

Canada's Digital Environment for Research, Innovation and Education

A submission under the Digital Economy Strategy Consultation

by

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Preface

The foundation for a prosperous, sustainable and growing digital economy is a broad base of highly qualified people who leverage an integrated digital environment to engage in activities including basic and exploratory research, development and commercialization activities, and ongoing collaboration across the innovation system. A critical mass of these highly qualified people are the stakeholders served by the authors of this document: the Canadian Digital Media Network (CDMN), the Canadian Research Knowledge Network (CRKN), the Canadian University Council of CIOs (CUCCIO), CANARIE Inc. and Compute Canada¹.

These national organizations are responsible for the development and management of components of Canada's *digital infrastructure for Research, Innovation and Education (RIE)*, and for *leveraging digital media to capture and capitalize on commercial opportunities*.

Given the respective roles of these organizations in supporting RIE in Canada, **it is our clear responsibility to provide the Government with a broad view of the digital infrastructure issues facing the RIE community and an innovative framework for addressing them.**

We are responding to Questions 3 and 4 of the Digital Economy Strategy consultation document, specifically the section entitled, "Capacity to Innovate Using Digital Technologies". The authors contend that a robust **integrated digital environment** will support a strong digital economy and position Canada as a nation successfully leveraging its digital advantage.

¹ See Appendix A for a brief description of these organizations.

Executive Summary

A successful digital economy hinges on success in Research, Innovation and Education (RIE) which is in turn increasingly reliant on a robust digital environment, a fact recognized in jurisdictions around the world where they are empowering their RIE community through digital technologies to create a competitive economic advantage.

The elements of the digital environment to support RIE have been evolving and include: the preservation and management of huge repositories of data and rich digital content; ever-larger compute capacity; digital devices and distributed sensors; low-latency, high-bandwidth networks; middleware that integrates the infrastructure and supports its use; and the expertise required to manage and operate them.

While some of these elements are offered under the authors' mandates, many are not, or are **offered in a fragmented or one-off manner creating gaps**. Additionally, there are increasing interdependencies between the elements of this digital environment requiring strong integration and alignment but **the existence of these gaps is compounded by a lack of roadmap or vision** to which the organizations may align.

The existence of these gaps and absence of a vision have severe consequences, including sub-optimal leverage of funding dollars, stalled or prevented discoveries resulting in lost or delayed opportunities for commercialization, and a "hollowing out" of Canada's highly qualified personnel (HQP).

Canada has developed a strong digital foundation but the five organizations participating in this joint submission believe strongly that Canada must move beyond ad-hoc development of the separate elements of the emerging digital environment for RIE and take a systemic view. **Canada needs a strategy for an integrated digital environment, together with a vision of how the various elements, and the organizations that provide them, must align.** We further assert that **the framework presented has the potential to spur broad downstream positive effects across private and public sector domains within the innovation system. This strategy would include:**

- Development of a *vision, management and operational strategy*;
- Adoption of an *integrated approach to planning and funding*;
- Creation of new *coordination mechanisms*;
- Creation of new approaches for *managing sustainability*;
- A mechanism to ensure *global coordination* of activity; and
- *Elimination* of institutional, regional and disciplinary *disparities*.

Benefits of evolving towards an integrated digital environment include:

- **Enhanced capacity for innovation** for a multitude of domains including the priorities identified in the S&T strategy;
- **Strengthened leverage of Canadian talent**, mining a rich vein of entrepreneurship and creativity;
- **Increased support for content creators and innovators** from the humanities, social sciences and cultural and creative industries; and
- **Maximized leverage of the intellectual capital** of Canada's HQPs and return on investment for programs and policies designed to attract and retain them.²

The organizations participating in this joint submission are working with each other, and are ready to work with the government of Canada and others to develop and implement this strategy.

² Including Canada Excellence Research Chairs, Canada Research Chairs, and the programs that provide Canadian credentials to foreign-educated professionals immigrating to Canada.

1. Introduction

This submission focuses on the need for an integrated strategy relating to the digital environment required to support the highly qualified personnel that underpin Canada's innovation system: the Research, Innovation and Education (RIE) communities. While the authors of this document provide components of digital infrastructure, the integration of these elements within a comprehensive vision and operating and management strategy is required to realize maximum benefit from Canadian intellect, talent and creativity. Countries such as The Netherlands, the United Kingdom and Australia are prominent among those that have accorded digital environments for RIE a high priority. These and other countries have identified the competitive economic advantage created when the RIE community is fully enabled through an integrated digital environment.

While each of the organizations submitting this joint proposal manages a component of the current digital infrastructure, the gaps that exist in the system have far-reaching and negative consequences. These gaps create a significant opportunity cost for the highly qualified personnel in the RIE communities, as resources are stretched to fill the void and discovery and innovation are stalled or prevented altogether. Another risk is the potential "hollowing out" of Canadian talent, as they migrate to jurisdictions with more robust digital environments. In addition, our current ability to manage and preserve a wide range of digital content is extremely limited; we risk losing opportunities for leveraging this rich and uniquely Canadian content in innovative ways. Lastly, the lack of an overarching vision to coordinate and integrate the organizations responsible for elements of the current infrastructure leads to potential duplication of effort (and sub-optimal use of funding) at one end of the spectrum, and a complete lack of necessary digital support at the other.

The elements of Canada's digital infrastructure for RIE have been evolving for several years, enabled by increasingly powerful computing and networking technology. Canada's investments in these areas are part of a world-wide response to the growing reliance on ever-increasing volumes of *shared research data*. A parallel shift towards greater reliance on *collaborative models* is a response to the flood of data and the collective need to manage it in a cost-effective way. The combination of highly skilled personnel, collaborative models, and appropriate supporting infrastructure were identified as key elements supporting Canada's innovation system in the Science Technology, and Innovation Council's 2008 State of the Nation Report³.

Traditionally, a digital infrastructure is thought of in terms of hardware and software which has evolved to include such elements as: the preservation and management of huge repositories of data and rich digital content; computers and servers; a wide range of network-accessible research equipment, digital devices and distributed sensors; low-latency, high-bandwidth networks; and the middleware and related tools and services that integrate the infrastructure and support its use. More recently, the definition has expanded to include the technical staff that develops the hardware and software and supports its

³ **State of the Nation 2008**, by the Science Technology and Innovation Council may be found at http://www.stic-csti.ca/eic/site/stic-csti.nsf/eng/h_00011.html

use, as well as the analytical and modeling skills needed by researchers, students and private sector innovators to effectively leverage the digital tools.

In short, the digital “infrastructure” is an integrated and comprehensive digital *environment* that supports research, innovation and education.

This next two sections of this document provide examples of Canada’s and the world’s digital infrastructure for RIE, indicating the ways in which that infrastructure is evolving, and outline the main requirements for a successful Canadian digital strategy in this area.

2. Trends in Digital Infrastructure

Canada has been making extensive investments in the country’s digital infrastructure for RIE for several years. With funding provided by the federal and provincial governments, the granting councils, the Canada Foundation for Innovation (CFI), Genome Canada, the post secondary institutions as well as the private sector, and with great vision and effort on the part of individual researchers and research communities, **the *foundation for a globally competitive digital infrastructure for RIE in Canada has been laid successfully, but trends in technology and in RIE demand an evolution of this environment.***

Elements of the country’s emerging digital infrastructure can be found in virtually every field, from humanities computing to particle physics. Examples that illustrate the breadth of these investments in Canada include:

- Since the creation of CFI in 1997, approximately \$250 million has been invested in the development of High Performance Computing (HPC) facilities by Compute Canada and its seven university-based consortia members. The integrated resources represent close to a *petaflop* (a million billion operations per second) of computing capability and are available to academic researchers across the country.
- CFI, NSERC and others have made significant investments in the creation of the world-leading Neptune and Venus cabled observatories off the coast of British Columbia. These projects exemplify a new generation of data collection capability based on distributed sensors, high bandwidth networks and sophisticated data storage and retrieval capability.
- Genome Canada has supported the development of a *Bioinformatics Platform* that provides infrastructure and tools for Genome Canada-funded projects and academic and industrial researchers across Canada. This platform offers over 1,000 software tools, major databanks and computing power dedicated to bioinformatics, including a Bioinformatics GRID solution, which allows users transparent access to a multitude of bioinformatics tools.⁴

⁴ More information on digital infrastructure for RIE may be found in Appendix B.

These and other elements of Canada's digital environment for RIE are part of an evolving *global* environment for RIE. CANARIE, Canada's national fibre optic backbone network, for example, is interconnected with peer networks in virtually every country, providing a seamless and powerful capability supporting collaboration and global data sharing.

Significant though these past infrastructure investments have been, **there are several trends that indicate that future investments in digital infrastructure for RIE must take on additional dimensions.**

Among the more significant trends are:

- The development of new data resources supporting social sciences and humanities collaboration within and beyond these domains, based in part on population data, census data and other longitudinal studies.
- The development of more extensive sensor-based networks, collecting environmental and other data relating to sensitive ecological areas, the state of critical infrastructure such as bridges and buildings, emergency preparedness and environmental threats such as tsunamis and earthquakes, to name a few.
- The emergence of rich digital media networks, sharing not just numbers but extensive textual resources, repositories of three-dimensional depictions of cultural artifacts, libraries of medical images, high definition audio and video materials, and other data⁵. These new data sources provide an opportunity to fully leverage Canada's cultural and creative talent pool to create new economic opportunities.
- The development of new architectures and tools to support data sharing and collaboration, often called "middleware", and the emergence of a new layer of "services" built on the combination of underlying infrastructure and the new middleware.
- The paradigm shifts occurring across research, education and innovation communities; successful research is increasingly reliant on a collaborative, multi-disciplinary approach based on the ability to effectively access, manipulate and analyze vast amounts of research data, wherever it may be; "digital natives" expect that social networking, multimedia publishing, videoconferencing and shared authoring tools will be part of their learning environment and increasingly they are demanding a tailored approach to their learning based on personal learning profiles and learning styles; and entrepreneurs and innovators are identifying and leveraging talent wherever they find it, using digital tools to create powerful teams that reinvent processes and create new products and markets.

⁵The Canadian Association of Research Libraries' submission to the Digital Economy Strategy calls for retrospective digitization of Canadian research content, and highlights the importance of an appropriate digital environment to support research data management. The Association of Universities and Colleges of Canada's submission calls for investment in collaborative centres of research excellence.

- The expansion of the intended user community for digital infrastructure beyond the traditional core of the research, innovation and education communities to include support for new public services and innovation across the economy. This includes public access to research data, as is currently being done with data from the Neptune underwater ocean observatory.

Clearly, the digital environment needed to respond to these trends will be much more comprehensive and integrated than what has been built over recent years. It is important to recognize that, while elements of the digital environment relating to RIE will be developed and planned by the provinces and provincial level organizations, pan-Canadian coordination will be required, given the interdependence of research and education at the post-secondary level. As research and innovation become more global, a coordinated national effort is required if Canada is to participate in global activities. Increasingly, the various elements of this environment are being built using common standards, supporting ease of use, widespread access and interoperability. Canada must continue to be part of this global effort.

For these reasons, it is critical that Canada move beyond ad-hoc development of the separate elements of the emerging digital environment for RIE and take a systemic view. Canada needs a strategy for an integrated digital environment, together with a vision of how the various elements, and the organizations that provide them, must align.

3. Requirements for a Successful Digital Strategy

Major portions of the emerging digital environment will be common across applications and domains. Accordingly, they can be thought of as *systemic* in nature, independent of specific research projects and even of discipline-specific initiatives⁶. The underlying network is the most obvious example, but such elements as the server platforms, pieces of the middleware, compute capability, analytical tools, collaboration tools, elements of the security system and the overall data and server architecture can be viewed as generic in this sense. **The breadth of these systemic elements leads naturally to the view that the digital environment for RIE is evolving towards a single, integrated *global* environment.**

As such, a successful integrated digital strategy must include the following:

- **A comprehensive vision, together with an operational and management strategy** to enable alignment and efficiency among the organizations responsible for the various components;
- **An integrated approach to planning and funding** is required given the integrated and systemic nature of the digital environment;
- **Creation of and support for new coordination mechanisms** that cut across current organizational, discipline and jurisdictional boundaries;

⁶Other elements of the digital infrastructure will be tailored to the needs of specific domains, for example highly specialized tools to permit remote operation of equipment such as the Canadian Light Source or modeling capabilities that are unique to genomics, astronomy or physics.

- **New approaches for managing sustainability** to ensure the continued evolution and support of the digital environment for future generations of researchers and other users;
- **A vision for the preservation and management of digital content** created across a range of scientific, cultural, educational, creative and technical domains;
- **A plan to address institutional, regional and disciplinary disparities**, especially relating to access, as maximum benefit is realized with the widest base of users; and
- **A strategy to ensure and support development of the analytical, modeling and collaborative skills** needed to use such shared resources effectively⁷.

4. Conclusion

The creation of a strategy to ensure the availability of an integrated digital environment supporting research, innovation and education, and in turn the entire innovation system, is fundamental to Canada's success in building a strong digital economy.

This document has described a strategy for the evolution of a digital environment for research, innovation and education in Canada. It recognizes that the success of such a strategy require all participants to create and actively participate in new approaches to coordination, sustainability and funding, as well as new efforts to promote access and skills development. The organizations participating in this joint submission recognize the need to work with each other, with the Government of Canada, and with other institutions and organizations across the country in order to develop and implement such a strategy, and join with all Canadians in reaping the benefits of a strong and growing innovation system.

⁷ More broadly, this focus on the skills of truly highly qualified personnel (HQP) constitutes one extreme on the spectrum of skills development challenges facing Canada as it develops its digital economy.

Appendix A: About the Submitters

About Canadian Research Knowledge Network (CRKN)

The Canadian Research Knowledge Network (CRKN) is a partnership of Canadian universities, dedicated to expanding digital content for the academic research enterprise in Canada. Through the coordinated leadership of librarians, researchers, and administrators, CRKN undertakes large-scale content acquisition and licensing initiatives in order to build knowledge infrastructure and research capacity in Canada's universities.

CRKN is a not-for-profit organization supported by its members - 75 universities as of June 2010. Established in 2000 as a pilot project and incorporated in 2004, CRKN's programs have been accelerated through major grants from the Canada Foundation for Innovation (CFI) and matching funds from provincial governments. The voting members of CRKN are the library directors at its member institutions, who work through CRKN to secure the broadest access to the world's knowledge for the benefit of the communities they serve – over 850,000 university researchers and students, as well as staff and the public.

For additional information, please visit: www.researchknowledge.ca

About CANARIE Inc.

CANARIE Inc. is Canada's Advanced Research and Innovation Network. Established in 1993, CANARIE manages an ultra high-speed network, hundreds of times faster than the internet, which facilitates leading-edge research and big science across Canada and around the world. More than 40,000 researchers at over 300 Canadian universities and colleges use the CANARIE Network, as well as researchers at institutes, hospitals, and government laboratories throughout the country. The CANARIE Network enables researchers to share and analyze massive amounts of data, which can lead to ground-breaking scientific discoveries. CANARIE's network, programs, and strategic partnerships with 12 regional networks in Canada, and 100 international networks in more than 80 countries, stimulate research that **delivers economic, social, and cultural benefits to Canadians.**

CANARIE is a non-profit corporation supported by membership fees, with major funding of its programs and activities provided by the Government of Canada. For additional information, please visit:

www.canarie.ca.

About Compute Canada

Compute Canada is leading the creation of a powerful national HPC platform for research. This national platform integrates High Performance Computing (HPC) resources at seven partner consortia across the country to create a dynamic computational resource. Compute Canada integrates high-performance computers, data resources and tools, and academic research facilities around the country. These integrated resources represent close to a petaflop of computing capability and online and long term storage with rapid access and retrieval over Canada's national, provincial and territorial high-performance networks.

Working in collaboration, Compute Canada and the university-based regional HPC consortia provide for overall architecture and planning, software integration, operations and management, and coordination of user support for the national HPC platform. As a national organization, Compute Canada coordinates and promotes the use of HPC in Canadian research and works to ensure that Canadian researchers have the computational facilities and expert services necessary to advance scientific knowledge and innovation. For additional information, please visit www.computecanada.org.

About the Canadian Digital Media Network (CDMN)

The CDMN, created in early 2009 through support from both high-tech companies and government, is focused on making deliberate investment in digital media innovation. Access to critical resources and strong partnerships between the business and research communities are a major focus for the CDMN. That has driven creation of The Communitech Hub: Digital Media and Mobile Accelerator in Waterloo Region and The University of Waterloo Stratford Campus, which will be digital centres linking to other such facilities across the country.

The Stratford Campus is a think-tank and forward-looking research centre that will drive the next generation of digital media technologies, applications and content models and ensure that there is a ready workforce in Canada to support innovation. The Communitech Hub is a digital media accelerator center providing a setting for start-up and established companies to collaborate and invest in innovation, with the equipment and tools needed for digital innovation.

CDMN now boasts a coast-to-coast collaboration corridor comprising leading Canadian commercialization digital media centres which join the founding Stratford Campus and Communitech Hub as nodes in the CDMN network. These now include: Wavefront in B.C.; Okanagan Research and

Innovation Centre (ORIC) in B.C.; Niagara Interactive Media Generator (nGen) in Ontario; and the NRC Institute for Information Technology (NRC-IIT) in New Brunswick. Other facilities with digital media expertise across Canada will be coming on board as the CDMN connects Canada's best and brightest researchers, implementers, and entrepreneurs to maximize the Digital Media opportunity.

About the Canadian University Council of CIOs (CUCCIO-CDPIUC)

CUCCIO-CDPIUC is the *Canadian University Council of CIOs - Conseil des dirigeants principaux de l'information des universités canadiennes*. Established in 2006, CUCCIO-CDPIUC serves as the national voice for IT-related issues in Canadian universities, provides a forum for its members to share ideas, best practices and new technologies and supports collaborative initiatives for and amongst its member universities. Examples include the development of a pan-Canadian access management federation supporting secure access to protected resources and services in higher education and beyond, the development of a common set of data for measuring and benchmarking IT in higher education and the availability of a secure, on-line repository and collaboration environment for its members.

Appendix B: Digital infrastructure in support of Research, Innovation and Education

- Since 1993 the federal Government, through Industry Canada, has supported the development of five generations of the country's national backbone network through CANARIE Inc. The provincial governments and universities have developed the regional linkages to connect individual campuses to the CANARIE backbone. The current generation of those networks has a transmission capacity of up to fifty billion bits per second and higher, which is comparable to the leading research and education (R&E) networks in the world;
- The astronomical community has developed a new data sharing capability (CANFAR) to advance Canada's strong position in astronomical research by enabling the effective delivery, processing, storage, analysis and distribution of very large datasets. This allows astronomers to effectively process the massive amounts of data generated by highly sophisticated and complex observatories;
- These and other elements of Canada's digital infrastructure for RIE are part of an evolving *global* infrastructure for RIE. CANARIE's national computer network, for example, is interconnected with peer networks in virtually every country, providing a seamless and powerful capability supporting collaboration and the sharing of data around the world. Other examples of the collaborative development of digital infrastructure are discipline specific, and not surprisingly some have been built around pre-existing collaborations relating to the construction of traditional shared infrastructure. For example, high energy physicists have developed a global network, built on CANARIE and its peer networks in other countries, to share data from the Large Hadron Collider at CERN in Switzerland. They have designed the server and data architectures to effectively and efficiently support the work of physicists around the world. The astronomical community and others are also developing the means of sharing access to data and analytic tools using innovative digital infrastructures. Neurologists and other brain researchers are using digital infrastructures to share brain imaging and mapping data that promotes discoveries in cognitive neuroscience, human brain development, and brain function deterioration associated with aging and Alzheimer's and Parkinson's Disease. Researchers are also studying how to reduce the greenhouse gas impact of information and communications technologies (ICT). These and other research initiatives demonstrate the depth and breadth of world-class Canadian research reliant on robust digital infrastructure.