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ARTIFICIAL INTELLIGENCE APPLICATIONS IN OFFICE AUTOMATION*

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ABSTRACT

A study of the potential applications of artificial intelligence to the field of office automation is presented. The office automation domain, along with some of its terminology, is briefly summarized. The potential contributions of artificial intelligence to help office automation better meet its objectives is then considered in light of this. Some research and development projects underway at our research centre are presented as illustrations and a number of useful classification tools are highlighted to help identify existing and potential application areas. These findings are summarized in the form of three matrices which identify interesting overlaps that can be addressed by expert system applications in office automation.

INTRODUCTION

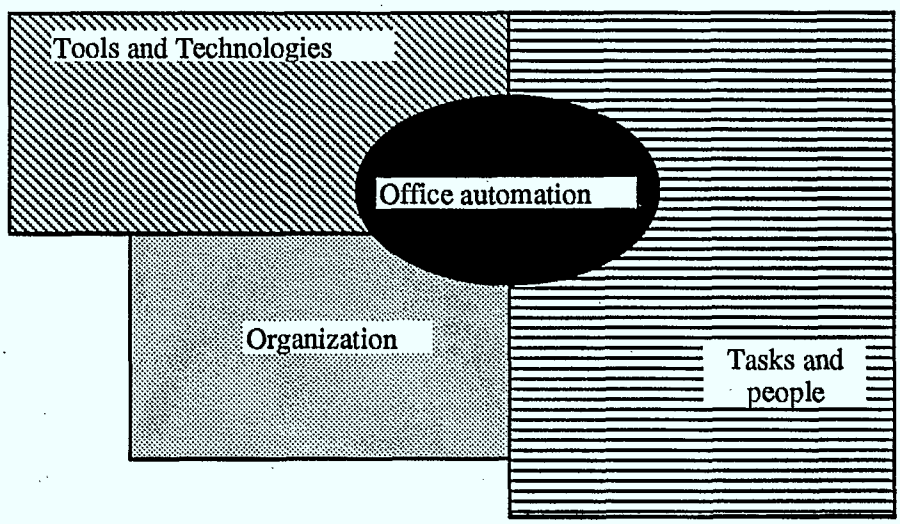
Office automation and artificial intelligence are both fields with extensive literature and varied research and development endeavors. As part of the expert systems group of a government research centre for workplace automation, we were naturally interested in trying to find the common ground, if any exists, between these two areas. The approach used was to try to identify office automation needs which were not or are not currently being met by conventional computing and communication technologies. The potential advantages offered by artificial intelligence solutions to these same problems can then be investigated.

Office automation appears to be an excellent field for artificial intelligence applications - particularly expert systems. The most fruitful approach will likely entail the addition of intelligent 'layers' to existing office information systems in an incremental 'add on' fashion. It is expected that artificial intelligence can contribute to almost all aspects of office work, from the very routine to the very exceptional.

What is office automation?

Office automation may be defined as the "careful adaptation of modern high technology for restructuring and improving office procedures to achieve increased productivity and effectiveness at the corporate executive level as well as the clerical and secretarial levels[1]" (see figure 1).

Figure 1 What is office automation?



There are two very general aims in office automation: to move as many traditional office functions to electronic media as possible and to introduce new forms of communication and information processing with this electronic media.[2] The automation of office functions can be seen as part of a larger trend - that of personal automation, the use of software tools to aid professionals in their work.[3] How can these goals be best addressed?

At this stage, some definitions may be helpful: *bureaucracy* is the formal organization through which a complex system achieves its goals. *Mechanization* is the application of physical devices to productive tasks. *High technology* is the automation of physical and mental tasks that are complex enough to require a long time to achieve. A *database* is the organized memory of an organization in the form of an electronic file. Finally, *office automation* is the achievement of self-directing productive activity through mechanization in the workplace.[4]

A good office implementation scheme should always based on a model of the office: a model of both the existing office system and a model of the system designed to replace it. There exists, therefore, a need to model the acquisition, storage, retrieval, manipulation and dispersal of information. Descriptive knowledge of what tasks need to be done, who is responsible for doing them, how they are to be done and so forth are just

as crucial as analytical knowledge needed to monitor task execution and to plan the next actions to take in order to meet set goals (see figure 2).

The majority of office information systems consist of documents with both text, image and voice. They are a specialized form of data support systems (e.g. databases for operational management), decision support systems (for tactical management) or executive support systems (for strategic management).[5] Office automation addresses all the ways of managing information: collecting, storing, analyzing and transmitting information. Assistance is provided to office workers in the form of computer and telecommunication technologies to help them better manage the logistics of the organization and its environment.[6]

Our approach is to develop a cybernetic model of the office. In this perspective, a complex system is characterized by its communication and control features. An office is an artificial or man-made system with a purpose, objectives, functions, tasks, activities and processes. The office system relies primarily on the interpretation of the intentions of all the actors involved.[7] It is an information input and output system that transforms information in such a way as to make it useful to decision makers in the organization [8].

Various authors present the office as a complex system within a number of nested environments.[9] This systemic or holistic view of the organization is clearly cybernetic in nature. The IBM research group, for example, appears to have based their office modelling on Stafford Beer's viable system model.[10] Other groups suggest using Checkland's approach to system analysis in modelling the office.[11] They define the office as "an interdisciplinary subsystem serving a purpose that is in constant flux." Each individual has a unique perspective and there are many underlying dimensions such as geography, time, social, cultural and political factors. The emphasis in this approach is on the information exchanged in order to solve problems in the workplace.

In general, the field of management cybernetics, whether based on Beer or Checkland (or both) appears to be a good candidate for the study and implementation of office automation systems. New office technologies consist primarily of computers, telecommunications and other office machines. Cybernetic modelling of a complex system such as an office will help in both the diagnostic and prescriptive phases of office automation - namely, the study of existing office systems and the design of new office automation systems to be implemented (see figure 3).

Figure 2. Factors influencing automation within organizations

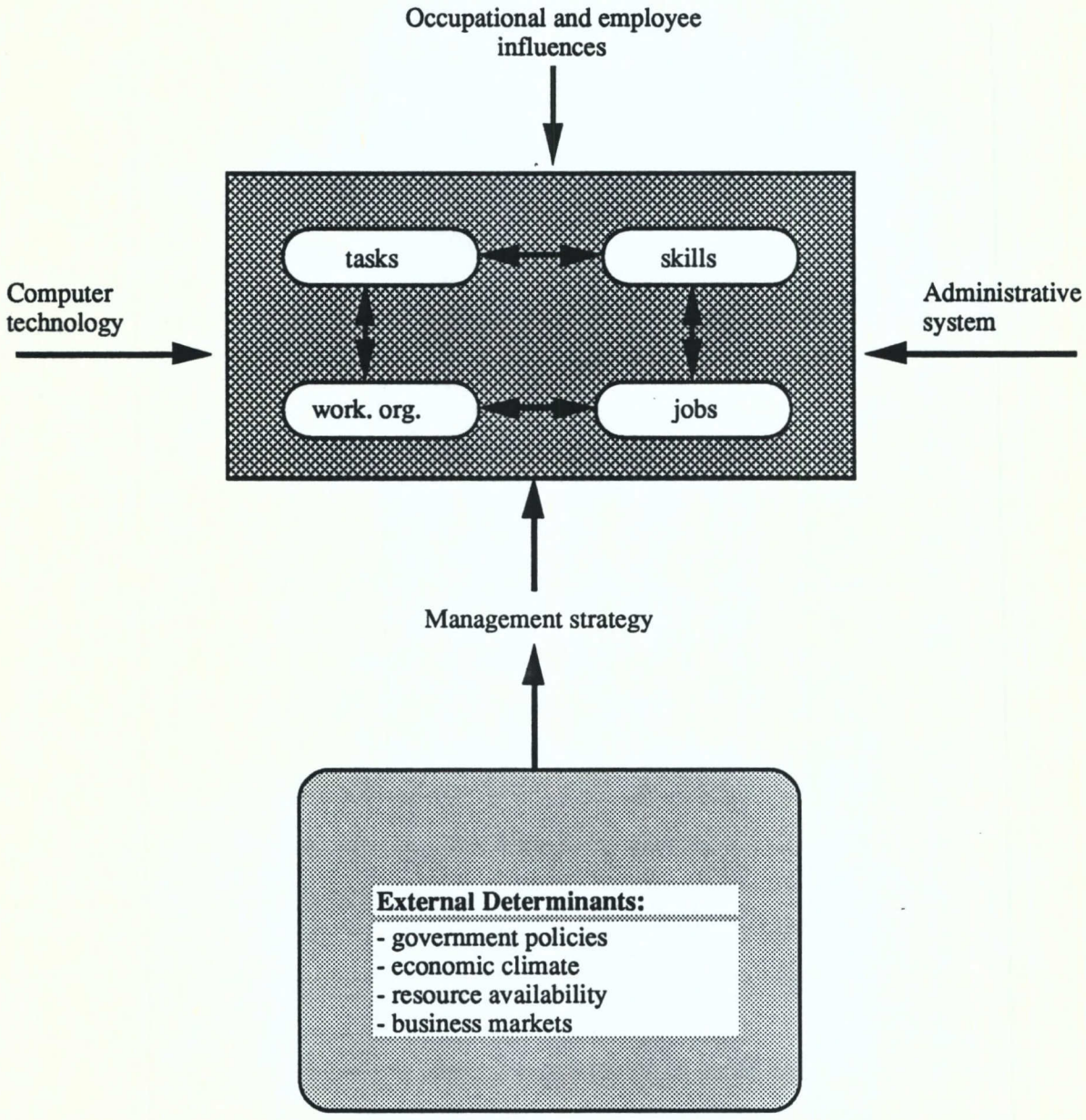
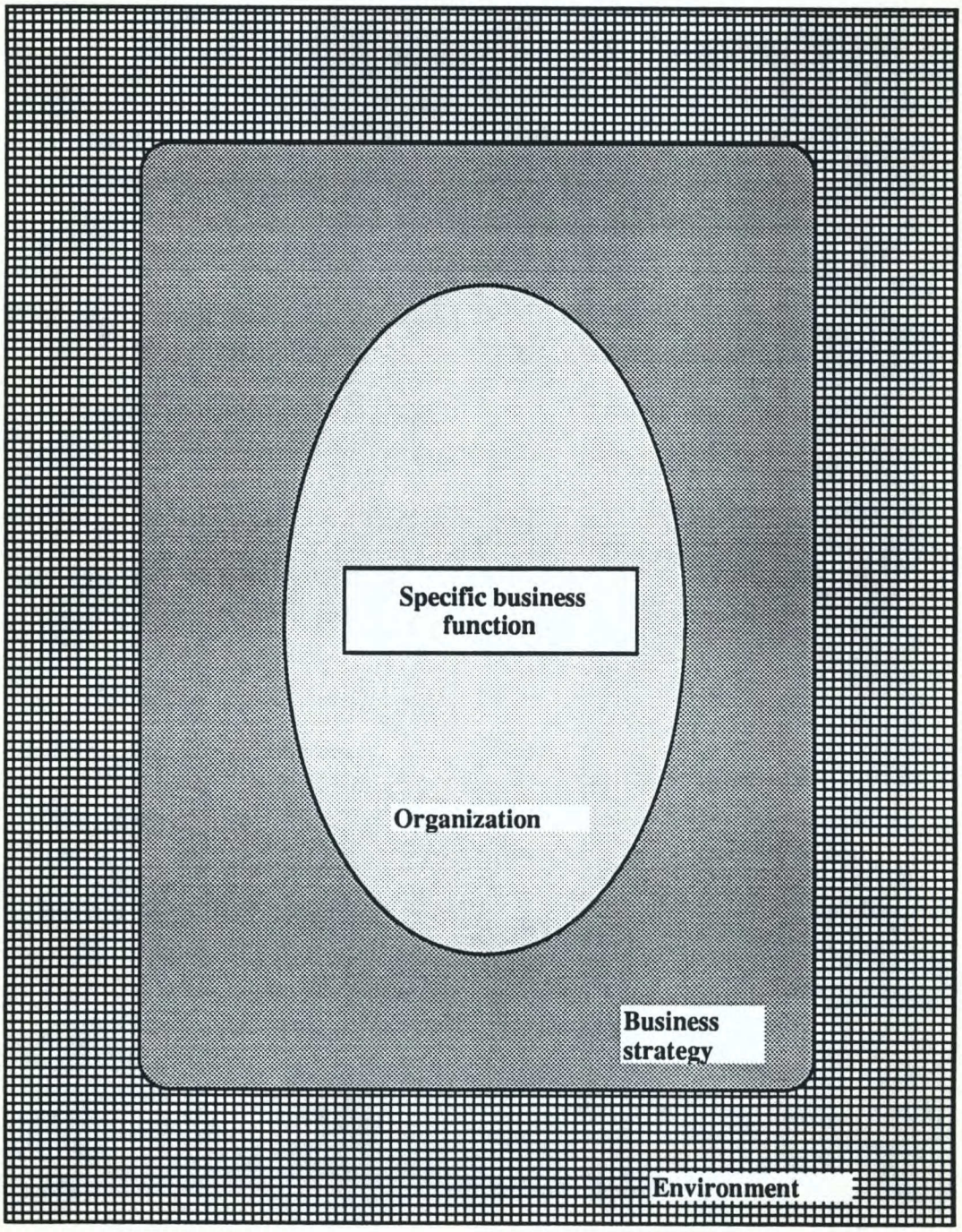


Figure 3 Organizational Environments



Where can artificial intelligence make a contribution?

Although artificial intelligence began by addressing very scientific applications today, now more and more office applications are being tackled. The combination of these two fields could produce a quantum leap in office worker productivity by making knowledge and expertise more readily available to a greater number of workers.[12]

This synergistic combination should ideally come about by both an AI push and an office automation pull. The best approach would be to add on intelligent layers to existing technologies. Not only will this help 'sell' AI technology, due to lowered capital investments on the part of the clients, but it will also result in much more practical systems. For example, automatic teller machines can become 'smarter' in order to do more than just accept deposits and dispense cash. Similarily, much more convivial interfaces, such as natural language ones, can be used to access corporate databases.[13]

There are two major types of overlap routes: the integration of artificial intelligence within office information systems and the use of artificial intelligence in their design and implementation. There are also two major types of research directions needed: to build theories (e.g. a model of an office task, meetings, groups, etc.) and to build actual advanced office systems (e.g. expert systems).

For example, both knowledge of the structure and knowledge of the functions of an office should be explicitly represented in the office model developed.[14] Office work consists of: collecting, storing, producing, processing and communicating information. These are inter-related in a complex fashion to the organizational objectives and goals.[15] A key characteristic of office work is that it is 'open-ended' - i.e. there is no way of anticipating every possible situation that may arise.[16] Thus user models should be a key ingredient in intelligent office systems.

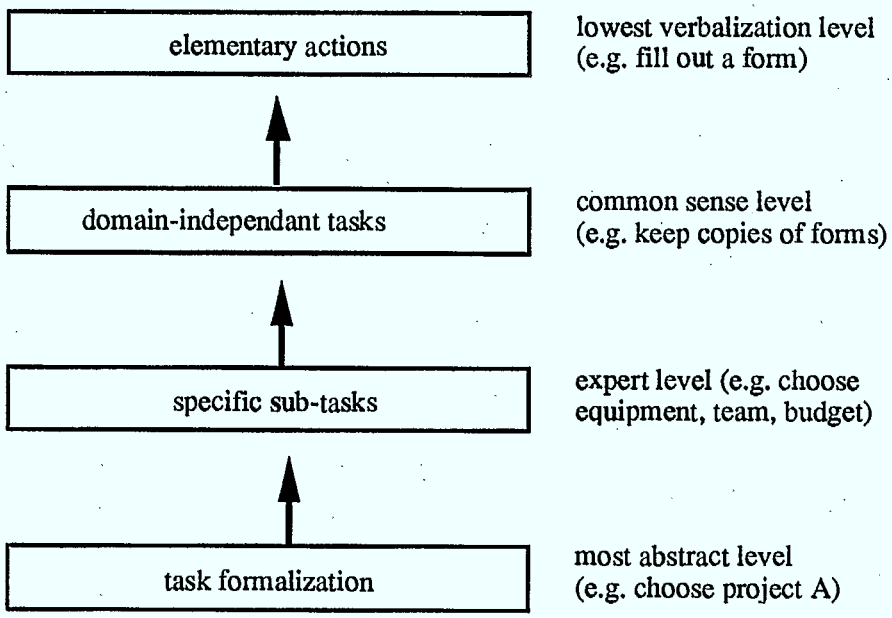
A number of taxonomies can be used to identify practical artificial intelligence applications for office automation. For example, office tasks may be categorized according to their information processing functions: perceptual discrimination, use of short term memory, simple judgmental skills, imaginative thinking, logical thinking and complex motor skills.[17] The potential artificial intelligence applications can then

be mapped on to these in order to identify the types of systems that are best suited for a given office task (see figure 4).

An alternative framework may be the three levels of organizational decision making: strategic, tactical and operational. In general, artificial intelligence is expected to be able to contribute to any task with a significant cognitive element. Potential applications can be found at all three levels of decision making (see figure 5).

Another type of overlap, of particular interest to our research group, is to consider the development of intelligent systems for government offices. Most governments have a variety of reporting requirements such as employee benefit plans, medical insurance claims, tax returns, etc.[19] There is a great potential for the use of expert systems in such types of form processing: examining them for completeness, assessing their accuracy, advising form fillers and routing completed forms to their proper destinations.[20]

Figure 4 Cognitive classification of office tasks

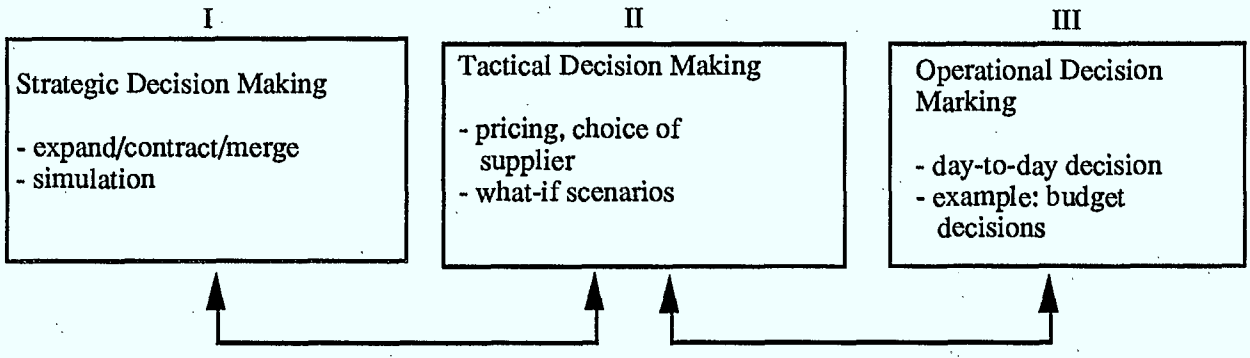


The possibilities for intelligent office automation appear to be literally endless. Some systems currently under development include a report delivery vehicle, publishing assistant, personal organizer, business planning[21], congressional assistant,

demonstration vehicle for the public, communication medium, analyzer of complex financial statements, mortgage loan analyzer[22], intelligent thesaurus, intelligent electronic bulletin board, text comprehension[23], human factors engineering assistant[24], assistant for management by exception[25], budget preparation assistant[26], intelligent integrated workstation[27], research assistant and group decision support system[28] (see appendix A for more examples).

18

Figure 5 Three levels of decision making



Implications for the Expert System Research and Development

Our research group seeks to identify some interesting and feasible niches that overlap both artificial intelligence and office automation. This niche should serve as a guide only and not become a constraint in the type of research projects undertaken. The only "constraint" is a self-imposed one and that is that our efforts yield an operational prototype within a year of starting the research project.

The following matrix (figure 6) shows the major types of artificial intelligence systems along one axis, with the five major domains in office automation along the other.[29,30] While at first glance it appears obvious to choose the cell which represents the intersection of expert systems with office automation, there are others that can and already do interest our group: natural language processing, vocal interfaces, intelligent tutorial systems and neural networks among others.

A second matrix (figure 7) elaborates on the expert system applications. The nine most common expert system application domains are listed together with the same office automation domains as the first matrix. Overlap areas for our research group include computer science, information management, education and training, and law applications.

The last matrix (figure 8) is the only one that is not filled in with illustrative examples. The axes represent the types of functions expert systems may perform together with the major functional areas of an office.[31] This matrix may be used for intra-group brainstorming or in discussions with potential clients or partners. It may even be useful for the process of project proposal evaluations. The idea is to be able to map projects onto a framework that will help identify what the expert system is expected to do and in which domain or environment it is expected to operate in.

The research and development projects of our research group can thus be considered in light of this analysis. These include: the development of an intelligent office in the form of a dedicated workstation for professionals, managers and other knowledge workers, a knowledge engineering workstation, knowledge acquisition aids, intelligent access to databases using natural language interfaces, vocal input and output systems for databases and intelligent aids for decision making, such as the QUARTZ system for project proposal evaluations.[32]

DISCUSSION

Potential intelligent office automation implementations can be plotted onto a three-dimensional classification scheme based on their purpose (see figure 9). The three major components of an office are tasks, tools and organizations. For example, are we addressing individuals or group work? Will the system train office workers or help them make decisions? Is the organization a private company, a university, the public sector? This framework can serve to precisely target the artificial intelligence products to an office automation context.

Although software still appears to have a long way to go in order to catch up with the recent advances in hardware, expert systems can be well-placed to addess this gap by offering cognitive support for office work.[32] The long term goal is to be able to provide better assistance to the human worker, and not to fully automate all his or her tasks. All

of these requirements can be met by present day expert system solutions.One useful exercise might be to identify time wasters in office work, the office automation solution offered, and how artificial intelligence can improve on this solution.[33] Some examples are provided in Table 1.

The joint venture model of a university-private sector partnership is greatly favored for such research.[34] Advantages include decreased risk for the company and the opportunity to create strategic alliances in the domain. Due to the different work styles of the groups, however, there can be problems with project coordination and intra-group dynamics.[35] Only by introducing successful prototypes into the office environment can artificial intelligence applications hope to gain a foothold in office automation.

How then, can artificial intelligence become the fourth key element in office automation systems? An interesting proposal is that of P. Strassman[36], who suggests adding three more layers to the seven (OSI) technology layers: layer 8 would be individual knowledge gaining (acquiring new knowledge, skills, etc.), layer 9, group cooperation (organize knowledge for group decision making in the form of expert systems for example) and layer 10, enterprise goal setting (identify threats and opportunities).

Figure 6 Possible office automation/artificial intelligence applications

Types of AI Systems	Major Office Automation Domains				
	Information management	Communications	Adminstrative support & services	Training	ergonomics
theorem provers					
expert systems	researcher profiles	network management	budgeting, contracts	expertise transfer to novices	to plan reorganizations
computer vision					
Robotics					
voice synthesis and recognition	handicapped users, security	voice mailbox	meetings management	language skills	team based design aid
natural language processing	database queries	intelligent electronic mail interface	translation	training needs analysis	user needs, analysis
machine learning					
parallel processing					
intelligent tutorial systems	wordprocessing, programming	how to use local networks	employee benefits, interviewing	how to retrain users of technology	how to assess office space

Figure 7 Possible office automation-expert system applications

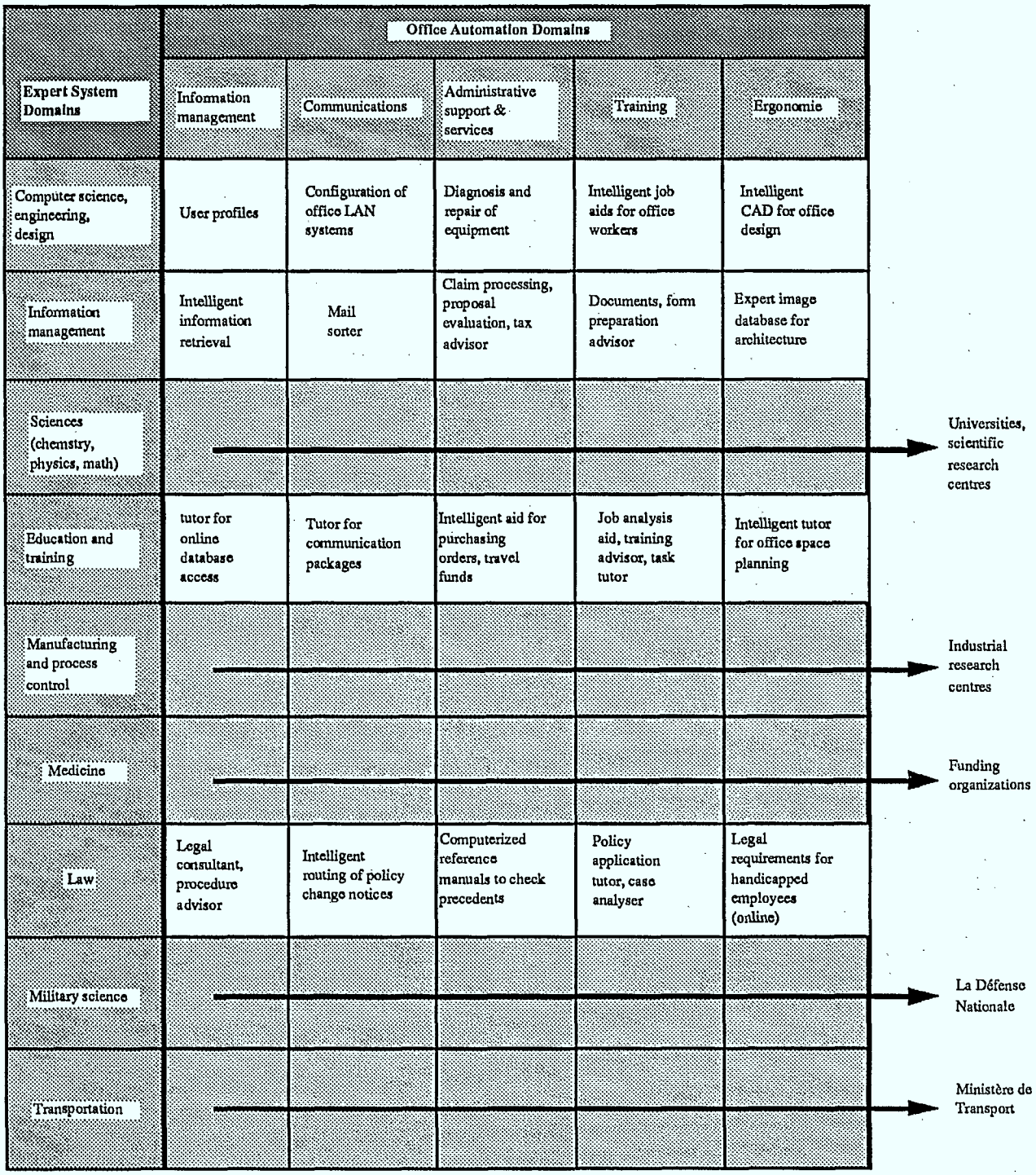
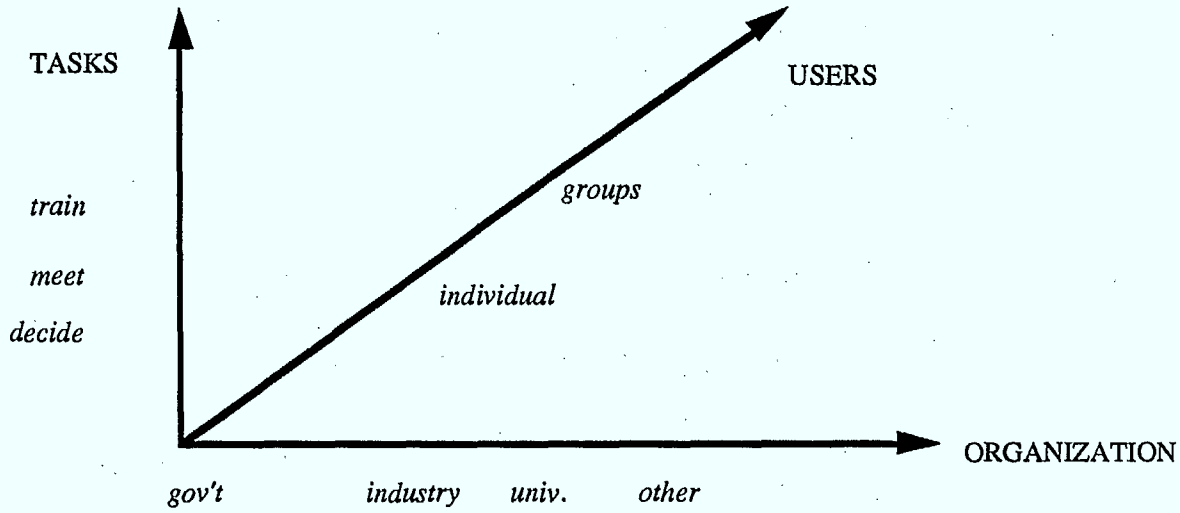


Figure 8 Group brainstorming fool for office automation-expert projects

General Classes of Expert Systems	Major Functional Areas of an Office							
	Finance	Personnel	Marketing	R & D	Design/ ingenierie	Legal/Dept	Accounting	Computing
Interpretation								
Prediction								
Design								
Instruction								
Planning								
Diagnostis, debug, and repair								
Monitor								
Control								

Figure 9 Major components of office automation



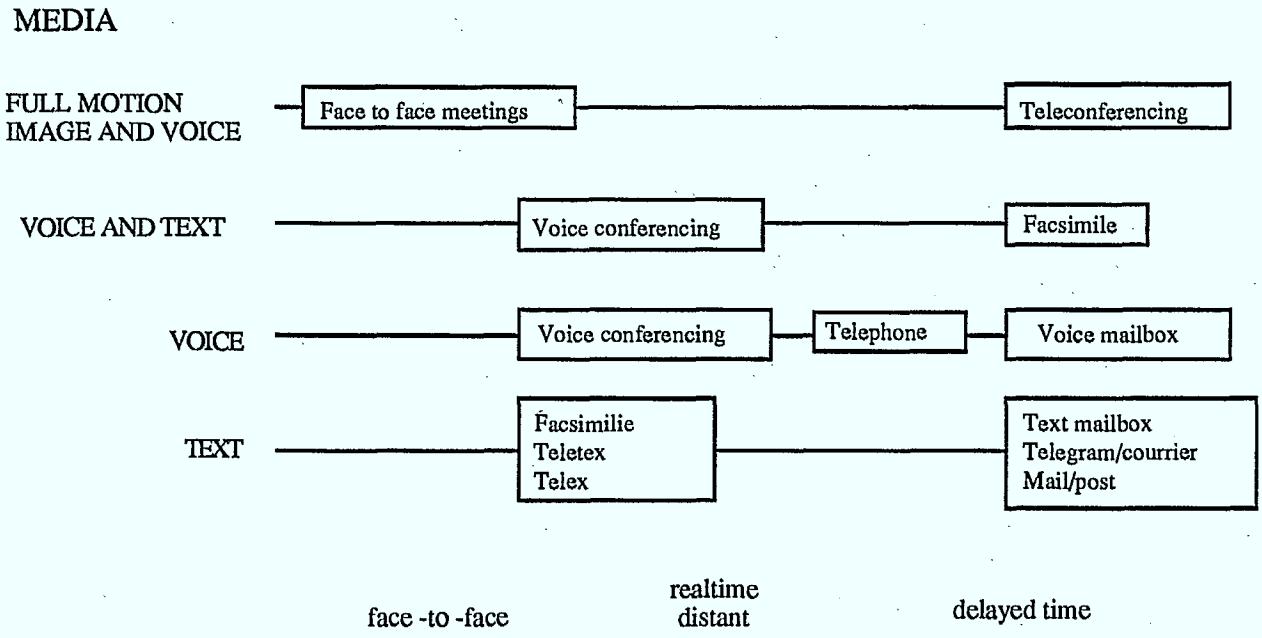
An alternative approach would be to address the spectrum of communication systems that exist in offices.[37] Communication can either be face-to-face or at a distance, and can take place either in real time or with a delay factor. With this framwework as a starting point, the implementation of artificial intelligence technologies in the office can improve office communication (see figure 10).

The work of Kaye and Karam[38] on a distributed system of cooperating knowledge-based assistants is a good illustration of how to implement intelligent office automation projects. The concept of an office environment with organizations, people, tasks, tools and a wide range of societal, cultural and political factors can be extended to include knowledgeable machine-based assistants.[39] These expert systems should be able to communicate not only with human users but also with one another.[40] In this way, the distributed knowledge of an office can be 'captured' or compiled (i.e. not all of the knowledge resides in one individual, but is distributed across many).[41]

Some research questions that require further investigation include: cognitive ergonomics (man-machine interfaces, how to facilitate and support human thought), rapid prototyping tools, design and testing standards, implementation of experimental

systems within organizational contexts and the study of organizational and societal impacts of new technologies in the workplace.

Figure 10 A Spectrum of Communication Systems



COMMUNICATION SYSTEMS

Some technological trends to keep an eye on include: VLSI, decreased data transmission costs due to phototonics, increased software capabilities such as non-quantitative expert systems, increased networking and multifunctional workstations (with integrated spreadsheets, databases, wordprocessing, graphics, OCR inputs and voice communications).

In the not too distant future, artificial intelligence will enable decision makers to 'brainstorm with a machine assistant'[42] by consulting company-wide communication and computer systems that are endowed with knowledge bases. Decision making in the office of the future will be the product of both human and machine intelligence - a hybrid (or cyborg?) decision maker. The challenge of office automation therefore lies primarily in the management of information[43] and it is precisely this challenge that can be met by artificial intelligence.

Artificial intelligence is expected to have dramatic impacts on office automation for this very reason. By compensating for human cognitive limitations (such as the 7 +/- 2 item short term memory, for example), the human/machine team will comprise a virtually invincible decision making entity. Researchers will be able to take the best of each domain to develop useful intelligent office automation tools to create a radical change in the way in which office workers of both today and tomorrow will carry out their tasks.

Table I Conventional and AI solutions to managerial problems

Managerial time waster	Office automation solution	Artificial intelligence solution
seeking information	on-line database access at all times	natural language interface to database
finding key people	speech mail systems	intelligent information retrieval systems
traveling to meetings	videoconferencing	intelligent videoconference meeting management
too many alternatives	decision support systems	expert systems
seeking order status	management information systems	intelligent executive support systems
scheduling meetings	electronic agendas	heuristical automatic meeting scheduler

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APPENDIX A.
SOME OFFICE AUTOMATION APPLICATIONS OF AI

MIRIAM

expert system for personnel management [Cadalen, H., Mulet-Marquis, D. and Benhamou, P. (1986). MIRIAM: un système expert dans la gestion prévisionnelle de personnel sous l'environnement ALOUETTE. EDP Bull. de la Dir. des études et recherches, Serie C. Mathem. et Informatique. No. 4. p. 35-61.]

SIS

an intelligent interview system to elicit system specifications from customers in order to produce the logical design of a database [Kawaguchi, A., Mizoguchi, R., Yamaguchi, T. and Kakusho, O. (1987). SIS: a shell for interview systems. Procs. IJCAI 87, Milan, 359-361.]

APPLICATION FORM SCREENING

an expert system that analyzes employee application forms for British Airways jobs [East, S. (1987). Application Form Screening: Pros and Cons of an Expert System Approach. Turing Institute Report TIOP-87-006.]

INFORMATION LENS

an intelligent system to support group problem solving by intelligent disseminaion of information (message filtering) [Malone, T., Grant, K., Turbak, F., Brobst, S. and Cohen, M. (1987). Information Lens: Intelligent Information-Sharing System. Communications of the ACM, 30, 5, 390-402.]

FOCES

an expert system that advises social workers on matching families with foster children [Winnett, S. and Fox., E. (1985). FOCES: Foster Care Expert System. Procs. 2nd. Annual Conference on Artificial Intelligence Applications, Miami Beach, Florida. pp. 230-235.]

PAYE

an expert system for the British tax system [Torsun, I. (1987). PAYE: a Tax Expert System. In Research and Development in Expert Systems III. M. Bramer (Ed). Cambridge: Cambridge University Press. pp. 68-80.]

TAX EXPERT

an expert system for the American tax system [Newquist, H. (1987). AI Expert. March 87. pp. 57-59.]

REX

an intelligent interface that helps employees perform regression analysis on data [commercial product, AT&T Technologies]

INFOSTRUCT

an intelligent assistant to help managers extract personal meaning from information [Gerrissen, J. and Strijland, P. (1986). Procs. IEEE SMC Conference, October, 1986. Atlanta, Georgia. pp. 949-953.]

EURISKO

an intelligent tool to facilitate access to databases which provides help, feedback and natural language processing capabilities [Barthes, C., Fontin, J., and Glize, P. (1988). Procs. 1st International Online Information Meeting. London. December 1988. pp. 431-441.]

WE

an intelligent visual environment for writing and thinking based on a cognitive model of written communication [Smith, J., Weiss, S., Ferguson, G., Bolter, J., Lansman, M. and Beard, D. (1987). AFIPS National Computer Conference. Chicago, Illinois. June 1987. pp. 725-736.]

ABF

an expert system for drafting legal documents that helps lawyers and paralegal personnel prepare legal documents [Sprowl, J., Evens, M., Osman, M. and Harr, H. 91987). AFIPS National Computer Conference. Chicago, Illinois. June 1987. pp. 711-717.]

MACIE

an expert system to monitor the progress of commercial research and development projects [Gallant, S. and Balachandra, R. 91986). IFAC Economics and Artificial Intelligence. Aix-en-Provence, France. pp.61-66.]

MAP

intelligent support for financial planning and budgeting. [commercial product, Citibank]

GADS

a graphical urban planning expert system [commercial product, IBM Research Division]

BRANDAID

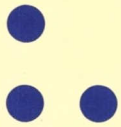
models markets to estimate profitability of various alternate product brands [commercial product, J.D. Little]

PARYS

a knowledge-based human resource management system which offers support for all phases (hiring, promotion, etc.) [commercial product, IIS Technologies, a Bell company]

TROPIC

an artificial intelligence-based computer aided design tool for architects [Allan, J. (ed.). CAD Systems. NY: North Holland



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