

HIGH PERFORMANCE COMPUTING IN CANADA: THE EARLY CHAPTERS

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This article was intended to be a history of high performance computing (HPC) in Canada, and the current environment. However, some major and exciting events took place during its preparation, prompting us to add a somewhat nostalgic flavour to this history and to focus on the most recent aspects of that history. These events are the fulfillment of the main mission of an organization known as C3.ca, and its formal conclusion to allow for the emergence of a new organization, Compute/Calcul Canada, with a new and ambitious mandate. The formal end of C3.ca was recommended by its Board of Directors in October, 2007, and subsequently approved by the organization's membership on November 16, 2007. For the purposes of this article, we think of this as the opening of Chapter 3 in the Canadian HPC story. As we celebrate this new chapter, we should also celebrate those chapters which came before, and reflect on the elements that have made this story so successful.

THE EARLY YEARS

The start of Canadian HPC is probably the purchase and installation of "Ferut" at the University of Toronto as a joint initiative of the University of Toronto and the National Research Council in 1952. This, of course, was back in the days when you could just say computing, since all computing was "high performance". Ferut was a Ferranti Mark I purchased for about \$300,000. There is probably more computing power in the toys in a MacDonald's Happy Meal today than available from Ferut, but it was very impressive at the time. In fact, it was powerful enough that it was used to draw the international boundary between Canada and the USA along the

SUMMARY

The HPC story in Canada provides an excellent example of what a coordinated, cooperative national initiative can achieve. We present here a summary of this story, with an intentionally nostalgic flavour appropriate to the closing of one successful chapter in this story, as a new one begins. Without providing all of the details, we try to present the keys to the success of this initiative, some idea of parallel paths followed in different areas of the country, and a table of the current HPC academic consortia.

St. Lawrence Seaway, as the US had no non-military computing suitable to the task.

Chapter 1 of our story runs from the time of the purchase of Ferut to the emergence of a nationally coordinated HPC strategy, and the national organization C3.ca, over 40 years later. The very early years were interesting, but the modern period really begins during the 1980's and it is on this period that we wish to focus. Canada's HPC efforts were sporadic during this chapter. For example a Cyber 205 supercomputer was installed in Calgary in 1985, but it was gone by 1991. A Cray XMP-4 was installed at the Ontario Centre for Large Scale Computing at the University of Toronto in 1988, but the machine and the Centre lasted only until about 1992. Finally, a Fujitsu VPX240 was installed in Calgary with a largely commercial mandate, but also made available to university researchers. It disappeared in 1996. [This is the favorite machine of one of the authors, ABM, as much of the work on his Master's thesis was done on it.]

All three of these machines were, without doubt, world class, but their stories highlight the problems with HPC in Canada in the past. They were single generation facilities, with at best minor upgrades to the hardware before they disappeared; they had no national mandate to support and develop HPC throughout the country; and they never had an opportunity to develop and maintain a staff to support the Canadian user community. With one outstanding exception, these three things were lacking in all HPC initiatives in Canada during this time period.

The exception was the computing resource maintained by the Meteorological Service of Canada, subsequently known as Environment Canada (EC). In 1962, that organization acquired the first of its facilities, which have been used ever since to run weather predictions. That first machine was a Bendix G20, with less computing power than a modern cell phone. Environment Canada has maintained a first rate facility and staff since then, with regular updates. Their most recent hardware is a supercomputer provided by IBM, which was installed in 2003 and updated in 2005. This continual updating and long term maintenance of a qualified support staff differentiates this facility from the other initiatives in Canada throughout the 40-year period of Chapter 1 of our story. However, Environment Canada did not have, nor has it ever had, a mandate to support general research requiring HPC resources across Canada.



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A DECADE OF ACHIEVEMENT

Before 1997

As is often the case, the transition from one chapter to another can be continuous. We choose to begin this one with the emergence of a national project, largely lead by Brian Unger of the University of Calgary. It started with the submission of an NSERC Major Facilities Access grant application called HPCnet. This application had 49 signatories from 11 Canadian universities, spanning the country from Victoria, BC to St. John's, NL. It was intended to support access to existing HPC resources, to develop new tools for using and accessing the facilities, and to foster collaborations. HPCnet was awarded 3 years of funding at the level of \$175,000 per year, beginning in 1996. Illustrative of the challenges facing the community, the Fujitsu VPX240 at Calgary was shutting down just as this award was made.

A number of critical steps followed this award. A group of academic researchers came together to administer the grant, and to award funding for support personnel and software development projects. The personnel team was the fore-runner of the national Technical Analyst Support Program (TASP) team that now spans the country. The project brought visibility and cohesion, and a sense of success. A broad community joined together, with members from the university, government and private sectors. It was supported administratively by the organization WURCnet based in Alberta, and the National Research Council (NRC).

The national community also set forth on an important visioning and planning mission, culminating in the creation of a new organization, C3.ca, and the publication of "A Business Case for the Establishment of an Advanced Computational Infrastructure for Canada", both in 1997. This was almost exactly 10 years ago.

The lack of existing resources was certainly a short-term impediment. However, the community was determined to share what it had. As an example, one of a number of initiatives was the provision of an AlphaServer 4100, by Digital Equipment Corporation (now HP Canada), located at Memorial University of Newfoundland (MUN). Digital and MUN made a commitment to make this facility available nationally. Thus, the community began to demonstrate that it could successfully share resources across the country.

The 1997 Business Case presented a plan for a national HPC infrastructure of hardware, software and personnel, joined by the high-speed national network CANARIE, "...applied to national needs and opportunities for research and innovation in the sciences, engineering, and the arts." It presented a notional 7-year budget of approximately \$225 Million, covering all aspects. Some of the research community thought this was wildly optimistic,

but turned out to be delightfully wrong.

As we reflect on the elements of the success of C3.ca, it is inspiring to recall that those 1997 plans included three phases:

1. Engaging the Community, 1997 - 98
2. Building Regional Infrastructure, 1999 - 2002
3. Collaboration for Competitiveness, 2003 - 05

With small adjustments for timing, the HPC community has evolved very much in line with those phases. Another of the intriguing aspects of this initiative was the people involved. It was driven and run by researchers, but supported by professionals and organizations, in particular the NRC and WURCnet.

1997 and Beyond

The year 1997 was an extraordinary one. In the early days of HPCnet and the early work towards the Business Case, there were no apparent sources of funding of the magnitude contemplated in those plans. However, in that same year, the Government of Canada created the Canada Foundation for Innovation. Suddenly, there was a real opportunity for significant funding. In one year, the community had the Business Case, an unprecedented funding opportunity, national cooperation, and momentum.

The year 1998 was, perhaps, even more extraordinary. It culminated in the submission of an application for renewal of the NSERC MFA grant, submission of a separate MFA proposal from universities in Quebec, and 11 parallel CFI applications, all under the umbrella of C3.ca and with a commitment to sharing resources.

A critical step in this process was this commitment to sharing. Participants and leaders from many of the CFI projects met at York University during the proposal phase, and formally agreed to provide access to external users to any facility that was funded via CFI, at the level of 20%. Specific wording was agreed to that would be included as a commitment in all CFI projects. The larger (non-Quebec) MFA proposal listed all 11 CFI projects with a short description of each. An important feature of the two MFA proposals was that each one referenced and complemented, but did not compete with, the other one.

In the end, 1998 and 1999 were years of great success. Both MFA grants were funded. The larger one was funded at \$300,000 for the first year, and \$600,000 for each of the successive years. Similarly, the other one was funded at \$100,000 for the first year, and \$200,000 for each of the next two. In June of 1999, five of the CFI projects were funded, with total CFI funding of \$16.4 M, and "project costs" totaling over \$40 M. But better things were still yet to come!

Birth of the Consortia

In 1993, CANARIE had been formed to create a leading-edge national network for Canadian researchers and, in 1997, the Canadian Foundation for Innovation (CFI) was announced. These were the initial conditions needed for the true emergence of the Canadian HPC community on to the modern world HPC scene. If CANARIE's research network was the information super-highway, then the HPC centres were to be the cities at the ends where much of the information was to be manufactured and from which it would be distributed.

Many of the early CFI proposals were multi-institutional, with various internal organizational structures. These were all the fore-runners of the current HPC "consortia". Across Canada there came to be seven regional consortia; ACEnet in the Atlantic, RQCHP in Eastern Quebec, CLUMÉQ in Western Quebec, HPCVL in Eastern Ontario, SCINET in the greater Toronto area, SHARCNET in Western Ontario, and WESTGRID in the western provinces. Between 1999 and 2004 these consortia were awarded no fewer than 12 major CFI awards totaling over \$100 M (project costs in excess of \$250 M). Each consortium award was the result of local need, desire and initiative, but each of these awards owed part of its success to the efforts of C3.ca and the members' lobbying of, and consultation with, the CFI. One of the strengths of C3.ca in these early days was that, while the success of the consortia was in part the result of the efforts of C3.ca, the organization itself was not tied to the success or even the existence of any consortia. This left C3.ca free to carry out its primary mission of promoting the need to fund HPC research in Canada.

The authors of this article were each involved in the creation of one of the seven consortia. While the ends were similar, the paths differed. ACEnet had its genesis as a very loose organization which submitted a Memorial-centered CFI proposal in the first CFI competition, under the informal name of Atlantic Computing Consortium, or AC3, with an obvious parallel to the name C3. Members of AC3 across Atlantic Canada worked cooperatively for a number of years, submitting CFI proposals that were quasi-independent of each other, but that referenced and supported other members of AC3 and their systems. This arrangement fitted the four-province, two-island geography of the times. However, in 2003, the community was ready to make the leap, and submitted an integrated CFI proposal, and ACEnet was born. Of course, the funding situation remains complex, with matching funding coming from numerous provincial and related organizations. In contrast, SHARCNET was largely born as a regional project and was driven to be so by the provincial funding organizations within Ontario at that time. While the Compaq-Western Centre for Computational Research might be considered its UWO-centric forerunner, SHARCNET truly began as a consortium much as it currently exists, although it has grown from seven institutions initially to its current seventeen members.

To give some perspective on what the creation of the consortia means to researchers, we'll consider what SHARCNET has meant to a HPC researcher at the University of Western Ontario. In 1998 the entire University was largely served by an 8 processor Cray SVI. Certainly a very good machine at the time and it was running at full load constantly. Today, SHARCNET provides over 8000 processors available from 15 different machines, with massive amounts of memory and disk storage. Better still, the Cray SVI was supported by a single dedicated, technical support person, while today SHARCNET employs over 18 technical support personnel. And this is only at SHARCNET; like all members of all consortia, UWO scientists can access any system, and consult any of the personnel, at any of the other consortia as well.

The technical support staff within SHARCNET are another legacy of C3.ca, as the first of these were hired in part with funds from the NSERC MFA grants. More importantly many of the SHARCNET personnel are part of a national support group known as the TECC. The creation of TECC, (Technical Experts in Compute/Calcul Canada), is a further example of the legacy of C3.ca which, interestingly, was created before Compute/Calcul Canada existed. TECC, founded in large part due to the efforts of a group of TASP supported staff at RQCHP, is a group of HPC experts who have agreed to work together to better support the Canadian HPC community and to provide guidance to national and regional groups which require access to personnel with high level technical skills. Members of this group work together, developing standards and exchanging information in order to maintain the hardware and software used by computational researchers across Canada.

The model of coordinated national efforts was the foundation of another project carried out under the auspices of C3.ca, the creation of The Long Range Plan for HPC in Canada (LRP). Published in 2005, the LRP provided a vision of a sustained and internationally competitive infrastructure for computationally-based research in Canada. It was one of the enablers of Chapter 3 in our story.

THE FUTURE

At the writing of this article, the HPC research community finds itself, yet again, at the edge of another exciting journey. In 2007, after extensive consultation with C3.ca, the consortia and universities, CFI created the National Platform Fund to "provide(s) generic research infrastructure, resources, services, and facilities that serve the needs of many research subjects and disciplines, and that require periodic reinvestments because of the nature of the technologies." targeted initially at HPC. The CFI invited a single, national proposal on HPC. The consortia responded, rolling up their sleeves, and creating such a proposal, with a structure that reflects the value and critical role that each

APPENDIX 1	
Important Events in Chapter 2 of the HPC Story	
1995:	Submission of the MFA Grant, HPCnet
1996:	Awarding of the MFA Grant, HPCnet, 3 years @ \$175,000 per year Formation of the organization HPCnet, and start of national planning Closing of the Fujitsu VPX240 at Calgary Donation of AlphaServer 4100 by Digital Equipment Corporation
1997:	Creation of C3.ca Publication of "A Business Case for the Establishment of an Advanced Computational Infrastructure for Canada"(December) of the Canada Foundation for Innovation
1998:	Formal commitment to a policy on external sharing and access Submission of NSERC MFA for renewal, listing all CFI projects Submission of Parallel MFA from Quebec universities Submission of 11 parallel CFI proposals
1999:	Awarding of both MFA grants Funding of 5 CFI projects, at a total of \$16.4 M (project costs of \$41 M) Emergence of the consortium model
2005:	Publication of "A Long Range Plan for HPC in Canada"
2007/08	Award of CFI National Platforms Grant Folding of C3.ca Creation of Compute/Calcul Canada

consortium plays, and a management and governance structure to ensure it is truly a national platform. As a result of this new CFI award, another \$150 M of infrastructure will be installed, new support funds are being awarded as an outgrowth of the earlier MFA awards, a new organization, Compute/Calcul Canada is being formed, and C3.ca, one of Canadian science's true success stories, is passing the torch after a job well done.

EPILOGUE

C3.ca was an organization whose successes were, in some sense, intangible. It was the members who won the CFI and NSERC grants, not the organization. But it was the organization, an organization of the members, which guided those members' cooperation, helped manage the national project and coordinated some of the major pro-

APPENDIX 2	
HPC Consortia in Canada, Current Membership	
WESTGRID:	U. Victoria, UBC, Simon Fraser, UNBC, U of Alberta, U of Calgary, U of Lethbridge, Banff Centre, Athabasca U, U of Saskatchewan, U of Regina, Brandon U, U of Winnipeg, U of Manitoba
SHARCNET:	McMaster U, U of Western Ontario, U of Guelph, U of Windsor, Sir Wilfrid Laurier U, Fanshawe College, Sheridan College, U of Waterloo, Brock U, York U, UOIT, Trent U, Laurentian U, Lakehead U, Perimeter Institute, Ontario College of Art & Design, Nipissing U.
HPCVL:	Queen's U, Royal Military College, Carleton U, U of Ottawa, Ryerson U, Seneca College, Loyalist College
SCINET:	U of Toronto
CLUMEQ:	Laval U, Université du Quebec (UQAM, ETS, INRS, UQAC, UQTR, UQAR, UQAT, UQO), McGill U.
RQCHP:	U de Montréal, Concordia U, U de Sherbrooke, Bishop's, École Polytechnique
ACEnet:	Memorial U, St. Francis Xavier U, U of New Brunswick, Saint Mary's U, UPEI, Dalhousie U, Mount Allison U, Acadia U, Cape Breton U

posals, and provided the advocacy that was critical to the creation and maintenance of the vibrant, and tremendously successful, HPC community in Canada. On that front C3.ca has been an unparalleled success. As we all celebrate the future, we should also celebrate the past, and always remember what the keys to our success have been.

We must also remember the essential role our many partners have played. Major computer vendors made major investments, and have played critical roles. Provincial governments have provided essential matching funds and, in many cases, funds for personnel. And CANARIE has provided the essential connections, without which the national infrastructure simply could not be used effectively and efficiently.