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Providing Links among Government, Academia, and Industry: The Role of CISTI in Scholarly Communication

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Abstract: Canada's success as a modern, knowledge-based economy depends on a strong national information infrastructure that is responsive to the needs of the country's innovation system for industrial development. The Canada Institute for Scientific and Technical Information (CISTI) at the National Research Council (NRC) is uniquely positioned to meet the needs of Canadian researchers and contribute to the Canadian innovation system by providing Canadian access to worldwide scholarly scientific, technical, and medical (STM) information and by leading in the development of the national information infrastructure linking Canadian industry, academia, and government. The emerging world of electronic information is transforming scholarly communication and changing the roles of researchers, users, publishers, and librarians. Increased collaboration will be critical to maintaining a robust national information infrastructure.

Résumé: Le succès d'une économie canadienne axée sur le savoir dépend d'une solide infrastructure d'information nationale pouvant satisfaire aux besoins de développement industriel éprouvés dans le système d'innovation du pays. L'Institut canadien de l'information scientifique et technique (ICIST) est en position idéale pour répondre aux besoins des chercheurs canadiens et pour contribuer au système d'innovation national en donnant accès pour les Canadiens à l'information scientifique, technique, et médicale du monde entier et en orchestrant le développement d'une infrastructure nationale d'information qui relierait entre eux l'industrie, l'université, et le

gouvernement. Le monde de l'information électronique en émergence est en train de transformer la communication savante ainsi que le rôle de chercheurs, usagers, éditeurs, et bibliothécaires. Une collaboration accrue entre ceux-ci sera essentielle pour maintenir une infrastructure d'information nationale robuste.

INTRODUCTION

Canada is building an information-based society characterized by an economy guided by a corpus of knowledge (Information Highway Advisory Council, 1996). To facilitate entrepreneurial innovation, the country needs a national information infrastructure to support the competitiveness of research and development (R&D) performers. The timely use of relevant, validated, scientific, technical, and medical (STM) information by these performers helps the development of new and improved products, processes, or services. This infrastructure defines the modern knowledge-based economy.

The present national information infrastructure must adapt to the global nature of the information society, emerging international markets, and new information technologies such as the World Wide Web. This paper will consider STM information, its impact on innovation by R&D performers, and the changing national information infrastructure in Canada.

Innovation is a term broadly conceived to mean the development of new products, services, or processes that can be successfully introduced into the marketplace. Industrial innovation is a turbulent and iterative process with numerous interactions among players leading to the incremental improvements that constitute innovation. Innovation can be introduced anywhere in the R&D technology production spectrum, revisiting points in the spectrum as need arises (National Research Council of Canada, 1994). Both new knowledge and the diffusion of know-how are critical to industrial innovation. These depend on the amount and quality of R&D performed, the effectiveness of diffusion, and the application of new technology.

The National Research Council of Canada (NRC) and other public bodies help create and sustain the environment that nurtures our innovators by associating knowledge with applications and by building links among players. As Canada's foremost R&D agency, NRC aims to be a leader in the development of an innovative, knowledge-based economy through science and technology.

THE CANADIAN INNOVATION SYSTEM

Canada's innovation system has many interacting players (Figure 1). At the centre of the system are individual firms acquiring and applying new knowledge and willing to bear the risks of innovation. Canadian industry is the prime vehicle for transforming innovative ideas, products, and processes into jobs, exports, and economic growth. Knowledge generators and knowledge facilitators fill complementary roles and share the information infrastructure. In quantitative terms, the knowledge generators in Canada's innovation system include: 4,485 industrial firms performing R&D, 35 research-intensive universities with their hundreds of laboratories, more than 140 federal and about 90 provincial research institutions, 14 national centres of excellence (NCEs), research consortia, and numerous teaching hospitals.

18.75P 26P 1 The Canadian Innovation System

The knowledge facilitators comprise: national programs for knowledge transfer, such as NRC's Industrial Research Assistance Program (IRAP) and the Canadian Technology Network (CTN), Industry Canada, the national granting councils, various national and regional science and technology organizations, NRC's Canada Institute for Scientific and Technical Information (CISTI), and the many firms providing both expertise and products such as patents, technology training, and engineering consulting.

The purpose of scholarly communication is to build the foundation for generating new knowledge. Scholarly communication can therefore be viewed as a subsystem of the larger innovation system. Increased co-operation, joint ventures, and sharing of infrastructure among the players in the scholarly communication system will

improve the effectiveness of the national innovation system and deliver enhanced economic benefits.

THE NATIONAL INFORMATION INFRASTRUCTURE

Canada's information infrastructure is shared by university, government, and industrial sectors and encourages exchange and collaboration among academic and government information producers, publishers, commercial information brokers, trade and professional groups (including scholarly and learned societies), researchers, libraries, and information technology developers. This infrastructure consists of the information itself, the dissemination systems and networks for using it, and the people and organizations who create it, add value to it, use it, and make it available. A distinction can be made between codified or published information versus tacit or contextual information, which carries the "spin" that can render codified information especially relevant.

CISTI's role within this complex information infrastructure is to provide Canadians with timely access to worldwide STM information and to lead in developing and adapting the national information infrastructure in response to the needs of STM information users and producers. As a hybrid organization, CISTI fills, on the one hand, a public policy role in developing the information systems linking Canadian industry, academia, and government, and, on the other hand, operates publishing and document delivery services as not-for-profit business lines based on Canadian strengths in electronic connectivity, research, and information resources.

Information creation, organization, dissemination, and archiving are integral to effective scholarly communication. Each contributes to the innovative process in a system of scholarly communication. In the mid-1990s we find ourselves in a transition from paper-based information systems to electronic systems, and this transition will continue for the foreseeable future as the pace of change accelerates towards fully electronic information systems. During this transition to a fully electronic information world, the roles of researchers, users, publishers, and librarians will evolve and continue to change (Montgomery, 1993). The players in

the scholarly communication system (Figure 2) can be considered to fall into the following categories:

- **researchers** or scholars, who are both the authors (knowledge generators) and users,
- **publishers**, who manage the knowledge-validation process, adding editorial value and distributing knowledge, and
- **librarians**, who supply knowledge and filter, organize, and archive information for retrieval on behalf of users.

The scientific article and the journals in which it first appeared have their origins in the seventeenth century. With the refinement of the Gutenberg printing press, publishing gradually evolved into our present-day system. The role of information intermediaries remains significant, owing to the volume of publications and the escalating costs of information, especially in STM publishing (Carrigan, 1995). Intermediaries organize, retrieve, and archive information for scholars. Although works of scholarship produced in and through the electronic media will change to exploit new technologies, information systems in the electronic world will, more than ever, require information intermediaries to add the value of filtering, organizing, and preserving.

15.75P 16.75P 2 Scholarly Communication Roles

The knowledge-validation or peer-review process is widely acknowledged to make a critical contribution to the scholarly process (Bishop, 1984). It is also inherently conservative and may slow the development of knowledge. Peer commentary has been proposed as an alternative (Harnad, 1996) that complements the existing peer-review system. Refereed journals are widely recognized as adding value through validation, readability, and searchability.

Secondary publishing or indexing and library cataloguing and reference services add value by organizing and retrieving information for the user. Preservation is a key role that traditionally has been carried out by libraries to ensure the availability of scholarly resources over time, regardless of format. With the proliferation of

electronic media, preservation of electronic resources will include migration from one platform to another. Information producers, intermediaries, and users will have to collaborate to ensure that today's electronic resources are available tomorrow.

Communication among researchers may take the form of correspondence (fax, post, and e-mail), mediated exchanges (journals and books, conferences), or information technology systems (the World Wide Web, bulletin boards, listservs, discussion lists) (Covi, 1996). Improving information access and distribution can improve scholarly communication. University and government systems for reward and recognition, such as research funding and researcher career promotion, rely on the traditional and formal means for communicating research results. However, informal information exchange, particularly where contextual or tacit information enriches the validated or codified information, leads to equally or more effective innovation and related economic benefits. Organizations such as NRC are beginning to adapt their recognition systems to reward technology transfer and industry collaboration.

MODELS OF SCHOLARLY COMMUNICATION

The following four models (Figure 3) of scholarly communication are proposed, which deliberately emphasize differences to illustrate the impact of electronic information technologies. These differences focus on role changes among players, which may bring related shifts in costs.

23P 35.36P 3 Models of Scholarly Communications

SCHOLAR-SUSTAINED MODEL

In this model, direct scholar-to-scholar communication takes place informally within the research community. This model parallels the "invisible colleges" or social circles of powerful peers that exist within academia (Crane, 1972). These networks of scholars-in-the-know tend toward exclusivity, presenting barriers to access for those outside the relatively closed knowledge system. The scholar-sustained model is driven by the information producer who may not be motivated to add value to

the information. Industry players risk being denied access to useful new knowledge relevant to innovation except through people networks and collaborative research projects. As electronic technologies evolve, scholars take on the functions and attendant costs for information organization, retrieval, and preservation -- that is now handled by librarians -- and validation and dissemination, now the purview of publishers.

NETWORK-DRIVEN MODEL

This is a disintermediation model and a variation on the scholar-sustained model. In such a system, there are no libraries, no publishers, no intermediaries. Instead, information passes from the researcher straight into information systems or networks. The particular challenges of disintermediation are the need for common formats and standards for access, presentation, organization, retrieval, and preservation. Users risk being overwhelmed by the volume of information in an unfiltered system. Storage of the information may be sporadic and non-standard, and therefore not reliable as a foundation on which to build further knowledge. Industrial innovators are forced to develop these skills themselves or pay others to retrieve information from vast and unorganized sources such as the World Wide Web.

INTERMEDIARY-DRIVEN MODEL

Secondary publishers, abstracters, indexers, and, for the Web, producers who assemble resources and navigate to other relevant sites are the lead players in the intermediary-driven model. There are no primary publishers except institutional and government self-publishers. Researchers make information available to others who gather, organize, and store it. Researchers, or their funding sponsors, must assume responsibility for submitting the information. In this model, the validation and peer-review functions of primary publishers are lost or replaced by "pointers" or citation bibliometrics. Again, the need for common formats and standards present a major challenge. At the other end of the system, users have to sort through all the possible locations for relevant material. Needless to say, the market for electronic

finding tools builds. In combination with the scholar-sustained model, insider groups thrive.

USER-PULL MODEL

In this model, clients initiate the knowledge-exchange process with an information request and seek the support of information intermediaries who search for the information in secondary and primary sources. Once located, information is delivered to the client, either fully or partially filtered for quality, possibly with customized packaging, and according to personalized interest profiles. This is a service model carrying implications for costs to cover the role of the information intermediary and risks related to the availability of information professionals and the market viability for customized information products.

CISTI'S ROLE

CISTI's role is to provide Canadian access to worldwide STM information and to lead nationally in developing the information infrastructure underpinning a knowledge-based economy. Since its founding in 1924, CISTI has evolved from its early role as the library of NRC, to a National Science Library (1957), to its present focus on collaborating with Canadian research institutions to serve researchers and Canadian-based industry in seeking national economic advantage. The Canadian research community remains both an important client group and a key partner for CISTI. CISTI is Canada's largest scientific publisher and also operates a world-class document delivery service. These principal business lines are supported by academic, industrial, and government clients in Canada and internationally.

The document delivery service provides copies and loans of documents from CISTI's collection, typically about 2,500 copies daily, increasingly via electronic ordering and delivery means. Through government allocation, the people of Canada own the most extensive and complete STM collection of journals, technical reports, conference proceedings, and books on the North American continent. This is a critical national resource, whose exploitation depends on an effective and innovative information infrastructure within CISTI, based on the core competence of

skilled information specialists, networks, computers, and applications. Through recent collaborative agreements with consortia of Canadian university and government research libraries, CISTI offers guaranteed affordable access to STM information, while sharing risks in information technology development.

NRC Research Press publishes 14 refereed scientific journals and a number of books and scholarly conference proceedings with the invaluable aid of many of Canada's and the world's scientists as editors and reviewers. Since 1929, when NRC began publishing the *Canadian Journal of Research*, close collaboration between government and academic researchers has been the foundation of this successful publishing endeavor.

Within NRC, CISTI contributes information-management expertise and systems. Examples include developing the NRC Intranet; hosting and advising on external Web sites for research programs and institutes; developing standards for the electronic information network at the core of the people-oriented Canadian Technology Network for small and medium-sized enterprises (SMEs); and co-ordinating a corporate expertise database to facilitate internal collaboration. Along with NRC's IRAP, whose role is to foster innovation, technology awareness, and technology foresight in SMEs, CISTI constitutes a key element of NRC's outreach activity and distributed innovation service to Canadian industry.

INFORMATION TRENDS

The information environment is changing rapidly and profoundly. The past decade has seen the proliferation of new information technologies, a multitude of information channels, and the use of multimedia formats. Increasingly, firms and governments depend on information in order to make effective and timely decisions. Consequently, information providers must contend with a competitive, dynamic, and challenging world.

A number of specific trends affect CISTI's future:

- Clients expect direct information access, leading to new roles for information intermediaries, producers, and users.
- To help advance innovation, clients need business, interdisciplinary, and time-limited information, in addition to traditional STM sources.
- The media for information capture, transfer, and analysis are currently unstable and rapidly evolving.
- Escalating costs of information force information gatekeepers in business, government, and academia to seek new solutions for acquiring just-in-time STM information.

As the library and information service provider for 2,000 NRC researchers across Canada, CISTI is developing and applying virtual library technologies to provide desktop electronic information access and delivery. Using internal clients as a testbed for developing new processes and products, CISTI is integrating its diverse services and giving researchers choices that take account of different technological, disciplinary, and social imperatives specific to research communities and their communication systems.

Cost containment is another priority as a response to client concern about managing rapid change in the information world in a fiscally constrained public R&D sector. CISTI's local presence within NRC research labs across Canada, coupled with national and international STM links, positions it to meet the needs of Canadian communities and to contribute effectively to the Canadian innovation system. This contribution can be made directly to STM information users and producers or through partners such as university libraries, scientific societies, trade associations, the information industry, and individual scholars and their sponsors.

Automated systems and networks underpin all CISTI products and services. As a result, CISTI and NRC plan to invest in technologies to support a virtual national science library that is integrated with electronic publishing technologies. This project recognizes the ubiquity of computers and network access at the desktop, the emergence and presence of the Internet as the conduit for access to worldwide information, and the rapid progress in the development of tools for authoring,

publishing, storing, and disseminating information. CISTI's Strategic Plan to 2001 (CISTI, 1996) calls for the Institute to contribute to technological competitiveness and innovation in information products and processes for Canadian R&D performers. Specifically, CISTI aims to apply electronic publishing technologies to improve the speed of information dissemination, to reduce the time required to deliver information directly to researchers' desktops, and to offer researchers more powerful information management and analysis tools, based on the Internet.

CONCLUSIONS

Canada's success as a modern knowledge-based economy depends on a strong national information infrastructure that is responsive to the needs of the country's innovation system. Innovation in firms is key to competitiveness and national economic benefits. The innovation system, and, within it, scholarly communication, are enhanced by Canadian researchers having access to worldwide STM information sources via a flexible information infrastructure. CISTI plays a lead role in adapting and evolving the national information infrastructure. In the future, increased collaboration among government, university, information industry, and research organizations in Canada will be critical to maintaining a robust and sustainable national information infrastructure.

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