

OFFICE AUTOMATION AND OFFICE MODELING
WITH INFORMATION CONTROL NETS

by

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CHAPTER 1

INTRODUCTION

The modern office system of today, and of the future, has been an ever increasing area of interest in the world of computer science over the past several years. This rapidly growing attention to office systems and practices has primarily been the result of increasing demands on the operation of today's office and the growing complexity of its functions. With the growing complexity of office tasks, it is common for a typical office worker to find himself spending much, if not a majority, of his time carrying out menial and routine tasks, i.e. information preparation, organization, filing, copying, transforming, analyzing and transmitting (Uhlig et al, 1979). In order to better utilize the employee resource, these tasks should be mechanized into an automated office system capable of performing these tasks quickly and efficiently. The immediate advantage of automating menial and routine office tasks is the freeing of time with which employees can devote greater attention and thought to the more complex matters of office management.

This paper will discuss in detail and define what is meant by "office automation". Justification for and the feasibility of automating office systems will be discussed in order to provide the reader with an appreciation for office automation efforts. During the course of this discussion certain basic components, procedures and functions, of the typical office will be presented

and defined. The application of the automated office concept to these components will be presented by illustrating some common automated office "tools" being developed and researched today to support automation of those components.

In order to implement office procedures into an automated office system, some method for precise specification of the activities comprising those procedures must be developed. This paper will explore the method of office modeling. Several different types of models will be presented, with special emphasis on the mathematical model, Information Control Nets (ICN). The advantages of the mathematically based office model will be mentioned with special attention given to the ICN office modeling scheme. An ICN example will be provided to illustrate the usefulness and applicability of the ICN model to office automation. Finally, some of the major advantages and disadvantages of the ICN model will be presented in an attempt to show ICN's strengths and weaknesses in application to office automation.

This paper is intended to describe the link between the basic tasks of an office environment and their precise specification using ICN. With this link having been established, the first major step to creating an automated, integrated office system will have been taken.

CHAPTER 2

OFFICE AUTOMATION IN GENERAL

Definition of Office Automation

The pace of progress during the last several years has stimulated efforts to develop machines and hasten their application to office work because information is so essential to all activities and especially to research and development. Significant office technological advances have been achieved, yet in the future even greater things are predicted. Routine office jobs are being eliminated, office work is being accomplished at fantastic speeds and the composition of office work is undergoing significant change. This new environment is where office automation realizes its potential.

The word "automation" first appeared in print about 1948. Since that time, this word has been accorded many different meanings. Some have associated the word "automation" with technological change while others have related it to the word "mechanization". Most commonly, the word is used to refer to the the manufacturing of products in a factory. However, these views are incomplete since data processing and information management have undergone so much technological change.

Automation today normally refers to the arrangement whereby one or more machines are operated without human participation

except to press some initiator button. Automation is the regulation of processing by which high-speed, self-correcting instruments or machines control the operations of other machines, (Terry, 1976). It is important to keep in mind that this reference to office machines does not necessarily always imply a computer. Non-computer office machines, such as copiers, printers, and postage meters can be integrated into a single office data processing unit; thus, qualifying them as components of the automated office.

Office automation more precisely refers to the processing of information by a number of steps, without direct human intervention, according to a previously programmed self-controlled sequence. It can be considered to indicate the use of machines capable of recording and storing information and of converting data for whatever uses the office has for it, (Rhee, 1968).

Reasons for Automation

Managers of present-day enterprises need to maintain considerable amounts of data in order for them to make effective business decisions (Terry, 1966). As the need for information management becomes more and more urgent, so does the need to process this information in a speedy and efficient way. This is the first reason for automation. In the fast paced circles of business activity present today, events that must lead to effective decision-making occur at an ever increasing rate (Terry, 1966). Under these conditions, the gathering, processing and distributing of data must be done as quickly as possible.

In many cases, only the speed and efficiency of computers can manage the vast amounts of paper work and calculations necessary to provide a level of information management sufficient to support rapid and well-informed decision making.

A second major reason for office automation is to reduce overall office expense, a goal that is sometimes difficult to realize. With the advanced office throughput and activity allowed by automation, the volume of work after automation often increases because managers have more timely useable information and desire further indicators relevant to planning and management. Also, some of the departmental operations may undergo transitions of one type or another causing a further increase in the volume of work to be performed. If information demands and office operations remained static before and after automation and there is an adequate volume of work, processing costs after automation normally are reduced (Terry, 1966). However, after automation the increased information demands cause costs to remain about level (Terry, 1966).

A very important reason for office automation is the overall reduction of errors during data processing. Office automation tends to integrate office data processing which helps to minimize the number of times data must be handled and introduces integrity checking computer routines, thus reducing the possibility for error. An overall improvement in the quality of office data and information is therefore an advantage of office automation.

The office work force represents one of the fastest growing groups in our economy (Terry, 1966). Ways of maintaining office

production with a minimal office work force have been actively sought by office managers. In many cases, the capacity of an automated office system exceeds the current demands of the enterprise which uses it. This then allows expansion of office activity and work load without the usual subsequent expansion in the work force to accomodate it.

The Feasibility of Automation

Automating the paper work of an enterprise can be a detailed and complicated task. It is essential that during the design phase of the automated office system that all aspects of the work to be automated be taken into careful consideration, that the objectives of the automated system be well defined and used as guides to determine the desired performance of the system, and that the proper equipment be selected for use. Office data processing is actually made up of two components: 1) the paper work and 2) the processing of the data involved with the paper work (Terry, 1966). These two components of data processing are related and the experts in each area should work together as a team, with each aware of the other's problems and performance goals.

In some feasibility studies, the erroneous assumption is made that office automation is desirable regardless of the current work performance. The result is that inefficiencies in the paper work processing are automated. Consequently, both the good and the bad features of the present manner of performing the office functions are preserved. Once automated into an integrated office system, these inefficiencies can be very

difficult to remove from the system without a complete restructuring of the automated system. In plain language, the enterprise is "stuck" with the inefficiencies that existed before automation. A complete and thorough investigation of the requirements of the automated system and a careful analysis of the performance specifications can minimize the risk of preserving current office inadequacies in a newly developed automated office system.

Another matter to be addressed when evaluating the feasibility of office automation concerns the availability and selection of equipment that will most adequately satisfy the enterprise's needs. Certain criterion upon which decisions concerning equipment acquisition should be based are resultant costs, time during processing, flexibility of usage and the ability to meet probable future demands (Terry, 1966). In other words, given many machines capable of doing the work required, which combination of machines will best serve a particular enterprise's needs?

It is important, however, that a balanced attention be maintained between technical machine characteristics such as machine speed, peak loads, scheduling, and procedures such as acquiring the source data, converting the data into a form suitable for machine processing, supplying the processed information in the best format and getting it to the right personnel at the right time.

In order for office automation to be utilized as an effective productivity tool in any enterprise, there are certain

elements as pointed out by Schatz (1981) which should be adopted and adhered to. First of all, the improvement of production must be a primary goal. Secondly, cost / benefit studies should be conducted as part of a feasibility study. Such a study can be quite beneficial in determining whether office automation is appropriate. Another important element to be considered is how the human interface with machine will be planned. Effective communication between office worker and machine is essential if automation is to be successful. Lastly, the enterprise's top management must be fully committed to the automation effort. Partial commitment could lead to much wasted effort and an office system which functions below its potential.

Social Aspects of Office Automation

One of the first social issues that arises from office automation concerns employment. The alterations that occur in employment can be viewed in two ways: 1) a way to provide greater employment opportunities and 2) diminished employment, even to the point of mass unemployment. Of course, it is the former of these two interpretations that office automation will seek to provide. In other words, office automation should be seen as a door into an expanded realm of office achievement and new opportunities for the future. However, this door represents a major shift of human effort from manual to mental work and from menial to more intellectually challenging pursuits. One perspective is that office automation provides a way to develop a more productive and abundant life. The other perspective is the natural fear that automation will cause many current employees to

suddenly find themselves underqualified for their jobs and unable to sell their obsolete abilities on the job market. However, past experience indicates that such similar technological advancements have enhanced rather than depressed the demand of the overall level of employment (Rhee, 1968). New demands develop and the need for a large labor force to build and maintain automating machines increases. However, the changing demands will likely cause displacement of many employees from one job to another with re-training required (Rhee, 1968). In order to do this and utilize the current labor force effectively with minimal job loss, businesses involved will be called upon to muster a high level of real management ability. Office automation is progress, progress means change, and change places before us challenges and threats which must be met and conquered.

It is proper to point out that the personal skill required of each employee in the near future will increase as office automation technology begins to dominate the business scene. This is not to suggest that the low-skilled and semi-skilled jobs will be forever eradicated from the job market. Associated with office automation itself are low-skilled and semi-skilled jobs which will require minimal amounts of training to perform. However, in today's technological society and especially in the technological society of the future, laborers with little or no job skill will continue to have uncertain employment opportunities.

Many experts feel we are at the beginning of a second industrial revolution which will substitute machines for human

beings in performing menial mental tasks just as the first industrial revolution substituted machines for carrying out most back-breaking physical labor. Perhaps, and wouldn't it be a shame if this new revolution were allowed to stagnate because of a refusal to accept and strive for progress in technology and management that calls for some individual sacrifice along the road to improvement.

CHAPTER 3

COMPONENTS OF OFFICE AUTOMATION

Basic Office Processes and Associated Activities

This section will present a typical office environment as a collection of office processes and the activities that comprise those processes. While all presented office processes will be defined, the "planning" process will be discussed in detail in order to provide an example of how the activities comprising the "planning" process are performed by the office workers involved.

Before a detailed look at the "planning" process can be made, the activities that represent the various stages or levels of the total "planning" process should be examined. Activities that will be discussed as components of office processes, like "planning", are as follows: 1) gathering information, 2) filing information, 3) organizing information, 4) retrieving information, 5) modifying information and 6) generating new information. There is some overlap in these activities. It must also be stressed that probably the most important activity that office workers perform is that of "communicating information", (Uhlig, 1979). The "communication" activity will be discussed in further detail in a subsequent section.

It is quite beneficial to identify some related things that go on in an office. In order to ensure that things are done in

a standard way, office processes are established. In other words, policies are established by office workers. A major process in any office is planning. Some other major processes include programming, budgeting, coordinating, monitoring, policy formulation and decision making. For each of these processes, an office worker carries out all of the activities that were mentioned earlier. Figure 1 illustrates how each office process is composed of the various office activities. It shows the office processes arrayed against the office activities in a table. As an example of how the stated activities comprising these office processes relate to the execution of the processes themselves, the "planning" process will now be discussed in detail.

Simply stated, "planning" is the process of setting long range goals and objectives for an organization and broad strategies for achieving those objectives. The nature and characteristics of a particular business usually determine what specific forms a business's goals and objectives assume, (Uhlig, 1979). For example, goals may be such things as "increase sales by a certain percent over a specific period of time", or "achieve a certain stated production rate by some target date". Objectives, on the other hand, are usually broad statements such as "improve the morale of workers in the office", or "maintain our current share of the market". Broad strategies to accomplish the stated objectives may also be developed in the planning process. These strategies might include such things as "achieve the goal of increasing overall productivity by putting more emphasis on product x and decreasing emphasis on product y".

Associated with the "planning" process is a considerable amount of information processing that is usually performed by humans. In order for goals and objectives to be set, and for strategies to be developed, there must be a consensus among the leadership of an organization on at least two points: 1) that the goals or objectives are appropriate, and 2) that the goals or objectives are achievable. In order to arrive at these two conclusions, managers must constantly monitor the status of their organization. This often involves gathering information concerning everything that is going on in the organization and it is often accomplished by such methods as face-to-face meetings with key personnel, reports (manual and automated), telephone conversations and traveling to meet others.

Retrieval of information is a special case of gathering information. Information retrieval refers to getting information from storage in files. This may be via the use of some automated systems, such as a management information system or simply getting a file folder from a filing cabinet. During this discussion the term "gather" will be used to refer to the activities which involve direct interaction with other human beings while the term "retrieve" will be used to refer to activities that involve obtaining information from files.

As information is gathered during the "planning" process, as in any other office process, the "analysis" activity begins. During analysis, areas of insufficient information are identified and additional information is gathered to provide those elements found lacking.

A phase of this analysis involves reading narrative information and comparing it with other narrative information. In handling narrative information, a great deal of hierarchical structuring must take place. The information must be sorted into categories pertinent to the business being conducted and then cross-referenced to other information in other reports or files (Uhlig, 1979). As narrative information is examined, the office worker begins to synthesize new information and to form hypotheses. This process often involves operating on numerical data to obtain projections with which to compare goals. This activity is employed to determine whether or not the originally defined goals were actually achievable. Other forms of narrative information analysis may include such sophisticated tools as forecasting models.

As the results of the "analysis" activity become available, the assumptions made during the analysis phase are evaluated. This evaluation usually involves a significant amount of communication between the individuals participating in it. As the evaluation continues, another activity is initiated, that of organizing the information. It is closely related to the analysis activity.

As an example of the functions performed during the organizing activity, suppose there are differing opinions on some topic. This arraying of opinions is both useful and beneficial to the overall "planning" process because it broadens the vision of management. Management often evaluates the value of these opinions depending on which office worker has which opinion.

In the organizing activity, data usually needs to be

plotted, formats need to be chosen for the data, specific data to be displayed needs to be chosen and several additional elements need to be considered. Decisions often depend on the particular format and arrangement chosen to represent the data. For example, the scale on the axes of plots of a set of numerical data may be crucial to making an intelligent decision based on that data.

The kinds of judgment which go into the organization of information and data are not easily programmed into a computer. However, a suitable synergetic combination of a personal computer and a human being may improve significantly the productivity of the worker involved in the activity. The area of interactive computer graphics stands as a prime example of how the union of human and computer combine to create a highly efficient working environment. Large productivity increases have been made possible by the application of interactive computer graphics to business and industry (Uhlig, 1979).

Following the organizing activity of the "planning" process, is another activity similar to organizing, the transforming of data. Mathematicians freely transform data from one coordinate system to another and from one frame of reference to another. It should be noted though, that the mathematical transformation of data from one frame of reference to another is just a special case of the more general act of transforming information from one frame of reference to another. For instance, the same concepts will be presented differently to different levels of management, depending on the outlook of the managers involved. Top managers

will receive highly summarized information, while lower levels of management will receive details corresponding to the level of their responsibilities.

Generating information is an activity which is strictly human in nature. It is during this activity that individuals develop new ideas. This activity is aided by all the preceding activities which eventually lead to the formulation of information which up to this point in time has not been available for use in the "planning" process. Automated office systems can help in capturing these new ideas and examining their consequences which in turn is important in "fixing" the idea. The term "fixing" is being used here to describe the concepts of accommodating and assimilating the new information into the office process already in progress.

While the new ideas and information are examined, the automated office system can help in modifying them to achieve further sophisticated input to the office process. Sometimes it is necessary to see something in writing, or to see a picture or graph before we can really understand it. As we gaze at the text or picture, it is possible to sense that there is something not quite right with the information presented. Using the automated office system, it can be corrected and become useful information. This then is the "modify" activity and is often referred to as "playing" with a concept until it becomes acceptable.

Lastly, the activity of "filing" also occupies a place during the execution of the "planning" process. It is this activity that makes possible the correlation of ideas across several sources of information which facilitates the development

of yet more useful ideas. The automated office system can act as a very important extension to individual brain power in filing information in sensible patterns, and in reasonable cross-referencings of information for later retrieval, (Uhlig, 1979).

At this point, it should be evident how the various activities that go on in an office, (see figure 1), participate in the execution of the "planning" process. The roles played by these activities in the other office processes are quite similar to those discussed. With this background now established, the other office processes will be defined.

First of all is the "programming" process. This process begins where the "planning" process stops. The "programming" process converts plans into actions. It is the process in which goals, objectives and strategies are implemented into a program (i.e. program in a general sense, not a computer program). Again, all of the previously discussed component activities are also performed during the "programming" process.

A natural extension to the "programming" process is the "budgeting" process. Once a program has been established, resources must be made available to carry it out. In the "budgeting" process competing demands for scarce resources (not just money) are resolved.

In the "coordination" process different opinions from various people who may have information relevant to an issue being considered are obtained. The opinions may be a position on a proposed policy, a new planning goal, or anything else on which an agreement is needed. Usually, this activity involves

several face-to-face meetings normally often at a fairly high expense.

Observing the progress toward the established goals is referred to as the "monitoring" process. This implies that the generalized goals and objectives have been converted into measureable goals and objectives during the "programming" process. Then, performance indicators can be developed, based on the data collected, to facilitate the measurement of progress toward the stated goals and objectives.

The process of "policy formulation" refers to the consensus of some group of managers as to the acceptable strategies for reaching goals and objectives. This process produces new policies and guidelines or the reaffirmation of previously existing policies and guidelines.

An immediate use of monitoring is to formulate decisions based on the events that have taken place. This is referred to as the "decision making" process. Decisions may be positive or negative. If goals are being met or exceeded, a decision may be made that monitoring of that particular area is no longer needed. Likewise, when performance does not meet specifications or objectives, decisions such as reallocation of resources to meet the goals may be made.

Office processes may vary slightly in character or description from organization to organization. However, the processes and their component activities presented are generally representative. Next is a discussion of some automated "tools" developed to support these basic office activities.

Automated "tools" to Support Office Procedures

In this section the author will discuss various supportive automated "tools" for the office and will present examples of some "tools" in existence today. When considering the amount of time and effort the typical office worker uses merely to communicate with other office workers during the course of a normal business day, it becomes evident that the best place to begin a discussion of automated office "tools" is with the communication activity.

Generally, when one speaks of automated office "tools" for support in the communication activity, one is usually referring to some kind of "computer-based message system". A computer-based message system is really nothing more than a data bank of messages. Quite simply, a computer based message system is one in which a user X may log on to a computer at some remote terminal site. At that time, user X may type a message and specify its placement, by the use of some special command language, into a message file owned by user Y. User Y, at some later time, logs on to the computer and reads the contents of his message file, thus retrieving his message from user X. The message may be received immediately by user Y, if at the time user X released his message to user Y, user Y was already logged on to the computer.

The type of communication mentioned above is sometimes referred to as "electronic mail". One can see the distinct advantages this system has over the conventional mail system simply because it allows the immediate transfer from one person to another, perhaps hundreds of miles away, of messages. The

simple example given here illustrates the case where the computer based message system is "centralized", i.e. all communication between office workers is done through a common computer and using a common memory store. Computer based message systems are often "distributed" across several distinct computers connected by a complex communication network. The distribution of a computer based message system is quite useful since it allows each remote site to have full access to their own processor and memory store while still allowing users at different sites to share information.

The computer based message system is an automated entity in itself. As such, it has associated with it various activities which must be performed in order to utilize its capabilities. Perhaps the most prominent of these associated activities is that of "input". How are the messages to be communicated between office workers entered into the computer system?

The most common way used today to input messages to a computer message system is referred to as "word processing", i.e. a "tool" which aids in the development and formatting of a message. Typically, word processing systems provide the user with such capabilities as backspacing to any previously typed character and deleting or replacing it or the user may proceed to affect some alteration in previously typed text. Word processors also allow the user to review text entered previously (text that has already scrolled off the top of a CRT for example), or the user may alternately look ahead at text that has not yet scrolled onto the screen from the bottom. These are just a few of the

many powerful, and sometimes complex, functions that typical word processors today allow a user to perform during the inputting of messages.

There are two basic types of word processing systems in use in offices today. These are referred to as line-oriented and full-screen word processors. Line-oriented word processors allow a user to replace words, insert or delete words or characters in a specific line. In this kind of word processor the user must operate on his text a line at a time. However, full-screen word processors allow the user to operate on his text in a two-dimensional mode. The entire text is displayed, or as much of it as will fit onto a single display. The user can then point to portions of the text such as a word or a string of characters, or a position between two characters, and can make insertions, deletions or revisions to the text. Full-screen word processing is generally much faster than line-oriented word processing and gives the user substantially more format control over his text. One can see the usefulness of such capabilities for inputting messages in a computer based message system.

In conclusion, the use of a computer based message system provides a way for people to interact, but frees these people from having to carry out that interaction in real time. For example, it is often quite difficult to get ahold of some office worker for which you have an important message. Worker A calls worker B. Worker B is not in and worker A leaves a message for him to call back. Worker B calls back sometime later only to find that worker A is now unavailable. Worker B leaves worker A a message to call back and etc. This common type of office

problem is virtually eliminated by a computer based message system (Uhlig, 1979). Worker A's message can be transmitted to worker B's private message file while worker B is unavailable. Worker B can retrieve his message from worker A while worker A is unavailable. Hence, at no time did both workers have to be available to affect the transfer of information.

Other advantages of computer based message systems include the ability to transmit information from anywhere and at anytime one desires. This is mainly due to the availability of telephone lines throughout the world. Decrease in tension is another real advantage. The potential to be "connected" to the office no matter where one is can take away the concern that something major may be happening which you need to know about, but don't because you cannot reach the office for some reason. Also, with computer based message systems, it is a small matter to send multiple copies of the same message to several people without making several separate phone calls and risk telling each person something different during each call. A computer based message system can be used as a substitute for travel. Lastly, the discipline of putting your thoughts concerning the operation of an office into writing before you communicate them to another person is invaluable.

Despite all the distinct advantages of computer based message systems, there remain issues that require further research. One of these concerns the narrow bandwidths (110-300 baud) employed by most people using computer based message systems. Thus transmission is slow. Input is limited by the

typing speed of the individual user. As with any form of the written word, all the nuances of speech are lost and the non-verbal cues given in face-to-face communication are lost. Finally, serious misunderstandings can arise when individuals attempt to do everything via messages. The ease with which a reply can be sent is sometimes the opposite of what is needed. A person may quickly read a message and reply with a message irrelevant to what was asked. If such misunderstandings are allowed to continue, they escalate over the course of several exchanges of messages into serious interpersonal problems, (Uhlig, 1979). In such a case, resolution can only be made by picking up the phone and talking directly to the individual involved.

Electronic Forms

In an office environment, it is not uncommon for much information to be gathered via forms of some kind. In most organizations, a great deal of effort is expended in this area and much of this effort is relatively unproductive, (Uhlig, 1979). This effort refers to first of all, filling out the form required and then analyzing it for obvious errors and verifying that the individual who filled the form out understood what was being requested by it. If errors or misunderstandings are detected, then the organization requesting the information must return to the person from whom the information was requested and explain how the form is properly filled out. Afterwards, the verification process proceeds again, etc.

In the future, the gathering of information in the automated

office will be done primarily by electronic means. The person from whom the information is required will receive the initial request electronically, perhaps as a message. He will then call up a forms system, give the form number, and he will be prompted for the information required. As he fills out the information on the form, the individual may obtain additional information regarding how to fill out the form from a documentation file. This may be done as simply as pointing to the field in question and pressing a key labeled "help". Upon issuing the command, the "forms" system will automatically and transparently connect to a database containing documentation on the particular form which is currently being filled out. The contents of the documentation for that particular field will then be displayed enabling the user to figure out exactly what information is being requested. As the information is being entered into the form, real-time edit checks can be made for format, type and content errors. If necessary, the completed form can then be sent to a human reviewer to check for errors not checkable by a computer program. If the information on the form is destined to be stored in a database, it can then be directly entered into the database in its appropriate location.

One distinct advantage of gathering information with the use of electronic forms is the flexibility provided in altering the forms used. Since all forms filled out are essentially a real-time copy of a master form stored in the "forms" system, changing a form involves changing the single master form. One can easily realize the advantage this has over the need to recall all printed, outdated forms currently being used and re-

printing and re-distributing the revised versions of those forms. The ability to instantly make a "global" change in any form or document and have it be instantly available to all offices located anywhere is definitely a formidable one.

Coordination "tools", Real-time and Non-real-time

The availability of automated communications "tools" in the future will greatly aid individuals in all aspects of the coordination activity discussed earlier, (Uhlig, 1979). The discussion on communication "tools" covered some parts of the coordination activity via computer based message systems. However, the fact that office workers will be able to sit at their own terminals in offices connected to other offices via computer communication networks will make possible kinds of coordination which have been very costly in the past.

There are basically two kinds of coordination to be discussed, real-time coordination and non-real-time coordination. Real-time coordination concerns the linking of two or more terminals together, via software, in such a way that anything typed on one terminal instantly appears on all the others. At first, this may not seem to add much capability until one closely examines some of the ways in which this kind of capability can be used. This capability is available on a number of computers used for development of documents. An individual who is jointly authoring a document with another individual will develop an initial draft. When the first draft is complete, the co-authors may then agree to meet, via a computer based message system, and revise the initial draft. This meeting will of course take

place at two remote terminals. At this time, the two authors may type messages to each other indicating any desired changes to the draft and agreeing upon those changes in real-time. Any or all parts of the draft may be loaded for revision and its corresponding changes discussed via messages sent to one another.

Real-time coordination has been used successfully when the co-authors are separated by either small or great distances. In either case, it adds the capability of greatly speeding up the coordination activity required to co-author a document. The alternative would be to exchange drafts by mail eventually leading to a face-to-face meeting of the authors involved. This process is both time consuming and expensive. Thus real-time coordination allows individuals to work on projects that otherwise would be postponed due to time and money considerations.

Non-real-time coordination provides the capability of using editing tools, such as the word processing systems discussed earlier, to indicate desired changes, insertions and deletions in the text of the document being prepared and then transmitting the document and its associated alterations via the linking tool previously mentioned to another author at some remote terminal. The other author can then review the suggested changes interactively, accepting or rejecting them as he sees fit.

Non-real-time coordination adds a great deal of capability in working jointly on a document with many authors by providing interactive computer "tools" to help manage the coordination activity itself. For example, each paragraph can be marked with

the date last changed and the name of the author who made that change. Then, during further revisions, the computer can be instructed to locate only those paragraphs that have been modified since a specific date, or it can be instructed to locate only those paragraphs changed by an indicated individual. Another advantage would be the elimination of paper drafts of documents created during the revision-making process.

Combined with the computer based message system approach to communication, real-time and non-real-time coordination can provide unquestionably powerful and beneficial "tools" with which to conduct crucial office business that might otherwise be severely delayed or never conducted all together.

Others

The automated "tools" presented are by no means an exhaustive list of those available today. However, the ones discussed are generally found to be the most common among automated office systems and should provide the reader with a good general understanding of how automated office "tools" are utilized within an office environment and what they provide in the way of increased efficiency and productivity of office functions.

Among other office processes benefitted by automated office "tools" are planning, business programming and budgeting, (Uhlig, 1979). All of the "tools" discussed in the preceding text will be useful in the planning process. Message systems will be very helpful in allowing managers involved in the planning process to communicate their ideas to one another quickly and efficiently.

Coordination "tools" will be used to ensure that all departments participate in the planning process. Since plans are primarily text oriented, the ability to handle narrative information on computer terminals in the office will greatly enhance the planning process.

Automated business programming (not to be confused with computer programming) "tools" already exist today. Interactive business programming "tools" will be integrated with planning tools. The fact that program information will be readily available will make that information much more valuable to the planning process.

Today, a significant amount of effort is expended in formulating budgets by individuals working with pencil and paper. However, the process of formulating a budget will always require a significant amount of human intervention since budgeting is so closely related to planning and programming, (Uhlig, 1979). However, interactive budgeting "tools" can be used to help keep the formulation of budgets from undermining a major program because of some interdependency the budget analyst was unaware of. Interactive budget systems will be able to spot such problems and immediately notify the analysts formulating the budget while the whole process is still fresh in their minds.

CHAPTER 4

OFFICE MODELING

Introduction

The office processes and activities discussed in an earlier section often interact with each other in a typical office environment in highly complex ways, (Newman, 1979). For instance, it is not always possible to begin carrying out the steps necessary in the programming process from start to finish without being interrupted at some point in time during its execution. Recall that the programming process turns plans made during execution of the planning process into action. It is the process in which the goals and objectives arrived at during the planning process are incorporated into a program of strategy. Recall also that generating new information, or developing new ideas, is an important activity performed during the planning process. It would be quite unrealistic in most cases to assume that all useful ideas concerning the formulation of goals and objectives would be arrived at during the the planning process. In the event that some key ideas are destined to be conceived at a later point in time, the programming process will be underway and managers will be mapping strategy towards the currently stated goals. When these new ideas are then introduced, the

programming process may have to back up to some previously performed activity and re-start execution from there, or the programming process may require re-execution from the beginning in order to incorporate any altered or new goals and objectives formulated from the newly acquired information. It is even quite possible that the current programming process will need to be scrubbed completely and the planning process re-executed. This sort of complication, which occurs often in typical office environments, certainly does not limit itself to the planning and programming processes. This complication, or some variation of it, may occur during any office process. Thus the typical office environment can prove to be a most difficult entity to automate.

It is clear a technique must be developed to accurately represent office operation as a whole and as a function of its component processes and activities. Such a technique should be both systematic and relatively easy to use. The technique thus referred to is known today as "office modeling". A model can be defined to be a limited abstraction of reality, (Hodge, 1969). It is limited in the sense that only subsets of relevant attributes and structures of office processes and activities are chosen to be incorporated into a model. Typically, an office fulfills its function by performing its processes as specified by some procedure. A procedure here refers to some pre-determined set of steps that must be taken during the performance of all or some subset of the basic office processes. These "steps" can also be referred to as "tasks" to be done with some partial and pre-determined ordering. Each task in turn may consist of basic information handling activities, such as those already discussed,

each of which requires resources to be carried out.

Hodge discusses several practical uses of office modeling. Among some of these are: 1) system specification and design, 2) comparison of different office systems and 3) assisting in office system implementation. Perhaps the most important of these is that of system specification and design.

During any kind of specification and design activity, whether directed at office systems or at less complex systems, the existence of some kind of methodology is required. With regard to office systems, design methodologies can be difficult to find. It seems today that most automated office equipment is designed under the influence of a rapidly changing technology rather than the office environment itself, (Hodge, 1969). One possible explanation for this is the lack of models of office activity that the system designer can use to test and validate his designs.

Recall that office models are basically hypotheses about the way offices function. To support this definition, the term "office" should also be defined. An office may be defined as a functional information processing unit of an organization, (Hodge, 1969). Thus, the most obvious kinds of office models are those that refer directly to this information processing function; models of office information flow, storage, retrieval and models of how this information is used in the decision making process.

Hypotheses on which such kinds of office models are based are hypotheses about how information is handled within the

office. For example, an information-flow model might assume that information flows between offices on paper forms and that each office maintains data bases in which it records the information and from which it extracts data to place on forms that leave that office. While this is a rather simplistic scheme, it will suffice for illustrative purposes.

During the design and specification process, a designer requires the existence of a model in order to provide him something against which to test his design during its development in order to validate it. Let us suppose that an office systems designer has adopted the primitive information-flow model presented above. Such a designer will most likely design a system based on electronic forms and data bases. He would then attempt to validate his system design by inventing hypothetical test cases that adhere to his model and by stimulating the behaviour of the system in handling each test case. Upon encountering any design problems, he will then attempt to solve them by altering the design and then perform another validity check as described above. The design process just described is often carried out in a very informal manner.

It is then quite evident that the success of office system designs depends heavily upon the existence of adequate office models. Newman, (1979), describes an "adequate" office model as one with the following characteristics: 1) simple, so that the designer understands it properly and does not forget its important properties, 2) simulation-oriented, lending itself to the proper testing of designs, and 3) accurate, leading to realistic predictions of system performance.

The employment of a faulty office model during the design of an automated office system greatly increases the probability that the completed office system will not perform adequately in meeting the demands of the office environment for which it was designed.

Types of Office Models

In a previous discussion, an office model was defined to be a limited abstraction. A model is limited in the sense that no one model is able to span all of our modeling needs or capture all of the nuances and complex details of a typical office environment. Such factors as desk size, psychological make-up of office workers and acoustics may very well be quite important to an office environment, but may not be taken into account by an office model. Even modeling all of the exceptional conditions which may arise in an office seems to be an infinite task. This has tended to give rise to various classifications of models due to the fact that more than one type of office model may prove useful within a given office. These different classifications tend to be derived from differing views of office environments. Newman, (1979), classifies the major types of office models in the following categories:

- 1) Information Flow Models - These models seek to represent office work in terms of units of information such as forms and memos that flow between offices. They allow the definition of the operations performed on each unit of information. They are also useful in defining the types of information units that exist within an office and the range of operations to be applied to

each.

2) Procedural Models - This class of models is based on the view that office work is basically procedural in nature, involving the execution of pre-defined sequences of steps, called procedures. Like information flow models, procedural models involve operations, or procedural steps, and operands, or units of information. These models emphasize the task-oriented nature of office work in the sense that each procedure is designed to perform a particular task, and they identify the important and often unpredictable roles played by people in carrying out procedures. In these two respects, these models offer a more accurate model than information flow.

3) Decision-Making Models - These models relate to the decision-making activities of managers and other office personnel. The more traditional model of decision-making treats it as the fairly objective activities of information gathering and analysis. Note that these activities are two of the major activities comprising the basic office processes. Recent studies have shown that there is a large element of unpredictability in organizational decision-making.

4) Database Models - Office work can often be modeled in terms of databases which contain information records that are created and manipulated by means of transactions, or queries if you prefer, that can be viewed by generating reports of the databases' contents. Business accounting and control methods are currently largely based on this type of model.

5) Behavioural Models - It is possible to view office work

as a social activity involving situations and encounters into which are woven the information processing tasks of the office. Organizational and sociological studies provide a considerable amount of information to support this approach to office modeling.

It should be noted that while these different types of office models are not mutually exclusive, they are not totally inclusive either. They merely serve to illustrate that office modeling can be approached from differing points of view. These different classes of models have each arisen from different disciplines such as operations research, computer science, management science, data processing and anthropology. Each classification therefore tends to be biased towards the discipline which influenced its development. These biases must be accepted if one of these classes of models is chosen for use in modeling an office system.

Also, inherent in each of these classes of models are certain limitations and restrictions, (Newman, 1979). These limitations and restrictions are most apparent in the information flow and database models since these tend to provide the most mechanistic view of an office environment. Classes of models such as decision-making and behavioural give more attention to the human element present in office operations.

Mathematical Models

In the preceeding discussion, the need for some technique to represent the operation of a typical office was presented and office modeling was suggested as that technique. A dicussion of

various classifications of office models followed. Each of these classifications represented a certain point of view from which the operations that go on within an office can be viewed. It should be noted that the procedural model is essentially an imposition of the procedure-oriented view on the information flow model. In a sense then, the information flow model is a simplified version of the more complex procedural model. The combination of these two models provides a powerful methodology that can be used in modeling office operations. Representing these two models within a strict analytical framework and expressing their concepts with a well-defined and precise notation yields a mathematical model.

Mathematical models are used primarily to provide rigorous mathematically traceable descriptions of, or approximations to office operations, (Meier et al, 1969). Using these models, one is able to gain insights into the important characteristics of each of the office processes and office activities and their interactions. This is because mathematical models can often be expressed at a high enough level of abstraction that properties, generalizations, individual differences and inconsistencies can often be discovered. This is considered a plus for mathematical modeling since from these insights can be developed a greater understanding of office processes, and theories of office process interaction which all lead to consistent and well-structured implementations, (Meier et al, 1969).

It must be noted however, that modeling done hastily and imprecisely can produce misleading and in some cases grossly incorrect results. In the design of static, well-understood

systems, mathematical modeling may not prove to be cost effective. Yet Meier et al, (1969), cite some important reasons for using mathematical models: 1) the technology of office systems is still in the formative stages, 2) typical offices are dynamic in nature (changes in office procedures, personnel or demands), and 3) there is no current comprehensive theory of office information systems. There are strong indications that the development of the office of the future will rely heavily on mathematical modeling and theoretical analysis. Thus, through studies of mathematical office models, system design of complex office systems can benefit greatly from new insights derived from those models.

Upon further evaluation of mathematical models, one can see several advantages inherent in their very nature. Some of these advantages are as follows:

1) It makes it possible to describe and comprehend the facts of a situation better than any verbal description could hope to do by forcing a logical examination and analysis of the problem.

2) It uncovers relations between the various aspects of a problem that may not be apparent in a verbal description.

3) It allows the establishment of measures of effectiveness.

4) It explains situations that have been left unexplained in the past by supplying cause and effect relationships.

5) It makes it possible to deal with the problem in its entirety and allows a consideration of all the major variables of the problem simultaneously.

6) It makes it possible to use mathematical techniques that

otherwise might appear inapplicable to the problem.

7) It frequently leads to solutions that may be adequately described and justified on the basis of verbal descriptions.

8) It forms an immediate bridge to the use of computers as an aid in problem solving, thus allowing the computer to be used as a tool in performing many common office procedures.

When applying a mathematical model to some office process or activity, there are certain questions that a modeler should ask at various stages of development. Does the model adequately describe the situation? Does it indicate what data are needed to perform the process or activity? Used conscientiously, a mathematical model can provide an office representation from which much useful information regarding the design and implementation of an automated office system can be derived, (Meier et al, 1969).

CHAPTER 5

INFORMATION CONTROL NETS

Having discussed some of the basic functions and procedures executed in a typical office environment and having presented the concept of office modeling with special emphasis on the mathematical approach, Information Control Nets, (ICN), a mathematical office modeling technique will now be presented. Information Control Nets is a modeling technique originally developed by researchers at the Xerox Palo Alto Research Center headed by Clarence A. Ellis. The ICN model has proven successful in capturing precise descriptions of office activities (Ellis et al, 1978) in testing the underlying office descriptions for certain flaws and inconsistencies, and in suggesting possible office restructuring permutations.

Information Control Nets have been applied to existing offices and to hypothetical automated offices. According to Ellis, the typical large office of today is a complex, highly parallel, interactive information processing system. Understanding current offices and designing future offices can be greatly enhanced by the leverage available from a mathematical model such as ICN. Whereas the office of the past has been able to slowly evolve and correct mistakes as it does, this may not be

adequate for the office of the future. Technological change may be rapid and radical, thus requiring an office system design and description that lends itself to accurate and rapid reorganization.

Information Control Nets are unstructured in terms of control flow structures in order to enable the ICN model to accurately describe activity flows as they exist in offices. As with other information systems, the typical office system has input, output and internal processing, but the individual activities tend to be relatively simple and the data structures involved somewhat complex. Thus there is an emphasis on data flow structures and data abstractions within the model. This emphasis will become apparent as the definition of ICN and some examples are provided.

Definition of ICN

In order to define the ICN model, the office will be considered as consisting of a set of related procedures. Ellis describes several basic aspects of ICNs via example diagrams. A presentation of these diagrams is given in figures 1, 2 and 3. Each of these related procedures are then subdivided into a set of related activities. These activities are connected by temporal orderings known as precedence constraints. The accomplishment of activities requires resources such as files, pencils, telephones, calculators and people. An Information Control Net expresses office functioning in terms of the above notions of procedures, activities, precedence constraints and resources in graphical form. A basic ICN is an ICN in which the

only resources modelled are data storage facilities called information repositories. Examples of information repositories include files, folders, forms, scratch paper, and people's heads. ICN diagrams use circles to denote activities and squares to denote repositories. A solid line from activity A to another activity, B, is a precedence arc and denotes that activity A must be completed before activity B can begin. Dashed lines to and from repositories denote respectively the storing of information into and the reading of information out of repositories. These ideas are illustrated by Figure 2.

Figure 2 depicts an office procedure in which receipt of a letter from a customer indicating parts or material to be ordered initiates execution of three activities. The first activity is to log order information from the customer. The second activity is to fill out an order form, and the third activity is to send an acknowledgement letter to the customer. The ICN of Figure 2 shows that activity a1, the log activity, must be completed before the beginning of activity a2, which in turn must be completed before the beginning of activity a3. In examining ICN diagrams, one occasionally encounters dangling arcs, coming out of nowhere or pointing to nothing. These are called initiation and termination arcs respectively and indicate where procedures start and stop. So the solid arc into node a1 indicates that a1 is an initial activity, and the solid arc out of a3 indicates that a3 is a terminal activity. Next, observe the data flow and database information of Figure 2. The four squares indicate that there are four repositories: a log book, a customer letter, an

order form, and a response letter. Dashed lines coming into an activity node from a repository indicate information input from that repository to that node, and dashed lines pointing out from an activity node into a repository indicate an output of information to that repository. Reading information from a repository is generally non-destructive. Activities may in general have an arbitrary but finite number of input repositories, and similarly an arbitrary number of output repositories. Notice that the basic ICN model is uninterpreted, i.e. the actual information items transferred are not specified, only the receiving repository.

Figure 3 illustrates the parallel processing control concept of ICNs. Notice that this figure denotes the same set of office activities; however, it should be noted that activity a2 and activity a3 can be done asynchronously. After activity a1 the AND node implies that we can do activities a2 and a3 in any order, or simultaneously. In this example, the repository labelled customer letter is used as the input for all three activities. Thus it is a shared database. The final control structure, the decision node is illustrated in Figure 4. This figure depicts an office in which, after logging the receipt of a customer letter, an order form or a rejection letter is created. The hollow dot is present in this diagram in place of the black dot of the diagram of Figure 3. The hollow dot denotes choice or decision. The hollow dot is considered an activity itself because it is frequently necessary, as in this case, for the decision to rely upon input data. Thus two dashed input arcs are drawn to the decision node d indicating that the accept/reject

decision is based upon information from two sources. In this case, information on the customer request letter and customer history data from the customer file are used to decide. This is in contrast to the parallel operation node with no decision. Therefore, in such a node, no data arcs enter or emanate and thus is not modelled as an activity. An activity within a procedure may itself be composed of many activities and thus may be described as a procedure. For example, the activity of sending an acknowledgement letter to a customer may contain a number of distinct, more elementary steps. Thus one of the advantages of this network representation is that it is a modular description which can show various levels of detail. ICNs can, and should, be drawn in a structured manner so that no single net becomes too large or complex to understand. Lower level, more detailed nets typically may refer to individual fields or areas of documents.

At this point, a formal definition of an ICN will be presented. An ICN is formally defined (Ellis et al, 1979) as various functional mappings between activities and repositories. One set of mappings, f , describes precedence constraints among activities, and another set of mappings, g , describes repository input-output requirements of activities. A basic ICN can contain additional useful information such as information concerning the particular data items transferred to or from repositories, information concerning who performs the activity, information concerning the amount of time the activity requires to execute and information concerning the amount of data transferred into and out of an activity. Some of these extensions will be

discussed later. A formal definition of an ICN thus is as follows:

Definition: A basic information control net is a 4-tuple $S=(f,g,I,O)$ over a set A of activities and a set R of repositories, where

1) I is a finite set of initial input repositories (note, input repositories are assumed to be loaded with information by some external process before execution of the ICN).

2) O is a finite set of final output repositories (note, output repositories may contain information used by some external process after execution of the ICN)

3) $f=f_i \cup f_o$ where f_i is a multivalued mapping of an activity to its sets of immediate predecessor activities, and f_o is a multivalued mapping of an activity to its sets of immediate successor activities.

4) $g=g_i \cup g_o$ where g_i is a single valued mapping function of an activity to its set of output repositories, and g_o is a single valued mapping function of an activity to its set of output repositories.

With respect to ICN diagrams, solid lines into an activity node correspond to the f_i function and solid lines out of an activity node correspond to the f_o function. Likewise, dashed lines into an activity node correspond to the g_i function and dashed lines out of an activity node to the g_o function.

As examples, the formal definitions corresponding to figures 1, 2, and 3 are given in tables 1, 2, and 3. Given the formal definitions, the execution of an ICN can be viewed as follows: Pick any activity a , then, in general:

$$fo(a) = \{\{B_{11}, B_{12}, \dots, B_{1,m(1)}\}, \{B_{21}, B_{22}, \dots, B_{2,m(2)}\}, \dots, \{B_{n1}, B_{n2}, \dots, B_{n,m(n)}\}\}$$

implies that after completion of activity a , a transition occurs which simultaneously initiates all of the activities $B_{i,1}$ through $B_{i,m(i)}$. The m 's denote functions that represent the number of elements in each of the n sets. Only one value of i ($1 \leq i \leq n$) can be selected as a result of a decision made within activity a . Note that if $n=1$, then no decision is needed and a is not a decision node. In general, if $m(i)=1$, for all i , then no parallel processing is initiated by completion of a . Because synchronization is frequently needed within offices, $fi(a)$ must also be taken into account. For instance, if a or b will execute, and one or the other must finish before c , then one way to model this is by utilizing a hollow dot with two arcs coming into it from a and b and one arc going out of the hollow dot to c . If a and b execute in parallel, and both must finish, then the black dot (AND node) with two incoming arcs can be used to signify that c will not execute before both a and b have executed to completion.

The execution of an ICN commences by a single S transition. Notice in the tables that $fi(a_1) = \{\{S\}\}$. This means that the net 'starts' by executing activity a_1 . It is always assumed without loss of generality that there is a single starting node, i.e. for all activities a in the set of activities A , there exists an activity S such that $\{\{S\}\}$ is an element of $fi(a)$. Likewise, execution of an ICN is terminated by any one S output transition. Notice in table 1 that $fo(a_3) = \{\{S\}\}$. The assumption just stated allows any complex procedure to be viewed as a single node. If

there are several S output nodes, the procedure when viewed as a single node would become a decision node. This single decision node, graphically represented as a hollow dot, would then appear as a decision activity within some office procedure specification which exists at a higher level.

Having formally defined ICNs, it is necessary to determine whether the concepts and notation of the ICN model provide a consistent and conflict-free representation of an office system. To examine this point, special attention will be given to office systems consistency and the ability to specify office procedures with ICNs that are free of inconsistencies. The example of Figure 4, for instance, describes the office procedure of processing a customer order. During this procedure, it is necessary to maintain a quantity ordered data item which must be used by during some of the activities in order to process the customer letter. If, during a particular execution of this office procedure, examination of this data item during activity a1 does not agree with an examination of the same data item during activity a3, then an inconsistency exists in the data required to execute this office procedure. Such inconsistencies as these can be easily detected by employing formal office models such as ICNs to describe office procedures. Within the automated office, data consistency is of major importance.

Ellis recognized that the ICN model itself must be a consistent and complete model in order to insure that its application to office systems can effectively detect possible

inconsistencies in office procedures. In examining the completeness and consistency of ICNs, it is useful to distinguish between ICNs, (Tables 1-3), and ICN diagrams, (Figures 2-4). Completeness of the ICN model refers to the ability of the mathematical notation used to describe all office procedures. The working meaning of office procedure would be any office procedure describable by an ICN diagram. To insure completeness, it is mandatory that any two black dots, (AND nodes), in an ICN diagram be separated by at least one activity node. Without this stipulation, it would be difficult for the notation to express the immediate sets of successor activities of the activities immediately preceding the AND nodes. Consistency of the ICN model provides the answer to the question: Given a mathematical description, does it always describe an office procedure? The working meaning of this is that the mathematical description has some ICN diagram that corresponds to it. If the mathematical description says that activity a1 is a predecessor of activity a2 but activity a2 is not a successor of a1, then the consistency constraint is violated (Ellis, et al, 1979).

Ellis defines consistency broadly to mean that "a collection of specifications or rules are not contradictory." Internal consistency is distinguished from external consistency in that internal consistency is defined as the impossibility of generating contradictory theorems, given a set of axioms and inference rules, whereas external consistency is defined as the absence of discrepancies between two sets of specifications of a system, between a system and assertions about that system, or between two "equivalent" systems.

Ellis further identifies several classes of consistency, which if breached could leave the automated office system in an undesirable state. Such classes include improper delegation of responsibility within the office. Too few or too many people with either too much or too little responsibility for the transactions that enter the office system may eventually cause the system to enter some undesirable state. A second class would be a contradictory information state. That is, if two different information repositories which contain copies of the same data item do not agree on the value of that data item, then the system is in an undesirable state. Such discrepancies frequently occur with respect to monetary figures. This class of inconsistency can also be termed a contradictory database state.

Distinguishing between ICN diagrams and ICNs, and defining consistency and completeness for the ICN model was necessary to address the idea of external consistency. To address the issue of internal consistency of the ICN model, refer to Figure 2 again. The acknowledgement operation used the customer order form as input. However, when parallel operation was introduced in Figure 3, the input of the acknowledge activity was changed to the customer letter. If we had not made this change, then the fill-out operation which writes onto the order form might conflict with the acknowledge operation occurring simultaneously which reads information from the order form. That is, whether the fill-out activity a2 occurs first or the acknowledge activity a3 occurs first or they occur simultaneously has not been specified. If activity a3 occurs before activity a2 then this

office procedure will not work. It is obvious that in some cases obsolete information can be obtained when this type of conflict occurs and in other applications it is even possible that two operations operating concurrently lead to some chaotic blend of the two operations as a result in some repository. Following are some definitions that describe the undesirable condition that leads to this problem. Then, some useful theorems (Ellis, et al, 1979) derived from these definitions are presented.

Definition: If a directed path in the precedence graph from node a to node b exists, then it is said that a is less than b and b is greater than a.

Definition: Two distinct activities a and b are in conflict at repository r if

- 1) a is not less than b, and
- 2) b is not less than a, and
- 3) either r is an input repository of one of the operators and an output repository of the other, or r is an output repository of both.

An ICN is conflict free if no two distinct activities are in conflict at any repository.

Definition: An ICN is functional if the final values in the output repositories are functions only of the initial values in the input repositories.

Theorem: Every conflict free ICN is functional.

Proof: It can be argued that since there are no conflicts the net can be directly mapped to one or more sequential execution sequences which all produce the correct values in the output repositories. Since these output values are independent

of the exact sequence of operations, they can be expressed as functions of the initial values in input repositories. Incidentally, the converse of this is false since a net may contain conflicts which do not affect the output repositories.

Definition: An ICN is determinate if the sequence of loadings of each repository is a function only of the initial values of the repositories.

Theorem: Every determinate ICN is functional.

Proof: Determinacy requires that given an arbitrary repository r , the sequence of values stored into r during the execution of the net must be a function of the initial values. In particular, the last value stored into r must be a function of the initial values. Since this property must hold for all repositories r , it must hold for all output repositories. Thus, determinacy is a stronger condition than functionality. The converse of this theorem is false since the sequence of loadings of a repository may be altered by time dependencies while the final value loaded can be independent of the temporal ordering of conflicting activities.

Theorem: Every conflict free ICN is determinate.

Proof: Assume that the net is not determinate. Then some repository can be found whose sequence of loadings depends upon the order in which asynchronous activities are executed. This implies that the net has a conflict, thus enabling a proof by contradiction.

These definitions and theorems describe undesirable conditions and relevant properties related to the notion of

internal consistency analysis.

ICN Example

Figure 5 describes the activities involved in and the input and output repositories utilized during a very common procedure in most offices, that of producing employee payroll checks. There are two important aspects of ICNs illustrated by the diagram of Figure 5. First of all, recall the definition describing when two distinct activity nodes of an ICN diagram are in conflict with each other. In particular, activity nodes a2 and a3 both satisfy the first two conditions of the node conflict definition. The AND node (black dot) of Figure 5 dictates that activities a2 and a3 are to be performed either simultaneously or asynchronously. However, neither node shares an output repository with the other, and neither node has as an input repository which is also an output repository of the other. Thus, condition three of the node conflict definition is not true in this case and nodes a2 and a3 are conflict free. In fact, the entire ICN diagram of Figure 5 is conflict free since there is no other parallel processing being performed in that procedure.

Notice also, that the ICN diagram of Figure 5 is also functional, i.e. the final values in the output repositories shown are functions solely of the initial values of the input repositories. If for instance nodes a2 and a3 shared a common output repository, then the sequence of execution of those nodes following the AND node would determine the final output values in that common repository. But since condition three of the conflict free definition is not true, it is clearly impossible to

produce a non-functional ICN, thus the theorem that states, "Every conflict free ICN is functional". It can be seen also that Figure 5 depicts an ICN which is determinate, i.e. the sequence of loadings of each repository of the diagram is a function only of the initial values of the repositories. Again, the only nodes that could pose a threat to determinacy, nodes a2 and a3, pose no problem since their sequence of execution would have no effect on the sequence of loadings into repository "check forms".

The second aspect of ICNs illustrated by Figure 5 together with the ICN diagram of Figure 6 is the ability to represent whole office procedures as simple activity nodes in the ICN specification of an office procedure at a higher level. Activity a1 of Figure 5, for example, is actually an office procedure in and of itself and whose expansion is shown in Figure 6. In this case, the procedure of payroll production is considered to exist at a higher level of abstractness than the computation of the paycheck data itself. It is this capability of ICN that allows the specification of office systems in a highly structured and modular model. This in turn facilitates ease of use of the ICN model, especially when describing very complex office procedures, and contributes much to the understandability of the final office representation.

Office Restructuring

This section will take a brief look at what is meant by office restructuring transformations. There is often as much to be gained from the office restructuring process as from the

introduction of automated equipment into the office. Even stronger than this, it has become apparent that the office must change upon introduction of an automated information system. Restructuring transformations can be subdivided into three parts: 1) automation, 2) reorganization, and 3) streamlining. Automation is considered to be replacing activities with identical or similar activities which automate the means of doing work. A second type of analysis is concerned with office reorganization. This employs global data flow analysis which includes parallelism transformations and does such things as shifting activities through decision nodes where advantageous. Lastly, streamlining, as opposed to reorganization uses local data flow information. Its goals are to omit useless activities, to decrease unnecessary communications overhead and to perform various other local alterations. Streamlining also leads to a minimal representation of office procedures. A simple example of streamlining will be given in a subsequent section. Additional information on office restructuring transformations and streamlining is given by Ellis and Morris, 1979. This paper will illustrate a method of formal analysis developed by Ellis which addresses throughput and workload questions. While formal analysis is not really a restructuring transformation, it is related.

Given an ICN description of an office, it is possible to efficiently answer basic questions such as:

1) How much work on the average comes into our office for the billing clerks and how much for the order administrators?

2) How much time is spent in forms fill-out and how much

time is spent in external communications with customers.

3) How much time is spent executing some procedure?

This analysis requires that a basic ICN be augmented by probabilities on the arcs out of decision nodes and timing information attached to all activity nodes. If the original office was well formed, it is possible to transform the ICN into an equivalent single person simulation of the original net. That is, all the existing parallelism is removed and control arcs are added to completely specify the ordering between activities. This transformation does not change the amount of time allocated to the various activities and classes of activities. Thus, the questions posed above will have the same answers before and after this transformation. The case that will be considered here is the case where the single person net forms a tree structure in which control forks caused by decisions are assumed never to join back together.

In this case, the formal analysis consists of rolling back a decision tree which is illustrated via Figure 7. Several parameters of interest can be attached to activities. In this example, the average amount of time in minutes that it takes to perform each activity has been added. The total amount of time, then, spent in this procedure on the average is found by starting at the leaves of the tree and rolling backward up the tree until the root node is reached. At each node an expected position value is calculated as the sum of the node weight plus the expected position values of all direct successors multiplied by their probabilities. Thus, in Figure 7, the expected position

value of node a6 is nine. This is because node a6 has no successors. The expected position value of node a3 computes to a value of $W(a3) + E(a5) \cdot 0.05 + E(a6) \cdot 0.5 = 3 + 25 \cdot 0.05 + 9 \cdot 0.5 = 20$, where W is weight and E is expected position value. The expected position value of the root node, a1, is then 24 minutes. Thus, each time this particular office procedure is executed in the office, it will take on the average 24 minutes to complete. Such prediction of procedure execution time is quite useful in answering throughput and workload related questions such as those mentioned above. Also, such information can be used for analysis of future system expansion to accomodate the ever changing demands and requirements of the typical office.

A Streamlining Example

The specification of office procedures typically leads to highly complex office descriptions which tend to obscure the underlying information flow within those procedures. This is often a result of such complications as excessive paper work, administrative work load increases, difficulties with personnel, inefficiencies in communication and redundant or unnecessary activities. The mathematical nature of ICN allows the application of rigorous transformations, such as streamlining, to office procedures which results in procedure descriptions that illustrate information flow in a more comprehensible fashion. Following is an example of such a streamlining transformation which illustrates the basic concepts of office streamlining as presented by Ellis.

Figure 8 depicts a simple office procedure executed,

possibly by a bank, when processing a customer loan application. There are several added information items present in this ICN diagram not previously illustrated by diagrams presented in preceding sections, which require explanation. First of all, u and v denote people associated with the various activities in the diagram. Notice that person v does not become necessary until after the concurrency node following the first decision node. This is due to the fact that person u cannot possibly perform more than one activity at once. Also note the inclusion of numeric labels on each of the possible branches coming out of a decision node. The purpose of these labels will become evident later. Finally, the repositories in Figure 8 have been subdivided into three types: internal long-term repositories, external repositories and short-term(temporary) repositories denoted by squares, diamonds and triangles respectively. External repositories represent sources of data that exist outside the procedure being described, for example the customer as depicted in Figure 8. All external repositories are long-term repositories. Temporary repositories represent those which are created during execution of the procedure and are used up by the procedure. Long-term repositories exist at all times and can be considered permanent to the procedure.

Office streamlining is a process which is used to map an existing office procedure description into a new procedure description which contains no unnecessary activities and has minimal communication between activities and repositories. To this end, two mappings are defined, mapping M_a which maps activities of the old system into activities in the new system

and mapping Mr which maps repositories from the old system into repositories in the new system. The rules governing the application of these mappings will be defined both formally and informally later.

In applying the mapping rules, particular attention must be given to the decision paths leading to the nodes to which the mapping rules are to be applied. A decision path refers to the branch taken from the most recently preceding decision node to some activity node. For example, the decision path at node 3 in Figure 8 is branch (1) from decision node 2. These paths are important since the transformation mappings of activities from the old system to the new system must preserve precedence. This restriction prevents the combination of activity nodes separated by a decision node. One further restriction is that if two or more nodes are mapped into one node of the new system, the new node must be an elementary node, i.e. a node which accesses at most one long-term repository.

Figure 8 depicts an office procedure in which a loan application from a customer is processed. The screening activity is done to produce information regarding the level of risk the applicant represents to the business. If the risk is too high, then the procedure is halted. Otherwise, concurrent execution of activities which fill in the loan form, check the loan rate and perform a credit check on the applicant are initiated. Information generated by the credit check activity is then evaluated by the decision at node 6 to determine whether or not to accept the loan application or reject it. The procedure then

continues on to perform whatever activities the business requires to complete the process. The temporary repositories u and v represent person u's and person v's temporary work space.

The ICN data flow diagram of Figure 8 can be simplified by applying two mapping rules. The first of these rules allows the combination of two nodes, or mapping of two nodes in the old system into one node of the new system, if two conditions are met: 1) the two nodes are on the same decision path, and 2) the two nodes access the same long-term repository as the one and only repository which they access, or the long-term repositories which they access are mapped into the same repository in the new system. Repositories are mapped into the new system with the simple rule that all long-term repositories map into a single repository in the new system, all short-term repositories map into a single short-term repository and external repositories map into themselves. This repository mapping, M_r , then expresses all information sources of the old system as just one or two sources in the new system making the data flow representation more abstract, but clearer and more compact. The second rule allows application of the activity mapping M_a to two nodes in the old system if 1) the nodes are on the same decision path, and 2) only one or neither node accesses a long term repository. A rigorous definition of these rules is given in table 4

The ICN diagram resulting from the streamlining of the diagram in Figure 8 is shown in Figure 9. Notice that activity nodes 3, 4, and 5 have been combined. Also note that there is only one internal long-term repository and only one short-term repository. The data flow represented by this streamlined version

of the loan procedure is much simpler and facilitates a better understanding of the interrelation between the activities involved in the procedure and their associated data flow. Communications have been reduced and unnecessary nodes have been eliminated.

Ellis calls this transformed ICN diagram the minimal form. It should be noted that streamlining is most useful when performed on highly complex ICN diagrams for it is those which pose the most serious complications to a thorough understanding of the underlying data flow of office procedures. For these complex diagrams, Ellis describes an intermediate form, which he calls the normal form, to which the streamlining mappings can be applied more systematically. This normal form involves the identification of source and sink node pairs within the ICN diagram. The mapping rules are then applied to this source/sink pairs representation. The sources and sinks are defined with respect to each data item that flows through the procedure. This necessitates the augmenting of the ICN diagram to be streamlined with data item identifiers used to indicate which data items flow and where. Ellis further describes the construction of the normal form in Ellis et al, 1979.

The usefulness of procedure streamlining lies in its ability to produce a procedure description which better facilitates understanding of the underlying data flow being modeled. This enhanced understanding in turn enables office managers to get a more coherent view of the total office activities. Elimination of unnecessary activity nodes saves valuable time during office

operation, helps reduce risk of inconsistencies in the office system and helps to minimize communication overhead.

While office streamlining has advantages, it is not without its shortcomings. A streamlined office procedure is still unable to show possible interrelationships between data contained in its repositories and the same data or similar data in repositories contained in other office procedures. For example, the loan information repository in Figure 8 could be a subset of information from a larger repository which exists at some higher level of abstraction. The streamlined representation of the loan procedure certainly does not illustrate this possibility. In fact, the streamlined description may actually obscure the notion of repository interconnectedness. Thus while data flow within an office procedure is made more compact and simpler to understand, data flow between and among several office procedures tends to become transparent.

Another potential shortcoming of streamlining can result from the combination of several nodes into one. Differing office environments, operation protocols and working conditions contribute characteristics to the nature of office activities unique to the office in which they are a part. Differences between like activities among different offices may determine whether or not the combination of those activities is appropriate relative to the office of which they are a part.

Since there are many office procedures that do not have interconnectedness of repositories with other procedures and whose component activities are well defined and understood within the containing office, the complications cited above will not

hinder the usefulness of office streamlining to those procedures. Thus streamlining ICN diagrams can be a useful tool for describing office procedures. It is the support of tools such as streamlining that makes ICN useful for modeling office systems.

ICN Advantages and Disadvantages

Up until this point, the ICN model as developed by the researchers at the Xerox Palo Alto Research Center has been presented both informally and formally using both ICN's defined mathematical notation and ICN diagrams as examples. Then, a discussion on the model's ability to adequately represent office systems was presented with special attention given to the notions of consistency and completeness. Certain common problem areas that the ICN model was subject to were then identified and definitions and theorems describing those problems were provided. One type of formal mathematical analysis was presented and it was shown how such analysis can be applied to the ICN model to help answer throughput and workload questions. Finally, an ICN example was developed and used as reference in pointing out some of the important properties and potential problems of ICN modeling. As a final topic of this section, some of the major advantages and disadvantages of the ICN model cited by Ellis will be presented.

Advantages:

- 1) Modularity: As was previously mentioned, since each activity of an ICN can itself be expanded into a net, it is possible to give a high level description of an office system

using a "macro net" to avoid lesser and more trivial details. When and if a more detailed description of some activity is needed, then a "micro net" corresponding to that activity provides the detail.

2) Parallelism: The precedence graph within an ICN clearly shows all asynchronous activities which can be done in parallel. This type of behavior is usually more difficult to capture in a linear description, e.g. a typical programming language.

3) Control Flow versus Data Flow: The ICN model clearly separates the flow of control indicated by the precedence arcs from the flow of data indicated by the data flow arcs. These arcs correspond to the solid and dashed lines of ICN diagrams respectively.

4) Formalism: Because of the mathematical nature of the model definition, it is possible to rigorously prove certain properties of offices and to apply transformations which render the office system more efficient and less confusing.

5) Uninterpreted: Many of the definitions, properties and theorems which were presented are independent of the semantics of the activities. Thus, the model can show the structure of the information flow without obscuring this by the details of the interpretation of activities. It therefore may be possible to detect similarities in structure of offices which do seemingly unrelated types of work. In some cases, it has been found useful to consider partially interpreted ICNs.

Disadvantages:

1) Completeness: A macro ICN of a complex office procedure should be a simple high level description. However, since this

macro schema is to be expanded into one or more levels of details, micro ICNs, it must be complete showing all files and documents in the system and all possible control paths. Thus the macro net could become more cluttered than necessary with information which might be better ignored in a high level office description.

2) Data abstraction: While the ICN model allows nested subnets to an arbitrary level of abstraction, it does not have facilities for arbitrary levels of data abstraction. Thus, micro nets must operate from the same level of data abstraction as macro nets. However, provisions were made to help provide at least some degree of data abstraction. Such provisions were presented in the previous discussion of ICNs and include the usage of temporary repositories and cases of designation within a lower level of abstraction data items or fields that were not designated at a higher level net. Refer to the ICN example for instances of these provisions.

3) Generality: There are some properties of office systems that cannot be easily tested by the ICN model. An example of this would be reachability, or what are the accessibility constraints on repositories and resources required by the activities of some office procedure. It is not likely that all properties of interest can be investigated via a single model.

4) Information Explosion: Some care has been taken to avoid the state model problem of requiring separate descriptions of each system state. Nevertheless, if one's goal is to capture a total specification in detail of an office, then there are

problems of capturing all exceptional conditions which may arise and all informal interactions. In practice, many possible branches and control flows have probabilities less than a certain threshold and may be excluded from the ICN specification.

Despite these deficiencies, the ICN model has proved useful for mathematical analysis and for aiding our understanding of office information flow. For example, ICNs are particularly useful to the office information analyst. Common reasons for information analysis are administrative work load increases, cost increases, excessive paper work, problems with personnel, inefficiencies in communication, and redundant or unnecessary activities. These complications contribute to one of the major problems that office managers face today, overly complex office procedures which make it difficult for managers to get a coherent view of their total office activities. Office information analysis can take advantage of the mathematical nature of ICNs and define transformations which produce office procedure descriptions free of complications commonly found in office procedures. The primary goal of information analysts is to produce a clear and compact view of the underlying office information flow. The overall effects of such transformations include the removal of redundant or unnecessary activities, the decrease in the number of forms and files, and the reduction in communication overhead.

Research is continuing on making these analysis tools available as an interactive system to the office administrator, and on dynamic analysis and simulation using the ICN model. Such an interactive facility could be used by office administrators in

a graphical environment where computer and human suggest new office structurings to each other. The suggested structurings could be analyzed for complications such as those mentioned previously in real time and potential problem areas identified during design thus preventing their implementation in the office system.

Success in any office system design depends heavily on the existence of good office models. A "good" model is one with the following qualities:

- 1) Simple: So a designer can understand it properly and does not forget its important properties.

- 2) Simulation-oriented: A model that lends itself to the proper testing of designs.

- 3) Accurate: Leads to realistic predictions of system performance.

The uninterpreted nature of ICN contributes to its ease of use even for simple problems. Details that must be included in an ICN for effective office representation can be modularized into nets and subnets which exist at varying levels of abstractness thus allowing attention to be focused on details of primary concern. ICN's facility for representing parallelism in an office also contributes to its ease of use since such graphical representation is relatively simple to analyze. The constructs and facilities of the ICN model make its application to office procedures rigorous and straight-forward thus enabling its application to office procedures of all types and complexities. As research and development continues in office automation, the

usage of mathematical models such as ICN will increase and office efficiency will consequently be enhanced.

CHAPTER 6

CONCLUSION

In the previous sections of this paper several aspects of office automation have been presented, some formally while others rather informally, yet in such a way as to describe a cross section of the thought, technological developments and research prevalent in the growth of office automation today. While what has been discussed in this paper is by no means a complete discussion of the work being done today in office automation, this paper has explored some of the major areas being studied today.

A definition of office automation was given initially followed by a discussion on why such a venture is justified today. Related to these areas, the notion of feasibility of office automation was explored and a brief look was made into the ramifications and impact on society that automation could have. Then a relatively new frame of thought for analyzing today's office environment was presented which placed special emphasis on such activities of the typical office as planning, programming, budgeting, coordination, policy formulation and monitoring. Succeeding this discussion was a brief survey of some of the more common automated tools that have been developed today and a look at a few to be developed in the future.

After having given a general overview of what is really

meant by office automation, attention was then diverted to analyzing methods of representing the office as a complex structure of procedures, processes, activities and data. To this end, the idea of office modeling was introduced as providing the means with which typical office operation can be represented systematically while being relatively easy to use. Several different types of office models were briefly discussed with special attention to the type known as the "mathematical" model. Mathematical office models were then discussed with regards to their applicability to office modeling and to the advantages they have over other types of office models.

Lastly, a mathematical model, ICN, developed by the researchers at the Xerox Palo Alto Research Center for application to office modeling was presented. A formal definition of both concept and notation was given and their applicability to office modeling was discussed in terms consistency and completeness. Since mathematical models are popular for their ease with which formal analyses can be performed on them, one such formal analysis useful to apply to office systems was introduced, that pertaining to office system throughput and workload. Finally, the major advantages and disadvantages of this mathematical model, Information Control Nets, were cited.

As time proceeds, office automation will find its way into almost every major office of the world. With such a drastic change in office structure there will be an accompanying impact on the business society and functioning of the office. Some of

these impacts were discussed in the section "Social Aspects of Office Automation". Relevant to this topic, is the need in the future of what C. A. Ellis terms "integration". Ellis defines three types of integration, functional, system and interdisciplinary. Functional integration refers to the need for the user's model of a system to be consistent and complete. System integration represents the need for effective operating systems for use in the automated office, programming languages, architecture, databases and artificial intelligence. Interdisciplinary integration is the need for researchers in computer science to interface with workers in sociology, political science, management science, psychology and even law. Thus the integration of office system development is seen as essential to effective, reliable and truly beneficial office systems. Today, office automation researchers and developers have made significant progress in applying the computer technology at present to office automation. Tomorrow, office automation will be at the heart of every major business, enterprise and corporation in America. As the demand for more sophisticated office management increases, so will the appreciation of and the desire for office automation.

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Office Processes vs. Office Activities

Processes	Activities								
Planning	C	G	R	A	O	T	G	M	F
Programming	o	a	e	n	r	r	e	o	i
Budgeting	m	t	t	a	g	a	n	d	l
Coordinating	m	h	r	l	a	n	e	i	e
Monitoring	u	e	i	y	n	s	r	f	
Policy	n	r	e	z	i	f	a	y	
Formulation	i		v	e	z	o	t		
Decision Making	c		e		e	r	e		
	a					m			
	t								
	e								

Figure 1

Information Control Net

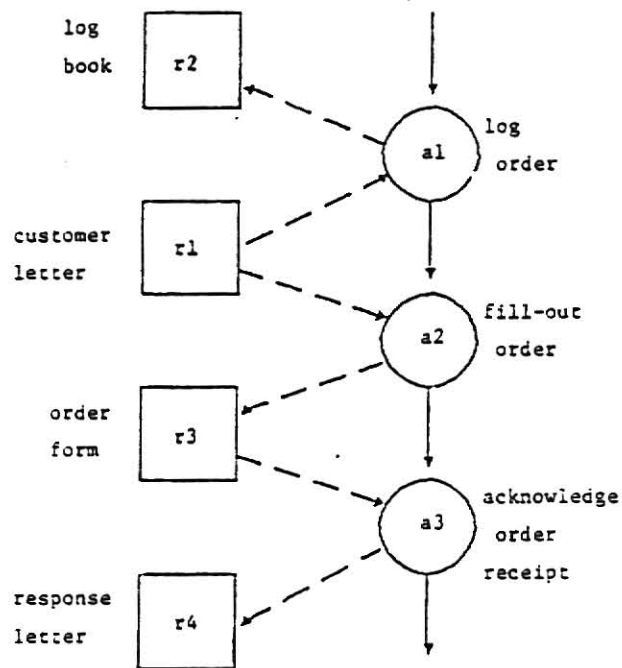


Figure 2

ICN with Parallelism

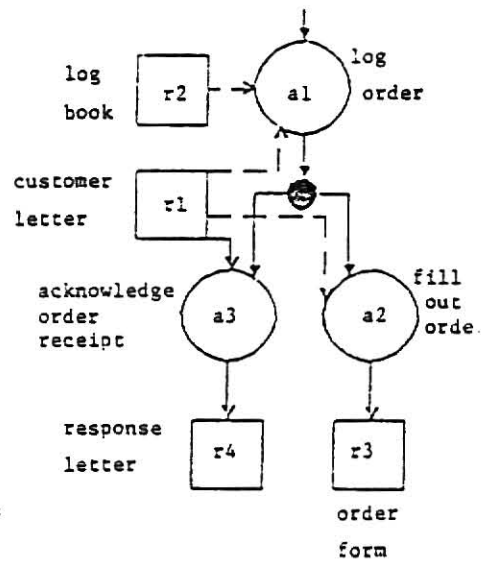


Figure 3

ICN with Decision Making

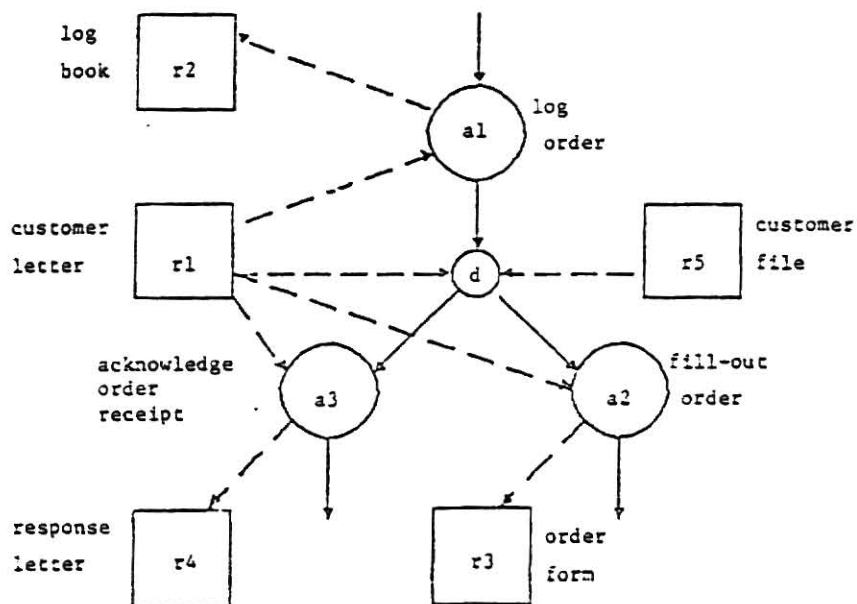


Figure 4

Payroll Production Procedure

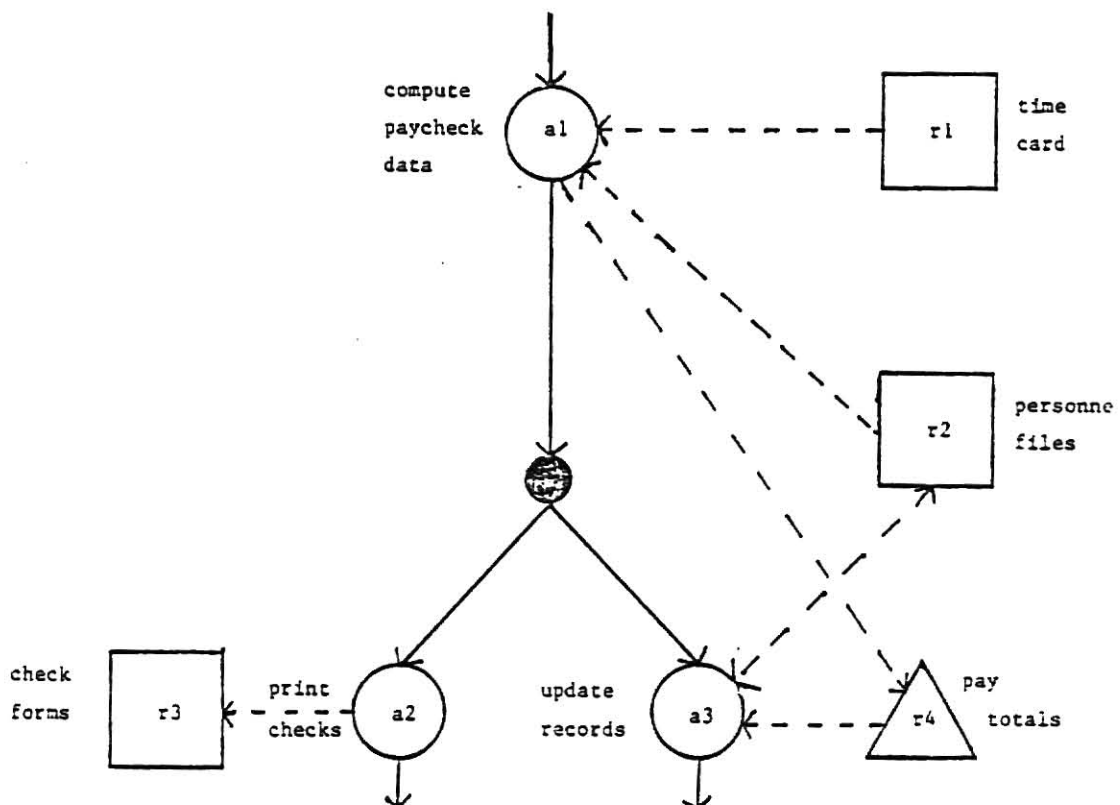


Figure 5

Compute Paycheck Data Procedure

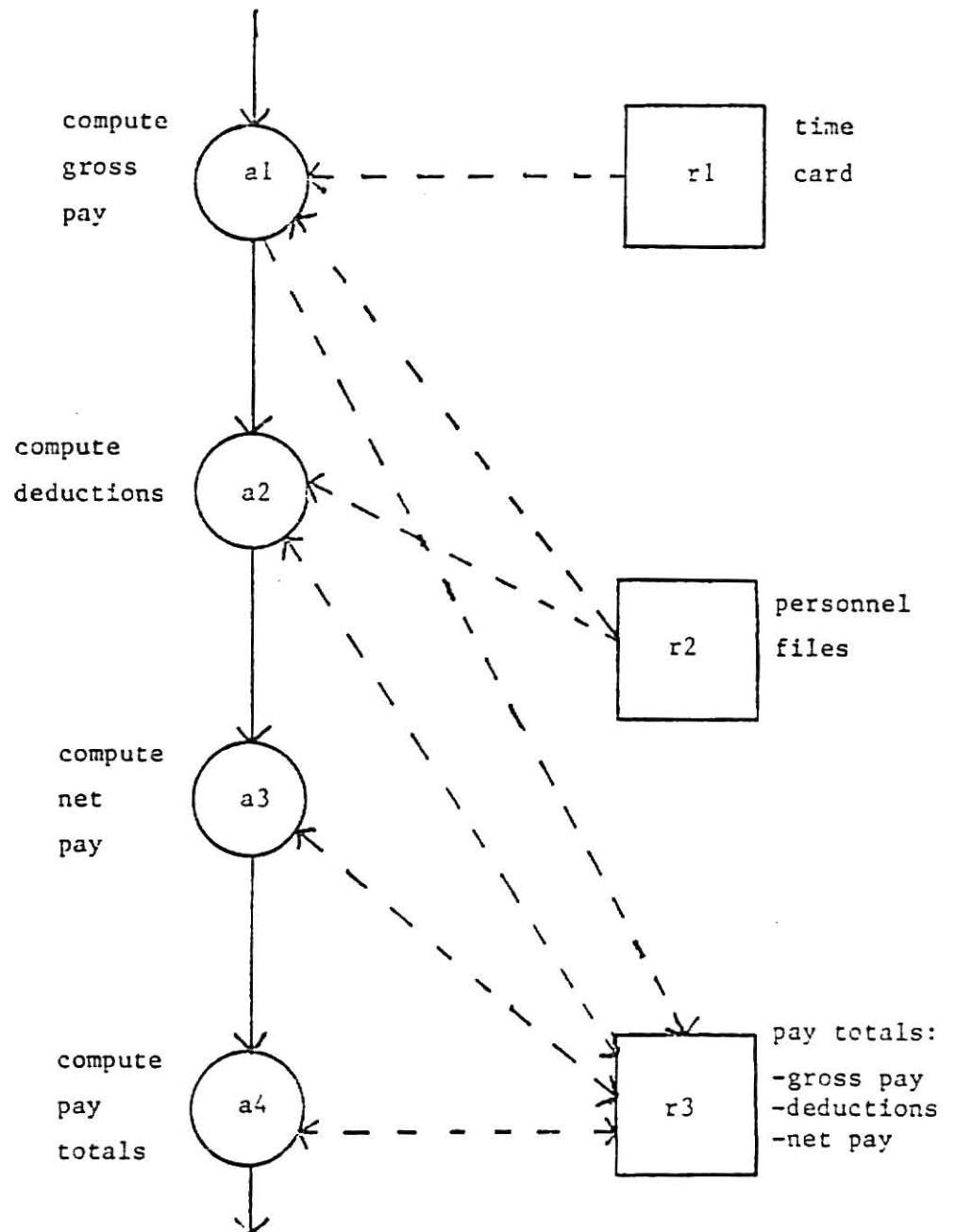


Figure 6

Timed Information Control Net

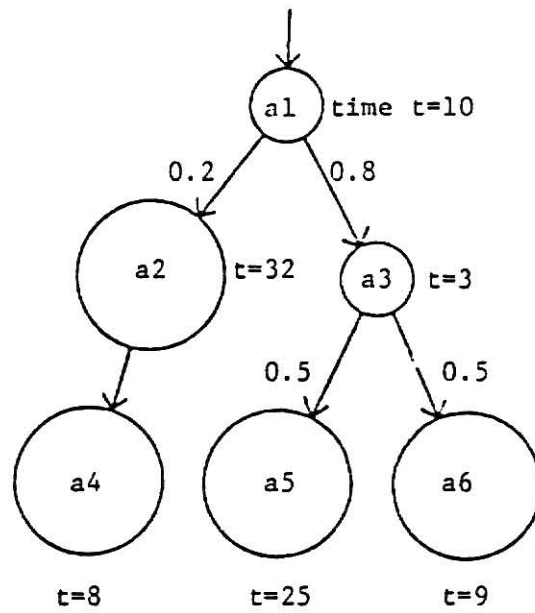


Figure 7

Loan Procedure

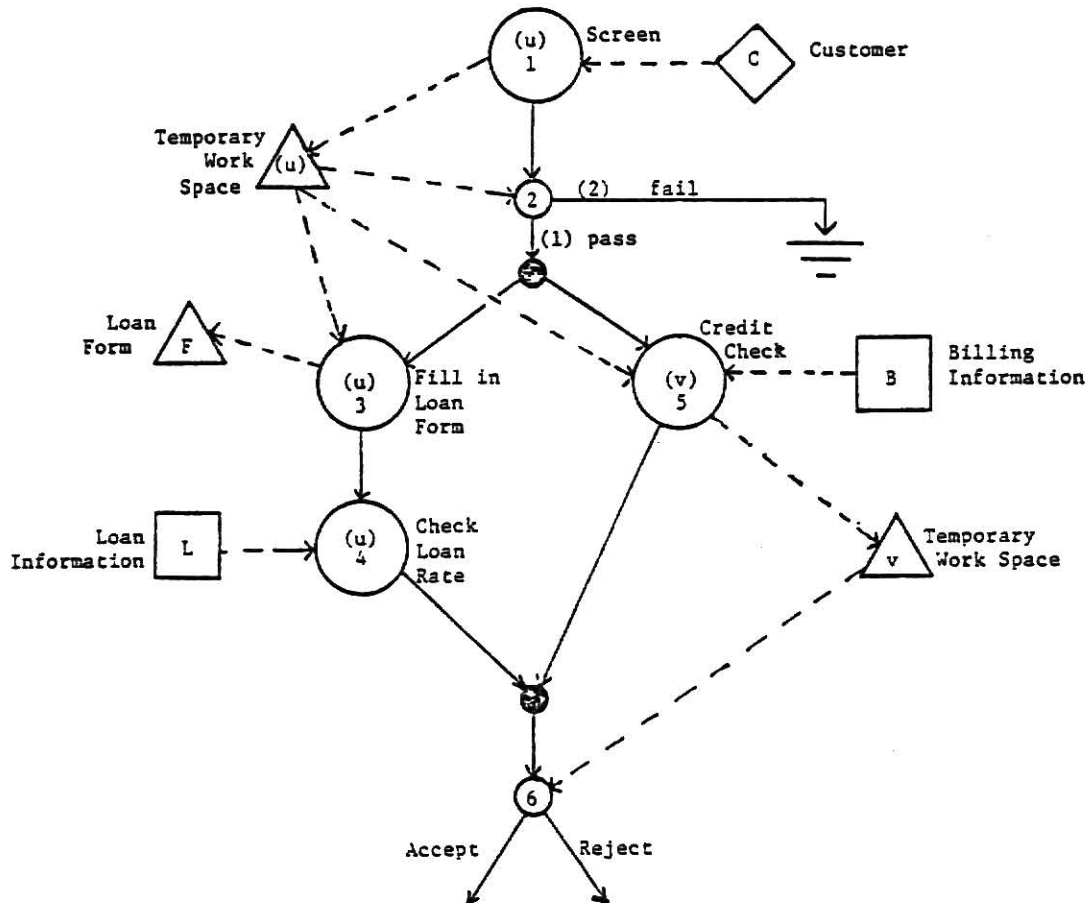


Figure 8

Loan Procedure
Minimal Form

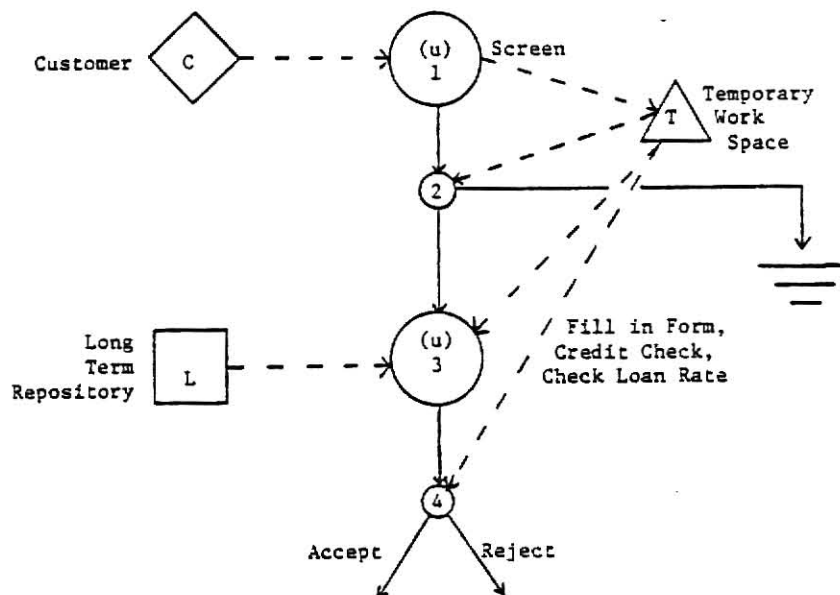


Figure 9

Basic Information Control Net

$A = \{a_1, a_2, a_3\}$

$R = \{r_1, r_2, r_3, r_4\}$

$I = \{r_1, r_2\}$

$O = \{r_2, r_3, r_4\}$

$fi(a_1) = \{S\}, fo(a_1) = \{a_2\}$

$gi(a_1) = \{r_1\}, go(a_1) = \{r_2\}$

$fi(a_2) = \{a_1\}, fo(a_2) = \{a_3\}$

$gi(a_2) = \{r_1\}, go(a_2) = \{r_3\}$

$fi(a_3) = \{a_2\}, fo(a_3) = \{S\}$

$gi(a_3) = \{r_3\}, go(a_3) = \{r_4\}$

Table 1

Information Control Net with Parallelism

$A = \{a_1, a_2, a_3\}$
 $R = \{r_1, r_2, r_3, r_4\}$
 $I = \{r_1, r_2\}$
 $O = \{r_2, r_3, r_4\}$

$fi(a_1) = \{S\}, fo(a_1) = \{a_2, a_3\}$
 $gi(a_1) = \{r_1\}, go(a_1) = \{r_2\}$
 $fi(a_2) = \{a_1\}, fo(a_2) = \{S\}$
 $gi(a_2) = \{r_1\}, go(a_2) = \{r_3\}$
 $fi(a_3) = \{a_1\}, fo(a_3) = \{S\}$
 $gi(a_3) = \{r_1\}, go(a_3) = \{r_4\}$

Table 2

Information Control Net with Decision-Making

$A = \{a_1, a_2, a_3, d\}$

$R = \{r_1, r_2, r_3, r_4, r_5\}$

$I = \{r_1, r_2, r_5\}$

$O = \{r_2, r_3, r_4, r_5\}$

$fi(a_1) = \{S\}, fo(a_1) = \{d\}$

$gi(a_1) = \{r_1\}, go(a_1) = \{r_2\}$

$fi(d) = \{a_1\}, fo(d) = \{\{a_2\}\{a_3\}\}$

$gi(d) = \{r_1, r_5\}, go(d) = \{\}$

$fi(a_2) = \{d\}, fo(a_2) = \{S\}$

$gi(a_2) = \{r_1\}, go(a_2) = \{r_3\}$

$fi(a_3) = \{d\}, fo(a_3) = \{S\}$

$gi(a_3) = \{r_1\}, go(a_3) = \{r_4\}$

Table 3

Minimal Form Transformation

Let A be the set of all activities

Let R be the set of all repositories

Let M_A be mapping : A to A'

Let M_R be mapping : R to R'

where

A' is set of all activities in new system

R' is set of all repositories in new system

Let $C(a)$ denote immediate decision path to node a ,

then, for all a, b in A , set $M_A(a) = M_A(b)$

if conditions 1, 2, & 3 or 1, 2, & 3' hold.

(assuming a & b are elementary)

1. $C(a) = C(b)$

2. a less than b (implies $M_A(a)$ less than $M_A(b)$), or a, b concurrent.

3. $r(a)$ in $(RP \cup RX)$ & $r(b)$ in $(RP \cup RX)$ &
($r(a) = r(b)$ or $M_R(r(a)) = M_R(r(b))$)

3'. either ($r(a)$ in $(RP \cup RX)$ or $r(b)$ in $(RP \cup RX)$), or
 $r(a), r(b)$ not in $(RP \cup RX)$

where,

$r(a)$ denotes repository at node a ,

RP denotes internal long term repositories, &

RX denotes external repositories

such that RP, RX are subsets of R .

Table 4

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WITH INFORMATION CONTROL NETS

by

ROBERT TODD KILLIAN

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OFFICE AUTOMATION AND OFFICE MODELING
WITH INFORMATION CONTROL NETS

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Abstract

Office automation is a rapidly growing field of Computer Science. With the vast amounts of information that must be handled efficiently in today's technological society, increasing demands are being placed on the ability to manage it effectively.

This paper discusses several aspects of office automation. It provides a definition of office automation and discusses various reasons why it is feasible. The office environment is presented as a complex system of parallel procedures composed of office processes and activities. Office modeling is presented as a useful technique in describing office operation and several types of office models are discussed with special emphasis on the mathematical model. Finally, Information Control Nets, a mathematical model of office information and control flow developed by the researchers at the Xerox Palo Alto Research Center is presented. A formal definition is given and useful theorems derived from that definition are provided. Examples are provided to illustrate Information Control Net's usefulness and applicability to office modeling.