CANARIE, Broadband, CA*net 4 and Intelligent-Infrastructure

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Andrew K. Bjerring
President and CEO
Outline

• Background and CANARIE
• Broadband
• CA*net 4, Lightpaths and UCLP
• Grids and Intelligent Infrastructure
Background and CANARIE
The Ultimate Driver...

Moore's Law: The Cost of Computing Power, Memory and Bandwidth Continues to Decrease...

“When the network is as fast as the computer’s internal links, the machine disintegrates across the net into a set of special purpose appliances” -George Gilder
The Evolution of the Internet

First wave
- Application: Transfer of text and data
- Network: An add-on to the computer
- Organizations: Real and local

Second wave
- Application: Widespread access to images, sound and video.
- Network: A partner with the computer
- Organizations: Increasing “virtual” elements

Third wave
- Application: Linking services; real time transactions
- Network: Integrated into an “intelligent infrastructure”
- Organizations: Emphasis shifting to “communities of interest”
The Canadian Policy Response

- NRC funded original CA*net in 1990
- Discussions led by Industry Canada during 1990-93 led to CANARIE’s formation in 1993
- Broader Connecting Canadians strategy 1994-2004
- Information Highway Advisory Council (IC/CH) 1994-97
- Advisory Council on Health Infostructure (HC) 1997-99
- E-Business Opportunities Roundtable (IC) 1999-2002
- Advisory Committee for Online Learning (IC/CMEC) 2001
- National Broadband Task Force (IC) 2001
- Innovation Strategy (IC/HRDC) 2002-04
- Canadian E-business Initiative (CeBI) 2002-2004
- *Telecom Policy Review 2005*
- *Anticipated ICT Sector Strategy 2005*
## CANARIE’s Program Role

<table>
<thead>
<tr>
<th>Phase</th>
<th>Time Period</th>
<th>Funding</th>
<th>Projects Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>1993-1995</td>
<td>$26 m</td>
<td>Stand-alone Technology Development projects</td>
</tr>
<tr>
<td>Phase 2</td>
<td>1995-1999</td>
<td>$80 m</td>
<td>Technology and Applications Development projects</td>
</tr>
<tr>
<td>Phase 3</td>
<td>1999-2004</td>
<td>$78 m</td>
<td>Strategic sectoral development through collaboration and addressing structural barriers</td>
</tr>
</tbody>
</table>

*Support for CA*net 1 and CA*net II were integrated in Phases 1 and 2. CA*net 3 ($55 m in 1998) and CA*net 4 ($110 m in 2002) were funded independently of and overlapped with Phase 3.*
### Phase 3 Programs (1999-2004)

<table>
<thead>
<tr>
<th>Program:</th>
<th>E-learning*</th>
<th>E-business*</th>
<th>E-health*</th>
<th>E-content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Funding</td>
<td>$29 Million</td>
<td>$26 Million</td>
<td>$4.3 Million</td>
<td>$4.4 Million</td>
</tr>
<tr>
<td>Number of Projects</td>
<td>32</td>
<td>28</td>
<td>23</td>
<td>22</td>
</tr>
<tr>
<td>Number of Participating Organizations</td>
<td>265</td>
<td>48</td>
<td>47</td>
<td>58</td>
</tr>
</tbody>
</table>

*Industry Canada funded*
Preparing for Phase 4

2002: Submission under the innovation initiative: “Networks For Innovation: A National Strategy for Canada”

2003: Building on CANARIE’s traditional application sectors (R/I/E), generation of strategic proposal: “CANARIE’s Next-Generation Internet Initiative: Towards a Digital Canada”

2004: Three inter-related planning documents prepared for Industry Canada:
   - CANARIE Retrospective 1993-2004 (Hickling Arthurs Low)
   - International Context (Conference Board of Canada)
   - CANARIE Strategy and Business Plan 2005-2010

2005: Preparing for ICT Sector Strategy
Status

• Industry Canada took only the CA*net 4 extension portion of CANARIE’s Business Plan to federal cabinet
  ➢ Was approved in principle for 2007-10
  ➢ No funding provided in Spring 2005 budget (not needed)
  ➢ No action yet taken on extension of mandate to 2010 (unclear how to do it without funding approval)

• The second half of the Business Plan focused on “E-Solutions”
  ➢ Possible new proposal to Cabinet in the context of the ICT Sector Strategy
Broadband
CA*net 4, Lightpaths and UCLP
## CA*net Generations

<table>
<thead>
<tr>
<th>Years</th>
<th>Core Technology</th>
<th>Initial Capacity (Mb/sec)</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA*net</td>
<td>1990-1997</td>
<td>Leased Lines</td>
<td>Basic email and file transfer</td>
</tr>
<tr>
<td>CA*net 2</td>
<td>1995-2000</td>
<td>ATM</td>
<td>Web applications plus large file sharing</td>
</tr>
<tr>
<td>CA*net 3</td>
<td>1998-2002</td>
<td>Optical</td>
<td>Full audiovisual sharing plus collaborative computing and data environments</td>
</tr>
<tr>
<td>CA*net 4</td>
<td>2002-7</td>
<td>Lightpaths</td>
<td>Grids and other third-wave applications</td>
</tr>
</tbody>
</table>
The CA*net 4 Concept

- CA*net 4 is a hybrid network
  - layer 3 based on (fewer) Juniper routers
  - layer 1 based on Nortel optical switches
- Currently three 10 Gbps lambdas
- Layer 1 capability enables end-to-end lightpaths
- Supports high bandwidth, low latency, dedicated links
- Customer control over lightpaths (UCLP) is the next step
# CA*net 4 Lambdas and Lightpath Applications

<table>
<thead>
<tr>
<th>Use Examples</th>
<th>Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide Range of Research and Education Uses (largely invisible)</td>
<td>Production Routed IP Network</td>
</tr>
<tr>
<td>HPC Grids or ORAN Diverse Routes</td>
<td>Permanent Lightpaths</td>
</tr>
<tr>
<td>Short Duration Research and Education Applications</td>
<td>Temporary Lightpaths</td>
</tr>
<tr>
<td>Federal Labs, Major Applications and International Commitments</td>
<td>Permanent or Temporary Lightpaths</td>
</tr>
</tbody>
</table>

Global Lambda Integrated Facility
Projected December 2004

Predicted international Research & Education Network bandwidth, to be made available for scheduled application and middleware research experiments by December 2004.
Utilization trends

Gbps


Network Capacity Limit

Jan 2005

CANARIE

Networks > Collaboration > Results > Réseaux > Collaboration > Résultats
Basic Lightpath Stats

- **Historical**
  - number of distinct projects: 19
  - number with Canadian client: 9/19 projects
  - number of short term: 15/19 projects

- **Current**
  - number of distinct projects: 15
  - number with Canadian client: 11/15 projects
  - number of short term: 2/15 projects

- **Anticipated**
  - number of distinct projects: 13
  - number with Canadian client: 11/13 projects
  - number of short term: 2/13
Status

- Software to distribute control over optical switches to allow users to create and manage end-to-end lightpaths from the edge
- Uses web services architecture (SOA)
- Three designs funded earlier under a “directed research” program
- Diffusion of UCLP v1 is underway (Open source)
  - Deployed across CA*net 4, KREOnet, I2Cat
  - Used by ORANO, Netera, BCnet, HEAnet, RISQ
  - Being tested by Internet2, SURFnet, AARnet, Nortel, Cisco, Meriton and others
- Call for proposals to develop UCLP v2 issued
Conclusion

CA*net 4 has been successfully launched [and is] supporting world class research and enabling Canada to maintain a lead in advanced networks that will in time be the standard commercially, impacting the country’s competitiveness. ...
Interim Evaluation

Key Recommendations

• Broaden CANARIE’s mandate
• Place increased emphasis on promotion of CA*net 4
• Accelerate the commercialization of UCLP
• Put CA*net 4 on a more permanent financial footing
New CA*net 4 Programs

**ORAN Support and Outreach:**
- $15 million
- to support lightpath capability
- to ensure universities, colleges and remote campuses can access CA*net 4
- to undertake promotion and awareness activities ($1 m)
**STATUS:** Proposals requested from and being discussed with ORANs

**CANARIE Connections Program:**
- $10 million
- to assist federal labs and private sector to connect sites and facilities to CA*net 4
- Expecting submissions from NRCan, Environment, DFO, Agriculture Canada, Stats Canada and others
**STATUS:** Call for proposals issued and discussions being held

**Intelligent Infrastructure:**
- $15 million
- to extend web services to instruments, sensors and controllers and other next-generation applications
**STATUS:** Call for proposals issued; 23 proposals; selection committee has short list
Grids and Intelligent Infrastructure
Intelligent Infrastructure:
The U.S. “Cyberinfrastructure” Initiative

Peter Freeman, Director, CISE, National Science Foundation

“We are in the midst of a revolution in the Kuhnian sense*; cyberinfrastructure is the future of science and engineering.”

“The goal of cyberinfrastructure is to provide an integrated, high-end system of computing, data facilities, connectivity, software, services, and instruments that enables all scientists, engineers and educators to work in new ways on advanced research problems that would not otherwise be solvable.”

*“[Science is] a series of peaceful interludes punctuated by intellectually violent revolutions . . . [in which] . . . one conceptual world view is replaced by another.” Thomas Kuhn, The Structure of Scientific Revolutions
UK e-Science Program

‘[The Grid] intends to make access to computing power, scientific data repositories and experimental facilities as easy as the Web makes access to information.’

Prime Minister Tony Blair, 2002

‘e-Science is about global collaboration in key areas of science, and the next generation of infrastructure that will enable it.’

John Taylor
Director General of Research Councils
Office of Science and Technology
Grids

Grids have some or all of the following properties…

- Large number of distributed sensors or instruments
- Distributed clusters of computers
- Large data sets
- Data archived in distributed repositories
- Large, distributed communities of end users
- Opportunities for collaborative analysis
- Complex simulations
- Immersive visualization

....and, of course, high speed networks
Some Examples ...

- Data storage grids
- Sensor grids
- Control grids
- Computing grids
- Visualization Grids
- Screen saver grids
- Grid Canada
- PlanetLab
- Grids for Kids
- Etc.
TRIUMF, CERN and ATLAS Grid

- TRIUMF has been selected as a Tier 1 site for CERN LHC ATLAS grid
  - One of only ten Tier 1 sites in the world
  - Requires 10 Gbps connection to CERN by Q1-2006 and 5 Gbps connection to backup Tier 1 site (ie Brookhaven)
  - Will also require dedicated 2 Gbe lightpaths to Canada’s Tier 2 sites at U of Toronto and U of Victoria

- TRIUMF tentatively agreed to contribute to costs of 10 Gbps circuit to CERN
  - Circuit may also be used to support a routed network for HEPnet (Canada’s High Energy Physics network)
Canadian Telescopes in Hawaii

- NRC is major participant in two telescopes in Hawaii
  - CFHT – Canada France Hawaii Telescope
  - Gemini – Hawaii and Chile
- NRC Hertzberg will be main repository for telescope data
  - Initial data volumes in 2005 will be over 7 Terabytes per month
  - Increasing to 100 Terabytes per month by 2006
- Collaborative project involving NRC, CANARIE, the Australian research network AARnet, National Lambda Rail in U.S. to swap lightpaths in order to make all the connections from the telescopes to Canada
National Virtual Observatory

- Discovery process will rely on advanced visualization and data mining tools
- Not tied to a single “bricks and mortar” location
- Will cross correlate existing multi-spectral databases petabytes in size
- http://www.us-vo.org/

No new telescopes or radio dishes. Just big networks interconnecting large databases
Neptune Grid

- Joint US-Canadian project to build large undersea fiber network off west coast of US and Canada
- Undersea network will connect instrumentation devices, robotic submarines, sensors, under sea cameras, etc
- Distributed computing and data storage devices on CA*net 4 and Internet 2 will be used to analyze and store data
Computing Grids

- HPCVL – network links provided by ORION
- SHARCnet – network links provided by ORION
- Westgrid – network links provided by CA*net 4
- ACEnet – network links to be provided by both CA*net 4 and provincial ORANs
- ETF (Extensible TeraGrid Facility) – 4 lambdas linking SDSC, Argonne, Pittsburgh
- DEISA – European network linking 17 HPC sites
Proposed expansion; Fully funded 4/3/2004

All sites: Parallel vis. + AccessGrid
Western Canada Research Grid

Project Description
WestGrid is a $48 million project to purchase and install innovative grid-enabled computing infrastructure across BC and Alberta.

Resources
Computing Resources (for parallel and serial computing):
- 1008 processor IBM (Xeon) blade cluster
- 266 processor SGI Origin 2000
- 144 processor HP AlphaServer-SC45

Also Access To:
- 160 processor HP Alpha cluster
- 192 processor AMD Athlon cluster
- 236 processor Origin 2000/2400/3400

Network Storage
- IBM Network storage facility with over 24 Terabytes of disk space and 135 Terabytes of tape size capacity

Visualization
- State-of-the-art SGI visualization server
- Access Grid collaboration capability at all partner organizations

Advanced Networks
- All resources linked by world-class research networks provided by BCNet, Nteria and CANARIE

Project Leaders
Jonathan Borwein
Simon Fraser University

Grenfell Patey
University of British Columbia

Jonathan Schaeffer
University of Alberta

Brian Unger
University of Calgary

Michel Vetter
Simon Fraser University / TRIUMF

Funding Agencies
- Canada Foundation for Innovation
- Alberta Science and Research Authority
- BC Knowledge Development Fund

Vendor Partners
- Hewlett-Packard
- IBM
- Silicon Graphics
- TRIMF
- TRIUMF

Partner Organizations
- UBC
- SFU
- U of A
- U of C
- U of L
- The Banff Centre
Purpose of i-Infrastructure

- To use common service oriented architecture to improve ability to access and control instruments, experimental facilities, databases, computers and sensors

- To allow remote access to distributed or difficult to reach instruments and facilities (e.g. remote telescopes)

- To facilitate international S&T collaboration relating to shared scientific instruments

- To reduce duplication by enabling consolidation and shared use of scientific instruments and facilities (e.g. NRC’s Nuclear Magnetic Resonance Farm in Ottawa)
How it works

• Web has been about accessing images, text, video and data

• Next generation “web services” makes instruments, databases, and sensors an integral part of the web

• Service oriented architectures based on web services and web services workflow (e.g. including UCLP) allow scientists to integrate data from sensors across networks linked to computers, software and databases to accomplish research objectives
• Web service workflow tools allow users to bind processes together (http://xml.coverpages.org/wsfl.html)

• Workflow links constituent services together in a hierarchical fashion to build larger composite services

• Workflow tools, in essence, "program the grid"

• Overlaps with areas such as "distributed system programming" and "virtual data management"
SOA Approach

CANARIE UCLP

New Web service

New development

WS**

WS*

WS**

WS*

WS**

WS*

WS**

WS*

Log Archive Process 2

Log Archive Process 1

LAN

ONSI5454

Lightpath

WS Process

WS HPC Process

CA*net 4

DATA MANAGEMENT SYSTEM

Instrument Pod

UDDI or WSIL service registry
Also AAA and security

USER with WSFL binding software

User defined WSFL bindings
Thank you! Are there any questions?