2. Scientific Plan 1992-1997

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Approved by the Advisory Board

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Canadian Workplace Automation Research Centre (CWARC)

Communications Canada

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1 Introduction

The Canadian Workplace Automation Research Centre (CWARC) was established in 1985. The Centre's first scientific plan proposed twelve main areas of research. Six years later, CWARC management began an in-depth review of the organization's structure, strategic areas of research and scientific programs. This review resulted in, among other things, the scientific plan presented here. The plan examines research trends, clients' needs, the scientific orientation of the research carried out at CWARC, and past, present and future research programs.

Work to reexamine and restructure the Centre's scientific programs began in the autumn of 1991 and was completed in June 1992. As a result of the effort, five research programs were selected. Some are a continuation of one or more of CWARC's original research priorities, while others reflect new trends in technological change and new workplace automation methodologies.

This document first describes CWARC's current mission and the objectives of its strategic plan. It then discusses CWARC's place in the Canadian research community and the programs that have marked CWARC's history. Lastly, it describes the research programs selected for the current fiscal year and their validation by the outside scientific community.

2 CWARC's Mission

2.1 Mission Statement

The Canadian Workplace Automation Research Centre (CWARC), an integral part of Communications Canada, is the largest centre in Canada devoted exclusively to research and development in all aspects of workplace automation. CWARC plays a major role in spearheading Canadian research efforts in this field, which has a profound effect on society and its institutions.

CWARC's mission is to pursue a program of advanced applied research in the field of information and communication technologies, in partnership with other organizations, in order to improve the performance of Canadian economic, social and cultural organizations. The areas targeted include, among others, informatics, telecommunications, optics, acoustics, graphics and their specific applications in information processing (the production, transformation, storage, distribution of and access to information). This work benefits consultants, manufacturers, software developers, governments and individual Canadians who use the technological applications and products developed by CWARC.

The purpose of applied research is to discover how knowledge acquired in basic research can be put to use in developing prototypes and methodologies.

Consequently, research at CWARC deals with the human, organizational, socioeconomic and technological dimensions of new information technologies, particularly with respect to the development, management, introduction and use of these technologies and their applications.

In detail, the mission statement signifies that:[1]

- CWARC's mission is to conduct research. Its role is not, therefore, to co-ordinate, finance or fund research carried out by other organizations or to promote the creation or growth of business enterprises. These tasks fall to other federal and provincial government agencies;
- The research carried out at CWARC must be both advanced and applied. This means it must focus exclusively on innovative applied research (pre-competitive and competitive) rather than on basic research and development. The research must involve products and services that are from three to ten years away from being marketed;
- Research activities focus on the human, organizational and technological dimensions of new information technologies, particularly with respect to the

1 Communications Canada. Canadian Workplace Automation Research Centre,-- *Strategic Plan 1991-1996* . (Laval, August 20, 1991), p. 7-9.

development, management, introduction and use of these technologies and their applications;

- The world of information and communication technologies is currently in a state of considerable flux. These technologies--which include, among other things, informatics, telecommunications, optics, acoustics, graphics and their specific applications in information processing (the production, transformation, storage, distribution of and access to information)--have a wide range of structural impacts on the economy and on society as a whole;
- The main purpose of the applied research carried out by CWARC is to improve organizational performance. Putting innovations to use is an important means of increasing organizational competitiveness and productivity;
- CWARC's clientele is diversified and includes social, economic and cultural organizations. More specifically, this means that CWARC's activities should benefit many groups, not only the Canadian government and private corporations;
- CWARC's mission is Canadian in the sense that its partners and clients and the beneficiaries of its activities must come from all regions of the country;
- CWARC's research is carried out in partnership with other organizations. The major partners include Canadian universities, research centres and institutes, because the applied research that CWARC does relies on the results of basic research carried out at such institutions;
- CWARC's clients include consultants, manufacturers, software developers, public and parapublic organizations and the users of these technological applications and products. Clients may also become involved as research partners in some development projects;
- CWARC carries out applied research for the collective benefit of consultants, manufacturers, software developers, governments and individual Canadians who use the technological applications and products developed by CWARC. This presupposes that the applied research conducted by CWARC should benefit producers and users.

2.2 Knowledge Transfer

To enable industry to benefit as quickly as possible from the research carried out at CWARC, technology transfer must be continuous and effective. The National Exchange Program was set up to enable representatives of industry and academia to work on research projects as members of CWARC's research teams.

The Exchange Program has three objectives:[2]

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2 Communications Canada, Information Services, Canadian Workplace Automation Research Centre (CWARC) : *National Exchange Program,* p.1.

- Establish mechanisms for continuous and efficient transfer of research results to the private sector through exchange of personnel;
- Ensure that the results of the work done at the Centre are made available rapidly to the private sector, the various levels of government, colleges and universities;
- Establish strong links with Canadian industries, universities and colleges to ensure that the Centre's activities are relevant to industry and to identify opportunities for fundamental research leading to product development.

Since CWARC was established, approximately 125 agreements have been signed under this program, 25 (or approximately 20%) with universities.

3 Objectives out Out in the 1991-1996 Strategic Plan

The Strategic Plan submitted in the summer of 1991 sets out the following objectives:[3]

- Ensure that the primary work of CWARC is applied research (i.e. between 65% and 80% of its research budget);
- Involve universities and other research centres as partners in most applied research projects;
- Link research priorities more closely with the needs of CWARC's clientele (manufacturers, federal government and users);
- Ensure that the organization carries out its Canadian mission by serving clients in all regions of the country (Ontario 36%, West 29%, Quebec 26%, Atlantic 9%);
- Strategically reorient CWARC's areas of research;
- Ensure that a critical mass of researchers is available on a long-term basis for each research area;
- Ensure that researchers concentrate on research rather than on seeking out research partners;
- Consolidate CWARC's reputation in Canada as a leader in information and communications technologies;
- Commit CWARC to increasing its administrative autonomy;
- Evaluate annually the extent to which the objectives in the strategic and operational plans have been met.

The strategic plan proposes changes in the organization's characteristics, orientations and targets. Among these changes, particular emphasis has been put on pursuing applied research, signing partnership agreements with universities, forging a closer link between clients' needs and research orientations, pursuing a Canadian mission, forming strategic alliances, keeping up to date with work at "competing" research centres, evaluating performance and establishing the scientific and consultative role of the Program and Project Committee. It is therefore crucial to situate CWARC's research programs in their larger context. Accordingly, one purpose of the Scientific Plan is to describe the research carried out at CWARC and trends in research elsewhere in Canada.

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3 René Poirier -- *Plans tactiques et opérationnels : Ébauche.* : (September 24, 1991), Appendix 2.

4 Research Trends and Clients' Needs

CWARC is the only Canadian research and development organization currently working in the field of wokplace automation, a field both very general and very specific. A number of Canadian research centres are working in related fields, however. In advanced information and communications technology research, the current trend is to form consortiums to work on projects with a potential impact on the Canadian economy. In this section, we examine some of these research centres and their projects. However, the list is far from exhaustive.

4.1 Research Centres

4.1.1 COMMUNICATIONS RESEARCH CENTRE (CRC)

Mission

The Communications Research Centre (CRC) is the principal research centre of Communications Canada. Its role is to undertake, aid and encourage scientific and industrial research in the communications field. As such, the CRC plays a crucial role in linking research and development efforts at universities and in industry.

Objectives

- Pursue research and development that supports the Department's role in developing and implementing telecommunications policies, regulations and standards
- Through partnerships and co-operative activities with the academic and industrial sectors, promote the development, application and commercialization of innovative communications and information technologies.[4]

Areas of Research

- Radio communications
- Satellite communications
- Microelectronic and optoelectronic devices and components
- Video
- Broadcast media.

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4 Communications Canada. --*Annual Report 1988-89*, p. 27.

Comments

CWARC's Multimedia Systems research team and the CRC's Informatics Application unit have worked together in datacasting projects involving the Visuaide 2000 firm. In addition, CWARC and the CRC both sit on federal commissions on the handicapped.

4.1.2 INSTITUTE FOR INFORMATION TECHNOLOGY (IIT)

Mission

The mission of the Institute for Information Technology, which is part of the National Research Council, is to help industry attain excellence in information technology software and systems by promoting, supporting and undertaking research and development programs focused on and oriented towards industry. To carry out its mission, the IIT co-operates with industrial, educational and government bodies and with other organizations.

Objectives

- Conduct and promote research in information technology fields related to software and system development, to improve overall Canadian competitiveness
- Develop technology for the Canadian software and systems industry in particular

Areas of Research

- Software engineering
- Knowledge-based systems
- Captor-based automation
- Systems integration.[5]

Comments

Communications Canada and the National Research Council Canada (NRC) have signed a memorandum of understanding, which may result in co-operation between CWARC and the IIT.

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5 National Research Council of Canada, Institut de technologie de l'information du CNRC, pamphlet (August 1991), p.2.

4.1.3 CANADIAN HEALTHCARE TELEMATICS INC. (CHTI)

Mission

Canadian Healthcare Telematics is a national centre whose mandate is to stimulate industry, the healthcare system, universities and government research organizations, to develop and apply telematics-based products and services which will further economic development and enhance the quality and cost-effectiveness of healthcare delivery in Canada. The CHTI conducts research and development programs that promote economic development and improve the efficiency and cost-effectiveness of healthcare delivery in Canada.

The CHTI assists Communications Canada research establishments with the transfer of technology to the public sector. In addition, the organization acts as a scientific advisor to Communications Canada on health and telematics programs funded by the Department.

Objectives

- Maintain an awareness of current trends and issues in the healthcare field and of the rapid changes in available and emerging telematics technologies in order to identify key areas of opportunity;
- Sponsor projects which test and demonstrate the application of existing and new telematics technologies in the healthcare field, for improved healthcare delivery and cost containment;
- Provide a national service dedicated to the production and dissemination of knowledge with the potential to improve healthcare delivery and provide acceptable economic returns.

Areas of Research

- Telemedicine
- Distance education.

Comments

This organization was created jointly by Communications Canada and Health and Welfare Canada. CWARC's Resources and Advice to Practitioners Network project, which is a part of the Technological Innovation and New Forms of Work Organization program, deals with similar themes.

4.1.4 CENTRE FRANCOPHONE DE RECHERCHE SUR L'INFORMATISATION DES ORGANISATIONS (CEFRIO)

Mission

The mission of CEFRIO, a francophone organization that conducts research on workplace automation, is to help improve organizational performance by transferring knowledge and university expertise in automation.

Objectives

- Gather, update and disseminate information from organizations
- Promote research and development and the creation of a network of partners, members and researchers in the field of automation
- Initiate and support research and development efforts in automation
- Disseminate the results of research and development.[6]

Areas of Research

- Study of appropriate automation management methods
  a) Benefit management
  b) Executive information and decision support systems
  c) Management of strategic information systems
  d) Integration of microcomputer-based and corporate information systems
  e) Strategic planning of information systems
  - Study of the impacts of automation on individuals, organizations and society
  a) Training
  b) Impact on the nature and organization of work
  c) Impact on company management, productivity and performance

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6 Mallette Major Martin, *Évaluation du CEFRIO : Rapport final.* (September 4, 1991). p.3.

- Study of the linguistic and cultural dimensions of automation[7]
  a) French-language writing and editing aids
  b) French-language text processing tools
  c) Computer-assisted translation
  d) Situation of organizations with respect to French-language text processing tools
  e) Prototypes and applications in the language industries.

In addition, the following areas, which were previously part of CEFRIO's expert system and artificial intelligence program, will be incorporated into the three areas of research discussed above:

a) Expert systems for training support in organizations
b) Human environments of expert systems
c) Status of expert and artificial intelligence
d) Integration of expert systems.

Comments

CEFRIO'S research priorities and CWARC's research projects and programs overlap somewhat:

- The "Computer-aided translation" item (under the "Linguistic and cultural dimensions of automation" heading) is similar to CWARC's computer-assisted translation program;
- The "Impact of automation on individuals, organizations an society area" is similar to CWARC's Performance Support Systems program and Technological Innovation and New Forms of Work Organizations program.

CEFRIO members come from government departments, universities and industry. Among its members are 24 Quebec firms, some of which are parapublic organizations.

A CWARC researcher, Mrs. Kim Dalkir, is a member of the CEFRIO scientific committee. CWARC's Director General is on the CEFRIO board of directors.

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7 Mallette Major Martin. *Évaluation du CEFRIO : Annexes*. (September 4, 1991), Appendix 1, p 1-3.

4.1.5 CENTRE DE RECHERCHE INFORMATIQUE DE MONTRÉAL (CRIM)

Mission

CRIM, the Montreal information science centre, carries out research and development activities that promote excellence and technology transfer in information science and its applications.

Objectives

- Undertake and promote research and development in members' areas of common interest
- Contribute to the dissemination and transfer of knowledge to users and encourage the application of this knowledge to benefit the Quebec economy
- Contribute to the creation of a highly-qualified labour pool, particularly at the doctoral level.

CRIM encourages individuals from universities, corporations and other organizations to take part in its activities. Its human, material and financial resources are available to all its members and other participants.[8]

Areas of Research

- Knowledge-based systems
- Speech recognition and signal interpretation
- Software engineering and the Centre de génie logiciel appliqué (Applied Software Engineering Centre)
- Parallel architectures
- Industrial automation and computer vision
- Telecomputing and networking
- Computer-assisted training environments and user interfaces.[9]

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8 Centre de recherche informatique de Montréal. *Plan d'action 1989-1992.* (May 1989) p. 3.
9 Centre de recherche informatique de Montréal. *Plan quinquennal 1992-1997.* (January 1992) p. 42.

Comments

CRIM's user interface and automatic speech recognition programs overlap with CWARC's Multimedia Systems program. Furthermore, some components of CWARC's Performance Support System program are also found in CRIM's intelligent training systems area of research.

CRIM has 53 members from the Quebec university, government and industrial sectors.

There are informal relations between CWARC and CRIM researchers in related fields. CWARC is considering setting up an official co-operation agreement with CRIM.

4.1.6 TELECOMMUNICATIONS RESEARCH INSTITUTE OF ONTARIO (TRIO)

Mission

TRIO's mission is to enhance the technological competitiveness of Canadian telecommunications companies through university and industry partnerships in focused and shared research programs led by the best Ontario researchers and to:

- Create world-class technology relevant and transferrable to Canadian industry;
- Increase the flow of trained researchers in relevant areas of technology;
- Expand and enhance the educational infrastructure to achieve a permanent increase in quality and capability in TRIO's member universities.

Objectives

- Acquire and develop potentially useful technologies and tools in universities and transfer them to industry
- Institute industrial leadership over focused pre-competitive university and joint university and industry research
- Achieve permanent expansion of world-class intra- and inter-university cooperative research capability
- Develop more skilled communications research engineers
- Generate industrial enthusiasm for longer-range technology planning and research topic identification
- Demonstrate capability as a productive performer of relevant research
- Develop strong industrial, university and governmental support for continuity.[10]

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10 Telecommunications Research Institute of Ontario, *Strategic Plan 1991-1992.* (July 1991) p. 8.

Areas of Research

- Electromagnetic compatibility
- Protocols and software engineering
- Mobile and satellite systems
- Network architecture and access
- Electromagnetic signal processing and systems
- Photonic networks and systems.[11]

Comments

CWARC is studying the idea of an official co-operation agreement with TRIO. The two organizations could have fruitful discussions on a number of topics, particularly the telepresence project.

11 TRIO: *Telecommunications Research Institute of Ontario*, pamphlet.

4.1.7 GOVERNMENT TELECOMMUNICATIONS AGENCY (GTA)

Mission

The mission of the Government Telecommunications Agency is to plan, provide and co-ordinate telecommunications and information products and services for the government to help it serve Canadians. The GTA acts as the focal point for the Government Telecommunications Architect function and for the delivery of common telecommunications services within Canada.[12]

Objectives

- Provide high-quality, economical services to federal departments and agencies
- Plan and meet the telecommunications requirements of the Government of Canada and ensure low-cost services in the future
- Organize and implement the Government Telecommunications Architect function.[13]

Comments

Negotiations are currently under way between GTA and CWARC to draft a memorandum of understanding to promote collaboration between the organizations. This would allow GTA to have research projects done by CWARC researchers.

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12 Government Telecommunications Agency, *Annual Report1990-1991*, back cover.
13 Communications Canada, Government Business Agency, Business Plan 1990/91, p. 4.

4.2 Projects with a Structural Impact on the Canadian Economy

These major projects, often developed by research consortiums, have short-term structural impacts on the Canadian economy.

4.2.1 VOLVOX

This multidisciplinary and multifunctional project has two main objectives:

- Develop a generic shell for decision support systems (DSS) that will serve as a platform for many different decision-making processes;
- Complete and validate the shell by developing DSSs for the following four sectors, where the need is the most urgent:
  a) environmental health sector (information management and data processing)
  b) environmental crisis management
  c) impact assessment and environmental management of hydroelectric facilities
  d) municipal land management.

These systems will be designed to meet decision-makers' needs in training, planning, design, evaluation, operation and management.

The consortium is made up of corporations, research centres, universities and colleges. The prime contractor is Groupe CGI Inc.[14] [15]

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14 Le consortium pour le projet Volvox, "Système informatisé d'aide à la décision : pour le développement économique durable du Québec en respect avec l'environnement et la santé publique : résumé du projet Volvox et présentation des documents supports" (November 1990) p.8.

15 Consortium Volvox, "Résumé du projet de recherche et développement Volvox" pamphlet p. 2.

4.2.2 MACROSCOPE

The goal of this state-of-the-art project is to develop a set of methods, software tools and training programs to provide organizations with comprehensive solutions to their information technology management problems. Methods and software tools will be developed for each of the four focal points of the project: strategy, architecture, productivity and benefits.

With such products, organizations will be able to plan and implement a business strategy, handle the expected technological changes and effectively manage profit recovery. Product development will be achieved through a series of activities comprising research and development, testing, and the verification of system integration efforts. Macroscope is the only product of its kind to offer a comprehensive, integrated approach to the use of information technologies in a wide range of areas. As such, it will enjoy a unique position on the world market.

DMR Group Inc. is the prime contractor for the project. A total of 14 firms and 2 research centres, including CRIM, are involved in the Macroscope project.[16]

16 Centre de recherche informatique de Montréal, *Rapport annuel 1990-1991*, p.11.

4.2.3 INTERFACE

The purpose of this leading-edge project is to develop new technologies for the design and implementation of advanced user-machine interfaces and for the development of an integrated workstation to facilitate the simulation and learning of complex real-time electronic systems.

The project comprises two parts:

- Sophisticated software to develop, with a minimum of traditional programming, user-machine interfaces that are easy to use and user-friendly yet have powerful application possibilities;
- A simulation and learning workstation with integrated hardware, software and methodologies providing a link with operational systems. The workstation will allow users to learn to use such systems in the workplace quickly, efficiently and in a way adapted to individuals.

Five organizations are involved in Interface: two private corporations (Virtual Prototypes Inc. and ADGA) and three public corporations (Hydro-Québec, CWARC and the Centre de recherche informatique de Montréal).

The goal of the project is to improve the technology for developing user-machine interfaces for complex real-time electronic systems, in order to facilitate the learning and mastery of these systems in the workplace.

The Interface project will have four main stages:

- Refinement of the basic technology, to make it usable in a wide variety of situations;
- Application of new simulation approaches to computer-assisted learning (CAL). As much as possible, the basic technology will be used and combined with other advanced technology to develop an integrated workstation and methodologies that respect the project's economic constraints;
- Validation of resulting products by major users in large-scale projects involving strategic applications;
- Promotion of new products in emerging international markets.[17]

17 "Interface ou Projet mobilisateur présenté au Fonds de développement technologique du Québec : Sommaire exécutif" (May 1991), p. 1-6.

4.2.4 TELECOM MULTIMEDIA

The purpose of this project is to design, develop and produce hardware interfaces and software that will allow switched multimedia communications between personal computers on existing telecommunications networks. To illustrate the potential of the concept, specific concrete applications will be developed for the communication platform. This major multidisciplinary project involves a wide range of expertise in areas such as multimedia systems, standardized technologies, technology introduction management, distance training and telemedicine.

This project is on the cutting edge of technological progress in the information industries. In addition, it will allow various applications for multimedia services to be tested.

The project promoter is the Groupe Conseil Innovitech Inc. Northern Telecom is the prime technology contractor. The consortium formed for the project comprises CWARC, INRS-Télécommunications, Bell Canada, BNR, Machina Sapiens, Public Technologies, Prima Telematic and PrimeTech.

4.2.5 DELTA

Delta is a Quebec government project to develop software tools and methods for text management, that is for such operations as storing, updating, indexing and retrieving texts and assistance in writing texts. The focus of the project is the development of the ACTE platform (short for *Atelier cognitif et textuel* or cognitive and textual workshop). The main significance of the project is that it tackles the issues involved in new text management software from a government-wide point of view and covers all foreseeable applications.

Delta is a joint effort involving a group of partners from the research community (the Computer Text Analysis Centre at the Université du Québec à Montréal and the School of Information and Library Sciences at the Université de Montréal), the Quebec government (Ministry of Communications, Office de la langue française, Commission des normes du travail, Société québécoise d'information juridique, among others) and the private sector (Destin Inc. and several other companies that will eventually join the project).[18]

18 Department of Communications. Direction générale des technologies de l'Information, *Projet Delta : Projet interministériel en gestion textuelle.* (June 1991), Supplementary Document, p. 4-5.

This ends the description of research centres that are carrying out activities related to those at CWARC, as well as major projects undertaken by consortiums of key players from the Canadian research community. To increase its understanding of the other organizations pursuing research and development in Canada, CWARC is currently working on a database of establishments engaged in research related to workplace automation. The database will index university research groups, laboratories and research centres; consultants and other service providers; public bodies; and companies engaged in research and development. This will allow CWARC to assemble, for each of its programs, a list of organizations working on related issues, providing a "map" of the field. In addition, the database will give a general picture of Canadian research on information and communications technologies.

5 Evolution of Research at CWARC

This section describes the evolution of research priorities at CWARC from its founding in 1984 to the present. Over the years, CWARC has increasingly concentrated on certain areas, as can be seen in its research agenda for 1987, the half-way point in the Centre's existence.

5.1 Original Areas of Research

In the original submission made to Treasury Board in 1984, CWARC's research priorities were divided among three directorates:

- Integrated Systems Directorate
  a) Open Systems Interconnection (OSI)
  b) Integrated office systems
  c) Local area networks (LANs)
  d) Interfaces and gateways
- Advanced Technology Directorate
  a) Expert systems
  b) Voice technologies
  c) Computer-assisted translation (CAT)
  d) Information management
- Organizational Research Directorate
  a) Decision-making processes
  b) Organizational impacts
  c) Productivity and performance
  d) User-friendliness assessment.

From the Centre's very beginning, it was fairly obvious that the resources allocated by Treasury Board would not be sufficient to establish large enough research groups for all twelve recommended research areas. Therefore, choices had to be made and areas had to be combined where possible.

In the Integrated Systems Directorate, two areas of research were eliminated:

- Local area networks, where very rapid advances had been made in the U.S. and three types had become standard. Not much remained to be done in this area and there was almost no local industry in Canada;
- Interfaces and gateways, an area that involves the development of highly specialized products rather than research.

As a result, resources were concentrated in two areas that were deemed to be much more important:

- In the field of integrated systems, the emphasis was put on the integration of new technologies to improve functionality and input/output interaction modes. Accordingly, this area was combined with voice technologies, which had been originally assigned to the Advanced Technologies Directorate;
- The strategic importance of the open systems interconnection field was already fairly well established by 1986, and has been confirmed to a much greater degree since then.

In the Advanced Technologies Directorate, the field of voice technologies was transferred to the Integrated Systems Directorate, allowing Advanced Technologies to concentrate its resources on two areas:

- Computer-assisted translation. This investment was easy to justify, since the Canadian government was spending approximately $100 million a year on translation at the time and the Secretary of State Department was very interested in this area;
- Expert systems, where the emphasis was put on the generation of knowledge bases and decision support systems. In this way, the fields of information management (in the form of knowledge management) and decision-making processes (initially in the Organizational Research Directorate) were to some extent combined with expert systems.

Lastly, in the Organizational Research Directorate, resources were concentrated in three areas: organizational impacts, productivity and performance, and user-friendliness assessment.

5.2 Priorities in 1987

In 1987, CWARC research teams concentrated on the following areas:[19]

- Open systems Interconnection (OSI)
- Voice technologies
- Expert systems
- Computer-assisted translation (CAT)
- Organizational impacts
- Productivity and performance
- User-friendliness assessment.

From 1987 to 1991, research in these areas progressed as planned, without any major changes.

In the Integrated Systems Directorate, the Informatics Group concentrated increasingly on the interconnection of open systems, while the Systematics Group, which was working on integrated workstations and systems, began to

19 Canadian Workplace Automation Research Centre, *Scinentific Plan 1987-1988 / 1991-1992* (March 9, 1987), p. 3-9.

expand the range of technologies used, adding graphic technologies to its earlier emphasis on voice technologies. In 1989, the group was renamed the Multimedia Systems Group.

In the Advanced Technologies Directorate, where the emphasis was on CAT and expert systems, several projects were also undertaken in information management. These were subsequently transferred to the Organizational Research Directorate.

During this time, the Organizational Research Directorate maintained most of its original orientations.

Following this discussion of the evolution of research at CWARC, the next chapter will address the major projects that CWARC has completed.

6 Major Projects Completed

This chapter discusses projects of major importance that have been carried out at various points in CWARC's history. Some projects are fields of research in themselves, while others involve more specific issues.

The projects are presented in two groups. The first includes projects whose impacts on the Canadian economy are known. The second group consists of projects whose economic impacts cannot yet be measured.

6.1 Projects with Measurable Impacts

6.1.1 OPEN SYSTEMS INTERCONNECTION (OSI)

At the time CWARC's first Scientific Plan was being prepared (the plan was subsequently approved by the Treasury Board), the movement in favour of adopting international standards on open systems interconnection was already in the process of becoming a worldwide trend. In anticipation of the needs resulting from this trend, the Scientific Plan called for the development of benchmark tests for OSI protocols. Thi task was assigned to the Integrated Systems Directorate (DLD).

In the summer of 1985, the DLD commissioned a feasibility study on the subject. In the autumn, the Department called for responses to a document dealing with OSI's implications for Canada. A significant show of support emerged for the four elements in the comprehensive strategy:

- The government must take a position in favour of the standards.

  This position was announced by Treasury Board in April 1987 and officially confirmed in a November 1987 directive.

- A national senior committee should be formed on the issue.

  The Canadian Interest Group on Open Systems (CIGOS) was created at the Department's initiative and met for the first time in October 1987.

- Additional research and development efforts are required.

  Three researchers from the Directorate were involved in the TODAC project, which was carried out jointly with the National Computing Centre (NCC) of Manchester, England, British Telecom and the Edmonton firm IDACOM, which was responsible for North American marketing. TODAC is a unique testing system for verifying the conformance of applications to the Office Document Architecture (ODA) international standard, and was chosen for the CEBIT 1990 trade fair in Hanover, Germany. TODAC is discussed in the next section of this chapter.

  In addition, at the Directorate's initiative, an industrial research chair on communications protocols was created at the Université de Montréal in November 1989. The financing for the five-year program includes $1.2 million from the National Sciences and Engineering Research Council Canada (NSERCC) and $500,000 from IDACOM, which became a division of Hewlett Packard in 1990.

- Testing services will be required.

  At CIGOS's first meeting in October 1987, CWARC proposed the broad lines of an OSI program. A motion in support of the program was adopted and CIGOS agreed to collaborate on the project.

In 1988, after visits to six new test centres that were being started up, two in the United States and four in Europe, and to the European Commission, the Directorate prepared a detailed proposal for the program. The proposal was discussed with the Treasury Board and several other departments before being submitted to CIGOS in December 1988.

In early 1989, CIGOS decided to form a working group to prepare a business plan and CWARC was invited to take part. The business plan was unanimously approved at an October 1989 meeting of CIGOS. At the same meeting, IDACOM, also a CIGOS member, submitted a proposal to establish a test centre corresponding to the main component of the business plan. The motion was approved unanimously and the test centre was officially announced at CIGOS' annual meeting in November 1989.

Subsequently, the Directorate participated very actively in negotiations with government authorities for funding the project. The negotiations were quite long, close to 18 months, owing mainly to the takeover of IDACOM by Hewlett Packard in 1990 and the need to rework the initial proposal several times. A version acceptable to all parties was submitted towards the end of the summer of 1991.

In the final proposal, the financing for the two-year start-up phase was divided as follows:

IDACOM	$3,450,000
Communications Canada	900,000
Federal Office of Regional Development - Quebec	900,000
Société de développement industriel	$1,000,000

In January 1992, the Treasury Board of Canada approved the submission for a $1,800,000 federal contribution. At the same time, the Quebec departments' request for $1,000,000 was submitted to the Quebec Treasury Board, which is expected to approve the funding in mid-February 1992.

Taking account of investments from CWARC and its partners in cash and employee salaries, a total of $9.245 million is being invested in OSI:

	TODAC	CHAIR	TESTS CENTRE	TOTAL
CWARC	415	500	307	1 222
MDC	-	-	593	593
[illegible]FORD-Q	-	-	900	900
Québec	-	-	1000	1000
NSERCC	-	1200	-	1200
IDACOM	55	500	3450	4005
British Telecom	35	-	-	35
NCC	290	-		290
TOTAL	795	2200	6250	9245

Although CWARC is far and away the main promoter of these activities, it contributed only $1.222 million or 13% of the total amount.

Since the Test Centre, which is responsible for the industrial research chair and for marketing TODAC, will not be established for several months, the economic impacts of the project cannot be measured at this time.

In the future, quantifiable impacts will include licensing fees for the test software and Test Centre revenues. There will also be a number of unquantifiable impacts. Indeed, the reason other countries have established test centres is to increase the competitiveness of their industries. With the size of the telecommunications and computer sectors in Canada, it is clear that the annual impacts will significantly exceed the total investment. Unfortunately, this type of impact cannot be measured.

6.1.2 TODAC

The purpose of the TODAC project was to define concepts and develop software tools for testing the compliance of applications to the international ODA (Open Document Architecture) standard and to demonstrate their usefulness. The project ran for approximately five years, from preliminary work in March 1987 to the end of the project in September 1991.

In undertaking this project with the National Computing Centre (NCC) of Great Britain, CWARC's main objective was to establish its reputation in the area of systems interconnection by forming a partnership with this prestigious organization. The development of ODA benchmark tests was part of the CWARC's mandate laid out in its Scientific Plan. The NCC, for its part, did not have the financial resources to take on the project alone and was interested in forming an alliance with a North American partner with a similar mandate.

CWARC assigned a highly experienced team to this project, including two outside specialists during the first year. CWARC thus came to play a major role in the technical sideof the project, as its accomplishments show.

The following technical contributions are the direct result of the work performed by the CWARC TODAC team. They have earned the team an international reputation and a Communications Canada merit award. The contributions include:

- Methodology and techniques for the automatic adaptation of software tools to a wide range of document application profiles (DAP), one of the most distinctive elements of TODAC technology;
- Methodologies and techniques for standard internal representation of the data elements handled by the tools, which contributes to system reliability and flexibility;
- Syntactic and semantic analysis of document application profiles (DAP);
- Formal notation for writing test cases;
- All tools for implementation testing;
- Major contributions to standardization, mainly in International Standards Organization technical report DTR10183,which deals with the methodology for testing DAP conformance (this includes, among other things, the formal notation for test cases developed at CWARC).

These achievements and their positive effect on CWARC's reputation have had and will have very positive strategic impacts:

- Request from the National Institute for Science and Technology (NIST) in Washington for CWARC to be party to an agreement to develop conformance testing tools complementary to those developed in the

TODAC project, which demonstrates the uniqueness of CWARC's expertise in North America;

- Request from the Canadian company KEYWORD for CWARC to provide consulting services in product development;
- Marketing of TODAC in Canada by the Test Centre Corporation, with technical support from CWARC for technology transfer;
- The project gives CWARC access to unique software tools and the ideal expertise for redirecting its efforts towards document architecture, an up-and-coming strategic area that is a part of the new program.

The total cost of the TODAC project was $795,000, of which CWARC contributed $415,000.

6.1.3 CONSORTEL

The goal of this project was to develop an integrated bidirectional broadband network transmitting voice, images and data digitally. The network, a completely digital fibre-optic distribution system, should be able to transmit all current and projected voice, image and data services directly into users' homes.

The project began in October 1987 and ended on November 30, 1990, when the Consortel firm announced the termination of research and development activities.

The total cost of the project was $12 million. The Quebec and federal communications departments each invested $2.25 million as part of a regional economic development agreement. CWARC did not contribute any funds to the project.

One of the repercussions of Consortel was a pilot project in Rimouski, which demonstrated the network's technical viability in transmitting very high quality telephone and cable television services. However, several services could not be included in the pilot project due to a lack of investors.

After Rimouski, an intensive search for investors was carried out and Ericsson, one of the largest multinational communications firms, showed interest in the project. Several meetings were held to establish links with the firm. Since the chances of Ericsson investing in the project were seen to be very good, the departments involved dropped out of the promotion effort, leaving it in the hands of the private sector. Indeed, one of the main spinoffs of the project was the transfer of the Consortel technology to the private sector.

Another spinoff of the project was the creation of the Nexfotel company by former employees from Consortel. Nexfotel has participated in the effort to relaunch the technology.

Thanks to government investments, this project allowed a very promising technology to be created. It is now up to the private sector to develop this technology and marketable products.

6.1.4 TRANSLATOR'S WORKSTATION (TWS), PHASE I

In 1986 and 1987, CWARC conducted detailed studies on the operational and technical specifications for an environment to help human translators. These studies brought to light the complex and multifaceted nature of the translator's task and showed that a comprehensive computer-assisted translation environment must contain and coherently integrate a wide range of tools.

In 1988, CWARC produced the first prototype of the workstation by integrating a group of commercial software packages on a personal computer. This workstation, dubbed TWS-1, was delivered to the Secretary of State Department and tested successfully in a working environment in 1989 and 1990.

The computer-assisted translation program at CWARC is currently developing two more advanced versions of the workstation.

The first phase of the project began in March 1986 and ended in November 1989. The total cost of the project was $250,000, of which CWARC contributed $125,000.

TWS-1 is currently being used at several Secretary of State Department Translation Bureau sites and is attracting an enormous amount of attention from translation units in the private sector. The evaluation of these pilot installations was positive.

6.1.5 CRITTER

The purpose of the CRITTER project is to develop specialized machine translation technology. It has allowed the computer-assisted translation group to:

- build a small world-class machine translation team;
- through research, develop new machine translation techniques;
- develop a tool box (CRITTER environment) that, in the future, will greatly facilitate the development of machine translation systems;
- illustrate these tools' capacity in a pilot project involving agricultural market reports.

CRITTER is one of the best machine translation technologies currently available.

The project ran from March 1987 to September 1990. Its total cost was $600,000, of which CWARC contributed $400,000.

6.1.6 IRIS

This project resulted in the development of a reading system for the blind. Based on character recognition and voice synthesis technologies, the system enables users to access printed documents directly and independently.

The project was carried out between April 1, 1987, and March 30, 1989.

The total cost was $357,250, of which CWARC contributed $57,250.

The Iris system is available commercially from Visuaide 2000; approximately 100 units have already been sold. Because of Iris's success, two additional projects are currently being carried out for the visually impaired, one to develop user interfaces that allow visually impaired persons to use commercial software packages (the Audicones project) and another to provide newspapers for the blind.

6.1.7 IMOSA PHASE I

Information Management and Office Systems Advancement (IMOSA) is an umbrella project for several smaller projects to improve organizations' ability to manage the portion of their institutional memory that is most affected by the introduction and use of integrated office automation systems.

In Phase I, the objective was to test the operational requirements specified in the FOREMOST report by designing, testing and implementing a prototype application. FOREMOST, the software package that resulted from this phase, has subsequently been purchased by several federal departments and parapublic organizations, where it is being used to increase the efficiency of information management.

Phase I of the project ran from December 1, 1989, to May 1, 1990. The total budget for the project was $210,750, with CWARC contributing $83,650.

6.1.8 IMOSA PHASE II

Information Management and Office Systems Advancement (IMOSA) is an umbrella project for several smaller projects to improve organizations' ability to manage the portion of their institutional memory that is most affected by the introduction and use of integrated office automation systems.

The purpose of Phase II of the project was to:

- Use the knowledge, know-how and experience acquired during Phase I to further the operational requirements presented in the document "Managing Information in Office Automation Systems;"
- Make tools and techniques accessible to the users concerned so that they can better manage their electronic documents.

Phase II of the project ran from January 28 to November 30, 1991.

The total budget for the phase was $109,948, of which CWARC contributed $54,413.

Although Phase II ended only recently, hundreds of requests for the documents produced in this phase have already been received from the private and public sectors. The methodology presented in the documents enables organizations to increase their efficiency and competitiveness.

A preliminary version of the operational requirements is already being used by the Ottawa-based Public Sector Systems firm in a major project with Labour Canada. In addition, the Computer Division of the National Archives of Canada has stated that using these requirements has allowed it to reduce the planning time for 800-workstation project by 15%.

6.1.9 IMPACT OF NEW TECHNOLOGIES ON ORGANIZATIONS AND EMPLOYMENT IN THE PUBLIC AND PARAPUBLIC SECTORS

The purpose of this area of research was to evaluate the effect of computerization on a variety of areas in the public and parapublic sectors. The areas studied included organizational structures; management and operating procedures; task content; job and compensation evaluation; hiring, recruiting, transfer, promotion and selection criteria; organizational climate and job satisfaction. An additional goal of this major project was to develop tools to evaluate these dimensions.

Work on the project began in January 1987 and ended in December 1991.

The total cost was $355,000, with CWARC contributing $260,000.

The project's impacts on the Canadian economy include:

- Review of job classification plans in CÉGEPs across the province of Quebec;
- Proposal made to senior management of the Ministry of Education to establish a technological incentive award;
- Measurement and management tools made available to union leaders, management personnel and employees across Canada, enabling them to manage the introduction of computers in their organizations;
- Through the extrapolation of the results, improved planning of computerization and ability to anticipate trends for different job categories, resulting in the effective distribution of computer tools. Over 300 research reports have been distributed.

6.1.10 EXPERT SYSTEMS

In the last three years, CWARC has carried out several projects involving expert systems:

- **Aladin** is a computer environment that provides support for the development of knowledge-based systems, to facilitate communication with experts and the acquisition of knowledge from them. The system incorporates the results of much of the research carried out in the field, including the typology of expert systems, methodologies, existing tools and knowledge engineering strategies. It provides an intelligent support system for knowledge engineers who are developing expert systems;
- **LOUTI-ADX** is a research and development project centred on the creation of a Macintosh-based multiexpert software design system for organization staff training programs. The goal is to achieve the preliminary integration of the ARGUMENT/DECIDEX (ADX) system's inference engine with the LOUTI design system;
- An expert system was developed for **Telefilm Canada** to help financial analysts in making decisions and recommendations on investment proposals. Analysts' recommendations are based on a number of unwritten rules which may change from year to year;
- A legal expert system was developed for the Legal Systems and Technology (LIST) Foundation.

These projects have a total cost of approximately $655,000.

The impacts of these projects on the Canadian economy include:

- Development of skills and know-how in knowledge processing and management, an advanced field recognized as having strategic importance for the economy. The major challenge today in computer science is to give computers the capacity to integrate information and provide strategic answers;
- Development of products based on this technology that Canadian organizations can use directly (for example, the system developed by LIST to assist companies in international trade);
- Development of technologies that use expert knowledge to improve organizations' performance and increase know-how (for example, the LOUTI-ADX project);
- Development of technologies to resolve complex organizational problems in order to reduce decision-making risks (for example, in the Telefilm project, where a system is used to reduce the risks involved in investing in film and television projects);
- Development of technologies to enable organizations to carry out their missions more effectively by facilitating project study and providing management and professionals with intelligent tools to help them in their work;

- Transfer to the private sector of advanced technologies for knowledge acquisition, modelling, management and communication.

6.1.11 COMPUTERIZATION AT THE CITY OF MONTREAL

CWARC and the City of Montreal signed a master agreement to undertake several joint projects in planning, evaluation and computerization. A plan to computerize city management was submitted in October 1988 and was followed by a master plan in March 1989. Subsequently, CWARC researchers were brought in to facilitate the introduction of computer systems in several departments, particularly for managing the city's vehicle fleet and physical plant and supply department shops.

These projects took place between October 1988 and June 1990.

Out of a total cost of $265,000 for the project, CWARC contributed $140,000.

The City of Montreal has already implemented many of the recommendations made in the master plan and the resulting introduction efforts have been a success. Expertise was also transferred to city management. Because of the innovativeness and professionalism of the master plan, CWARC obtained a high level of visibility at the City of Montreal from the project. Researchers' experiences in managing the introduction have enabled them to refine their methods of action research. Two researchers associated with the projects were hired by the City of Montreal, mainly to implement the results of their research.

6.2 Projects with Impacts Not Currently Measureable

6.2.1 SUPERKIOSK

This project involved the design and development of a public-access terminal providing transaction and information services. The multiple-service terminal is equipped with a multimedia presentation interface consisting of a smart card reader, touch screen, telephone, printer, and interactive videodisk, and provides high-quality images and sound.

The project began in August 1990 and ended on October 11, 1991.

The total cost of the project was $755,000; CWARC invested $300,000 of this amount.

The expected economic impacts include:

- Development of a service industry to provide interactive communication for the general public;
- Creation of a national interest group (like the Canadian Bankers' Association) to standardize procedures for transactions between terminals of the same type across the country;
- Research on the possibility of setting up a national network of public-access terminals called Presence Canada for governmental and private sector applications.

6.2.2 SECSI

This project involved setting up a computer-based listening and consultation service on sexuality. SECSI is a fully automated, interactive system that offers information and advice on AIDS over the telephone. A prototype was shown at the Fifth International AIDS Conference in Montreal in June 1989. A demonstration model was tested at EXPOTEC '89.

The project began in June 1988 and ended on October 1, 1989.

The total cost was $180,000, of which CWARC contributed $135,000.

Potential economic impacts include work for Prima Telematic Inc., should the project be resumed. This company has a nonexclusive license to use SECSI.

6.2.3 MEDIALOG

Medialog is an electronic multimedia arts and culture library. It has three goals:

- Provide as many people as possible with access to multimedia cultural products and information on these products, including the possibility of reproducing them;
- Develop new ways of paying creators and collecting royalties;
- Promote technological innovations in multimedia and telematics and develop Canadian expertise in the distribution of electronic information.

Medialog is one of 15 projects selected by Communications Canada for its Vision 2000 program.

Phase I of the project began in January 1990 and ended in June 1991. Phase II is currently in progress.

The total cost of Phase I was $1,549,000; CWARC contributed $658,000.

Expected economic impacts include:

- Development of an electronic information distribution industry in Canada to challenge increasing American encroachment in this field;
- Development of valuable expertise that will allow original Canadian content to be incorporated into the offered databases.

6.2.4 PROFESSIONALS IN THE BANKING INDUSTRY - THEIR EXPERIENCES WITH COMPUTERIZATION

This project involved exploratory research on the impact of computerization on professionals working in the banking sector. Approximately one hundred professionals working in two major Canadian banks were interviewed. Particular attention was paid to comparing the experiences of men and women working in these organizations.

The project took place between September 15, 1988, and June 11, 1990.

The project cost $133,506; CWARC's contribution was $98,219.

The project's economic impact cannot be measured at present as the summary report for the project has not been published.

6.2.5 EXECMEDIA

The purpose of this study is to gain a better understanding of how managers use various means of communication (telephones, memos, meetings, fax machines and electronic mail) and of the main reasons for their choices.

The project began March 1, 1990, and ended August 31, 1991.

CWARC's contribution to the project was $52,661 out of a total budget of $100,792.

Since no reports on the project have been published, its economic impact cannot be evaluated at this time.

6.2.6 TELNETS

Telecommunications-Network Based Services and Organizational Strategy (TELNETS) is a project studying the impact of technological change, particularly the introduction of network-based telecommunications services. The study focuses on five sectors of the Canadian economy: residential and commercial real estate, education, healthcare, specialized transport and insurance.

The project ran from April 1, 1990 to December 31, 1991, with the period of January 1 to March 31, 1992 set aside for the preparation and publication of results.

CWARC contributed $178,000 of the total cost of $299,775.

As the results had not been published at the time this plan was written, it is too early to measure the project's impact on the Canadian economy.

7 Research Programs for 1991

Near the end of the 1990-1991 fiscal year, the Centre decided to review its research orientations and concentrate its efforts on a limited nember of research programs.

Several criteria were used to select programs:

- the relevance of the field or the need to change the direction of research;
- the existence of a well-established group;
- available and required resources;
- existing expertise.

In two cases, Multimedia Systems and Computer-Assisted Translation, the decision was obvious. Both programs met the above criteria and were a continuation of the research priorities established in 1987. In each case, the project group was well established and had sufficient expertise and the field of research was still relevant. All CWARC had to do was allocate enough resources to allow the programs to consolidate their positions.

The Open Systems Interconnection group had already carried out its mandate and nearly completed the transfer of knowledge to the private sector. The group's world-class expertise, however, made it an ideal base for redirecting efforts towards the emerging field of information architecture. This field is now part of the new Information Architecture program.

Among the fields targeted by the Organizational Research Directorate, some areas of research had become less relevant while new trends had emerged. The choice was difficult because this is an extremely vast field and the Centre's limited resources make it essential to define precise niches. Two research areas were eventually selected, leading to the Technological Innovation and New Forms of Work Organization program and the Performance Support Systems program.

The field of expert systems is no longer a research priority for CWARC. Expert systems have evolved from a field of research to a means of conducting research projects. In addition, the private sector has developed a great deal of expertise in this field, to the point where it is doing very well on its own. Several years ago, the Centre began to transfer its expertise to the private sector, particularly in knowledge acquisition, and the transfer is continuing as scheduled.

In all, five research programs were selected:

- Information Architecture
- Technological Innovation and New Forms of Work Organization
- Performance Support Systems
- Multimedia Systems
- Computer-Assisted Translation.

In addition, the Technology, Art, Media and Society program, which is being launched, will be developed further when the necessary resources are available. The program will focus primarily on projects dealing with the application of new technologies to art and culture, within a perspective of functional integration of Communications Canada's two main priorities: technological development and cultural activities. In particular, this program will carry out part of the mandate that was originally assigned to the Canadian Cultural Enterprises Research Institute and which this independent agency was unable to pursue as a result of the February 1991 budget cuts.

The following sections describe the CWARC's five research programs.

7.1 Information Architecture

DESCRIPTION

A new rhetoric has emerged from the use of computer technologies in data processing. In this rhetoric, the techniques involved in implementing computer-based means of expression are applied in an integrated fashion to different types of content using sophisticated interactive composition and presentation tools. Furthermore, continued advances in interconnection and networking technologies have fuelled users' desire to share and exchange information. Because of these changes, it has become necessary to clarify information forms and structures by using specific representations. Despite the imposing technological requirements of this new rhetoric, its ultimate goal remains the same as that of traditional rhetoric: to communicate and be understood. In the hope of attaining this goal, research will focus on techniques for modelling and representing information, particularly as applied to the generic notion of the structured electronic document. In addition, the effect of these representation techniques on the communication of the meaning of information content will be examined.

Unlike programs that have already gained a certain momentum, the proposed program is a new initiative that requires a start-up phase to develop experimental software tools and links with universities and other research centres. A period of approximately five years, including a one-year start-up period, will be needed to meet these objectives. The expected results are not directed at a specific application but rather at all applications that use structured information, such as multimedia, translation and libraries. The economic impact of the program will therefore be more indirect than direct. The objective of the program is to supplement various applications, which will face increasing demands from users, by providing software tools that will allow the applications to take advantage of the new rhetoric.

A better understanding of the general context of the proposed research can be obtained by comparing the current and expected needs of information workers and the evolution of the corpus of information.

Corpus	Needs
- increasing size	- collective corpus, in other words, one with unlimited sharing and exchange possibilities
- increasing complexity	
- multiple content types	- cope with information overload, i.e. use content meaning
- content elements located on different computers	

The development of new representation technologies such as ODA, SGML, HyTime, HyperODA and GDID, and the keen interest shown in so-called hyperapplications like hypertext and hypermedia indicate that a rational and coherent structuring of information content is essential in order to meet the needs of information workers.

Although some applications are already available that provide information tools (interfaces) meeting some of these needs, most use a corpus that works with ad hoc representations, which goes against the idea of a collective corpus. Most hypertext and hypermedia applications are subject to this problem. For this reason, the study of the normative aspect of representation technologies will remain a major focus of the program.

The current trend towards the convergence of technologies (open systems) has in turn led to a similar trend in document representation (Open Document Processing). Some attempts to standardize the representation of documents with multiple content types have already borne fruit. Others, which propose mechanisms for representing hyperdocuments, are still in the development phase. Since these standards do not specify an OSI-type interconnection infrastructure, they may be adopted more quickly than OSI applications. However, potential developers will have to find software tools that allow them to deal with the inherent complexity of some of these standards.

The area of content meaning is also being developed from several different research perspectives including knowledge bases and neural networks. The notion of logical structure (similar to meaning) that is found in structured documents has remained relatively unexplored. By identifying specific logical elements in a document, for example, potentially beneficial processing contexts can be established for use in cognitive indexing and computer-assisted translation. The notion of document class, which is also applicable to structured documents, appears to be beneficial in reconstructing the logical structures of optically-scanned documents.

Looking toward the future, we see that interesting work is being done at Xerox PARC on the semantics of electronic document handling and the relationships between graphic and visual structures in the communication of meaning. A European project plans to use structured ODA documents to allow visually-impaired persons to access information. In the coming months, a better picture will be obtained of the state of research in this field and the research orientations proposed in this program will be validated by recognized researchers working in similar fields.

AREAS OF RESEARCH

The program proposes to study the following areas:

- Multimedia information structures;
- Fragmented documents;
- Heuristic information;
- Object-oriented databases.

METHODOLOGY

As stated earlier, the new rhetoric resulting from the use of computers has broadened the traditional notion of the document, particularly with respect to the variety of content types, the notion of logical structure, and the modes of use. To coherently formulate the issues involved in determining research methodologies and approaches, we must more precisely define the notion of the document as used in research.

Traditional computer documents, which make up the major part of the current corpus of information, do not adhere to any notion of structure. In other words, there are no mechanisms in traditional computer documents for organizing information in logical elements (for example, paragraphs, sections, summary and conclusion). Although some documents may contain mechanisms associated with formatting, these elements imply an organization tailored to the presentation rather than the logical organization of content (or meaning). It is now recognized that this type of document limits the functionality of applications. To fill this gap, standardization organizations have proposed various ways of representing information in documents, involving structural mechanisms of varying degrees of sophistication: ODA (Open Document Architecture), SGML (Standardized General Markup Language) and SDML (Standard Music Description Language). This is the same approach used in our research.

The way information is used in hypertext applications has generated a need for systems that allow information elements to be accessed non-sequentially and interactively. This, in turn, has led to the concept of the hyperdocument, that is, a more or less dynamic collection of document fragments. Some technologies have also emerged in this area and are in the process of being standardized: HyTime (based on SGML) and HyperODA. The rational use of hyperdocuments will eventually require the creation of a technology infrastructure allowing document fragments to be stored, distributed and retrieved in a network context. Technologies that provide tools for using and managing objects in a network context (such as OMG's Object Request Broker and SuiteDOME) are particularly promising and will be studied carefully. Object-oriented databases complete the necessary technological infrastructure.

Besides the work described previously involving documents and hyperdocuments, the program proposes to explore an additional level of abstraction in its research on information overload. This will provide a model for, and a means of, representing information to create semantic links among documents and hyperdocuments. Such linkages could eventually be equipped with heuristic mechanisms to provide a self-adaptation feature, allowing documents to be automatically adapted to the user consulting them. This type of document is called a metadocument.

The development part of the program will require the production of software tools to provide an infrastructure for experimenting with concepts. This approach is based on the observation that application developers will

endorse generic (or standardized) approaches only when they have tools that allow them to avoid becoming involved in the technology. The advent of multimedia applications that integrate various types of content (text, graphics, images, video and audio) will result in increased complexity of underlying information structures. These applications will introduce new elements in the utilization of information: the need to be able to use information fragments rather than documents and to synchronize these fragments in time to present information (temporal management). This problem is addressed in emergent technologies such as HyTime and HyperODA. However, these technologies do not provide an application programming interface (API).

The applied research part of the program requires a great deal more thought because it involves a radical approach that is aimed at defining a structural representation for information in which content can be modified to correspond to the context of use. Some applications, such as context-sensitive help systems, are already headed in this direction but use mechanisms integrated with the information. The technology envisaged here would take an approach closer to that used in HyTime but would have links between information fragments that could contain decisional elements (for example, means of measuring semantic proximity based on cognitive indexing techniques). Various prototypes are planned to determine the practicality of integrating such technology.

The research program plans to model and implement a generic representation structure that will provide an infrastructure for experimenting with pertinent methodologies and techniques. This approach has several advantages: complete control over the model, capacity to intervene, a single application programming interface (API) for the associated tools (inspectors, graphical browsers and convertors), the relatively easy integration of derived applications and a uniform reference for researchers. The concept of a generic structure has already been used to advantage in a previous project (TODAC).

CLIENTS AND PARTNERS

Since the program is still in the start-up stage, this is a list of prospective partners only. In a few months, of course, the list will be more definitive. The **prospective partners** are:

- National Library (Electronic Document Delivery initiative)
- ISTC (Interdepartmental Artificial Intelligence Research and Development Fund)
- Neurope Lab, Geneva
- Xerox PARC, California
- ITRC (Information Technology Research Centre)

- CRIM (Centre de recherche informatique de Montréal)
- Universities.

In the research and development portion of the program, software tools will be produced for use by application developers and for creating concept validation prototypes. In addition, the expertise in standardized technologies acquired during projects may be useful for consultants and system integrators. The other **clients** of the research program include:

- Internal CWARC programs (Multimedia Systems, Computer-Assisted Translation)
- National Archives.

EXPECTED RESULTS

In most cases, research results will be in the form of prototypes or software tools that can be used by application developers. Some of the technologies developed by CWARC in its TODAC, INDEXPERT and MEMO projects will also be used in the program.

Of course, we will continue to monitor the evolution of information representation technologies (ODA, SGML, HyTime, HyperODA, GDID) that are already defined or are in the process of being defined by standardization organizations.

CURRENT AND PLANNED PROJECTS

Once we have acquired a firm grasp of the research being conducted in Canada and abroad and once our prospective partners have been made aware of our general plans, we will be able to formulate a coherent project strategy. Some prospective areas include:

- Methodology and tools for using logical structures in documents;
- Methodology and tools for using hyperdocument sharing and exchange technologies;
- Modelling and implementation of an experimental generic representation system for processing hyperdocuments and metadocuments;
- Methodology for using a generic data interface for structured documents and hyperdocuments.

REFERENCE

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7.2 Technological Innovation and New Forms of Work Organization

DESCRIPTION

Canada is part of a global revolution which is transforming many aspects of work organization. New technologies of information and communications (NTICs) are making it increasingly possible to alter dramatically the nature and performance of intellectual or knowledge-based work in a manner which often holds the potential to be beneficial to both organizational and individual performance and to the quality of working life.

Technological innovations and applications in such areas as networking and video-conferencing, integration of multiple media (text, video, sound, etc.), interactive technologies, artificial intelligence and expert systems contain the promise of new forms of organizing work. These new forms include decentralizing work away from large organizations; restructuring lines of communications and control; creating new and more effective work contacts and relationships across great distances; and redesigning individual tasks. Some of these trends are already occurring. Past and current CWARC research has been at the forefront in determining how to make technology/work organization interfaces function effectively and in seeing that the results are passed on (for example, CWARC's research on implementation processes, user needs, telework and networks).

Many factors influence the ability of organizations and individuals to maximize the potential gains or conversely, to underutilize or ineffectively use NTICs and not attain those gains in productivity, effectiveness and job satisfaction. These factors range from design of the technologies themselves, to their selection, adoption and implementation in organizational settings, to how they are used and adapted by employees. Overarching many of these factors are external pressures (issues of competitiveness, and demographic and social change, for example) to alter the way organizations conduct their work, accompanied by internal pressures for change from the workforce (e.g. demands for more meaningful work and increased responsability).

The program's focus is on the human, social and organizational factors that will allow technology-associated change in the workplace to be managed as effectively as possible. The program refocuses attention on knowledge-based work and the workplace: how work is organized, designed and carried out; who does it and with what values and tools; and how it is changing. The approach is multidisciplinary and integrated, which more accurately reflects the complexity of the relationships between new technologies, people, workplaces and society.

Increasing performance through technological change in the workplace is not simply a question of developing and implementing the correct technical

tools. Since the beginning of the industrial revolution, organizations and their managements have sought through such means as Taylorism and Fordism and more contemporary solutions such as "work reengineering" to increase workforce productivity and effectiveness by applying new technologies. This is fundamentally a technologically determinist approach: it reduces the organization and its workforce to their most instrumental dimensions, and reifies and redefines workplace productivity according to the potential offered by the new technologies themselves.

This approach is attractive but flawed. Contemporary workplace reality, in Canada and elsewhere, suggests that technical change in work processes usually do not by themselves guarantee that organizational and individual productivity will be maintained, let alone increased. Workplaces are an interdependent combination of technical and social factors, and contradictions abound. Whether widely recognized or not, the technologies themselves often contain assumptions and choices concerning how work should be organized and performed, e.g., the fast-growing "groupware" software which presupposes that collaborative work is inherently superior to individual work and takes little or no account of the analysis of work group dynamics.

NTCIs are designed, adopted, implement and effective inas well influenced bya complex human, social and organizational context. This context is irrevocably linked to changes in how work is structured; the knowledge and skills required for specific tasks; the interests, perceptions and relations among members of the organization; how technology is redefined and applied by users and how effectively organizational change is managed. Im other words, technological change implies organizational change and development; increasing performance requires both technical and organizational innovation.

The challenge therefore is: (a) to reinvent ways of designing, organizing and conducting work, by means of integrating and harmonizing NTICs with their workplace settings; and (b) to assist organizations and their members in understanding and optimizing the performance potential inherent in NTICs and in reducing the costs of change by providing fieldtested knowledge, approaches, products and services.

The goal of the program is to contribute to the productuvity and effectiveness of Canadian organizations in the public, parapublic and private sectors; to minimize the costs of organizational change; and to enhance the quality of work life. The program's main objective is consequently to develop, test and transfer the knowledge and the investigative and intervention tools required to support and facilitate the adoption of NTICs and organizational development as applicable to innovative forms of workplace organization, job design and work processes.

AREAS OF RESEARCH

The program comprises the following areas of research:

- Distance work (telework and its variants such as satellite offices, neighbourhood work centres, flexible work arrangements and working at home). This research will examine distance work in relation to existing organizations and to new organizations based on this principle;
- Network applications and computer-supported cooperative work (insofar as they relate to redefining and redesigning work organization and performance);
- User-friendly interfaces in their organizational and work group contexts;
- Development and validation of appropriate applied research methodologies.

Among the research questions that will be addressed are:

- What are the effects of these alternative work arrangements on productivity and performance at the organizational, work group and individual level, and how can they be further enhanced? What are the most appropriate tools and techniques to determine impacts on productivity and performance?
- What are the effects of alternative work arrangements on work processes, job content, skill levels (from both an objective and a subjective viewpoint), promotion and career prospects, financial rewards, job satisfaction and overall quality of working life? What steps can be taken to maximize the positive aspects?
- What changes in management mechanisms and control systems and in organizational behaviour and culture are required in order to make these new forms of work organization most effective?
- What factors and techniques most enhance the effectiveness of change implementation and management, from conception, and design and introduction to adoption and maintenance?
- What are the broader social effects of these new work technologies (e.g. relations of organizations to their larger environments, urbanization trends subcontracting, contracting, gender relations, family/work interaction, etc.)?

METHODOLOGY

Several major methodological issues must be considered First, there is an extensive literature which draws attention to the apparent paradox between massive technological change in workplaces and slowdowns and even declines in productivity gains. The existence of this paradox is, of course, dependent on the degree of confidence that the scientific community has in the reliability and validity of productivity measurement. Recent research has called this type of measurement into question, and this ongoing debate must

be kept in mind when conducting research and drawing conclusions about the productivity effects of new forms of work organization.

Second and relatedly, sociologists are currently debating whether, and to what extent, causality links can be established between variables. Given the complexity of the relationships this research project focuses on, it seems obvious that strictness and caution are called for whenever we formulate conclusions and make recommendations based on our research. It also seems obvious that laboratory research is best avoided.

Third, much research on the impacts of technology has tended to be of the "snapshot" variety. There has recently been a sensible call for more longitudinal work, which would result in a better understanding of the various steps in the implentation process and of the associated effects, for example, from the initial novelty and incomplete understanding of the technology through to advanced use. Whenever possible, our research will attempt to focus on the longer term.

Fourth, our methodologies and research tools need to be sensitive to the possible distortions arising from users inherent positive bias towards technology; this is especially true when using data from self-reporting surveys.

Lastly, as often the case in applied research, we will at times—especially when carrying out intensive, extended organizational analyses—be forced to compromise between the requirements of "ideal" research and the interests and availability of our partners and clients.

Our research will be based on the following methodologies:

- Formative and naturalistic evaluations;
- Quantitative and qualitative methods;
- Longitudinal and comparative studies;
- Pilot projects in organizations (multi-site and multi-year where possible);
- Quasi-experimental designs (attempting to control the effects of certain variables);
- Alternate, innovative methodologies (including visual anthropology, video and photography).

CLIENTS AND PARTNERS

As CWARC is a national research centre and as this program is multidisciplinary in orientation, our main role in regard to our research partners will be to champion integrated methods and promote synergy. Consequently, we will put special emphasis on developing and carrying out joint research projects; transferring fundamental knoledge to our research partners; allowing them to develop approaches and tools based on this

knowledge; publishing and otherwise disseminating our research findings; and providing specialized consulting expertise.

Three priorities will be to develop long-term research links with: (a) private sector sites among initial targets in this area will be the financial services sector and small and medium size business; (b) the federal government, which is especially interested in telework arrangements and social and organizational issues related to the impact of technology; and (c) unions and labour associations in all economic sectors, on the premise that employee participation is a essential to effective long term technological change.

The program's **partners** are :

- At CWARC:
  a) Performance Support Systems Program (through our research on user-friendliness, on the implementation and impact of performance technologies, and on the social and organizational issues around the effective use of competency enhancement tools; initial collaboration will be on the Interface project),
  b) Multimedia Systems Program (through expertise on the social/organizational and user aspects of design specifications of new applications, through studies of user needs, and through research on the implementation process and impacts of pilot projects; initial collaboration could be in such areas as Medialog Phase II, Audicones and computer-supported co-operative work),
  c) IMOSA special project (development of records management tools that facilitate distance work),
  d) Computer-Assisted Translation Program (through formative evaluation of the organizational aspects of the user interface in translation workstations);
- In Canada:
  a) Research centres (Canadian Labour Market Productivity Centre, Institute for Research on Public Policy, Centre francophone de recherche en informatisation des organisations, UQAM/Centre de recherche et d'évaluation sociale des technologies; CGI/Centre de recherche en connectivité, Information Technology Research Centre, Alberta Research Council),
  b) Universities (Moncton, Laval, École Polytechnique, UQAM, McGill, Carleton, Western Ontario/Centre for Administrative and Information Studies, Waterloo, York, Simon Fraser),
  c) Governments and government agencies (Treasury Board/Personnel Policy Branch and Information Technology Management Division, Industry Science and Technology Canada, Revenue Canada, Consumer and Corporate Affairs Canada, Atlantic Canada Opportunities Agency),
  d) Parapublic and private sectors (Groupe LGS, CGI, Montréal Trust, various Quebec health institutions),
  e) Managment training centres (Canadian Centre for Management Development/Information Technology Management courses, Banff

Centre for Management/Managing Information Technology Effectively courses),

f) Industry Associations (Canadian Federation of Independent Business, ITAC, Canadian Information Processing Society),

g) Labour associations (Public Service Alliance of Canada and other federal public service unions, Canadian Labour Congress),

h) Media (National Film Board);

- International:

a) European Community Research Programs (MONITOR, FAST),

b) Centre for Information and Communication Technologies (University of Sussex, U.K., part of the Economic and Social Research Council's Programme on Information and Communication Technologies),

c) Neurope Lab (Geneva),

d) Swedish Centre for Working Life,

e) CIRCIT (Centre for International Research on Communication and Information Technologies, Melbourne, Australia), Technological Change and Work Organisation Program, and Union Research Centre on Office Technology.

CWRAC has already contacted many potential research partners in Canada; the results can be seen in the partnerships listed above. Partners contribute specialized expertise, research sites and funding for joint research projects. International contacts will be pursued in the summer and fall of 1992 as resources permit.

Many of the research partners will also be **clients** of the program. Since the research program has such broad implications, its clientele is correspondingly diverse:

- Federal government and various provincial governments;
- Parapublic and non-profit organizations (e.g. health sector);
- Private sector and industry associations;
- Unions, professional and trade associations, user groups;
- Management training programs;
- Consulting companies;
- General public.

All geographic regions of Canada can potentially benefit from this research. For example, research on telework variants will have implications both for highly urbanized regions (e.g. southern Ontario) and for rural and isolated areas.

Central agencies in the federal government (Treasury Board and the Public Service 2000 Secretariat) have expressed interest in the program's emphasis on telework for at least three reasons: a policy on government employees working at home is being developed; some pilot telework projects have already been implemented or are in the planning stages; and

recognition of CWARC's growing expertise based on its satellite office project in southern Ontario. More broadly, the Secretary of the Treasury Board has recently indicated that he expects CWARC to play a major role in developing new and more flexible forms of work organization in the federal government.

Outside the public sector, the program has already developed good client relationships in the health care sector, including with some of the major consulting firms providing advice on the design and implementation of automation projects in the health care field. Considerable effort will be devoted in the program's first year to solidifying relationships with private companies, industry associations and professionnal and trade associations.

EXPECTED RESULTS

One of the major results of this program will be a body of knowledge regarding the advantages, disadvantages and ways of maximizing the benefits of the new forms of work organization made possible by technological advances. In particular, we will provide organizations and their employees, as well as the larger Canadian society, with research-supported findings, examples and recommendations about the most appropriate choices and decisions for their specific situations.

More modestly, but of equal importance, we will attempt to increase the sensitivity of Canadian organizations to the full spectrum of possible consequences of changing their work patterns. In other words, if the program is successful, more Canadian organizations and workers will be asking and seeking answers to the "right" questions about technological change and its effects on their work—before, during and after the changes are implemented. In this sense the program is one which will sometimes ask difficult and critical questions, based on the conviction that in the longer term this is the most effective way to extract maximum benefit from technological change and reduce the frequency of bad choices and failed implementations. The program will be prepared to state bluntly what tends to work well and what doesn't, why and under what circumstances, and what can be done about it.

In addition to the obvious interest these findings will have for the management consulting community, the program should eventually result in increased Canadian competence in the telework field, consistent with societal and organizational needs and with the values of various groups in the workplace. As a result, we look forward to a growth in feasible alternatives for organizing and conducting work. Technological developments will stimulate a rethinking of the concepts of workplace and work and this could have economic and social benefits both in urban areas and in rural and more isolated areas of Canada where economic opportunities are limited in part by geographic factors.

Through collaborative research with other CWARC programs, the program will contribute to the development of pre-competitive technological products and services with the potential to make work organization and performance more effective and productive.

Outside CWARC, several specific products are anticipated:

- **"Is this the right technology for our workplace?: A guide for decision-makers, purchasers and users."** When making purchasing decisions, organizations are frequently forced to rely on information from the technology suppliers and on their own intuition ans experience. We will produce a publication and video based on our field research findings and covering the types of worplace-related questions and answers that organizations should be asking and getting from their suppliers in order to make intelligent decisions. Potential target market: small and medium size businesses, with the Canadian Federation of Independant Businesses as a possible partner/client.
- **Telework**: a) Guide and video on how to determine whether telework is an appropriate solution; implementing telework effectively; and the foreseeable impacts and effects of telework. Potential target market: public, parapublic and private sectors. b) Software packages, systems and related management pratices designed for distributed workplaces.
- **Implementing Technological Change**: Recommended pratices guide for organizations, based on case studies and pilot projects in a variety of fields.

Research results will be passed on to four target groups:

- organizations, managers, employees and their respective associations;
- specialized audiences—through conference and seminar presentations and articles in learned journals and trade magazines;
- to practitioners-management consultants and management training programs (e.g. CCMD, Banff School of Management, Executive MBA programs) through presentations and bulletins on research findings, methodological tools and approaches;
- to the general public-the program has potential as a public education vehicle, through the use of films and videos, articles on op-ed pages of newspapers, etc.

We will also investigate new and more effective ways of transmitting research results, particularly through the expanded use of films and videos.

CURRENT AND PLANNED PROJECTS

Current projects:

- **RAP (Resource and Advice to Practitioners Network)**: Qualitative evaluation and implementation strategies for a world-first computerized consultation and decision-making network, intended to provide general

practitioners with access to advice from specialized resources and professional training for the treatment of mental health problems. This project also explores new ways of organizing health practice, for example, how users appropriate network technologies to improve their professional practices and the performance.

Research emphasis: networks; new modes of work organization; formative evaluation; implementation processes and organizational dynamics;

- **Telework**: Implementation and evaluation of satellite work offices in the Ontario region of DOC.

  Research emphasis: development of new forms of work organization; networks; formative evaluation; implementation processes; management mechanisms and organizational dynamics.

Projects under discussion and/or development:

- **Distributed workplace management system**: development, on-site testing and analysis of management procedures and systems, including software tools, that could facilitate distance working;
- **Distance work in the public sector**: multi-site research on the design, implementation and organizational and work-process effects of various telework arrangements in the federal government;
- **Individuals, organization, work and technological change**: research on the validation of implementation methodologies at existing CWARC research sites, and of findings using audio-visual methods;
- **Collaboration**: critical evaluation of the roles which communications technologies might play in enhancing collaborative, long-distance research work through networks;
- **Automation of health care facilities:** research concerning the effects of automating diagnostic practices in Quebec hospitals. Research areas will include managiement of the organizational change process; the effects on organizational structure and lines of communication; and the nature of the work of nurses and doctors, including interaction between these job categories;
- **Productivity measurement**: the organizational factors and work pratices involved in the effective design of software productivity measurement tools, as applied in the financial services industry;
- **User friendliness of hand-held and portable computers**: relationships between user performance and satisfaction, organizational environment and device user friendliness.

The following projects, to be carried out collaboratively with other CWARC programs, are also under discussion/development:

- **Interface**: design and implementation of user-machine interfaces for integrated workstations; evaluation of functional and organizational aspects of user friendliness; on-site implementation and testing processes;

- **Medialog**: research on implementation processes, user needs and organizational settings in upcoming field trials;
- **TWS (Translator's workstation) Part II**: user friendliness networks and work organization .

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7.3 Performance Support Systems

DESCRIPTION

The current reality of downsizing, rapid technological change, and increasing competition from abroad make training and human resource development a key strategic investment. A recent Conference Board report on training expenditures found a direct correlation between the investment in training, the return on investment, and employee satisfaction. In Canada, however, the training context is far from ideal, with dispersed employee populations, large distances between branches, small populations of each job group, inadequate training department capacity and no tradition of setting specific training objectives. A recent Employment and Immigration Canada study found that only one-quarter of privately-owned companies in Canada provide formal training for their employees. Add the downward trend in the basic proficiency levels of persons entering the labour market and the conclusion becomes inescapable: training in Canada is in critical state.

While debate rages on concerning the respective roles of the private and public sectors in solving the human resource crisis, Canada continues to lag behind all major industrialized countries in investment in training. Recently, a Canadian Treasury Board official publicly called for a radical transformation in the way government thinks about training; he recommended the creation of a special fund for research into new training methods and technologies and called on goverment departments to increase their training investments by 10% a year for the next five years.

The challenge will not be met by traditional training approaches based on the transmission of information and procedures from an instructor to largely passive students. Employees learning higher level skills will soon be the rule rather than the exception. This is due to the replacement of unskilled or semiskilled jobs by skilled jobs, the growing proportion of workers classified as knowledge or information workers, and the ever-increasing rate of change in modern organizations which requires workers to continually master new concepts and processes and to apply their skills to many similar tasks and fields of knowledge.

To be prepared to handle these increasing demands, employees require training and support which not only provides a higher level of content but also puts more responsibility and control in employees' hands. This need is rooted in the fact that the development of higher level skills is necessarily a learner-centred process, research clearly showing the direct relationship between learning and personal involvement and effort. We must increasingly enable learners to define their own needs and we must design flexible training structures that let learners choose the sequence, content and learning strategies that meet these needs.

Addressing these challenges requires a new perspective on how we treat and help people in the workplace. While one cannot dispute the need for improved quality in training, many experts now question the assumption that training is the primary solution to human performance problems. Rather, training should be seen as the alternative of last resort in many cases . On one hand, the benefits of formal training are often overestimated, as new content is rarely grasped by all trainees and the impact of learning out of context can be short-lived. Indeed, some experts estimate that only about 20% of training content is actually put to use on the job. On the other hand, 80 to 90% of job-related learning occurs informally on the job. Even for performance problems caused by gaps in knowledge and skills (as opposed to communication, motivational or other problems), training away from the job is often not the best solution. Developing and delivering this type of training can entail very significant costs, not the least of which is the cost of removing employees from their work environment. Given the high costs associated with traditional training solutions, a primary objective of the present research program is to examine ways and means of enhancing performance on the job.

Methodology

Performance technology is the methodology that accords best with this new training perpective. Performance technology includes all traditional human resource functions but also embraces the concept that training is only one of many possible solutions. The performance technology approach is global in that it systematically and scientifically takes into account all the interrated elements of the problem under consideration. The main elements analyzed include: (1) the system, that is, the worker, the work, the workplace, and the work tools; and (2) the environment, involving such factors as resources, competition, government regulations, the available labour force and the customer base (see Figure 1). The boundary between the environment and the system is determined by the extent to which the system can control a given factor. For example, some technological developments remain entirely beyond the control of a business and are therefore environmental. To keep pace with the competition, the business may well use similar technology or develop its own. Every organization aims to effectively manage and control all aspects of its system while also attempting to control the environmental aspects. Failure to manage these various aspects can threaten an organization's viability. The fundamental weakness of the traditional training perspective is that it is centered only on the worker and ignores the many other possible causes of performance deficiencies.

A global approach to identifying and solving problems is by no means unique to performance technology. Parallels can increasingly be found in other fields, including total quality management and "simultaneous or concurrent engineering," a cross-functional team approach to optimizing design and manufacturing processes, functions and systems. A more global approach to computerization is now also being applied in the services sector to re-engineer and in some cases re-integrate work processes before implementing information systems, in order to maximize the productivity

gains from the new technology. Clearly, those developing solutions to human performance problems have much to learn and gain from these related approaches.

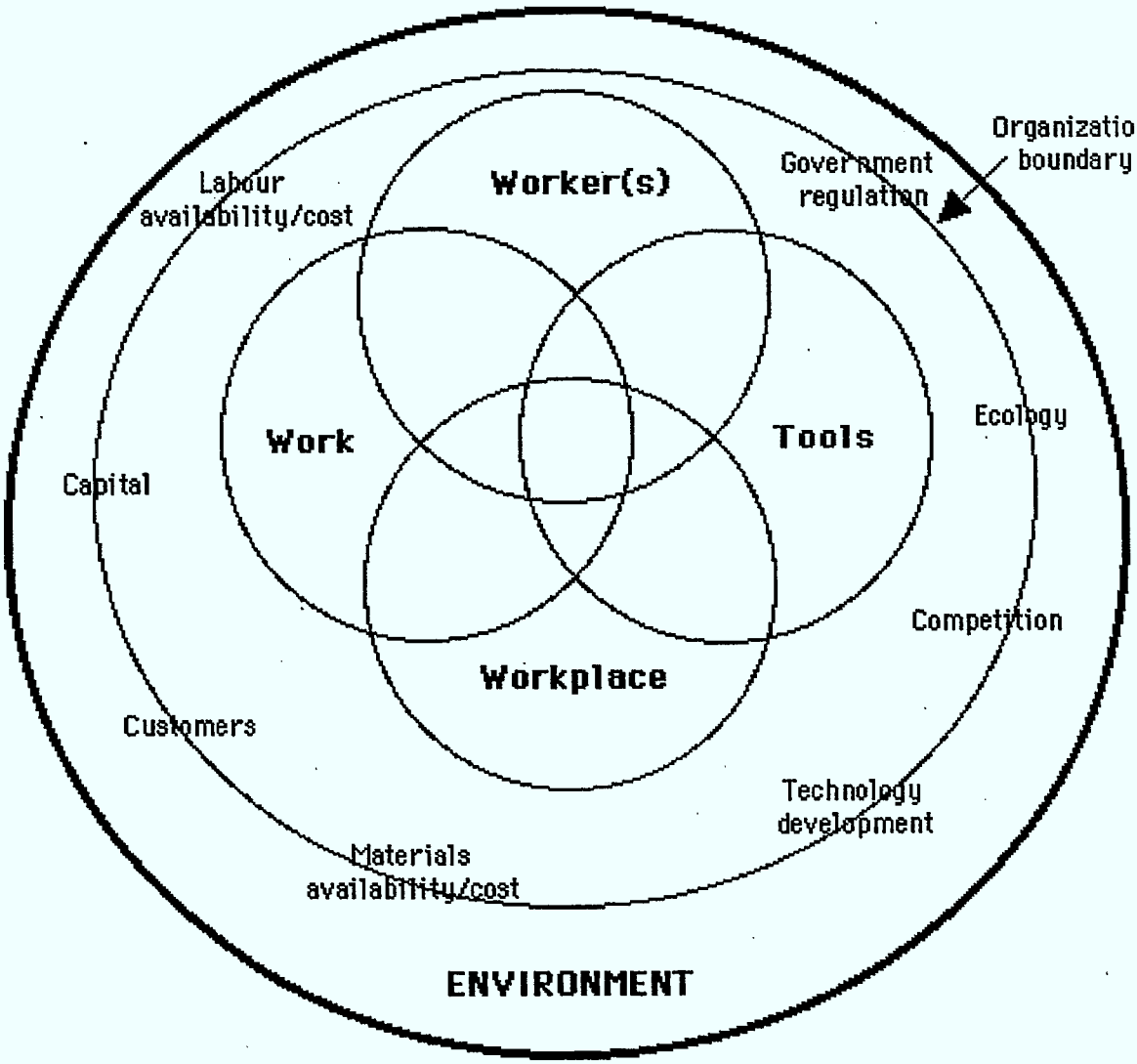

Figure : Performance Technology - System and Environment

The performance technology process begins by defining the existing state of the system and environment. A performance analysis is then carried out which identifies gaps between the existing and desired outcomes (Figure 2). The analysis produces a list of performance problems, causes and potential solutions. The range of solution interventions is graphically represented in Figure 3. As can be seen, worker-centered plans might involve training, education, improved incentives, or new supervisory plans. A tool-based intervention might, for example, automate the various components of a task and lead the worker to take on more responsability in a redesigned job. As is always true with a global approach to problem solving, each intervention

affects to a greater or lesser extent every part of the system, and the effects should be anticipated and managed.

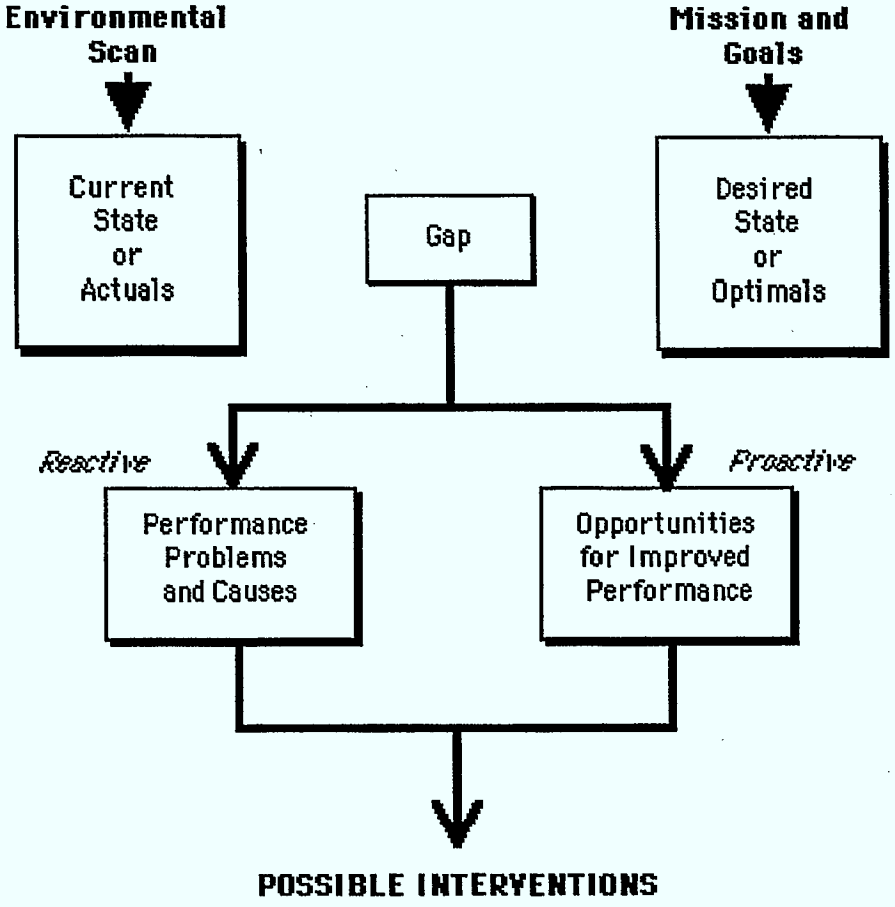

Figure 2: Performance Analysis Process

Research Program Orientation

To help attain the objective mentioned above (that is, to improve on-the-job performance), we have chosen to study a type of intervention which balances all the critical components of the system. Being composed of well-defined parts, this intervention gives rise to development, implementation, testing and evaluation activities—in other words, to applied research. The intervention, shown in the centre of Figure 3, is called a performance support system.

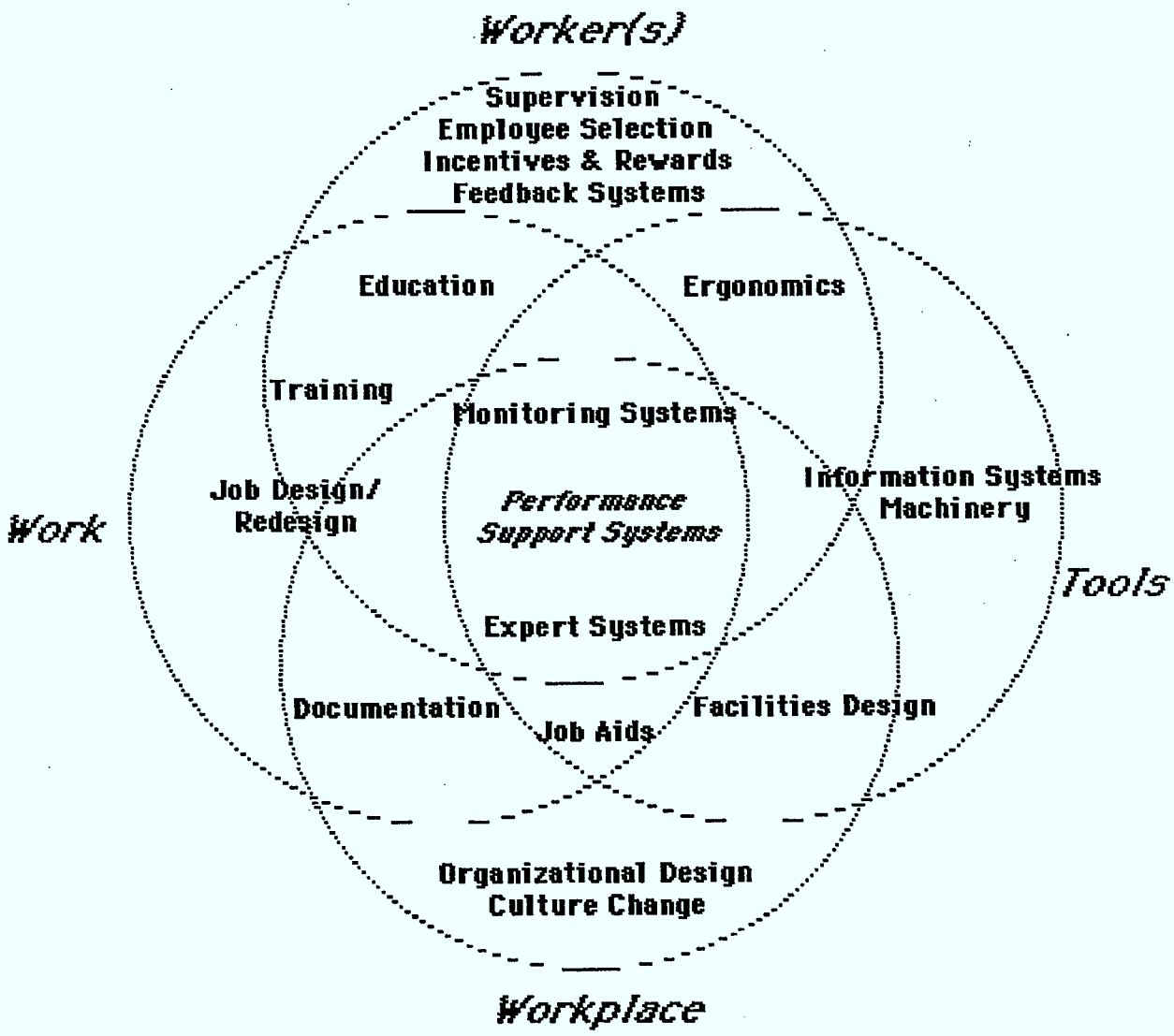

Figure 3: Possible Performance Improvement Interventions

Performance support systems (PSSs) are designed to improve worker productivity by supplying immediate on-the-job access to integrated information, learning opportunities and expert consultation—with scope and sequence controlled by the user (see Figure 4 for the components of a PSS, which are also explained in detail below). PSSs can form a partial, technological substitute for on-the-job training or an apprenticeship, avoiding many of the limitations of conventional training discussed earlier. Learning occurs on site. Productivity is enhanced because the appropriate assistance arrives just as it is needed. Employees benefit because they acquire knowledge and skill with less memorization. Emphasis is placed on providing workers with assistance in solving real problems on the job in real time. Because these activities occur in a job context, users learn from their interactions with the system. As users gain competence, they rely less on the

system. The more sophisticated the system, the more users can learn and increase their performance.

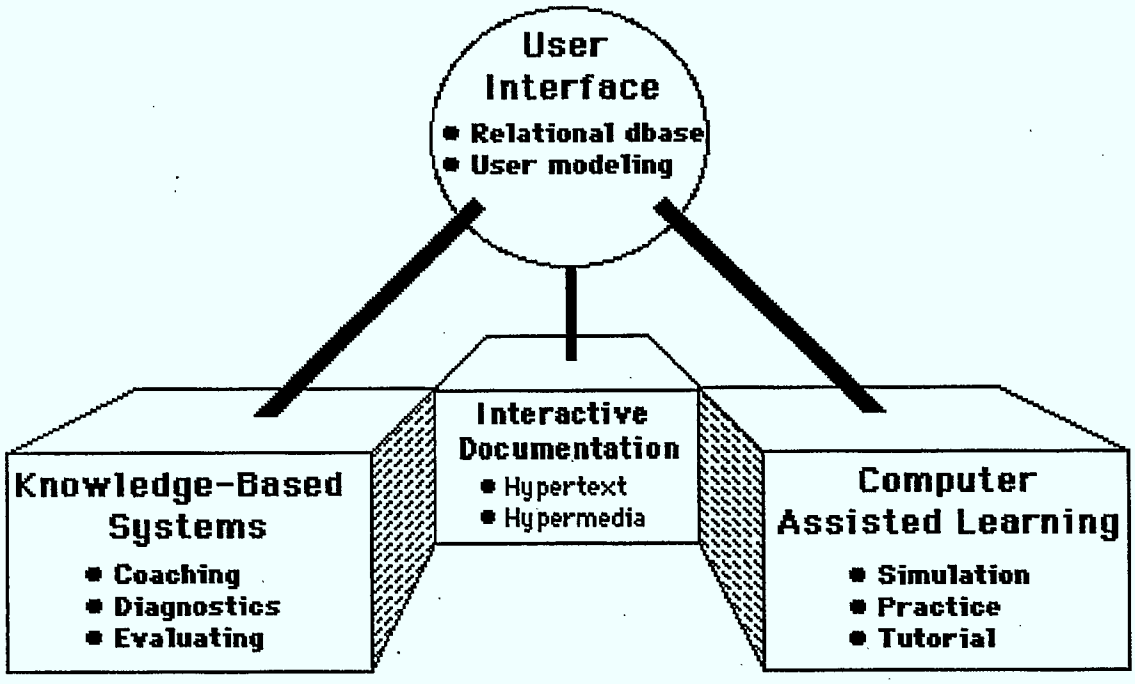

Figure 4: Basic Structure of a Performance Support System

Before discussing the specific nature and advantages of performance support systems, it is important to note that PSSs share the advantages of computer-based training (CBT) over conventional training, including:

- flexible delivery, independent of time and place;
- uniformity of content, quality and instructional/support strategies;
- individualize training;
- easier maintenance and updating.

Performance systems also represent ideal applications of artificial intelligence (AI) concepts and techniques, a field in which CWARC has a significant investment. Indeed, some experts feel that training and performance support are fields in wich AI have the greatest impact and that the most useful applications of AI will be ones that reduce the need for traditional training. Finally, because PSSs are computer-based and structured as on-the-job training they can, like CBT, result in an optimization of the training cost/benefit ratio.

Defining PSSs

Although PSSs need not necessarily computerized (human assistance and user guides are but two examples), our research program will focus mainly on electronic applications of the concept. Several definitions of this type of

PSS exist; Gloria Gery's is one of the most complete. Gery proposes an electronic performance support system that is *an integrated electronic environment available to and easily accessible by each employee and structured to provide immediate, individualized on-line access to the full range of tools—information, software, guidance, advice and assiatance, data, images, tools and assesment and monitoring systems—to permit the employee to perform his or her job with minimum of support and intervention by others.*

Unfortunately, this definition includes so much that the concept loses meaning. It may be more useful to define a PSS by its essential characteristics:

- it is an integrated set of software tools, including various conventional (e.g. database) and advanced technologies (e.g. AI-based simulation) as required;
- it provides a centralized store of information and knowledge necessary for a user to complete or master a task. This criterion excludes software tools designed primarily to automate tasks, since these are not intended to provide information or knowledge to users. For example, an expert system which does not allow users to examine its rule base or to question its conclusions would not "qualify" as a good PSS component;
- it typically involves problem solving and decision making in complex, dynamic task environments, where the complexity of work processes and/or the number of information elements or outcomes to be considered are high (see Figure 5);

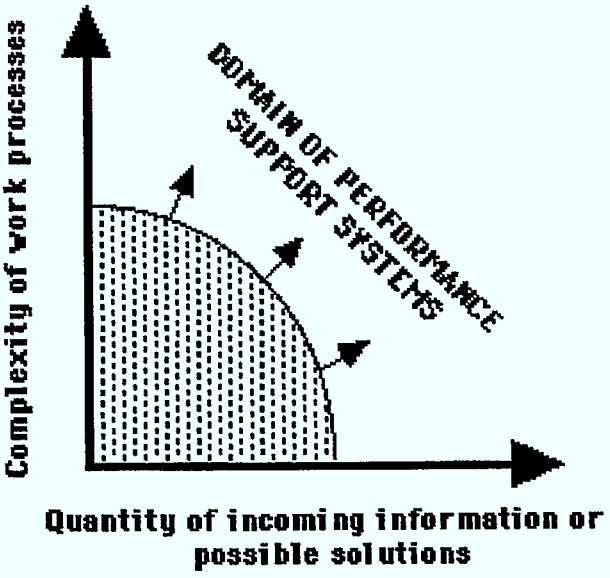

Figure 5: Key Dimensions of PSS Applications

- it is easily accessible at or very near the time the task is performed (as much as possible, the same tools are used to perform a task and to learn how to perform the task);
- it is useful to a wide range of users, from novices to experienced users.

The basic structure of a typical PSS was illustrated in Figure 4. As the illustration suggests, performance support systems integrate three key functions: interactive documentation, expert consultation and learning support. These functions are supported by a "friendly" user interface, ideally one which adapts to the user. Each fonction (or component) is described below. There follows a discussion of the role of the user interface in accessing and integrating PSS functions:

- Expert consultation

  This function is served by knowledge-based systems, which can be used to support diagnostic, classification, troubleshooting or other tasks that require inference and where the number of rules or heuristics to be applied exceeds the capacity of the user. Without knowledge-based assistance, the user could conceivably still perform the task, but effectiveness would be lower and some factors would be ignored. The primary benefits to the user and organization are therefore in performance efficiency and quality control. In particular, knowledge-based systems:

  a) can represent more complex problems than traditional forms of job aids;
  b) are not limited to a fixed procedure to solve a problem;
  c) can provide solutions which are highly specific to each situation (e.g. they "ask" only relevant questions to quickly zoom in on the solution);
  d) are easily modifiable and therefore easier to keep up to date;
  e) can be designed to adapt to changing conditions and new information (e.g. case-based reasoning systems) and are therefore easier to extend;
  f) contrary to a printed document, they can be consulted quickly and regularly in the high-pressure environment of day-to-day occupational activities;
  g) can explain the reasoning behind all advice or recommendations generated, thereby allowing implicit learning through use.

  Expert consultation, along with intelligent simulations and adaptive interface capabilities (described below), represents an ideal application of artificial intelligence concepts and techniques.

- Interactive documentation

  This component performs the same role as conventional documentation, that is, searching and retrieval of information from glossaries, taxonomies, procedure or component descriptions, case histories, and so on. Interactive documentation in a PSS addresses limitations in both the design and format of much conventional documentation.

  The computer-based format eliminates many of the costs and problems associated with the production, distribution and updating of paper-based documentation. Costs and problems associated with the use of conventional documentation are addressed by careful design (using

principles of effective text design and media display) on a hypertext/hypermedia software platform.

- Learning support

  While the use of knowledge-based systems and interactive documentation has incidental learning effects on the user, a PSS should also provide opportunities for explicit instruction at or near the time of task performance. PSS learning support has several advantages over conventional CBT:

  a) learning in context is much more powerful and longer lasting than learning outside the job context;
  b) instructional interventions in the job context encourage the worker to broaden his perspective on the task being performed and thus situate it logically in the context of the whole job;
  c) in cases where the PSS works alongside a software system, development costs are reduced because simulation of the target system does not have to be created artificially (special-purpose tools exist for developing this type of "concurrent training").

  The learning components of a PSS should ideally be subject to learner control. In order for employees to be prepared to handle the type of complex and difficult tasks we intend to investigate, training and support must be much richer in content and must give users more responsibility and control over their learning.

  To a large extent, learner control is incorporated into a PSS during the component design phase. Unlike conventional computer-based training components, PSS components do not emphasize prerequisites (that is, there is no predetermined learning sequence). Content is structured in small modules so that the user can efficiently access and complete the specific learning activity required for the task to be performed. During the learning activity, control may be shared between the user and the PSS (for example, as in an intelligent simulation which modifies its guidance based on the user's level of expertise), but selection of the learning activity remains under the user's control.

User Interface

The user interface of a performance support system should have the following basic characteristics:

- it should be intuitively easy to use, requiring minimal training for familiarization (an awkward interface defeats the purpose of a PSS);
- all components should present a similar interface, based on the same principles of user interaction design (if the PSS supports the use of another software system, consistency between the PSS and operational system interfaces must be assured);

- information generated by each component should be accessible to and usable by the other components without additional manipulation, conversion or processing of the information.

Although standard interface design need not offer adaptive features, it is our contention that such capabilities will dramatically improve the effectiveness of PSSs. This is thus one of the project's major areas of study and experimentation. User profiling and modeling techniques can be used as a basis for creating an adaptive user interface which changes the view and functionality of the system according to the user's preferences, level of expertise and behaviour during use. Naturally, such an interface should adapt to the evolving nature of users, providing more instruction and guidance to novices and leaving more latitude to experienced users. This approach forms the basis of the "operator assistant" concept developed by Sheridan for command, control and communications environments. Table 1 provides examples of adaptive user interface applications for each of the four components of a PSS, including the interface itself.

PSS Component	Examples of Adaptive User Interfaces
User Interface	- user interactions with the PSS are "tracked"—resulting data contribute to user profile - system modifies its presentation and media forms based on assessed user preferences - novices are directed towards the PSS learning support functions - novices are provided with a simplified view of the PSS - frequently used functions are given priority positioning and access in menus, etc.
Expert Consultation	- consultation system which progresses from direct intervention in early stages (coaching) to user-initiated requests (advising) - "programming by example": system which detects repetitive tasks and, if function is not already available, automates the tasks for the user
Interactive Documentation	- adaptive searching: user's idiosyncratic terms are added automatically as synonyms to list of keywords
Learning support	- learner modeling to evaluate user knowledge and misconceptions and determine best instructional strategy - intelligent simulations which adapt to the user by changing number of parameters, time limits, language and content level of feedback, etc.

Table 1

The design of the user interface must ensure that the PSS is perceived by the user as a truly integrated set of complementary tools. This user-level integration must be supported by software-level integration, since the components of a PSS are interdependent. Components draw information and data from each other via a relational database structure, although this is essentially transparent to the user. The interdependency avoids redundancy, reduces development time, increases power and flexibility of the system, and facilitates propagation of changes across components. For example:

- in order for a tutorial module (learning support) to be an effective tool for learning about the regulations impacting on a task, it should be linked to

the actual database of regulations (interactive documentation) used in the job context;

- the rule base of a knowledge-based consultation system can be accessed by a learning tool which performs a critiquing or evaluation function following completion of a task;
- interactions between the user and a software system can be recorded to generate a library of task-related cases or scenarios. These can be retrieved by a case-based reasoning knowledge-based system for on-the-job coaching, and used by a simulation-based learning tool to provide locally relevant training.

Main objectives

The main objectives of the PSS program are:

- To systematically investigate key conceptual, human, methodological and organizational issues that have important implications for the relative effectiveness of PSSs:
  a) Adaptive interfaces for performance support systems (knowledge-based user modeling, cognitive ergonomics),
  b) Considerations/criteria for selecting appropriate performance support system applications,
  c) Design, development and implementation methodologies, with particular emphasis on rapid and cost-effective development methods (feasibility and implications) and the establishment of standards for technology-based performance enhancement,
  d) Optimizing the allocation of knowledge and tasks/functions between performance support system and user (implications for system and job design),
  e) Impact of performance support systems on user knowledge/skill development (performance vs. competence issues, integration of optimal instructional strategies),
  f) Organizational requirements of performance support systems (integration of training, documentation, job design, system engineering and human resource functions; lessons to be learned from integrated manufacturing, concurrent engineering, etc.),
  g) Organizational impacts of performance support systems (worker satisfaction and communications, financial costs/benefits, employee selection, management and control systems);
- To collaboratively design, develop, implement and test performance support systems in Canadian organizations where such an approach has been identified as a suitable solution to human performance problems;
- To transfer advanced knowledge, technologies, standards and methodologies about the design and implementation of performance support systems to the Canadian private and public sectors;
- To promote performance technology and performance support systems as cost-effective productivity-enhancing alternatives to conventional training

and human resource development, via documented implementations in actual work contexts;

- To contribute actively to knowledge development in this growing research and development (R&D) field through information gathering activities and scientific publications.

AREAS OF RESEARCH

To make optimal use of scarce R&D resources, CWARC needs to pursue projects with comparatively high potential for success in terms of meeting research objectives, improving practices in Canadian industry, and creating opportunities for future work and collaboration with other research organizations. Projects with the following characteristics will have priority:

Research Factors

- Applied research: projects in the pre-competitive research category, three to five-year before commercial lauch. Projects with a significant development component are acceptable but should be subcontracted.

Strategic Factors

- Promising partnership opportunities: with key research, user or other organizations;
- Projects involving organizations in strategically important industries: for example, knowledge-based industries, non-renewable natural resources, transportation and communications;
- Projects involving trade associations: these sectoral bodies represent a potentially high leverage mechanism for upgrading Canadian competitiveness, particularly in the areas of education and training. Moreover, they probably represent small and medium size business better than Chambers of Commerce or other general business groups do;
- Implementations in small and medium size businesses: such organizations often provide a superior research context because senior management support can be secured and maintained, and most variables and interactions can be measured and/or manipulated. They are more likely to prove better models for PSS implementation, due to their greater receptivity to non-traditional training approaches, their higher level of flexibility superior quality of their internal communications. Finally, though small and medium size businesses are the motor of the Canadian economy, they are not known for their investment in human resource development. They consequently have the most to gain from performance technology and performance support systems.

Organizational Factors

- Human resources policies of client organizations: well-developed approaches to human resources management and development, as indicated by factors such as level of investment, attitudes of senior

management, qualifications of training staff, application of proven methods and concepts, etc.;

- Organizational co-operation: willingness to provide a suitable research environment (e.g. freeing employees, making information available to researchers); acceptance of research methods; agreement to make research findings available for interested parties.

Human factors

- Performance support systems designed to enhance productivity and the quality of work life: computer tools which are highly integrated into the work context have the potential for "dequalifying" employees or otherwise negatively affecting employee satisfaction. We will therefore concentrate on identifying research ans implementation contexts where PSSs have a positive a positive impact (for example, reducing routine work, managing complexity, facilitating acquisition of higher-level skills).

Content/contextual factors

- Performance support for demanding task environments (high stress, complex tasks—for example, design, criticality, time pressure, cognitive load): the power of most current performance support systems is significantly underutilized. Our intention is to select implementation contexts which challenge the capabilities of such systems (for example, air traffic control, instructional design, high-volume public enquiry environments);
- Performance support for complex real-time electronic systems: such systems are increasingly applied in varied contexts, have very significant software components and are in such rapid evolution that conventional training development and delivery approaches cannot be applied successfully (for example, air traffic control, nuclear plant operation, network control and monitoring systems, military applications);
- Performance support for PSS-related areas of expertise: research activities should ideally lead to improved techniques and tools for personnel involved in future PSS developments, namely knowledge engineers, training-program developers and instructional designers.

CLIENTS AND PARTNERS

The **internal partners** of the program are:

- Technological Innovation and New Forms of Work Organization program: collaboration on organizational dimensions of performance support system design and implementation (work design/organization impacts, "user friendliness", etc.); conversely, collaboration on potential performance support aspects of existing projects such as Telework and the Resource and Advice to Practitioners (RAP) Network. Close collaborative arrangements are already in place for the INTERFACE project.

- Information Architecture program: possible collaboration on performance support aspects and the impacts of tools currently being developed for electronic information managers, including AI-based text retrieval and intelligent interfaces.
- Multimédia Systems program: possible collaboration on adaptive interface issues and developments, multimedia databases, interactive documentation, implementation issues and other domains of common interest.
- Computer-Assisted Translation program: possible collaboration on performance support aspects and impacts of translator workstation prototypes (Translator's Workstation-TWS).

The **current private, public and university research partners** are:

- Centre de recherche informatique de Montréal (CRIM);
- Industry, Science and Technology Canada (AI Fund);
- Training and Development Canada;
- Employment and Immigration Canada;
- Treasury Board;
- Université de Montréal;
- Concordia University;
- Softwords Research International.

The **clients** of the program are:

- Revenue Canada Taxation;
- Centre Saint-Laurent (Environment Canada);
- ADGA Group Inc.;
- Virtual Prototypes Inc.;
- Hydro-Québec.

EXPECTED RESULTS

The first result generated by the research program will be a body of knowledge on human performance support systems. This will provide guidance and pratical examples to businesses regarding the most appropriate choices for their particular circumstances.

The second expected result will be a series prototype performance support systems, mainly personalized or specialized wokstations designed to support particular task—for example, the TRANSFORM project, which is developing a performance support system for courseware designers. However, we will not be in the business of developing generic tools (for example, a course authoring system). This orientation is one of the thing

that distinguish us from other research centres, like CRIM, which concentrate on shorter-term R&D and more strictly development-oriented R&D work.

The third aspect concerns the breadth or scope of our intervention. Since development-oriented research stops at the creation of effective (i.e. technically functional) tools, the focus of the research program will extend to preliminary analysis (which form the basis of system design) and system implementation studies (how the job or task has been improved; impacts on the organization, on user satisfaction, etc.). The development work per se will be contacted out to private sector specialists in the field, thereby creating and promoting a Canadian performance support industry.

Lastly, we hope to increase awareness of these new approaches to training and performance support, through publication of scientific articles and promotional activities such as participating in conferences and exhibitions, and to encourage adoption of these new technologies in the workplace.

CURRENT AND PLANNED PROJECTS

CWARC is currently involved in several major projects that focus on the application of performance technology principles and the design, implementation and testing of performance support systems. These innovative projects have a number of features in common: they all closely track the work of other research in Canada, the United States, Europe and elsewhere to ensure they are using the latest methods and data; they all utilize existing, affordable technology to ensure the project results will be both generalizable and accessible to public and private sector organizations; finally, the design of each project is based on factors identified as highly critical to the Canadian context with special care being taken to assess and address the needs of a clearly-identified clientele. The three projects are:

- **TRANSFORM**: This project, funded largely by the ISTC's Artificial Intelligence Fund, aims to develop (using knowledge-based system technology), a PSS to assist Public Service training professionals in their instructional design tasks. The project will contribute to developing and refining a PSS development methodology; it will also build a prototype system intended to help companies develop their own performance support systems and tools. The first operational prototype, scheduled for completion in early 1993, will provide support in task and content analysis. Research approaches used in the project include system design and implementation research—in particular, formative evaluation. The prototype will be built by a private compagny specializing in AI and computer-based training, in close collaboration with CWARC and its partners, Health & Immigration Canada and Training and Development Canada.
- **INTERFACE**: Funded by a partnership comprising three private sector companies (Virtual Prototypes Inc., the ADGA Group Inc. and Hydro-Québec), CWARC, CRIM and the Québec Fonds de développement

technologique du Québec (FDTQ), this project is focuses on the complex process of developing a methodology and implementing performance support systems for operators of complex, rapidly evolving, real-time electronic systems. Potential implementation projects include CAATS (Canadian Automated Air Traffic Control System) and several potential Hydro-Québec applications, including an advanced power distribution management system.

- **VOLVOX**: Funded in part by the ISTC and the FDTQ, this multi-partner project aims to develop a generic decision support system shell applicable in a wide variety of decision making contexts. The system will include various components to facilitatie decision making in complex situations; the components include knowledge acquisition tools, multi-format databases, expert systems, modeling tools, and decision support tools. Concept validation will be carried out with potential users in the following fields: public health information management and data processing; environmental emergency management; environmental management and impact assessment of hydroelectric facilities; and municipal land management. CWARC's involvement will focus on knowledge-based components and adaptive interfaces.

Other smaller scale projects include:

- **PEPS** (Public Enquiry Prompt System): This project involves the developing of a performance support tool for Tier 1 central enquiries officers in the Revenue Canada Income Tax division. These employees are required to answer tax law questions, use forms, perform calculations, give explanations, answer procedural questions, handle information and reference materials, and so on. PEPS will provide an integrated work environment incorporating the following components: tax and tax procedures knowledge bases; a hypertext system; a decision support system; a text retrieval system; electronic letter and flash form creation system; electronic mail and a bulletin board; and the ability to adapt the process to a given client's history or situation. The system will help resolve a number of current employee performance and employee/client satisfaction problems, including slow response times to client queries and high rate of employee burnout and turnover.
- **AMETHYST**: This project aims to develop a knowledge-based system prototype Public Service pay clerks in performing their work. Employee will be able to consult the system when solving specific problems and making specific decisions related to their work. Information provided by the system will assist users in completing forms, performing pay actions, advising employees and answering enquiries about pay and benefits.
- **Analyse ergonomique du travail de l'ingénieur de la connaissance:** Researchers from the École Polytechnique de Montréal are collaborating with CWARC on this project to analyze the work and tasks performed by knowledge engineers, the ultimate goal being to better define performance support system requirements for this increasingly important occupational group.

REFERENCE

Dalkir, Kim, Jacques Lecavalier and Richard Schmid. "Research Program Proposal : Performance Support Systems." Canadian Workplace Automation Research Centre. March 13, 1992. 22 pp.

7.4 Multimedia Systems

DESCRIPTION

User-system communication has evolved considerably in the last 20 years. At first, communication was written—the medium being a keyboard and a screen—with the user-system dialogue occuring in a low-level language. Later, natural language was used. (The written dialogue in many ways parallels voice communications between two persons—on a telephone, for example.) Today, the dialogue has been enriched by the incorporation of graphics and video. In the future, the user-system dialogue will no longer be limited to a single medium (keyboard/screen or telephone, for example), but will be multimedia, with simultaneous delivery of text, graphics, videos, voice ans sound.

This service-side trend can also be observed in the evolution of communications networks and systems, which are now able to transmit several types of information in a single digital format. "Telematics", or the conjuncture of telecommunication and computer technologies, is prompting information transmitters (telecommunications and broadcasters alike) to undertake a fundamental re-examination of their original mandates.

As a result, the deceding factor in many purchasing decisions is no longer the particular technology used (telecommunications or computer) but rather how the two are integrated. Computer hardware manufacturers can no longer market a product without also the possibility of worldwide communications links. For their part, telecommunications manufacturers, who recently acquired the right to offer value-added services to users, are extending their domain to include computer systems.

In 1990, the world market for telecommunications equipment alone was valued at $138 billion; it is expected to reach $300 billion by the year 2000. The growth curve for the software industry is similar. Exports currently account for approximately 35% of the production of Canadian telecommunications firms; unfortunately, the export figures for the software industry are less impressive. During the last few years, however, the growth in the Canadian telecommunications industry has not kept pace with the world market, and our industry has lost ground. In fact, in 1988, Canadian imports of telecommunications equipment exceeded exports for the first time.

It is not surprising therefore that, from CWARC's founding in 1984, Communications Canada has targeted information technologies as a strategic sector for advanced applied research.

One area of information technologies certain to be marked by major advances in the 1990s is multimedia communication, that is, communication that includes a variety of media such as voice, data, text, graphics and video. These advances will arise from the integration of three technologies

currently considered separate: computers, telecommunications and audiovisual production. Almost every sector of the economy is likely to be affected by the introduction of multimedia technology: communications, advertising, publishing, information industries, leisure industries and others. The Canadian market for applications linked to information distribution and training is estimated to be worth $275 million; for 1995. this program will target both areas for major applications.

In addition, as part of the Vision 2000 program, a working group composed of experts in education, training, finance, health care, government and the information and leisure industries met to define the factors determining their future needs. Analysis of the session result allows us to identify the primary requirements for communications systems in the year 2000: ease of use, portability, transparent access, affortability and multimedia capacity.

Multimedia is a reltively old concept. Today, however, in part because it has become affortable, its possibilities seem nearly limitless. Multimedia is a central aspect of what is commonly called the second computer revolution (the first being the introduction of the personnal computer). Mutimedia encompasses a variety of fields: the accessing and distributing of electronic information; specialized workstations; and private, organized and public communication. Common to all these services is a direct link between the user and the information system (or between two users in the case of interpersonal communication through an electronic medium).

In fact, multimedia is much more than the simple capacity to represent images and data from a variety of media on the same screen. It is an integrated set of new technologies for acquiring, manipulating and presenting information from many different sources.

It is impossible and pointless to attempt to do everything in this field. The technology is evolving very rapidly and the current players are very powerful. They include computer giants IBM, Apple and Microsoft; the telecommunications firms AT&T and Northern Telecom; and consumer electronics manufacturers Sony and Philips. Their ranks will grow sigificantly in years to come as these new technologies—all digital—converge toward ultimate integration in what is usually referred to as the "telecomputer" at the end of the decade. Much has been written and numerous conferences held on this subject.

While not forgetting the main technological orientations of today (e.g. international standardization and the data compression and operating systems fields), a number of problems remain to be resolved before new services for managing, organizing and presenting mutimedia information can be developed. For example:

- Complexity of organizing multiple types of information: the structure of multimedia documents must be flexible enough to allow for very large numbers of basic objects of different types. It must also allow these same objects to be organized in relation to one another in time and in space;

- Indexing of multimedia information in the production process: index design must allow consultation both directly using specialized indexes and using filters and/or multimedia links;
- New interface concepts: these concepts may be pertinent for complex information searchers through the use of interface agents that do most of the work for the user;
- Multimedia communication: widely distributed resources must be shared, users must be able to initiate and end sessions easily.

Thus, the most appropriate field of study for this research program would appear to be multimedia integration issues. These include how to organize information to facilitate access and the study of user/system interactions.

AREAS OF RESEARCH

This program comprises three areas of research: management of multimedia objects; user-system interface tools; and the ergonomics of user-system interfaces.

- Management of Multimedia Objects

  The principal objective of this area of research is the manipulation, organization and presentation of multiple-type composite objects. An apt metaphor for the way multimedia information is structured today is a library that has not yet adopted the Dewey decimal system. Multimedia information is not organized for efficient exchanges between multiple applications or platforms. This is incompatible with the current open systems strategy advocated by most computer and telecommunications manufacturers.

  The status of this area of research is the following:

  a) Some standards are being developed, such as HyTime and MHEG. However, there is no assurance that these standards, which are still under study by international committees, will be endorsed either in the short or medium term by firms working on multimedia and hypermedia applications;
  b) The software tools that are now available commercially deal with all or some of the problems of representing, accessing and storing multimedia objects. However, a number of problems require much more work:
     + object-oriented databases are only available for a very limited number of hardware and software platforms and provide no tools for managing the indexing of contents associated with some objects. In addition, mechanisms for managing multi-user access are not always available,
     + authoring systems have several problems: generally, they are closed-development environments; most are linked to specific applications; they use simplistic mechanisms for implementing

hypermedia links, particularly in the area of object identification; temporal synchronization mechanisms between objects are ineffective; and they include no provision for manipulating objects located in different computers.

Four objectives are involved in this research:

a) software modelling of multiple-type composite objects;

b) organization of multiple-type composite objects in higher-level structures;

c) distribution of multiple-type composite objects (i.e. the problem of objects located on several different computers);

d) permanence of multiple-type composite objects (a permanent object is one that outlives the application that created it).

- User-System Interface Tools

As Pierre Lévy has remarked, a user-system interface refers to the set of software and hardware tools that provide for communication between a computer system and its human users.

Most current authoring systems are not open-ended enough. While a number of application development libraries exist, they can be used only in the specific environments for which they were designed. Furthermore, certain basic co-operative work mechanisms have yet to be worked out.

In short, it is still impossible for two or more users located at a distance from one another to work together using a co-operative desktop.

Three objectives will be pursued in this area:

a) a library of object-oriented software components that can be reused in the development of interactive applications;

b) a programming environment designed specifically for co-operative work;

c) an authoring system designed to assist development teams in designing co-operative multimedia applications.

- Ergonomics of User-System Interfaces

There is no library of usability routines available on the market that can be used in an existing environment. Current tools do not have flexible mechanisms for managing hypermedia. Although they do provide such mechanisms for hypertext, they leave it up to the developer to create other media links. No satisfactory solution has yet been found for networks with large numbers of hypermedia links.

A great deal of experimentation is also being done in the use of three-dimensional tools to assist in representing large corpora of information.

The most interesting work includes Xerox PARC's Cam Tree and Information Visualizer.

Existing co-operative work applications usually are linked closely with one task (text editing, conferencing, electronic mail) and are based on a videoconferencing model that provides an individual work environment and requires users to initiate group work sessions independently. Instead, applications are needed to integrate the group work model into the desktop-style work environment.

Four main objectives will be pursued in this area:

a) the definition and development of usability techniques adapted to multimedia and co-operative work;

b) the creation of a model for the various metaphors required in the development of multimedia documents;

c) the exploration of the use of interface agents and three-dimensional representation models;

d) the formulation of a recommendation on the integration of social protocols into co-operative applications, based on case studies and an analysis of existing software.

METHODOLOGY

The development of multimedia projects generally requires expertise in four areas:

- interactive dialogue technology;
- multimedia information exchange technology;
- multimedia object management tools;
- ergonomic recommendations and tools for user-system interfaces.

Specific research will not be pursued on the first two technologies. An understanding of their operation is nonetheless indispensable in carrying out pilot projects. They will be studied in the framework of other research projects, based on their anticipate evolutions and on current or projected needs.

The last two areas form the heart of the present research program.

Our strategy is to study the elements involved in common problems relatively independently of existing technologies, which are evolving very rapidly. Our bottom-up approach is pragmatic and centred on the needs of two generic families of applications. Work will be validated at each stage, through various experimental prototypes. The two application families studied are information-base access, for which the paradigm is the electronic library, and interpersonal media-based communication, for which the model is co-operative work.

An electronic library enables users to consult collections of multimedia documents consisting of basic objects of different types (text, audio, video, photos and animation) that are organized in relation to each other in space and time. Electronic libraries contain large numbers of documents, as well as various indexes. Hypermedia links allow one document or document portion to be linked to another document or document portion. The main problems associated with electronic-library-type applications relate to consultation and the production of multiple collections of documents scattered over several geographic locations.

Computer-assisted co-operative work sessions allow two or more users to work on the same task simultaneously (writing projects, decision-making, training, etc.) through a telecommunications link. The link between the users is achieved through the usual microcomputer interfaces, supplemented by vocal dialogue. The main problems associated with this kind of application are technical (initiating and ending sessions, resource sharing, views distribution) and cognitive (user interfaces and social protocols) in nature.

CLIENTS AND PARTNERS

The pilot projects to be developed under this program are intended for three different **clienteles**:

- Consortiums of users and producers of goods and services. Solutions will therefore be generic ones that can be validated by specific applications (for example, the Superkiosk network or the Medialog R&D consortium);
- Consultants, in the framework of a specific mandate. Adaptations, sometimes major ones, of existing technologies can open up unsuspected markets;
- Clients with specific needs. The objective of the project is to find innovative solutions to special problems, (for example, the Mediatex or Audicones project).

The **current partners** in the program are:

- Sherbrooke Communications Research Centre (CRCS);
- École Polytechnique;
- Université de Montréal.

Potential partners include:

- Bell Northern Research (BNR);
- CRIM (Centre de recherche informatique de Montréal);
- TRIO (Telecommunications Research Institute of Ontario) (Toronto);
- Simon Fraser University Excite Research Centre (Vancouver);
- MCC, Virginia Tech, and Professor Schneiderman's laboratory (United States);

- The French research establishments INRIA and CNRS (man-machine communication program).

EXPECTED RESULTS

The following summary gives the approximate deadlines for the various project activities over the next three years. Of course, the furthest dates are the most tentative. The needs of future partners and clients will also influence the final outcome.

- In 1992
  a) Co-operative library and authoring system (breadboard version),
  b) Library written in C++ implementing permanent objects under MS-Windows 3.0,
  c) Prototype interfaces supporting different metaphors for multimedia document design;
- In 1993
  a) Co-operative library and authoring system (Version 1.0 under Windows NT),
  b) Recommendations on the integration of social protocols into co-operative applications,
  c) First co-operative applications,
  d) Prototype for a co-operative work interface based on the group work metaphor and user-generated interface adaptability scale specifications,
  e) Library written in C++ implementing object sharing on networked PC (Windows) and Macintosh platforms;
- In 1994
  a) Co-operative desktop (breadboard version),
  b) Co-operative library and authoring system (Version 2.0 under Windows NT),
  c) Prototype interface with three-dimensional representations for large information corpora;
- In 1995
  a) Co-operative desktop (Versions 1.0 and 2.0),
  b) Co-operative library and authoring system (Version 3 on Windows NT, Macintosh and Unix),
  c) Breadboard using interface agents.

CURRENT AND PLANNED PROJECTS

Current projects include:

- **Rec-Audiotex**: Speech-recognition interface for interactive telephone services (one application has almost been completed for an urban transit information system in Victoria, British Columbia).

- **Medialog**: Medialog is a service providing access to multiple collections of multimedia information. Its features include consultation, reproduction (including the payment of royalties), and communication between users. Phase I, which was carried out jointly with the Cinémathèque québécoise, the Montreal Museum of Fine Arts and ON/Q Corporation, has been completed; phase II, which is being carried out with CEDROM Technologies and a consortium of user partners, is still in progress.
- **Coop**: This is a multimedia communications tool used in telework projects to allow users working away from the office to share text, sound and video resources on a personal computer.
- **Mediatex**: This project is a French-language real-time captioning service for the hearing-impaired that uses stenotype-based automatic transcription software (project carried out in partnership with IBM France for the Canadian Broadcasting Corporation).
- **Audicones**: Interface allowing visually-impaired persons to access commercial software packages through hearing (screen reader using sound and speech synthesis) and sense of touch (braille tablet). In addition, users of the IRIS system will test a new home delivery service for newspapers for the blind.

The following project is planned:

- **Multimedia Telecommunications**: This project will design, develop and produce hardware interfaces and software allowing switched multimedia communication between personal computers over existing telecommunications networks. Specific applications demonstrating the concept's potential will also be developed for this platform.

REFERENCE

Descout, Raymond. "Programme de recherche : Groupe des Systèmes multimedia." March 17, 1992. 18 pp.

7.5 Computer-Assisted Translation

DESCRIPTION

Computer-assisted translation focuses on the application of natural language processing technologies to translation problems.

In machine and computer-assisted translation, it is crucial to examine to what extent existing technologies can make a real contribution to solving translation problems.

The first efforts in machine translation (MT) date back to the beginning of the 1950s. Since then, researchers have concentrated on finding general, indeed even universal, solutions to translation problems. The focus has been on making computers that can produce machine translations of good quality from any kind of source text.

However, it must be observed that this strategy has had very little success. Despite all the effort and money invested over the last 45 years, machine translation occupies at best a marginal position in the market. Most large translation units have reached the conclusion that machine translation is not cost-effective. For example, the Department of the Secretary of State of Canada has tested most commercial MT packages available on the market but, to date, no system has gone beyond the testing phase. Each time, the translations produced by the machine were of such poor quality that they could not be used.

The great difficulty in machine translation is that translating a text presupposes that one has understood it and the process of understanding brings into play all the resources of human intelligence. These resources include not only a thorough knowledge of the source and target languages, but also detailed knowledge of the extralinguistic universe in which the text to be translated is interpreted. In other words, translation is an intelligent activity.

Machine translation is therefore the province of artificial intelligence. Although there has been much progress made in linguistic theory over the last 30 years, we still know very little about the phenomena of linguistic signification. We know even less about how to describe, represent, store and utilize on computers the prodigious quantity of non-linguistic knowledge required to simulate in a general way the human translator's capacity for intelligent reasoning.

Therefore, one must conclude that, in the foreseeable future, it is highly unlikely that machines will be developed that can produce translations (a) entirely automatically, (b) of high quality, and (c) for a variety of texts, corresponding to the needs of a wide range of clients.

The only way to put this technology at the service of translators is to identify "sub-optimization" techniques, specifically designed to make the most of a technology that is far from being optimum. In practice, this means taking approaches that give up on one or more of the three attributes of a universal translation machine: (a) ability to produce high-quality translations, (b) completely automatically, (c) of any type of text.

AREAS OF RESEARCH

The research strategy emphasized in the program has three priorities: computer-assisted translation in general cases, specialized machine translation in specific cases and the automatic generation of bilingual texts.

- **Machine-aided human translation** provides tools to make the translator's job easier. The translator asks the computer for help only in the most mechanical aspects of his or her work. Although the translator's work is automated only partially, real gains in productivity result.

  Bi-textual representation is one of the areas studied in computer-assisted translation. It will allow a new generation of dedicated translation tools to be produced, probably very soon. The notion of bi-textual representation infers an explicit and formal representation of the links between the source text and the translation. Bi-textual representation will be used, among other things, to build tools for judging the quality of translations;
- In the field of **machine translation**, the program concentrates on natural sublanguages, which are characterized by a limited vocabulary, syntax and semantics. By restricting in this way the range of problems that a machine translation system must deal with, a high level of automation can be combined with reasonably high quality machine output;
- **Bilingual generation** is used to completely automate the task of drafting texts in both languages. It is used primarily in the description of numerical data (for example, stock market reports).

METHODOLOGY

By combining the two winning strategies of machine-aided human translation and specialized machine translation, one obtains a coherent whole that qualifies as a comprehensive strategy. On one hand, machine-aided human translation has the advantage of universality; since it is limited to automating only the simplest tasks, it can be applied to practically all translation situations. On the other hand, specialized machine translation completely automates the translation of the simplest texts (which are also the least interesting for human translators). In both cases, the philosophy is the same: limit automation to the tasks that we know how best to automate. In fact, a specialized MT system can be included among the tools in the translator's workstation (TWS) environment.

With future technological advances, the two strategies will tend to converge, bringing about increasing automation in the field of translation. On one hand, progress made in the development of general tools for machine-aided human translation will relieve the human translator of a growing number of tasks. On the other hand, progress in machine translation will allow sublanguages of increasing complexity to be handled, so that human translation will not be required at all in some areas.

There is every reason to believe that a new generation of machine-aided human translation tools will be developed very soon that will have a very significant impact, because they will be specifically adapted to translation. All of these new tools will be based on bi-textual representation, which can be defined as the explicit and formal representation of the links between the source text and the translation.

Generally, correspondences can be found between the sections, paragraphs, sentences, phrases and individual words of the source text and the translation. Of course, a one-to-one correspondence is not always found, particularly in the case of the smaller units, where more complex correspondences are very common: one sentence in the text corresponds to several sentences in the translation, one word in the source text corresponds to several words in the translation, and so on. But there is always a correspondence of some kind.

Very recent research appears to show that so-called alignment algorithms can be developed to automatically determine the correspondences between a text and its translation, thus creating a bi-textual structure. With time, these algorithms will evolve from their currently relatively crude level (they can now detect correspondences between sentences, but nothing smaller) to a more sophisticated one, in which correspondences between words can be discerned.

This research is very important, since it allows nothing less than a new generation of aids for computer-assisted translation and terminology to be envisaged. One could imagine an entire series of these tools, but here we will limit ourselves to illustrating two possibilities: bilingual concordances and translation checking.

A bilingual concordance for the sequence *s* in bi-text *ST* would list each instance of *s* and its translation *t*, along with their respective contexts. There are many reasons to believe that the concept of bilingual concordance is of major significance for translators and terminologists. Each time the translator comes upon the sequence *s*, he or she could look in a bi-textual memory bank for solutions that other translators had already found to the problem.

Bi-textual representation also opens the door to another key concept: translation checking. Over the last several years, tools have appeared on the market that are able, to a certain extent, to check and correct spelling and grammar. Although they are useful to translators, they cannot be used to correct the translation as a translation, in other words, to verify its

correspondence with the source text. Bi-textual representation, will allow translators to verify automatically the extent to which their translation obeys certain general rules of translation.

A very simple example is that a good translation must usually reformulate in the target language all parts of the source text. Since to err is human, translators will sometimes forget to translate a sentence or even a whole paragraph of the source text. There is no computer tool available now that can help translators avoid such simple errors. There is every reason to believe, however, that a good alignment algorithm will be able to detect such omissions.

In the longer term, this approach should lead to the implementation of increasingly sophisticated checking mechanisms. For example, preliminary research at CWARC has shown that systems can be developed that automatically check for the presence of false friends (pairs of words in the two languages that look the same but do not mean the same thing), which is a major problem for translators. In addition, there is reason to believe that tools can also be developed to help translators ensure that the terminology in their texts is consistent.

No such tools are currently available on the market. We believe that the computer-assisted translation team at CWARC is in an excellent position to be the first in the world to develop them. This technology could be the wave of the future, since it appears to be much less problematic technologically speaking than large-scale machine translation.

CLIENTS AND PARTNERS

The main **client** of the program is:

- Department of the Secretary of State.

Potential clients include:

- Statistics Canada.

Partners in the program include:

- Industry, Science and Technology Canada (Interdepartmental Artificial Intelligence Research and Development Fund);
- Université de Montréal.

EXPECTED RESULTS

The results expected from the research include:

- Second and third versions of the Translator's Workstation;
- Demonstration of tools related specifically to the translator's task;
- Developments in bilingual generation.

CURRENT AND PLANNED PROJECTS

Current projects include:

- **TWS**: Version 2.0 of the Translator's Workstation (TWS) will function in a network environment allowing users to share hardware and software resources. Version 3.0, which will feature an improved user interface, is to be delivered in March 1993;
- **Exploration of the concept of bi-textual representation**: this project will explore this new area to determine potential applications;
- **Bilingual generation for Statistics Canada**: this project involves the creation of a pilot system that will automatically generate bilingual reports on various statistical indexes.

Upcoming projects include:

- Bi-textual applications;
- Specialized machine translation applications.

REFERENCE

Isabelle, Pierre. "Le programme du CCRIT en traduction assistée par ordinateur : Bilan et propositions." Canadian Workplace Automation Research Centre. February 1992. 18 pp.

8 Validation of Plan by Outside Researchers

To ensure that its scientific programs are validated by the outside scientific community, CWARC has set up a Scientific Committee composed of a dozen researchers from universities and private and public research centres. The committee met on April 15 and 16, 1992. Focusing on the Centre's five research programs, it made a number of comments and recommendations, which were carefully studied by the program managers concerned. In addition, committee members made general comments on the programs as a whole and on the role and mandate of the Scientific Committee.

8.1 Role of Advisory Board and Scientific Committee

To begin, it is important to distinguish between the Advisory Board and the Scientific Committee.

The role of CWARC's **advisory board** is to advise Department representatives, through the assistant deputy minister responsible, on the Centre's research activities by:

- reviewing research programs each year to assess their relevance in relation to the Centre's objectives and the economic situation in Canada; their value; and the effectiveness of their management;
- recommending measures that will help ensure efficient co-ordination between Centre research programs and programs run by industry, universities and other federal and provincial departments;
- providing advice on other questions submitted by the Department that are within the board's area of expertise.

Representation on the board reflects the general makeup of CWARC's Canadian clientele, that is to say, its current, potential, past, present and future clients. The fifteen-member board meets four times a year. The members' marketing orientation is intended to complement the scientific orientation of the Scientific Committee.

The **Scientific Committee** meets once a year to evaluate, and provide advice and recommendations on, the Centre's research programs.

The scientific committee's role is to review the research programs planned for the coming year. To do so, it studies programs presented by Centre researchers and makes recommendations on their scientific orientation from a strategic point of view, as well as examining links between programs. It also reviews CWARC programs as a whole.

A majority of the members of the Scientific Committee come from outside the Centre and represent past, current and potential partners. Most are from

universities and private and public research organizations in Canada, although non-Canadians may also sit on the committee.

Committee members study CWARC's scientific plan closely to carry out their mandate. The plan discusses trends in research and needs, the scientific orientation of the research carried out at CWARC, and current research programs.

A scientific plan is usually drawn up for five years, but must be evaluated yearly, with a major review after three years.

The members of each year's Scientific Committee are appointed by the Advisory Board, based on recommendations from the scientific advisor and the Programs and Projects Committee (PPC). Half the members are from the previous year's committee.

The scientific advisor is in charge of providing follow-up after the meeting and transmitting the Scientific Committee's recommendations and proposals on implementing them to CWARC's director general and the Advisory Board. The Advisory Board then informs the members of the scientific community of its decisions.

8.2 Programs Presented

Five research programs were presented at the Scientific Committee's first meeting in April 1992. A discussion period followed each program manager's presentation.

Comments on the **Computer-Assisted Translation** program focused on the program's relation to basic research, the use of bi-textuality techniques to store texts making up part of an organization's institutional memory, the possibility of using automatic translation techniques in other fields and, lastly, opportunities for bi-textual products.

The discussion on the **Performance Supports Systems** (PSS) program centred on the important distinction between proficiency and performance, system design methodology, and the need for research to be user-oriented rather than task-oriented.

The presentation on the **Multimedia Systems** program prompted discussion and comments on the links between the program and CWARC'S mission, as well as on the establisment of criteria for several aspects of research carried out under the program (selection of projects, partners and type of multimedia, and text/image redundancy).

The main comments on the Technological Innovation and **New Forms of Work Organization** program dealt with the importance of new technologies, the participation of one member of the program in all CWARC technological

projects, and the establisment of an official process to link the social and technological aspects of the various research programs.

Lastly, discussions on the **Information Architecture** program centred on the program's objectives, medium-based information representation, and the importance of information structures in information-sharing environments.

8.3 General Discussion

During the general discussion that followed the presentations, the committee members made two main recommendations: that formal links be established between the technological and human dimensions of CWARC's work and that program evaluation principles be developed.

Since its creation, CWARC has faced the challenge of translating technological progress into a force to humanize the workplace. Concretely, this means that all technological projects carried out at CWARC must take account of the organization's basic human and technological dimensions.

When a project is presented to the programs and projects committee (PPC) for approval, the Centre's main researchers become familiar with it and begin to get an idea of where it fits into CWARC's research structure. After it is approved, it may be linked with one or two research programs. Therefore, the PPC is the ideal place to develop links between programs by setting up multiprogram research projects.

The results of research program are, of course, available to researchers in other programs, subject to agreements with partners.

The second recommendation deals with program evaluation. To understand the scope of the recommendation, it is important to clearly define what we mean by a "program." A program is a set of activities and projects with the aim of:

- developing and enriching a base of advanced know-how, knowledge and expertise in a specific field of research linked to information and communication technologies;
- carrying out applied research in co-operation with industry, government, universities and other research centres;
- transferring the results of the research and the expertise and know-how gained to Canadian economic, social and cultural organizations.

Each program is thus linked to a theme related to CWARC's mission and objectives. Each program proposes a hypothetical answer to a major research question, and an approach for tackling one or more problems related to the theme.

A program should also be seen as a group of researchers working on a common theme. Therefore, programs provide expertise through their researchers.

Expertise is developed in two ways: through program activities that promote the growth of expertise and through projects that allow the expertise developed in a program to be applied. The real links between research programs are therefore found at the project level.

Research programs are evaluated at two different levels:

- at the project level, where projects are assessed through an internal process using performance indicators and criteria. Since projects are the driving force behind a program, program evaluation occurs mainly at this level.
- at the program level, where the development of expertise is assessed. This part of program evaluation is handled by the Scientific Committee.

At the next meeting of the Scientific Committee, members will hear a status report on the development of expertise in the various programs, as well as a description of the projects carried out and the performance indicators for programs and projects.

9.Conclusion

This scientific plan defines CWARC's place in the larger research and development community, as well as the major areas in which it wishes to make a contribution to research. To be effective, the Centre must constantly seek out potential clients, entertain proposals from potential clients and partners, understand the meaning and scope of proposals, suggest appropriate action plans, provide adequate solutions, and demonstrate that its actions have a structural impact on the economy.

Thus, the scientific plan provides a guide for organizations wishing to submit research projects to the Centre. It should be viewed as a flexible rather than a rigid framework. It must be revised and adjusted annually to reflect internal results and new external trends.