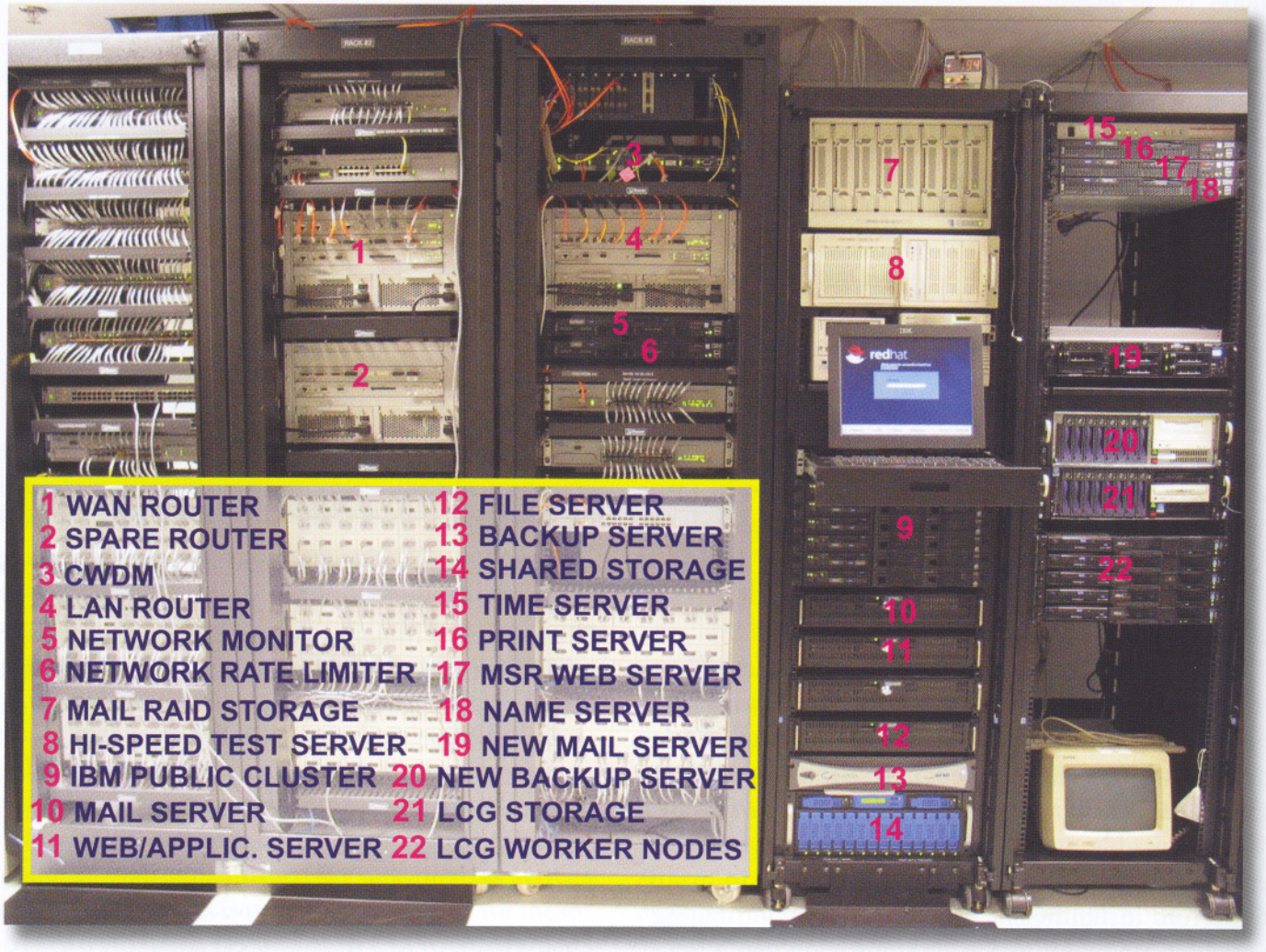
Corrie Kost

Providing the Best in Computing and Networking Environment

Computing support is an essential element of all scientific endeavors. This is especially true for research facilities such as TRIUMF where computers, in addition to their role in collecting and recording data from experiments, are used to assist in the design of equipment and the selection, exchange and analysis of massive amounts of data from experiments carried out at TRIUMF and other laboratories around the world.

TRIUMF's computing support group, although small, has its roots firmly founded in the time when the facility was under construction more than 30 years ago. Back then, computing hardware support was provided by facilities housed at UBC and the main function of the group was to support simulation and analysis of measurements relating to the design and construction of "the world's largest cyclotron". It was some 6 years after TRIUMF became operational that we acquired our first local central computing facility in 1980 – a VAX-780. TRIUMF's international stature required access to a global interconnecting network long before such a facility became commercially available. Hence networks used were largely user-developed ones. By 1984 we were doing remote logins and file transfers on a global scale (albeit at a rate which pales by today's standards). Two years later the global mail facility, GMAIL, was up and running. Linux, now the dominant open-source operating system at most high-energy physics laboratories, was inevitable after



The main components of TRIUMF's central computing facility - notably the time, name, backup, mail, print, web, file, application and compute servers.

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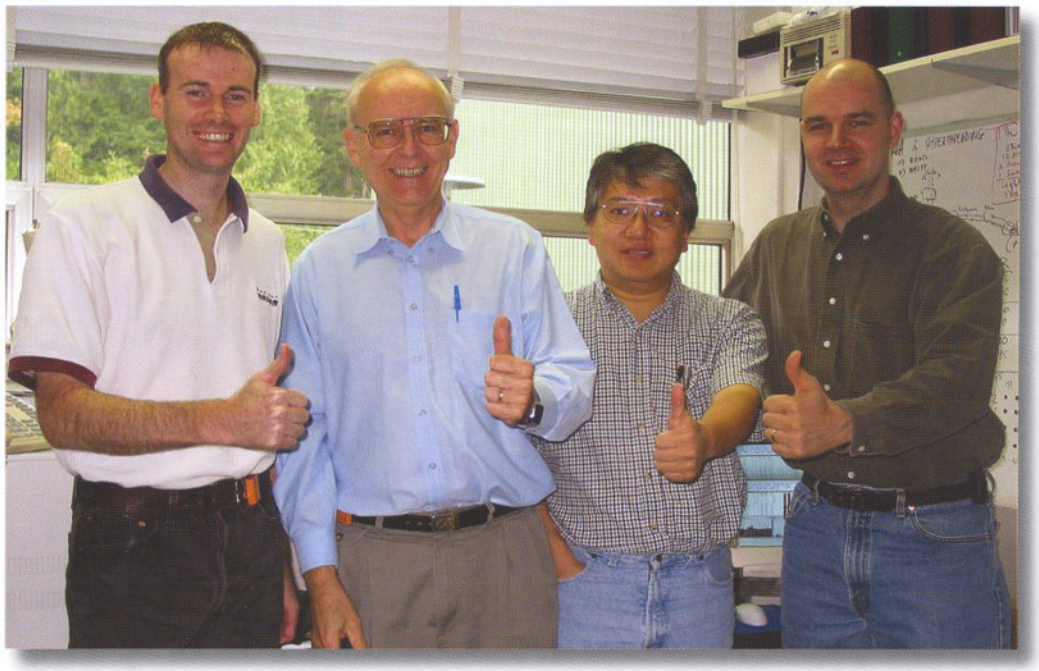
UNIX was declared the preferred operating system back in 1991. This occurred at the inaugural meeting at the Fermi National Accelerator Laboratory in the US of the High Energy Physics Unix Coordination group (HEPiX). Since then TRIUMF has twice hosted this important meeting.

It was the high-energy physics community together with key developments at CERN that spawned what is now the world-wide-web. The web has had a profound impact at TRIUMF and continues to do so, since the web's collaborative, open, sharing nature aligned well with the international scope of the work done at TRIUMF. However, the open nature and extensive connectivity to the world has not been without some drawbacks. Complicating factors such as spam and viruses have led to what can, at best, be termed "challenging and interesting times"!



The TRIUMF team that established the data transfer record. From left to right Steve McDonald from TRIUMF, Corrie Kost from TRIUMF, Wade Hong from Carleton University and Bryan Caron from the University of Alberta/TRIUMF.

Since 1980 computing hardware resources at TRIUMF have more than doubled every 2 years. As well, the diversity of computing support is expanding; on-site wireless internet access for laptops, email access from any browser anywhere in the world, and contributions to world-class software such as GEANT4, ACCSIM and PHYSICA. The latter provides a high level, interactive programming environment for sophisticated mathematical analysis. PHYSICA consists of a fully procedural programming language, with built-in user-friendly graphics and capabilities. Combining an accessible user interface along with comprehensive mathematical and graphical features, PHYSICA provides a general purpose research tool for scientific, engineering and technical applications.

TRIUMF has also made important contributions to GEANT4, a large software toolkit for simulating particle interactions in matter, with applications in high energy physics (such as simulations of the ATLAS detector at the Large Hadron Collider), space science, nuclear medicine, accelerator design, radiation physics, and other fields. The software, developed using object-oriented design and current software engineering methodologies, is the product of an international collaboration formed by individuals from a number of cooperating institutes, mainly high-energy physics experiment teams and universities. It is one of the world's largest academic software collaborative efforts to date. It was built on the accumulated experience in Monte Carlo simulations of many physicists and software developers around the world. TRIUMF was approached to join this collaboration in its early stages, in part because a number of its scientists and engineers were experts in the field and were thus able to contribute immediately. The R&D phase of the project was completed in late 1998 with delivery of the first production release. TRIUMF remains very active in the present collaboration by continuing the development and refinement of the software and providing ongoing maintenance and user support.

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ACCSIM is a product of TRIUMF's computational physics expertise as well as its contacts with CERN and other laboratories where synchrotrons and storage rings are designed, constructed and operated. It was originally created as a simulation of a proposed accumulator ring designed to store large numbers of protons from the TRIUMF cyclotron, but soon thereafter was generalized and applied to other high-intensity proton rings, both existing and proposed, in Europe, the U.S.A., and Japan. The aim of the program is to provide as detailed and comprehensive a simulation as possible, within the limits of reasonable computing time on typical desktop computers. Thus ACCSIM includes not only "tracking" calculations to follow the trajectories of particles in the ring, but also simulations of interactions of the particles in the beam of various types including "space charge" effects caused by electric forces between charged particles, a topic of great concern to designers of the current generation of proton rings. This program is now joined by similar simulation programs developed at other accelerator labs, in what has become a very active sub-field of computational accelerator physics. Because of its scope and relative ease of use, ACCSIM remains extremely popular and is still in continuous development. It is currently in use by accelerator physicists at TRIUMF, CERN, KEK and JAERI (Japan); BNL, LANL and ORNL (U.S.A.); and recently IHEP (China).

Martin Pinard, President of Silicon Graphics Canada presenter of the 2003 CANARIE award for new technology to Corrie Kost who led the TRIUMF team.

On the communications front a major milestone (which set a number of world records) was reached when, as a demonstration held in conjunction with the iGrid2002 conference in Amsterdam, 1 Terabyte of simulated ATLAS experimental data was transferred from TRIUMF to CERN, a span of some 12,000km, using a 2.5Gbps dedicated fibre link, at a rate equivalent to transferring the entire contents of a CD in under 8 seconds or a full length DVD movie in 1 minute. In recognition of this accomplishment CANARIE, Canada's advanced internet organization, conferred the team with the 2003 IWAY award for "New Technology Development". The next phase, planned for summer 2004, will use 10Gbit end-to-end "lightpaths" and attempt to improve the record by a factor of 5 to 10. All this is preparatory to plans to transfer a significant fraction of the many petabytes (million-gigabytes) of data to be generated by the CERN ATLAS experiment beginning in 2007.

A proposal that TRIUMF serve as ATLAS Canada's regional data centre is now under active consideration. If approved, by 2007 TRIUMF would be the home for a large computer cluster, comprised of 1000's of CPUs. One of the main physics goals of the ATLAS collaboration is to discover and study the yet-to-be-found Higgs particle, the key to why fundamental particles have mass. In the figure on page 20 note the presence of the LCG facility – which represents Canada's (albeit currently somewhat token) contribution to the Large Hadron Collider (LHC) Computing Grid (LCG)

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for the ATLAS experiment. This experiment is the largest collaborative effort ever mounted in physics, involving some 2000 physicists from 34 countries including an active Canadian group supported by TRIUMF.

There were two significant computing support events last year. The first was moving TRIUMF's Computing Services from the Chemistry Annex, its home for over 20 years, to the new ISAC-II building over the weekend preceding April 1, 2003. This involved not only moving people but all the network equipment and computers. As well, support had to be provided for hundreds of additional network connections for occupants of this new building. It all went as planned – except for one ironic event. After years of living with the flaky air-conditioner in the old facility, the new building's air-conditioning unit failed the day after we moved in all the computing equipment – due to a single line of bad code in its control system!

The second major event was the inauguration of WestGrid, a $48 million computing complex spread across Alberta and British Columbia, which now allows access by TRIUMF staff to high-performance computing. Grid-Computing, that is, the ability to readily use computers and networks located at multiple sites, will be an essential element of the WestGrid initiative. From TRIUMF's perspective, the most heavily used component has been the blade-based 1008 3.06GHz Xeon CPU cluster installed at UBC. Experience acquired on WestGrid will be an invaluable stepping stone to establishing the ATLAS regional centre at TRIUMF.

Locally, the emphasis recently has been upgrading the site's network infrastructure to a 1Gbit fibre backbone, with 10/100Mbit to the approximate 800 devices sitting on the network. In anticipation of future needs, the new ISAC-II has been wired to allow Gigabit to the desktop when the need arises. As well, legacy, overloaded, unreliable, and obsolete equipment continued to be replaced. In the past, TRIUMF computing services has, every 18 months, typically purchased a new machine consisting of the best hardware available at the time and installed the most recent CERN-supported release of the Linux operating system. This year a new approach was taken by purchasing a small cluster of Linux machines. Now new and more powerful worker nodes can be added and defective and/or obsolete nodes culled with almost complete transparency to the users. By implementing the OpenMosix kernel

Replacing a defective member of a cluster.

on the head node, automatic process migration to the least busy participating worker nodes can occur, thus maintaining an even load across the cluster. Traditional batch support is also provided. This ability to perform as a traditional batch computer cluster as well as an automatic load sharing interactive cluster, is both unique and advantageous. It allows growth as required, with minimal effort and disruption to the users. It also improves reliability by avoiding the expensive and troublesome tear-down and rebuild approach of the past.

The accomplishments of TRIUMF's Computing Services group has, as is evident from the above brief description, played a vital role in TRIUMF's ability to carry out world-class physics and attract international scientists to TRIUMF to carry out their research programs. The group's software contributions are also playing an important role in many laboratories around the world, further enhancing TRIUMF's well-deserved reputation.

Corrie Kost is a Research Scientist at TRIUMF in charge of Computing Services, supporting infrastructure and all aspects of scientific computing.