of a page of information does not destroy the original copy on the disk, an office worker (non-computer person) has a file cabinet image which says that when a page of information is taken out of a file, it obviously is no longer in the file. A user-friendly system design may choose to somehow take this into account; for example, there may be a "remove from file" command, and a "copy from file" command. Formal models