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Vijay K. Sood, Hydro-Québec

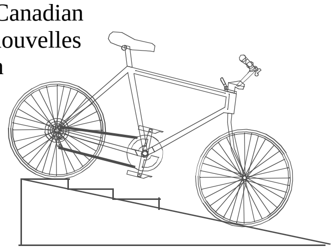
J'espère que vous allez feuilleter ce numéro en relaxant dans votre hamac, tout en buvant un rafraîchissement, et en absorbant les rayons du soleil!

Ce numéro est plus épais qu'à l'habitude et je remercie tout ceux qui y ont contribué. Le thème de ce numéro est directement relié avec la nouvelle économie soit la nouvelle façon de faire des affaires ainsi que le traitement numérique du signal. Le premier article raconte comment une université réussit à amener sa propriété intellectuelle sur le marché. Le deuxième article est à propos d'une petite entreprise dans le domaine de la haute technologie, et des spin-off des université et de l'industrie. Voilà les sujets d'importance pour la nouvelle économie et les futurs créateurs d'emplois. Le troisième article concerne l'équipement le plus récent qui sera utilisé par l'industrie suivant l'explosion de l'Internet. Le quatrième article est aussi à propos d'une petite entreprise dynamique qui utilise la puissance des microprocesseurs pour produire de la marchandise de qualité dans l'industrie de la puissance électrique. Et finalement, un article pour retourner en arrière et regarder le passé - afin de s'assurer qu'on ne l'oublie pas.

Nous avons reçu une lettre intéressante qui fait bien réfléchir sur la fuite des cerveaux aux États-Unis. Ce phénomène est réel et coûte cher au Canada. Les politiciens ont tendance à minimiser le tout, mais nous qui sommes directement impliqués voyons ses effets à tous les jours.

Finalement, nous avons assisté à la remise de prix à la réunion EIC en mars à Ottawa et à la CCECE 2000 en mai à Halifax. Nous incluons des photos des gagnants dans ce numéro. Je félicite tous les gagnant(e)s. J'aimerais aussi m'excuser à Nicolas Georganas et Clifford Smith pour l'erreur de noms dans le numéro CR34. Merci Nicolas de l'avoir remarqué.

Les choses avancent au bureau du Canadian Review et nous attendons de vos nouvelles avec impatience. Veuillez jeter un coup d'oeil à notre site web www.ieee.ca et, bien entendu, profitez bien de votre été!



Cover picture / *Photo de couverture*

The Manitoba Hydro 250 MVA Transformer in Rosser, Manitoba is being used for a "smart" relay transformer asset management application. Using a T-PRO transformer relay (inset) from APT Power Technologies in conjunction with the IEEE C57.91-1995 standard, information such as loss-of-life and related overload conditions are being examined. Instead of just using current as an indication of transformer overload, an ambient temperature probe is used to monitor the outside temperature along with a transformer top-oil temperature probe, to determine the transformer hot-spot temperature.

Taking these temperature variables and combining them with current information one is able to provide unique overload protection such as adaptive overload, automated load shedding and predictive overload early warning. (providing a scale reference is Dr. Glenn Swift, Senior Research Engineer at APT Power Technologies).

Hope that this issue of the CR will catch you at the height of summer; and you will enjoy reading it swinging in your hammock, ... sipping a cold one.

This issue is larger than normal and I thank the people who took time to write. The theme of this issue is very much in line with the New Economy... the new way of doing business and DSPs. The first article is about how a university is taking its intellectual property to market. The second article is about a small business in the hi-tech field, and spin-offs between universities and industries. These are the new dynamics for the new economy and the creators of future jobs. The third article is about the latest equipment that will be used by industry in the Internet related explosion. The fourth article is again from a small dynamic company using the power of micro-processors to produce quality products for use in the power industry. And finally, a book review to go back in history - just so that we do not forget our past.

We have a thought-provoking letter about the Brain Drain of our talent to the US. This phenomenon is real and expensive for Canada. Politicians tend to downplay this, but we on the ground floor see it often.

Finally, we had awards presentations at the EIC meeting in March in Ottawa and at the CCECE 2000 in May in Halifax. There are pictures of the award winners in this issue. My congratulations to all the winners. I also apologize to Nicolas Georganas and Clifford Smith for the mix-up in their names in issue # CR34. Thanks, Nicolas, for pointing it out.

Things are rolling along at the CR office, and we look forward to hearing from you. Please check out our website at www.ieee.ca and, most of all, enjoy the summer!

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Newslog Editor

Rédactrice des Coupures de presse

Isabelle Chabot is a patent agent trainee at Swabey Ogilvy Renault, patent and trademark agents in Montreal.

Isabelle Chabot travaille à Montréal chez Swabey Ogilvy Renault, agents de brevets et de marques de commerce, comme agent de brevets en formation.

Send any news clippings you would like to contribute via e-mail to i.chabot@ieee.ca

Veuillez faire parvenir les coupures de presse proposées par e-mail à i.chabot@ieee.ca

MAR 2 ~ Bell and NeoPoint Inc. of La Jolla, Calif. have introduced the new "smart phone". Accessing the Internet, sending and receiving emails, paying bills, checking bank accounts, and trading stocks are just a few features of this new product. It also has voice-command functions automated with a simple verbal prompt.

MAR 2 ~ Neteka Inc. of Toronto has developed new software that will allow usage of web addresses in different languages, such as Russian and Chinese. The new technology, owned by the University of Toronto as well as a group of recent graduates from the University of Toronto and the University of Calgary, will help the growth of the Internet in Asia and Europe and allow it to be more efficient internationally.

MAR 14 ~ Nortel Networks entame une poursuite contre un compétiteur dans le domaine de la fibre optique. Optical Networks est accusé d'avoir violé des brevets en technologie de transmission de données, de pratiques commerciales injustes et de concurrence déloyale.

MAR 23 ~ Kaval Telecom Inc. of Markham, Ont. has designed equipment that allows wireless signals to go through steel and concrete. Linknet, Kaval's new product, allows carriers to combine several kinds of signals in a single system, and several carriers to use the same system. Clearnet Communications Inc., MCI WorldCom Inc.'s SkyTel and Bell Mobility Inc. are all carriers who have hired Kaval to extend the reach of their wireless signals.

MAR 24 ~ Excite Canada and @Home Canada are planning a merger to form a new entity called Excite@Canada. It will be a new kind of World Wide Web portal designed for consumers who connect to the Internet via high-speed modems.

MAR 24 ~ Netgraphe Inc. of Quebec, a leader in the Internet portal industry, has bought APG Solutions & Technologies, a 14-year-old national systems integrator. The deal was closed for $120 million in cash and shares. Netgraphe also assumed APG's debt of $10 million.

MAR 31 ~ IBM Canada Ltd. is working with Intria Items Inc. and Symcor Services both of Toronto to develop, within the next year, electronic images of checks to be available through the Internet. They are also working towards making more information available electronically to bank customers.

APR 3 ~ The Canadian Network for Research, Industry, and Education (CANARIE) honored Dr. Charles Laszlo at a gala dinner by presenting him with an award recognizing his and ALDS Inc.'s contribution to making communication technologies accessible to people with hearing loss.

APR 6 ~ Conventus Intuitive Networks Inc. of Kanata, Ontario has developed a new product, Travel Assistant, that allows travelers to access their corporate networks and email while on the road. They also offer hotel high-speed Internet access. This could become a must-have for the frequent business traveler.

APR 8 ~ The Canadian government will invest $33.9 million in Research In Motion Ltd. This investment will help RIM develop its next generation of wireless devices. Despite its overnight success, RIM continues to thrive as its share value continues to rise on the TSE.

APR 13 ~ Pcsupport.com Inc., of Burnaby, BC is developing new software that allows a technician to take remote control of a user's computer through the Internet to solve problems and fix bugs. The company is currently worth approximately $72 million.

MAY 4 ~ Symantec Corp, a breveté sa nouvelle technologie qui accélère le processus d'inspection de fichiers sur PC, sur serveurs ainsi que celle de fichiers envoyés sur le Web. Cette technologie réduit la quantité de données requises pour une inspection anti-virus et augmente la vitesse d'inspection.

MAY 19 ~ UForce et Netergy Networks ont fusionné leurs efforts pour accélérer la croissance d'Uforce. Uforce aura désormais accès à des ressources financières supplémentaire et à l'équipe de développeurs de Netergy

JUN 1 ~ AT&T Canada acquired a leader in electronic business by joining forces with Toronto-based DMC. DMC will serve as an independent and strategic entity for AT&T Canada's Internet services and electronic business.

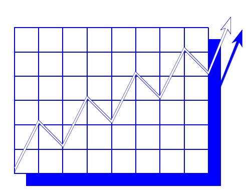
JUN 2 ~ Xros was bought by Nortel Networks. Nortel's latest acquisition fits perfectly into its plan to become the pioneer of entirely optical Internet services.

JUN 7 ~ Un nouveau modem passif DIVA ADSL USB a été lancé par Eicon Technologies. Ce produit permet une connexion simple plein débit et comprend un dispositif de sécurité spécial: le programme de sécurité Internet ZoneAlarm de Zone Labs. Ce dernier protège les ordinateurs branchés sur Internet contre les attaques externes.

JUN 8 ~ The Bank of Nova Scotia and TIM Dealer Services Inc. are teaming up to link the Internet and the automobile world. They will provide auto dealerships with an Internet-based credit application and approval system. Entrust Technologies will be responsible for the encryption of all the information processed over the Inter-net. The system will be integrated directly into the dealer's existing computer system.

JUN 13 ~ Plus de Canadiens profiteront des services sans fil de Bell Mobilité. Une entente visant à utiliser le réseau de représentants indépendants d'Excel Canada vient d'être signé entre Bell Mobilité et Excel Télécommunications. Excel Canada pourra vendre les services sans fil de Bell Mobilité en utilisant son réseau national de 23,000 représentants indépendants.

Special thanks to Alexandra Daoud and Sébastien Marcoux for their help with this item.



Technology Commercialization - The Choices Facing Researchers

by *Don Morberg and Geoff Moon*
University Technologies International Inc, Calgary, AB

Abstract

Technology commercialization, the development of commercial products from research discoveries, is coming of age as an industry in North America. A number of avenues are available to the researcher who chooses to commercialize; and a number of informed business decisions must be made, on the part of the researcher and on the part of the commercializing organization even before the technology is offered commercially. Calgary-based University Technologies International Inc. has a unique approach to commercialization., heavily based on consultation with inventors and versatility of choices.

Sommaire

L'industrie de la commercialisation de la technologie, c'est-à-dire du développement de produits commerciaux à partir de découvertes scientifiques, approche la maturité en Amérique du Nord. Plusieurs choix sont offerts aux chercheurs qui décident de commercialiser, et un grand nombre de décisions d'affaire doivent être prises, autant du côté du chercheur que du côté de l'organisation en charge de la commercialisation et ce, bien avant que la technologie soit disponible commercialement. University Technologies International Inc. de Calgary propose une approche unique vers la commercialisation, basée en grande partie sur des consultations avec les inventeurs et une polyvalence des options considérées.

1.0 Introduction

Technology Transfer, as it is known to university-based researchers, is the movement of research knowledge to and from research facilities. As an example, this might involve an exchange, loan or sale of biological materials to assist a researcher in following a particular line of investigation. In other cases it might involve the purchase or licensing of the research discovery by a commercial end user. An engineering company, for example, might license the discovery of a new electrical component or controlling software to augment, develop or improve its business and give it a competitive edge in the market place. A significant industry has grown up in North America around the commercial aspects of technology transfer. To differentiate the commercial aspects from the non-commercial exchange of research materials and information, the former is referred to with growing acceptance as technology commercialization.

In most North American universities, the primary source of research discoveries, there is a particular office or department which handles both the commercial and non-commercial transfer of technology. Known as Technology Transfer Offices, Industry Liaison Offices or Research Services Offices, these departments may offer any or all of the spectrum of technology commercialization services - assessment, intellectual property protection, development, negotiation, sale, licensing, company creation or other commercialization options. Many also handle the non-commercial aspects such as product development contracts and materials transfer agreements. Operating under the institution's intellectual property policy, they can advise the inventor of the procedure, rights, responsibilities and rewards involved. Policies vary from institution to institution.

Through these offices, or through outside agencies approved by the intellectual property policy, a number of channels are open to a university inventor/researcher with a discovery to commercialize. Independent inventors, those not attached to a post-secondary institution, may prefer to go the commercialization route on their own, paying all costs and negotiating their own licenses or agreements. Others will engage a professional technology commercialization company to handle the process for a share of the revenue or a percentage of the resulting start-up company. Each route has its advantages and challenges and much will depend on the mindset of the inventor and his or her inclination toward involvement in the commercialization process.

Experience has shown that not all researcher/inventors have the interest in the process. Commercialization is a different world from the research laboratory and not all have a bent for it or even an interest in it. But involved in the process or not, the inventor is well advised to seek the advice of professionals in order to protect his discovery, and to obtain the maximum financial return. Commercialization professionals assist entrepreneurs through the tough business decisions to ensure successful commercialization which results in the maximum benefit of new products and services.

Whether or not the inventor seeks that assistance, the commercialization route available, the process and the stages involved are similar.

Technology transfer is the movement of scientific knowledge from one party to another. Technology commercialization is when that transfer involves the making or selling of a product with the aim of providing a financial return to the inventor. Often these terms are used interchangeably. In North America, technology commercialization is a $50 billion business, according to the Association of University Technology Managers which annually publishes figures on the direct and indirect financial impact of commercialization. This is the value that industry and government paid to support research and paid in license fees for the products of that research. The industry employs 280,000 people. In the United States, commercialization of government-sponsored research is mandated under the Bayh-Dole Act of 1980. Similar regulation has been hotly debated in Canada. Sponsored research in N. America totals about $34 billion; two-thirds of it from government sources. Canada accounts for about four per cent of each of these totals. That four per cent, translated into dollars, means technology commercialization in Canada has a direct economic impact of $20 million annually in licensing revenue and the creation of about 60 high technology companies a year.

2.0 Stakeholders

Most electronic and electrical engineers have experience with or have observed the technology commercialization process. How a researcher or inventor enters the process of commercialization depends largely on where he or she is working. Much of the research that is undertaken by engineers in post-secondary institutions and research labs tends to have a higher percentage of industry sponsorship, occasionally with a pre-determined path to commercialization or to ownership of the research results.

An inventor with a private company will be governed by that company's intellectual and research policies. Most retain all rights to their employees' inventions and compensate the employees in various other ways. In most cases the employee is under an obligation to reveal to their employer anything that they believe is a new invention. During the time of the discovery the researcher should keep detailed records of its development consistent with the scientific method. In some cases, private companies or research labs have their commercialization done by a third party like UTI.

3.0 The Technology Commercialization Process

There are a number of important stages to the technology commercialization process.

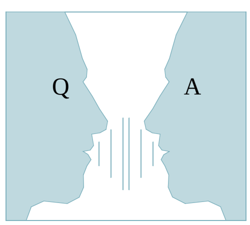
3.1 Disclosure and Assignment

The first step is for the technology commercialization company to gain an understanding of the technology. In order to do this the inventor must be willing to disclose the technology in a confidential written document. The technology or product has to be clearly described in terms of its function, stage of development, and advantages comparable to other similar products. The researcher should describe under what circumstances the invention was made, who else might have knowledge of the invention, and a listing of any publications or reports that may contain information related to the invention. A written description of the invention and supporting drawings is needed, perhaps with a description of alternative methods, materials, or construction which could accomplish the same result. The researcher must describe possible uses and applications for the invention and, possibly what companies would be interested in commercializing such an invention. Should a working prototype be available it could be examined. It is important that the researcher be very thorough in preparing this disclosure. An Assignment Agreement may be signed empowering the technology commercialization company to act as an agent for the inventor and make business deals on his or her behalf.

3.2 Technology Assessment

Following this disclosure and assignment, the next stage consists of a technical, business, and legal assessment. Using proprietary tools and years of experience, technology commercialization managers and their teams assess a technology's scientific and technical value, marketability and commercial potential, and intellectual protectability. Each year in North America, TC managers review about 12,000 disclosures. Only some are commercially viable and even fewer are protectable. Under patent legislation, something new but obvious is not protectable. Something new and not useful is not protectable. Something new that cannot be built is not protectable either. About 2,700 patents are issued annually to university researchers in North America; and when it comes to signing on the bottom line, about 3,700 legal licensing agreements or options are entered into annually.

To get to that stage, questions to be asked include:



- Is the discovery novel?
- Does it have merit?
- Does it have value?
- Is there a need for it?
- Could there be a desire for it?
- Is the technology patentable?
- Does a market exist?
- Could a market be created?
- Are there any barriers to commercialization?
- What is the strength of potential patents?

These questions and many more are addressed in the initial assessment of the technology. Questions about the inventor are also asked:

- Is the inventor enthusiastic about commercialization and willing to be part of the process?
- Does the inventor understand business principles?
- Are there more great ideas where this one came from?

Every day the professional commercialization manager sees brilliant ideas and inventions which he or she knows will never earn the first dollar. They have missed the market window; they're too far ahead of the market, they would be too expensive for the market to bear, they are no improvement on what already exists, they can't be protected, no one will pay for it. This is where due diligence enters the commercialization picture. Due diligence supplies the technical and market data managers require to make the necessary business decisions. Market data includes such business information as costs, competition, edge and potential. The manager will already have a good idea of intellectual property protection: patent, copyright, industrial design trademark or trade secret. There may also be existing third party interest - is there a company or financial backer who is interested in this product? The lower a technology is on the assessment scale, the riskier it is to commercialize and the considerations weighing on the decision are considerable. This expertise and experience can be of enormous benefit to the inventor.

3.3 Intellectual Property Protection

Evolving from the assessment is an intellectual property protection strategy. An item can be commercialized without Intellectual Property protection, but the window of opportunity is smaller and the risk of someone copying the technology is higher. In certain cases, it lessens the value of the technology on the market; protected technology is worth more. An idea is protected by a patent, an expression of an idea by copyright, and a mark identifying an idea by trademark.

Protection doesn't come cheap. An average Canadian patent costs $12,000. An international patent can cost $50,000. Will the technology return that cost? Are the patent claims valid? If the claims are challenged; the patent costs can skyrocket. It takes business acumen to make the right decisions on the correct and appropriate level of Intellectual Property protection. A patent attorney or agent can get a patent for you, but there has to be business decisions made on the correct level of protection. Spending $50,000 on a product with a potential market of $5,000 is obviously no way to succeed financially; but it is done with startling regularity. According to industry statistics, only two patents in one hundred makes back their patenting costs.

3.4 Commercialization Strategy

The initial assessment and due diligence will generally point to a commercialization strategy. A commercialization plan will be chosen which will best meet the unique needs of the invention. The usual commercialization routes are sale, license, joint venture/partnership or company creation. The appropriate approach to commercialization depends upon factors such as competition, the marketplace, funding, and the nature of the technology.

If the Intellectual Property protection is not strong or the window of opportunity is short, selling the know-how may be the best option. Licensing which will be discussed in more detail later is the most common method and can be for a one-time payment as in software or an ongoing revenue stream. Joint venturing means finding a business partner who will take the technology into that company's business activity or develop a new activity in partnership with the inventor. Creation of a start-up company is probably the most exciting and dramatic, but does however offer significant financial, and organizational challenges.

3.5 Licensing

Licensing is often an appropriate commercialization strategy. Established companies often have the development, manufacturing, and marketing resources necessary for commercialization success. These companies can often be identified through searching databases. Selecting the best licensee from a group of interested candidates is a critical first step. Criteria include their proven ability to market and sell as well as manufacture the product. Confidentiality agreements must be signed before any information is provided to a potential licensee. Once a suitable licensee has been identified, a license contract is negotiated and signed by all parties involved. Basic elements of a license agreement include: the identity of the parties, the subject of the license, and the obligations of the licensor and licensee. Terms and conditions vary depending upon the particular licensing situation. The process does not end here however as the licensee must be monitored to ensure that all parties are fulfilling their responsibilities as outlined in the contract.

3.6 Company Creation

If certain circumstances and conditions exist, the technology manager may suggest the research discovery be commercialized through the formation of a company. This risky and rewarding route should only be taken if there are check marks beside a great number of boxes including:

- Is the technology actually a platform of technologies?
- Is the technology capable of supporting a company or a business division of a company?
- Is the researcher committed to becoming involved in the formation, operation and development of the company?
- Is there a place for the company in the market?
- Is there a place for the company in future markets?
- Can the company generate support among financial backers?
- Can the company be viable and contribute to the economy?
- Can the company attract the quality of management required?

If the answer to these and many other questions is yes, commercialization through company creation is one of the most effective methods of moving technology from the lab to the market. In terms of company creation, Canadian universities per capita outstrip their American counterparts. Of the more than 350 companies started annually from university technology, more than 15 per cent are started in Canada.

4.0 Tips for Inventors

- Success comes from the realization that the developer must be market driven.
- Do not underestimate the time and resources required.
- Get the best and most experienced people working with you.
- Determine your "window of opportunity."
- Assess all options for commercialization.
- Take advantage of existing infrastructure services.
- Recognize that the inventor himself may not be the best person to commercialize.

The researcher has both legal and ethical responsibilities. The researcher must fully-disclose the discovery, must become knowledgeable about the commercialization process, be supportive and cooperative, be trusting and business-like with an ability and a desire to understand and work in a business environment. He or she must be patient. Commercialization is a time-consuming process. It can take two years to bring software to market, five years to market a circuit board, eight years to market a vaccine.

5.0 The Value of Dealing with Technology Transfer Professionals

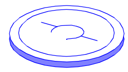
It is most important to recognize that the successful transfer of technology is a long-term process and does not follow a set timetable. The process is complex, highly interactive, and involves many stakeholders. It may be years before a suitable window of opportunity for commercial development opens. Experience has shown that it may take seven to12 years before significant returns on an invention are realized.

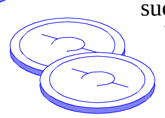
Technology transfer professionals have forms, processes, sources, contacts, and knowledge in place. The wheel does not have to be re-invented each and every time. Technology Transfer professionals are non-biased and non-judgmental. Their focus is to maximize the value of and the return from the technology. Their experience and training makes them good at analyzing the potential of the technology. Their knowledge of markets and products and their contacts and networks assist them in placing it for maximum benefit. They have experience in negotiating and licensing.

The TC professional must do the best he or she can for the technology and the researcher to obtain the maximum benefit from the technology. The professional must be diligent, accountable, honest and straightforward.

6.0 Success Stories

It is through the efforts of services like this that the results of an invention can be brought to public use and benefit. In the Engineering field, UTI's primary success to date has been in commercializing the prolific and significant GPS-related technologies from the University of Calgary's Department of Geomatics. The satellite and receiver-controlling software from that department has given it a worldwide reputation. In mechanical engineering, Dr. William Shaw invented and patented a process of creating bonds through mechanical alloying of polymers. This process has been licensed to an industrial coating company and other developments will be coming from that technology. Dr. John Remmers of the University's Medical Faculty teamed with engineering to develop a line of very successful devices for combating sleep apnea. UTI has a number of very promising technologies from the engineering field which are in development including the gastric motility device of Dr. Martin Mintchev and the mammography imaging technology of Dr. Raj Rangayyan of the University of Calgary's Electrical and Computer Engineering Department





Two of the more significant success stories resulting from technology developed at the University of Calgary are:

- Dr. Michel Fattouche of Department of Computer and Electrical Engineering in the Faculty of Engineering working with communications engineer Hatim Zaghloul developed and patented high-speed wireless communications technology. With some licensing assistance from UTI, the two took their discoveries and formed Wi-LAN Inc. a leading innovator in the field of high-speed wireless communications products, offering unique, cost-effective wireless solutions based on its two patented wireless technologies - Wide-band Orthogonal Frequency Division Multiplexing (W-OFDM) and Multi-Code Direct Sequence Spread Spectrum (MC-DSSS). These patented technologies are at the foundation of proposed international standards, and the technology that they protect is at the heart of Wi-LAN's wireless products. The company was listed on the Toronto Stock Exchange in March 1998 and achieved a market capitalization of more than $500,000,000. Wi-LAN's stock symbol is WIN and it can be tracked on the company's web site at http://www.wilan.com.
- At the same time, Dr. Fattouche was working with Dr. Gérard Lachapelle of the UofC's Department of Geomatics, Faculty of Engineering, and Richard Klukas the Faculty's Department of Mechanical Engineering to develop patented wireless location technology, a major thrust of which is a system of pinpointing the location of cellular telephones and similar devices using GPS-like technology. The result was the creation of a sister company to Wi-Lan. Cell-Loc Inc. went public in March 1997 and also raised more than $500,000,000 in the market. Its premier product, The Cellocate System™, was formally launched into the marketplace in February 1999 after three years of intensive field testing. It is a network-based Time Difference Of Arrival (TDOA) enabler of wireless location services such as fleet and asset management for dispatch and transportation businesses; tracking stolen phones and/or criminals; tracking children, patients, and pets; tracking stolen vehicles; location-sensitive billing; and location of cellular and PCS handset users in emergency situations. Cell-Loc's stock symbol on the Toronto Stock Exchange and the Canadian Venture Exchange is CLQ. Additional information on the company is available on its web site http://www.cell-loc.com. Additional information on the University of Calgary's Geomatics, Computer or Electrical Engineering programs can be found on the university's web site http://www.ucalgary.ca.

7.0 Additional Information

[1]. Association of University Technology Managers "Annual Licensing Survey", 60 Revere Drive, Suite 500, Northbrook, IL 60062, Phone: 847-559-0846, Fax: 847-480-9282, E-mail: autm@autm.net

[2]. Licensing Executives Society International Ronald "Making the Licensing Decision" LES (USA & Canada) Inc, 1800 Diagonal Road, Suite 280, Alexandria, VA 22314-2840, USA, Phone 703-836 3106; Fax 703-836 3107, E-mail leshq@aol.com, Web www.usa-canada.les.org

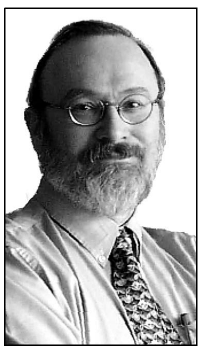
[3]. University Technologies International Inc. Suite 204, 609, 14th St. NW, Calgary, Alberta, Canada, T2N 2A1, Phone 403-270-7027, Fax 403-270-2384, E-Mail info@uti.ca, Web http://www.uti.ca.

[4]. Wi-LAN Inc. 300, 801 Manning Road N.E. , Calgary, Alberta, Canada, T2E 8J5, Phone: 403-273-9133, Toll Free: 1-800-258-6876, Fax: 403-273-5100, Email: info@wilan.com, Web http://www.wilan.com.

[5]. Cell-Loc Inc. 220 Franklin Atrium, 3015 Fifth Ave. NE, Calgary, Alberta, Canada, T2A 6T8, Phone 403-569-5700, Toll Free 1-877-569-5700, Fax 403-569-5701, E-mail info@call-loc.com, Web http://www.cell-loc.com.

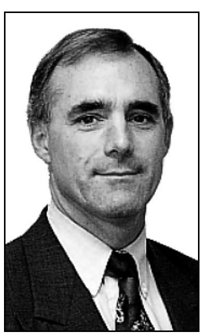
[6]. University of Calgary, 2500 University Drive NW, Calgary, Alberta, Canada, T2N 1N4, Phone 403-220-5110, Fax 403-282-7298, Web http://www.ucalgary.ca.

About the Authors



Don Morberg, Communications Manager at University Technologies International Inc. joined the company in November, 1995. As Communications Manager, he is responsible for all of UTI's internal and external communications as well as communications support to the senior management. He is responsible for UTI's corporate communications including writing, editing, media relations, brochures, documentation, the quarterly newsletter UTI Ink and UTI's Internet site www.uti.ca.

Don holds a diploma in journalism from Vancouver City College and has a wide range of experience as a journalist, writer, editor, photographer and webmaster in the media and in corporate and government communications.



Geoff Moon is Manager, Technology Transfer, at University Technologies International Inc. He joined UTI in March 1996 in his present capacity. He is responsible for evaluating, developing and marketing identified technologies in the areas of engineering and the physical sciences. He is also responsible for the protection and patenting of intellectual properties assigned to his portfolio as well as negotiating and administering licenses relating to these properties.

Geoff holds a Computer Science Diploma from Red River Community College; an Advanced Systems Design Diploma from Herzing Institute and an MBA For Working Professionals Certificate from The University of Western Ontario. For 16 years prior to joining UTI, Geoff worked in various senior technical/sales and technical marketing positions within 3M Canada Inc. and Kodak Canada Inc.

About University Technologies International Inc.

University Technologies International Inc., a for-profit technology commercialization company based in Calgary and wholly-owned by the University of Calgary, is uniquely placed to supply technology commercialization services to researchers not only at the University of Calgary, but at any other education or research facility which requests its expertise. About to enter its eleventh year of operation, UTI has made its professional services available to researchers and inventors at the University of Calgary, University of Lethbridge, Defence Research Establishment Suffield, Agriculture and Agri-food Canada, other post-secondary institutions, hospitals, research laboratories and garages and basements.

At its inception in 1989, UTI Inc. represented a unique approach to technology commercialization. It was the first private, for-profit institution to handle technology commercialization for a University in Canada and has become a model for other such institutions world-wide. As a company, UTI became profitable in its fourth year of operation. Now employing 14, UTI Inc. has, in its 11 year history, returned close to $15,000,000 to the University of Calgary and its researchers in the form of royalty payments, support, donations and contributions including three annual fellowships of $15,000 each to promising post-graduate or post-doctoral researchers. The company continues to expand its business outside the realm of the university, dealing with a growing number of independent inventors and researchers.

During its operation, the company has entered into more than 350 legal agreements to commercialize technologies and been involved in the creation of 15 companies. Additionally it has used it expertise to assist in the business development of ten other companies. More information on UTI Inc. is available at http://www.uti.ca.

Thought for the Day

How come being in a pickle means the same thing as being in a jam?

Embedded Ultra Low-Power Digital Signal Processing

by Todd Schneider and Robert Brennan,
dspfactory Ltd., Waterloo, ON
Edward Chau, University of Guelph, Guelph, ON

Abstract

This paper presents an overview of the requirements for ultra low-power embedded DSP systems, the technology that was developed for our signal processing system, and a detailed look at a demanding application: a digital, frequency domain, beamforming hearing aid.

Sommaire

Cet article présente un sommaire des exigences des systèmes embarqués de très faible puissance pour le traitement numérique du signal. Cette technologie a été développée pour notre système de traitement du signal. L'article présente une analyse détaillée d'une application particulièrement exigeante, soit un appareil acoustique numérique pour malentendants atténuant les bruits de fond, amplifiant les conversations selon leur direction et oeuvrant dans le domaine fréquence.

1.0 Introduction

The wide-spread and growing use of portable, battery-powered devices like cellular telephones, audio-capable personal digital assistants (PDAs), MP3 players and similar applications has resulted in an increasing demand for miniature, ultra low-power digital signal processing (DSP) technology. Many of these devices make heavy use of digital signal processing techniques like modulation, demodulation, filtering, automatic gain control, equalization and subband coding and decoding. In these devices, users expect a range of DSP-based features to be delivered with little impact on battery life and in miniature, portable packages.

The conflicting demands of ultra-low power consumption and increasing DSP functionality have led to a number of advances in algorithms, semiconductor technologies and system architectures. Based on research for digital hearing aids that started in the early 1990's, we have developed a new DSP system that has benefited from advances in all of these areas. It offers miniature size, ultra low-power consumption and is sufficiently flexible to support a wide range of applications.

This technology will result in a new range of devices where ultra low-power, miniature DSP technology is embedded into a system or sub-system and invisibly performs a useful task. By embedding ultra low-power, miniature signal processing capabilities, we expect improved performance in everything from embedded sensors to digital hearing aids, especially in adverse signal conditions.

This paper presents an overview of the requirements for ultra low-power embedded DSP systems, the technology that was developed for our signal processing system, and a detailed look at a demanding application: a digital, frequency-domain, beamforming hearing aid.

2.0 System Overview

2.1 Requirements

The requirements for embedding DSP systems into miniature, ultra low-power applications are challenging (Table 1). These requirements were driven by our initial application, digital hearing aids. In this application, size and power consumption are particularly restrictive.

Table 1: Requirements for a miniature, ultra low-power DSP system

Size	• Miniature size (hearing aids require a complete DSP system in less than 3 x 5 x 3 mm)
Power	• Single-battery operation; operates to 0.9 volts • Less that 1 mA system current consumption (< 0.1 mW/MIPS for DSP platform)
Performance	• At least 5 MIPS of signal processing capability • Flexibility to support a wide range of applications • Broadcast quality fidelity (minimum 8 kHz bandwidth) • Less than 10 ms group delay • More than 50 dB of gain adjustment

3.0 System Design

Figure 1 shows a block diagram of the system. It consists of three major components:

- Weighted overlap-add (WOLA) filterbank coprocessor,
- RCORE DSP core, and
- Input-output processor (IOP).

A mixed-signal sub-system contains the analog-to-digital converters (A/D), a digital-to-analog converter (D/A) and other interface circuitry. Both the RCORE and the WOLA coprocesor can run concurrently providing approximately 5 MIPS performance on a 1 MHz system clock.

Figure 2 shows the processing model for the system. A time domain input signal, x(n), is transformed into the frequency domain by the analysis filterbank, the RCORE can then manipulate the gains applied to the complex output from the filterbank. The synthesis filterbank transforms data back to a time-domain signal, y(n). In essence, the design is an over-sampled, subband CODEC. The output from the WOLA is complex and contains both magnitude and phase information.

3.1 WOLA Filterbank

The vast majority of DSP algorithms, everything from subband CODECs to directional processing, can be cast into a filtering paradigm. Thus, our design incorporates an efficient, hardware-based filtering coprocessor, the weighted overlap-add (WOLA) filterbank [1,3,8]. The WOLA is implemented in hardware and this results in:

- Greatly reduced power consumption because a signal processing architecture optimized for filtering is more power efficient than a general purpose architecture doing the same processing, and
- Reduced chip size because less memory is required.

To provide the flexibility required for a range of applications, the WOLA filterbank has a number of adjustable parameters. The fast Fourier transform (FFT) Size (N), window length (L) and input block step size (R) are all adjustable. Two key innovations in the WOLA filterbank design are the incorporation of adjustable oversampling and the provision for two filterbank stackings, even and odd. Adjustable oversampling allows a user selectable trade-off to be made between fidelity, group-delay and power consumption [1]. Results for some configurations are shown in Table 2. Note how reduced group delay (greater oversampling and/or a smaller window length) can be “traded” for increased power consumption, reduced fidelity (a lower spurious-free dynamic range, SFDR) or both. The WOLA filterbank can be configured from 4 to 128 bands.

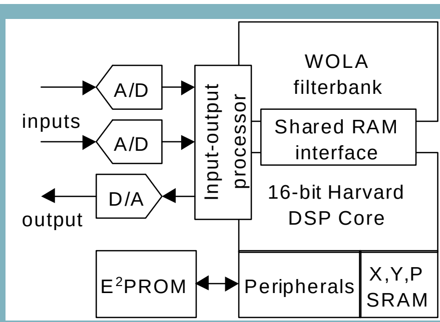


Figure 1: Block diagram of DSP system

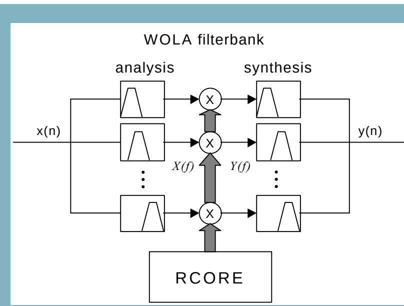


Figure 2: System processing model

Table 2: Sample filterbank configurations (SFDR: spurious-free dynamic range; relative power for filterbank only)

Bands (=N/2)	OS (=N/R)	Delay (ms)	Rel. Power	SFDR (dB)
16	2	14	1	65
16	4	6	1.5	50
32	4	12	1.6	45
128	1	27	2	40

Figure 3 shows frequency response plots for even and odd stackings. For the configurations shown, 16 bands of frequency equalization are available, each with over 40 dB of gain adjustment. Both stackings (even and odd) have a group delay (τ) of only 6 milliseconds, including the blocking delay introduced by the IOP (which simultaneously inputs and outputs blocks of data while the WOLA filterbank is running).

Even stacking uses a traditional FFT and provides N/2-1 (where N is the FFT size) full bands and two half bands (at DC and the Nyquist frequency). Odd stacking provides N/2 equal width bands. Having two stackings provides for more precise equalization because there are twice the number of band edges.

Finally, the WOLA filterbank can operate in stereo mode and simultaneously convert two time-domain signals into the frequency domain. This feature, along with the complex output signal from the filterbank, makes the WOLA filterbank ideal for the implementation of frequency-domain directional processing algorithms and demodulators.

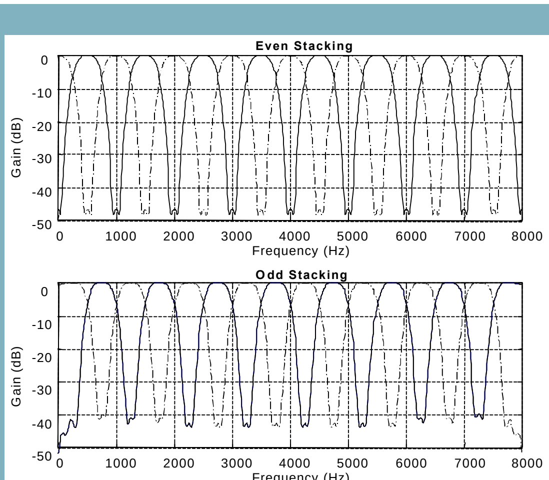


Figure 3: Frequency responses for even and odd stacking (16-channels, t = 6 ms, fs = 16 kHz)

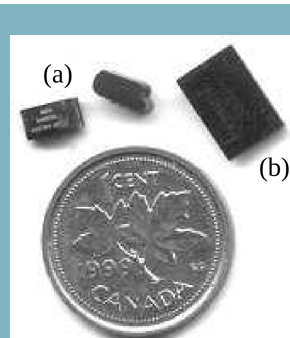


Figure 4: Packaged DSP system:
(a) hybirds for hearing aid applications, and
(b) a multi-chip module for PDA and other portable applications

3.2 RCORE DSP Core

The RCORE DSP core provides the flexibility needed to implement a wide range of signal processing algorithms. It has access to the frequency domain data (output from the analysis section of the WOLA filterbank) and the time-domain data (in the WOLA filterbank input and output FIFO buffers).

The RCORE is a fully software programmable, 16-bit, dual-Harvard DSP core. It performs a single-cycle multiply accumulate with simultaneous update of two address pointers. It has instructions that are specialized for audio processing (e.g., single-cycle normalization and denormalization) and a 40-bit accumulator. It interfaces with the WOLA filterbank and the IOP through shared memory.

3.3 Input-Output Processor (IOP)

The IOP is a block-based direct-memory access controller that is tightly coupled to the WOLA filterbank. It operates on blocks of data and only interrupts the DSP core when necessary. This reduces power consumption because the DSP core can switch to a low-power sleep mode when it is not needed for calculations.

The IOP incorporates decimation and interpolation filters that work in conjunction with oversampling A/D and D/A converters. The decimation filter has an integral DC removal filter.

3.4 System Implementation

Further reductions in power consumption are provided by (1) operating directly at single battery voltage (the system will operate down to 0.9 volts) and (2) using low-power, deep submicron semiconductor technology [7].

The entire system (Figure 1) is implemented on three integrated circuits. The WOLA filterbank, RCORE, IOP and associated peripherals are fabricated using 0.18μ technology on a die that is less than 10 mm^2.

The design also incorporates an ultra low-power integrated circuit that has two 14-bit A/Ds and a 14-bit D/A converter. This subsystem also has programmable input and output gain blocks as well as an on-chip oscillator and charge-pump. The entire mixed-signal subsystem is under software control via a low-speed, single-wire synchronous serial interface. This circuit is fabricated using 1.0μ semiconductor technology on a die that is less than 8 mm^2. A third, off-the-shelf EEPROM die provides non-volatile memory for the system.

Figure 4 shows packaged versions of the system that incorporate the digital die, the mixed-signal die and the EEPROM die (128 kbits).

4.0 Applications

Our DSP system has a wide range of applications. It is already implemented in digital hearing aids [6], speech recorders (as a subband CODEC) and PDA applications.

We are actively working on several directional processing algorithms, everything from simple two-microphone delay-and-sum systems to advanced frequency domain beamforming. The stereo processing mode of the WOLA filterbank greatly simplifies the implementation of these algorithms. The remainder of this paper discusses these interesting applications in more detail.

4.1 Beamforming Hearing Aid

Background noise amplified by a hearing aid makes it very difficult for many hearing aid users to understand speech. A proven approach to improve speech intelligibility for these users in background noise is to employ a beamformer [5]. A beamformer is a spatial filter that allows filtering of signals depending on the direction-of-arrival (DOA) of the signals. Assuming that the user tends to face with the desired signal source, a beamformer can be used to suppress sounds that are not originating from this look-forward direction, thereby improving speech intelligibility.

In order to resolve the signal DOA, a beamformer needs to employ an array of two or more sensors (microphones). Generally, the more sensors that are available in the array, the better the beamformer performance. Some beamformers developed for speech intelligibility enhancement have employed arrays of five or more microphones [5]. However, with the small size of typical hearing aids, it is often impractical to implement an array of more than two microphones.

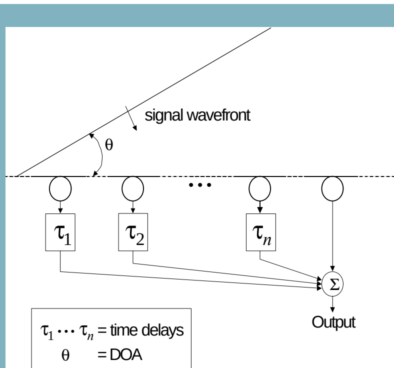


Figure 5: Delay-and-sum Beamforming

While there are many different beamforming techniques, from simple fixed-array approaches to highly complex adaptive algorithms, the simplest technique is the classical delay-and-sum method. The idea of classical delay-and-sum beamforming is to introduce an appropriate time delay (or phase shift in frequency domain) to compensate the propagation delay of a signal source arriving at the individual microphones from a specific DOA and frequency [4]. Essentially, the time delay is applied such that the signals from each microphone will be time-aligned. The time-aligned signals are then summed together so that the power of the signal components originating from a particular DOA is enhanced relative to the power of those from other directions (see Figure 5).

The gain response of the classical delay-and-sum beamformer is both frequency- and DOA-dependent. Consider an array of two microphones separated by a distance d. Let $\omega_m = \pi c/d$, where c is the speed of sound. Figure 6 shows the beam patterns (polar plot of the beamformer gain response) of a beamformer aimed at 0 degree DOA for signals at various frequencies. As can be seen in the figure, at frequencies lower than ω_m, the nulls are degraded and, at higher frequencies, spatial aliasing causes additional main lobes to appear. This occurs because, while the propagation delay of the signal wavefront remains the same for all frequencies, the corresponding phase delays are different at different frequencies.

Frequency-dependent gain response is clearly undesirable in hearing aid applications, where the gain response of the beamformer should be consistent over all frequencies of interest. Fortunately, with the use of a powerful DSP platform and a stereo filterbank, the problem of a frequency-dependent beam pattern can be easily alleviated by applying a frequency-domain extension to the classical delay-and-sum algorithm.

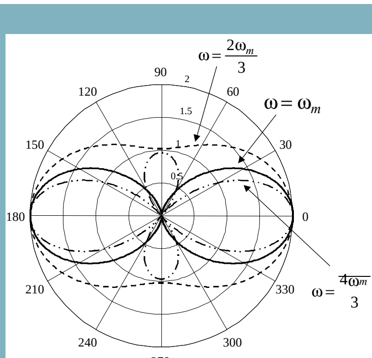


Figure 6: Beam patterns at different frequencies for 0-degree steering

Assuming again an array of two microphones, the new algorithm introduces two additional frequency-dependent delays so that, in effect, besides applying the constant beamforming delay, it also applies a variable delay (as a function of frequency) to both of the received signals at the microphones. The variable delays compensate for the different phase delays at each frequency component, so that the resulting phase delay over all frequencies is the same as that at ω_m. This provides the same beam patterns over all frequencies. However, to avoid spatial aliasing, ω_m must be set at the highest frequency of interest. Figure 7 shows the new beamformer for the case of a two-microphone array. In the figure, τ_1 is the constant beamforming delay (for aiming towards a particular DOA), and $\tau_1^*(\omega)$ and $\tau_2^*(\omega)$ are the two frequency-dependent delays for compensation. The summation sign in the figure actually denotes the "butterfly" operation instead of the simple arithmetic summation. Note that this beamformer can be implemented only in the frequency domain, because the actual phase delay between the two received signals at each frequency must be known for all times.

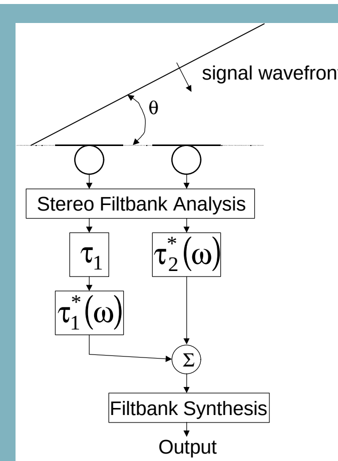


Figure 7: Extension to Classical Delay-and-Sum Beamformer

In theory, this beamformer will produce exactly the same beam pattern for any frequency component $\omega \le \omega_m$. In practice, however, the beam pattern is subject to "maladjustment" because of the finite bandwidth of the filterbank subbands. Clearly, the effect of this maladjustment is more apparent with wider subbands. We have found that with a 64-band WOLA filterbank, the effect of this maladjustment is negligible.

Another potential cause for maladjustment in this beamformer is that the determination of the phase delay at each subband assumes that the dominant energy in the subband comes from a single signal source only. The reason for this is that for signal sources with different DOA, different compensation is needed to produce the consistent beam patterns. Hence, as long as the dominant energy in each subband is contributed by one signal source only, the compensations will be accurate.

For simulation, this beamformer has been implemented in C, using the WOLA filterbank structure [1] with 16-band and 64-band implementations. A 10-second male speech utterance (target) is mixed in white noise at various SNR for use as the test signal. In general, the simulation has shown that an average of 10 dB improvement can be obtained using the frequency-domain beamformer. While it has been found that the performance of this beamformer tends to degrade quickly when more than one noise source is present, overall, with an efficient filterbank and DSP platform, this beamformer is a simple yet effective way of providing background noise reduction in digital hearing aids.

Finally, since the beamformer described here is a relatively simple algorithm that performs well under favorable conditions, the development of our ultra low-power DSP platform offers the computing resources for more complex algorithms. One novel approach we are investigating involves a neural network based system that supplements the frequency-domain beamformer to provide better background noise suppression. Figure 8 shows the block diagram of the overall system.

Assuming that the neural network module will operate without on-line adaptation, a static neural network is simply a sequence of multiply-sum operations, with the activation function easily approximated by a look-up table. We expect that this system can be implemented easily on our DSP platform, provided a satisfactory neural network solution can be found.

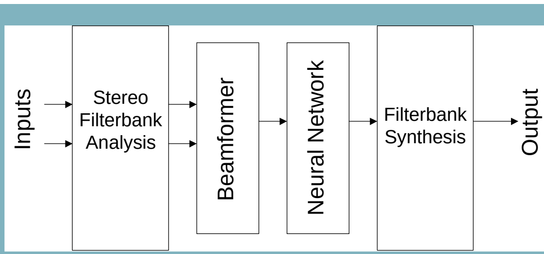


Figure 8: Block Diagram of Novel System

5.0 Conclusions

Software programmable, ultra low-power, miniature DSP systems will result in whole new range of DSP applications such as digital hearing aids, audio enabled personal digital assistants and portable audio playback devices. Our design demonstrates that ultra low-power DSP systems can offer sufficient computational capability and flexibility to be used in a range of applications.

We believe our experience in this area can be generalized to other ultra low power, miniature applications: the greatest savings in power and size comes from having an efficient algorithm that is targeted at a specific algorithm or a class of algorithms. Our design is an application specific signal processor (ASSP) that incorporates very efficient, yet flexible filtering

The specific example of a beamforming hearing aid illustrates that even complex, two-input frequency domain algorithms can be supported on such miniature, ultra low-power platforms. In the near future, such algorithms will bring much needed benefit to hearing aid users and possibly find application in other systems (e.g., speech recognition front-end processing) where an improvement in SNR will result in more robust system operation.

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7.0 Glossary

DOA	- Direction of Arrival
IOP	- Input-Output Processor
CODEC	- Coder/Decoder
RCORE	- DSP Core
WOLA	- Weighted Overlap-Add
DSP	- Digital Signal Processor
PDA	- Personal Digital Assistant
SNR	- Signal to Noise Ratio
ASSP	- Application Specific Signal Processor
FFT	- Fast Fourier Transform
SFDR	- Spurious-Free Dynamic Range
FIFO	- First In - First Out
EEPROM	- Erasable Programmable Read Only Memory

About dspfactory Ltd. : dspfactory is a rapidly growing, dynamic company with expertise in digital signal processing (DSP) architectures and algorithms for miniature, ultra low-power audio and baseband applications. Its mission is to embed ultra low-power, miniature DSPs invisibly into a wide range of products. Target products for its technology include hearing aids, baseband wireless, personal digital assistants, personal digital audio players, cellular telephones and embedded sensors -- in short, any DSP-based products that are portable and battery-powered. More information is available at www.dspfactory.com

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Todd Schneider graduated from the University of Waterloo with a B.A.Sc. (1989) and a M.A.Sc. (1991), both in Electrical Engineering.

He is now the VP Technology at dspfactory. His technical interests include DSP algorithms, system architectures for efficient DSP systems, DSP tools and Linux.

He is a member of the IEEE and the Audio Engineering Society.

Robert Brennan graduated with a doctoral degree in electrical engineering from the University of Waterloo in 1991 investigating low bit-rate speech coders.

As VP Research at dspfactory, he continues work on filterbank speech decomposition methods and speech enhancement/processing strategies.

He is a member of the IEEE and the Acoustical Society of America.

Edward Chau is currently pursuing his M.Sc. Degree in Engineering Systems and Computing at the University of Guelph. He obtained his B.A.Sc. in Electrical Engineering at University of Waterloo in 1999.

His primary research interests include Neural Network & Evolution Computing approaches to Digital Signal Processing, particularly in audio signal processing. He is currently developing a neural network based noise reduction module for digital hearing aids. He would like to thank dspfactory and the Natural Science and Engineering Research Council for their support in his graduate research.

The Engineering Institute of Canada - L'institut canadien des ingénieurs

The **Engineering Institute of Canada** (EIC) announces its year 2000 Honours, Awards and Fellowships. Seven senior awards and eighteen Fellows were recognized during National Engineering Week, at the Institute's Annual Awards Banquet held at the National Arts Centre in Ottawa, on 6 March 2000.

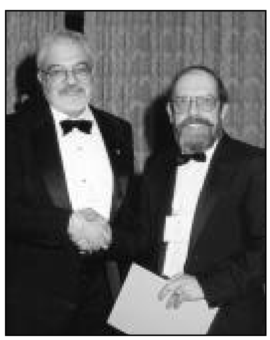
Left to Right: R. Kearney, R. Garneau, M. Mohitpour, E. Petriu, N. Georganas, C. Desmond, P. Kaiser, A. Rollin, W. Krzymien, A. Carty, M. El-Hawary, B. Lukajic, F. Matich, A. Perks (for further details see IEEE Canadian Review #34, Spring 2000 issue).

Absent from the presentation were: Pan Agathoklis, John W. Bandler and Aziz Y. Chikwani

IEEE Canada Members win big at the EIC Awards

André Rollin, president of EIC, presented the awards.

Emil Petriu (Fellow) & André Rollin



Mo El-Hawary (CP Railway Engineering Medal) & André Rollin

André Rollin & Celia Desmond (John B. Sterling Medal)

Nicolas Georganas (Julian C. Smith Medal) & André Rollin

André Rollin & Witold Krzymien (Fellow)

Eric Holdrinet served as the Maître de Cérémonie

André Rollin & Tho Le-Ngoc (Fellow)

Advanced High Availability Software For Linux - 5NINES Telecom Deployments

by Robert Pettigrew and Noel Lesniak

Motorola Computer Group

Abstract

This article provides an overview of the telecom industry's first advanced high availability software for Linux (HA-Linux) applications. Recently launched by Motorola Computer Group (MCG), the Linux solution provides "hot swap" and active/standby processor switchover capabilities for carrier-grade networking, wireless and Internet applications that run 24-hours a day, 365 days a year.

Sommaire

Cet article présente le premier logiciel à haute disponibilité de l'industrie des Télécommunications pour les applications Linux (HA-Linux). Motorola Computer Group (MCG) a récemment lancé sa solution Linux qui permet d'extraire à chaud et de changer le statut du processeur du mode actif au mode veille. Ce logiciel sera particulièrement utile pour les distributeurs de réseaux, spécialement pour les applications sans-fil et pour l'Internet qui sont disponibles 24 heures sur 24, 365 jours par année.

1.0 Introduction

The unprecedented adoption of the Internet as a business and consumer “utility” has resulted in explosive growth in the wireless and Internet sectors of the telecommunications industry. Convergence of data and voice - and soon multimedia communications - are driving the need for telecommunications embedded computer systems that must operate all day, every day, with almost no interruption. With Internet and e-commerce becoming as ubiquitous in our everyday lives as the telephone, loss of service has become intolerable since it represents lost revenue, a lost transaction or worse yet a lost customer.

Today the world's telecommunications infrastructure markets are clamouring for “off-the-shelf” computing solutions that enable them to cut costs, reduce time to market and meet international carrier grade telecommunications standards for 5NINES availability. 5NINES availability equates to 99.999% availability - five minutes or less of planned and unplanned downtime per year.

With its very low cost and freely available source code, Linux is being rapidly adopted as the platform of choice for new telecom applications. Until recently however, the software components required to implement a high availability Linux solution - supported by service, training and systems integration capabilities - were not available. MCG has built on its fault tolerant, embedded and telecom systems expertise to develop advanced high availability for Linux that meets the needs of mission critical applications requiring 99.999% service availability. Operations, Administration and Maintenance (OA&M) platforms, call servers, IP gateways, gatekeepers and home location registers are some of the applications where the benefits of high availability Linux is projected to have significant impact.

MCG's advanced HA-Linux framework (Figure 1), coupled with the CPX8000 family of CompactPCI-based systems enables the development of 5NINES-capable systems.

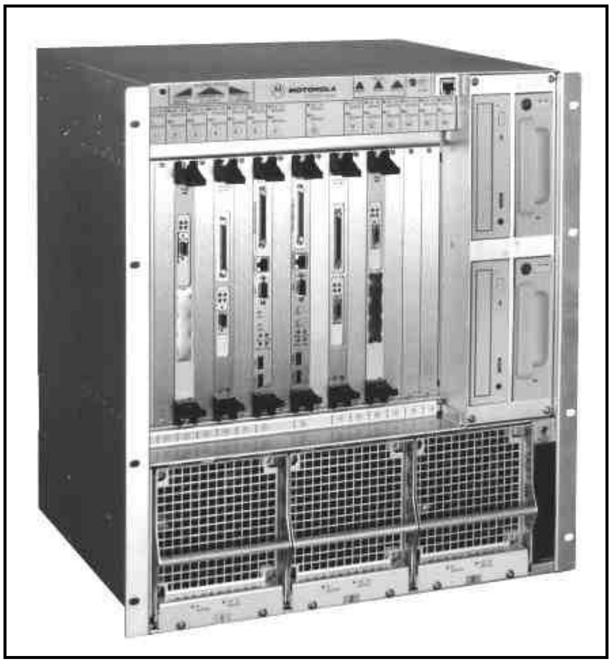


Figure 1: “Off-the-shelf” CPX8216 Carrier Grade HA Platform

2.0 Linux: Ready For Prime Time

Only seven years old, Linux is now the world's fastest growing operating system largely due to its stable, open architecture. Distributed under the GNU General Public License, a “free” license, anyone can modify the Linux source code and redistribute it. Although Linus Torvalds owns the trademark for the name and leads kernel development, no one owns or controls it and the system has therefore benefited from the contributions of many talented developers.

In 1994, Linux visionary Mark Bolzern, president and founder of WorkGroup Solutions, Inc. and a member of the non-profit Linux International board, predicted Linux would be as revolutionary to operating systems, as the PC was to hardware, by providing a common standard everyone could access [1]. Data released by industry analyst IDC suggests he may be right. Last year IDC reported that in 1999 Linux server license distributions exceeded 1.4 million copies, doubling the 1998 shipments. At the same time all shipments of Unix server licenses totaled only 839,000, growing just 1.3% over 1998 (Figure 2). IDC further predicted that Linux shipments would grow at a CAGR of 25% through 2003. Among the many major technology companies supporting the Linux O/S are Dialogic, IBM, Informix, Intel, Motorola, Natural Microsystems, and Oracle.

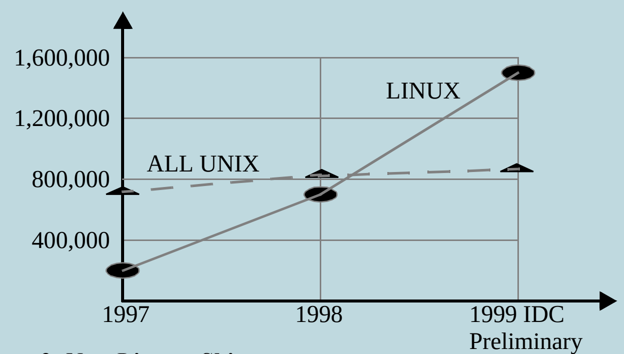


Figure 2: New License Shipments

While there has been considerable discussion about the challenge Linux represents in the server and desktop markets, MCG's introduction of HA-Linux now makes it a compelling choice for Original Equipment Manufactures (OEMs) building for mission critical industry sectors like data storage, medical imaging and telecom. Not only does Linux provide a full-featured O/S with proven reliability, the open source model enables lower cost, greater control and simplified licensing.

3.0 5NINES In The Telecom Environment

5NINES availability is critical for a growing number of telecom applications such as 911 and Emergency Services; Call Control and Setup; IP Telephony; Packet Switching; billing; OA&M; and e-commerce where the web store never closes.

Even so, application software and operating system maintenance and upgrades are always necessary. For example, software updates are done, on average, twice a year in the telecommunications industry. This could result in up to 60 minutes of downtime annually, potentially putting 5 NINES beyond reach. Achieving 5NINES (five minutes or less of downtime a year), for both planned and unplanned events, requires:

- Increasingly more stringent qualifying component reliability and a service-minded system design - a 3NINES platform,
- A combination of redundancy throughout the hardware architecture (including the CPU), combined with fault management and warm or hot restart models - 4NINES applications, and
- An architecture that supports hot upgrade of software - 5NINES.

4.0 MCG's Advanced HA-Linux Solution

MCG's HA-Linux - with "hot swap" capability and support for both Intel- and PowerPC-based system platforms - is the first Linux offering for carrier-grade networking, wireless and Internet applications that require 5NINES availability. HA-Linux refers to an integrated set of Linux kernel and application level components that provide high-availability (HA) functionality on MCG's CPX8000 Series of carrier grade, NEBS/ETSI compliant platforms.

The CPX8000 Series is CompactPCI-based. CompactPCI has been widely adopted by the telecom industry, bringing the power and performance of low-cost computing technology to this mission critical sector. A primary driver has been the ability to hot swap boards. When coupled with component redundancy schemes, it offers inherent fault recovery and online service leading to a HA system.

CPX8000 is a family of carrier grade, NEBS compliant system platforms that feature an advanced HA architecture. The core of this advanced architecture is the hot swap controller and bridge module that allows the system processors to access both I/O domains under control of HA-Linux. This patent pending facility enables mission critical applications to rapidly switch over to a standby system processor and to access both I/O domains after a system processor failure making the CPX8000 ideal for 5NINES applications.

The advanced features of HA-Linux allow OEMs to develop and network operators to deploy and operate applications that meet or exceed 5NINES. Planned upgrades of hardware and software can be implemented without disrupting services.

In addition to the ability to "hot swap" system components like processors, I/O controllers, power modules & fans, HA-Linux provides:

- Active stand-by system and CPU support, enabling applications to continue service while switching to a standby processor,
- Management of telecom alarms and component status LED's, allowing easy and error free operations by craft personnel,
- Simple network management protocol (SNMP) support with an SNMP agent, system MIB and Event Manager MIB, enabling system state changes and events to be monitored and managed by the network and operations management system, and
- An inter-system communications interface that allows applications in the primary and backup system processors to communicate with each other to facilitate rapid switch over to the backup.

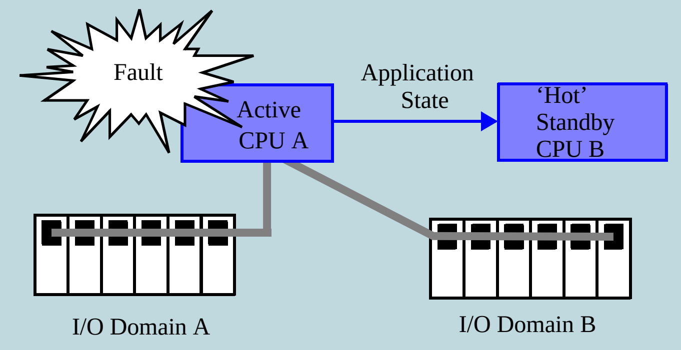


Figure 3: Advanced HA Architecture

4.1 Intel x86 and PowerPC Support

HA-Linux capabilities are offered on MCG's Intel x86- and PowerPC-based processor modules, giving OEM's the choice of processor architecture that is best for their application. HA-Linux runs with the Red Hat distribution in the Intel x86 environment and with the Linux PPC kernel in the PowerPC environment.

4.2 "Hot Swap" of All System Components

The CPX8000 system architecture features redundant "hot swap" components for all active system elements (field replaceable units). HA-Linux controls and manages these redundant "hot swap" components to enable applications to continue providing service even when a system component has failed. This "hot swap" support allows any system component to be switched over to a backup component in order to continue operation. Then the faulty component is replaced with a spare and subsequently returned to active operation.

4.3 System Processor Switch Over

HA-Linux enables high availability applications to switch over from the active system or CPU module to a standby system or CPU module in order to continue service. HA-Linux uses the CPX8000's Hot Swap Controller and Bridge to switch the CPX8000's I/O domain to the standby CPU module in order to rapidly begin application processing on the backup CPU module with access to all the system's I/O components. HA-Linux provides heartbeat, messaging, and checkpoint services to aid in developing high availability applications for this environment.

4.4 Telco Alarms

HA-Linux fully supports the critical, major, and minor visual and dry contact telco alarms on MCG's carrier grade, NEBS compliant system platforms. These telco alarms give craft and operations personnel easy to understand indications of system status conditions that may require their attention. The telco alarms are turned on and off based on rules in the configuration database and component status changes as they occur in the system. These alarm changes can also be communicated through an interface to SNMP.

4.5 In Service and Out of Service LED's

HA-Linux supports In Service (Green) and Out of Service (Red) LED's associated with each component in the CPX8000 system, allowing craft or operations personnel to easily see the status of components in the system and to quickly and correctly identify out of service conditions. The service status changes can also be communicated through an interface to SNMP.

4.6 SNMP V3 Agent, System MIB and Event Manager MIB

HA-Linux includes an SNMP agent, System MIB and Event Manager MIB so the system can be easily integrated into an operations/ network management network and managed remotely. The UCD SNMP v3 agent is provided along with a system MIB and an event manager MIB. This allows operators and network managers to access system and component statuses and to remotely configure and operate the system. Additional UCD functionality provides information on processes, disks, memory, and load average plus shell commands and error handling capabilities.

4.7 Diskless Operation

To support cost effective embedded system configurations that are diskless, HA-Linux provides a network boot facility that allows system slot and non-system slot processors to network boot using standard network boot mechanisms like "bootp" and "tftp".

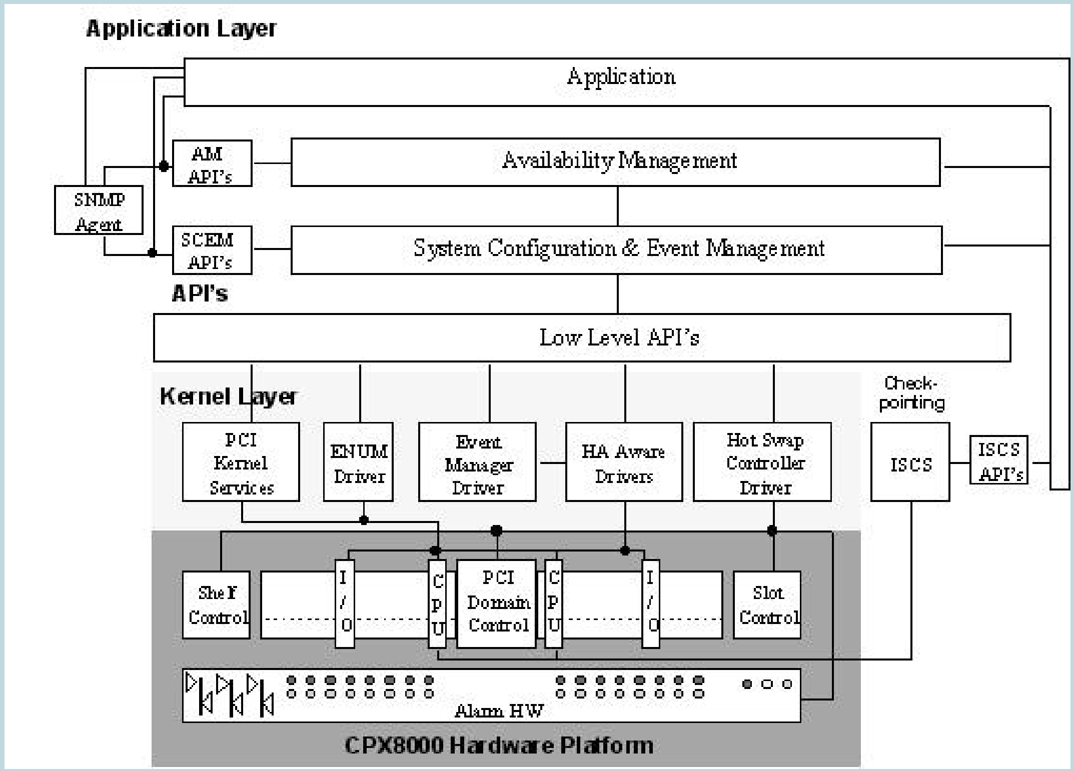


Figure 4: HA-Linux Software Architecture

4.8 System Configuration and Event Manager

The System Configuration and Event Manager (SCEM) is fundamental to the HA operation of the system. It provided integrated configuration, event, alarming, and availability management capabilities. The SCEM is composed of Linux kernel and application components

4.9 Linux Kernel Components

SCEM Linux kernel components include the following:

- PCI Kernel Services supports full dynamic insertion and deletion of PCI devices into the PCI configuration tree,
- The ENUM Hander enables the system to respond to the removal and insertion of components using predetermined rules and policies by signaling the insertion or removal of non-system slot components,
- The Hot Swap Controller Driver provides an interface to the Hot Swap controller and Bridge module in a multi-domain system. Supported functions include the power on and off of components, connect and disconnect of PCI devices, access to LED's and alarms, access to domain control signals, and event notification of state changes for system components. A low-level API interface is provided,
- HA-Aware Device Drivers are Linux drivers that provide comprehensive error checking, possible switchover to backup devices upon failure, latent fault checking to determine that devices are operational, and watchdog timers to check devices that may become inactive,
- The Event Manager Driver provides a convenient mechanism for a kernel module to send event messages to the SCEM, and
- The V-Term Driver allows the system processor to interrogate local components, run tests, and set configuration options on non-system slot processor cards. For example, this allows the system to determine the Ethernet addresses assigned to the network interfaces of each non-system slot PowerPC-based processor board.

4.10 Linux Application Components

SCEM Application Components include the following:

- The Availability Manager manages asynchronous events that can effect the availability of the system. In a distributed environment this will encompass a cross shelf approach that can be integrated with cluster management,
- The Shelf Event Manager is primarily concerned with asynchronous events like hardware and software component failures within a shelf, it responds to these events based on policies and distributes event messages to processes,
- The Event Manager API Library provides application program interface (API) services for applications and utilities that need to communicate with the event manager. API services allow easy access to event manager status and the attributes of devices and objects, sending and receiving event messages, and to log messages to the event manager's log file,
- The Configuration Manager allows the addition or removal of components and objects to and from the system and maintains a model of component dependencies and hierarchies in order for the system to make decisions in response to events,
- The Alarm Manager controls the telco visual and dry contact alarms and component "In Service" and "Out of Service" visual alarms using a configurable rule set,
- HA-Aware Device Driver Methods are used to define, undefine, configure, unconfigure, and change a device, and
- User Interface Utilities provide interfaces for system operators and network managers to display, change, & manage devices and objects in the system. Both local & remote interfaces are available.

4.11 Inter System Communication Services

Inter-System Communications Services (ISCS) provides a mechanism for data communication between two system domains in order to facilitate rapid application switch over to a standby system or system processor. The domains can exist within a shelf in the case of the CPX8000 or across multiple shelves.

The ISCS is critical in managing high availability applications in that it provides mechanisms for applications to checkpoint, heartbeat, and manage fail-over events, as well as providing:

- Application to application message and data communication,
- Remote program execution,
- File transfer, and
- Logging services.

API's exist for applications to access these services.

5.0 Conclusion

The need for high availability embedded solutions is becoming increasingly important to OEMs designing systems for the data storage, medical imaging, telecom and other industries that use a growing number of mission critical applications in their business.

HA-Linux development will focus on advancements in scalability and availability of CPX8000 systems through the addition of clustering, availability management, backplane messaging & network management. Although HA-Linux systems support ethernet & ATM, additional communication protocols will be supported with HA-Aware drivers.

As the CPX8000 family of systems grow and the underlying architecture and hardware is enhanced, HA-Linux will take advantage of these enhancements to provide increasingly higher availability while providing new features and functions that further enable the "application readiness" of the platform for the telecom industry.

6.0 References

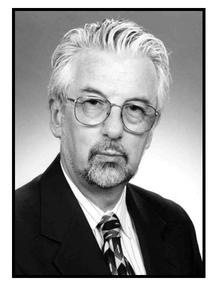
[1]. An article about Linux and its significance, (1994) Mark Bolzern, President, WorkGroup Solutions, http://www.li.org/li/resources/papers/1994-linuxsig/lxsig.txt

2.0 Glossary

5NINES	- 99.999% availability
HA	- High availability
I/O	- Input/output
IDC	- International Data Corporation
IP	- Internet Protocol
ISCS	- Inter-system Communications Services
MIB	- Management Information Base
O/S	- Operating System
OA&M	- Operations, Administration and Maintenance
SCEM	- The System Configuration and Event Manager
SNMP	- Simple Network Management Protocol

About the Authors

As Canadian Engineering Manager with Motorola Computer Group (MCG), **Rob Pettigrew** is responsible for ensuring the requirements of Canadian customers are reflected through innovative product design. To a large degree, his role involves managing partnerships with OEMs such as Nortel, Newbridge, and Glenayre that reduce development time and result in breakthrough products for the telecommunications sector. He manages teams of engineers across Canada who ensure OEMs in the telecommunications sector succeed in the intensely competitive global telecom market



Noel Lesniak has been with Motorola for 20 years in various roles. He is currently business manager in the Motorola Computer Group's Telecom Business Unit with responsibility for High Availability Software Platforms.

Noel led the team to determine the Computer Group's Linux strategy and to drive its high availability Linux initiatives. Prior positions included Business Manger for Unix and Linux Telecom Platforms and Product Line Manager for the FX Series of fault tolerant, NEBS compliant systems.

IEEE Applauds Great Engineering Achievements

Nominated by 29 professional engineering societies, the top 20 list of Great Engineering Achievements was selected and ranked by a distinguished panel of the nation's top engineers, working in anonymity to ensure objectivity. The top 20 list was announced as part of National Engineers Week 2000 at the National Press Club by Neil Armstrong, an engineer and astronaut whose moon landing in 1969 was listed in #12, "Space Exploration".

List of the Top 20 Great Engineering Achievements of the 20th Century

1. Electrification
2. Automobile
3. Airplane
4. Safe and abundant water
5. Electronics
6. Radio and Television
7. Agricultural Mechanization
8. Computers
9. Telephone
10. Air Conditioning and Refrigeration
11. Interstate Highways
12. Space Exploration
13. Internet
14. Imaging Technologies
15. Household Appliances
16. Health Technologies
17. Petroleum and Gas Technologies
18. Laser and Fiber Optics
19. Nuclear Technologies
20. High Performance Materials

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IEEE Canadian Conference on Electrical & Computer Engineering, Halifax, N. Scotia, May 7-10, 2000

1.0 Introduction

Borrowing from the nautical history of Nova Scotia, “Navigating to a New Era” was the theme of the 2000 IEEE Canadian Conference on Electrical and Computer Engineering held at the World Trade and Convention Centre in Halifax, Nova Scotia. Some 255 registrants from across Canada and from 23 countries around the world learned from the 244 papers presented by 479 authors. Papers presented both academia and industry. These covered a host of topics including the Internet, electronic commerce, power systems, biomedical engineering, robotic control, digital networks, wireless communications, signal processing, software engineering, electronics, and a special invited session on electrothermal processes.

2.0 Plenary Sessions

Each day of the conference began with a Plenary Session, for a total of four. The first Session featured Dr. Robert T.H. Alden of McMaster University, whose topic “Putting Your Course on the Web” was of particular interest to the many attendees from academia. Dr. Alden is well known within IEEE for his monthly column in The Institute “Travelling the Information Highway”.

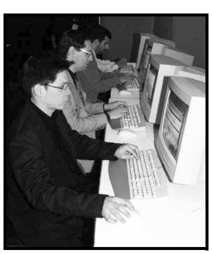
The second day of the conference featured parallel plenary sessions, one in Power and one in Communications. Dr. Roy Billington of the University of Saskatchewan enlightened the audience on the challenges of ensuring the continuation of a reliable power supply in the face of the major restructuring that the electric power industry is now experiencing in North America and in many parts of the world.

Dr. Ibrahim Gedeon, Vice-President of Global Data Network Engineering for Nortel Networks spoke on the technical enabling strategies that would permit collapsing of the traditional OSI communications network. According to Dr. Gedeon, the dawn of the Optical Network is upon us.

The final session was applicable to virtually all aspects of engineering, as Dr. Armin Eberlein of the University of Calgary explained the fundamentals of “Requirements Engineering”. Several examples illustrated the crucial importance of requirements engineering to overall project success.

3.0 Exhibits and Technical Tour

Nine exhibitors provided participants with the opportunity to interface with government and industry representatives. Representatives of the IEEE Financial Advantage program were on hand to explain the benefits now available to Canadian Members for the first time.



A very popular exhibit was the bank of computers supplied by TARA, which in conjunction with MTT Mpowered PC™ provided delegates with high-speed Internet access. TARA, the Telecom Applications Research Alliance, also conducted tours of its research and development facility on Tuesday night.

4.0 Receptions and Banquets

At a cocktail reception on Sunday evening, delegates were welcomed to “Halifax, Canada's Smart City”, by Dr. Samuel E. Scully, Vice President, Academic and Provost for Dalhousie University and City Councilor Graham Read, P.Eng.

The keynote speaker at the IEEE Awards Banquet on Monday evening was Dr. Tom Traves, President and vice-chancellor of Dalhousie University who spoke on “Universities, Engineers, and the Knowledge Economy”. The guest of honour was Canada's first practicing engineer to hold the office of Lieutenant-Governor, Nova Scotia's own James Kinley, P.Eng.

To help the delegates master the fine art of eating a lobster, IEEE Past President Wally Read presented an insightful demonstration in full east-coast regalia, assisted by IEEE Canada Administrator Cathie Lowell.

5.0 Student Paper Awards

The two best student papers were acknowledged at the luncheon on Monday. In alphabetic order, they are “Capacity of Multiple Antenna Systems in Rayleigh Fading Channels” by Eric Gauthier, A. Yongacoglu, and J-Y. Chouinard of University of Ottawa, and “Enhancement of Vessel Contours in Retinal Angiograms”, by Nayer Wanas, Mahmoud El-Sakka and Mohamed S. Kamel of University of Waterloo and University of Western Ontario. The papers will have the opportunity to be published in the Canadian Journal of Electrical and Computer Engineering.

6.0 Post-Conference Proceedings Sales

Those who could not attend have the opportunity to purchase the Proceedings at a discount price. They are available on a fully indexed CD-ROM or a two-volume, 1300-page hardcopy set. Visit the Conference web site http://is.dal.ca/~ccece00/ for prices and ordering information.

7.0 CCECE 2001

Next year's conference will be held in Toronto, Ontario, on May 13-16 2001. Visit their web site at http://www.ieee.ca/~ccece01, or e-mail c.lowell@ieee.ca.

R.W. Creighton, P. Eng,
IEEE Canadian Atlantic Section

Amethyst Group Dancers entertained at the Banquet

IEEE Canada Awards Presentation in May 2000 at CCECE'2000, Halifax, NS

John Lodge (left) received the Outstanding Engineer Award

Nicolas Georganas (left) received the McNaughton Award from Celia Desmond, President of IEEE Canada

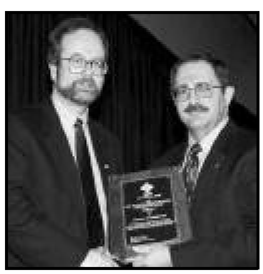
Wally Read (left) received the Outstanding Service Award

David Vice (left) receives the Reginald A. Fessenden Award from Celia Desmond

Absent was Clarence de Silva who received the Outstanding Engineering Educator Award

Paul Fortier (left) received the Eastern Canada Council Merit Award

Bill Kennedy (R) received the Edward F. Glass Western Canada Council Merit Award from Mrs. Glass (L) and her son Mr. Glass (C)



Robert Creighton (left) received the RAB Award for services from Dan Benini, IEEE

Ferial El-Hawary (left) received the RAB Award for services from Dan Benini, IEEE

Some of the recipients of the IEEE Third Millennium Awards were presented with their medals and certificates (below) by Celia Desmond. For other award winners see page 29.

Robert Alden (left)

Ray Findlay (left)

Vijay Bhargava (left)

Mo El-Hawary (left)

Om Malik (left)

Gentlemen Engineers: The Working Lives of Frank And Walter Shanly

by Richard White

published by the University of Toronto Press in 1999

(ISBN 0-8020-0887-9)

The Engineering Institute of Canada (EIC) published in 1957 a book called *Daylight Through the Mountain,* which contains an account of the lives and letters of the Shanly brothers, edited by Frank Walker and researched by Gladys Walker. As the Walkers noted, Walter Shanly was - at the age of forty - the general manager of the longest railway in the world and was later to sit as a member of Parliament, while Frank Shanly built more miles of railway in Canada than any engineer prior to the construction of the transcontinental railway to the Pacific. Both were also successful consulting engineers. But this book is devoted principally to the brothers' letters and the narrative material is limited to the first 60 of its 400-odd pages.

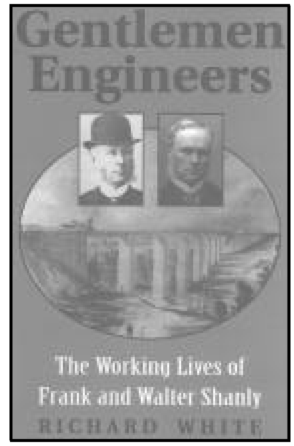
More recently, the lives of the Shanlys have been captured by Richard White, who has also made an important contribution to the history of the beginnings of the engineering profession in Canada by devoting 200 pages of his book to an eminently readable and strongly narrative biography of the brothers, followed by 50 pages that include the index and bibliography as well as extensive textual notes. The selection of photographs is also interesting. As well, White's book has a strong element of social history, not only of engineering in Canada in the mid-to-late 19th century, but also of the transition of a family with roots in the rural Irish gentry into a group of related individuals operating as North American urban professionals. The research for this book was originally done for academic thesis purposes within the Department of History at the University of Toronto. White is currently a free-lance historian and university-level teacher.

The book is in three parts. The first covers the Shanly family background in Ireland and its emigration to Canada. It goes on to describe how Walter and Frank learned the business of engineering and the contributions both made in the mid-1850s to the building of what became the Western Division of the Grand Trunk Railway of Canada. The second takes Frank's career from 1855 until his sudden death in 1882, and Walter's from 1855 until his death at forty-four years. The third part is quite short and is a discussion of the author's thesis that the Shanly brothers were indeed gentlemen engineers.

White notes that the Shanlys were originally Celtic Catholic gentry whose lands were confiscated by the English. By the time James Shanly and his family emigrated to Canada in 1836, they had become Anglo-Irish and Anglican. In Canada they were part of the British group. James had been a city lawyer in Dublin who turned to rural estate management and lived relatively well in this profession and as a country gentleman. He and his first wife had eight children, of whom Walter was the fifth (born 1817) and Frank the last, at whose birth (in 1820) Mrs. Shanly died. With his second wife, James has three more children.

The emigrants included the parents, the five surviving boys from the first family, and two boys and a girl from the second. Their reasons for leaving Ireland were complex - the influence of Irish politics, the loss of the family lands, the prospect of an insecure retirement for James, and lack of career opportunities for the seven boys in the family. After a number of stopovers on the way, James built a substantial home and farm at Thorndale, north of London, Ontario, intending to establish a life-style as a country gentleman and a secure base for his large family. But in these he was not successful. The problem lay, in White's view, not in the desire of James Shanly to be a gentleman in Canada, but in trying to be a country gentleman. Nor, after the first enthusiasm for the pioneering life had worn off, did the situation appeal to the younger generation and, one by one they left home.

Walter had made friends with a neighbouring family, also from Ireland. But two years after arriving, Hamilton Killaly had given up farming and returned to his original profession of civil engineering. He worked first on the Welland Canal and, in 1840, was appointed to chair the new Board of Works for the Province of Canada. Later that year, he took Walter - then 23 - to Montreal with him to begin his training as civil engineer. His first two jobs - with the Board of Works on the Chambly Canal and with the Trustees of Montreal Roads - were short-lived. However, in July 1841 he was appointed to the engineering staff of the Beauharnois Canal. This was to be his first long-term job, and the one on which he learned to "engineer" in the professional sense. When it ended for him in November 1845, Walter had done what he set out to do and now called himself a civil engineer. The Board continued to employ him on different assignments until the summer of 1846 when, following the replacement of the Board by the Department of Public Works, he was assigned to the Welland Canal to work under Samuel Keefer.



Frank's decision to become a civil engineer took longer to reach than his brother's. In his younger years and in comparison with Walter, he was bolder, less disciplined, less reliable and more attracted to fun and parties and the sowing of "wild oats" than to work. Frank did work periodically on the family farm and, from 1840, in the small milling and distillery enterprises set up by his father at Thornbury. He also had jobs away from home. But by the summer of 1846 he had written to Walter to ask what he should be studying to enter the civil engineering profession - and about job prospects in it. Neither Walter nor Killaly was able to help Frank regarding the latter. But by the end of the year, at the age of 26, he had found himself a temporary position on one of the preliminary surveys for the Great Western Railway, working out of Hamilton, and left home for good. This job lasted until August 1847. Frank then tried, unsuccessfully, to find work in the United States before accepting an offer from Walter to assist him on the Welland and to study some more for the profession. This was the first - but by no means the last - time the brothers worked together. For both of them, this job ended in July 1848 when the Department ran out of money.

By October Frank had found work as an office assistant with the Northern Railroad of New York on the construction of its line from Ogdensburg to Rouse's Point on Lake Champlain. He reported back to Walter that the company wanted him as well and, in November, he joined the project and initially took charge of the Eastern Division. This was Walter's first railway job. But he found that, while some parts of the job were new to him, much of his canal experience could be applied to railway construction. In the spring of 1849, after reorganization within the company, Walter became the resident engineer for the western part of the line, with Frank as his assistant. At this time, Frank was gaining valuable experience in construction management, but was weak on design. Walter did all he could to supplement Frank's knowledge and experience in both of these aspects of civil engineering. Fortunately, he was a fast learner. Walter remained with the Ogdensburg line until January 1851, when he came back to Canada to be chief engineer of the proposed Bytown and Prescott Railway. Frank had moved on over a year earlier to work on the enlarging of the Union Canal in Pennsylvania, where he remained until November 1851. Around this time he began calling himself a civil engineer.

Looking back on the brothers' apprenticeships "on-the-job," Richard White concludes that ....."All in all, it was an unpredictable and uncertain process that Frank and Walter had to follow to become engineers. Unregulated the profession may have been, but easily accessible it definitely was not. In fact, seeing how precarious the process was for Frank and Walter, as well as how completely the profession was controlled by established engineers, one is tempted to think that gaining entry to it in those unregulated years was harder than it would become later in the century after formal education and strict professional accreditation had been established." At the same time, White concludes that Walter had a much stronger commitment to independence within the profession than had Frank.

In the case of the Shanly brothers, it is also important to add that their ability to learn and practice engineering was helped significantly by the "off-the-job" classical education they had received privately in Ireland and by observation of how their father combined the law with estate management accounting, report writing and other personal skills.

From 1852 to 1856 the Shanly brothers engineered the railway that began life as the Toronto and Guelph. It later became the Western Division of the Grand Trunk Railway and was extended from Guelph to Sarnia. Walter was chief engineer of the Division, and Frank a step below him as the resident engineer. In White's view, it was the GTR project that proved their competence as well as their separate abilities and set them up for the rest of their careers. It was also a period during which the Shanly brothers worked closely with Casimir Gzowski, whose company held the construction contract for the line. His methods were not always acceptable to Walter who, generally speaking, did not have a high regard for contractors. But after administrative changes affecting the Western Division and the contract, Frank effectively worked for Gzowski rather than Walter - who, by then, had begun to build an extensive railway and canal consulting practice that occupied him on and off for the rest of his career. For Frank, the GTR project also represented an end to his "wild oats" years - but not to his risk-taking, expensive habits or debts. He was married in September 1853 and over the next 20 years he and his wife had eleven children, not all of whom survived childhood. Walter never married. In 1856, Walter was 39 years old and Frank 36.

After the GTR and some "lean" months, Frank went to work for the next three years for the Welland Railway. Not sharing his brother's disdain for contracting, Frank then contracted to reconstruct the Northern Railway's line from Toronto to Collingwood. By the time this work was finished in 1862, the civil war in the United States had reduced the demand in Canada for the new railway and other construction. So for the mid-1860s - and having money problems - Frank turned to consulting.

In 1856, while still employed on Grand Trunk work, Walter undertook to lead a survey, for the Department of Public Works, of a canal route from Ottawa to Georgian Bay by way of the Mattawa and French Rivers. However, early in 1858 and before the canal report was written, he was appointed general manager of the entire GTR system. But problems within the senior company management led to Walter being appointed general traffic manager, but still the principal manager within the GTR. The GTR's troubles continued and, following a royal commission report, Walter resigned in March 1862. For him, it had not been a major accomplishment. Surprisingly, however, instead of returning to civil engineering he turned to politics and to business.

Grand Trunk Railway Bridge over River Eramosa at Rockwood, Canada West, c 1860. One of the splendid stone-piered bridges built by the Shanly brothers.

Both Frank and Walter Shanly ran as conservatives for senior elected political office - which was rare for engineers and always has been, and possibly unique for engineer brothers. Walter was elected to the Legislative Assembly of the Province of Canada in June 1863 as the representative of the South Grenville riding, where he owned property. In 1867 he was elected to the House of Commons for the same riding. He ran again in 1872, but was defeated, as was Frank in his one and only attempt to win the Toronto Centre seat. As an engineer, Walter's presence as a parliamentarian was appreciated and his committee assignments reflected his professional, consulting and business expertise. He spoke in the Assembly and the House principally when matters involving this expertise arose. He took little part in most debates on national issues.

In the summer of 1865, Walter Shanly was elected president of the Edwardsburg Starch Company in Eastern Ontario - a position he held for over 20 years. ESC was a small industrial concern founded by two English immigrants in 1858. Over the years, it was a successful venture whose interests Walter supported in the House of Commons. Walter also became interested in the Mechanics' Bank in Montreal, which did reasonably well during the good years of the 1870s but which failed in 1879.

The civil engineering project for which the Shanly brothers are perhaps best remembered is the construction of the $5 million, five-mile long Hoosac Tunnel near North Adams, Massachusetts, the story of which White tells in his chapter on Walter's later career. Originally, Frank and Walter formed a partnership to bid on the Hoosac job, although it was Walter who pursued the contract. It was signed on Christmas Eve 1868. The following morning that Walter wrote a letter to Frank in which he said..... "If there is any of the old fire left in us, we must wake it up in this Hoosac business. I believe we can let daylight through the mountain in four years....."

It took six years to excavate the tunnel to its full size. Walter had to carry the main construction management burden after Frank dissolved their partnership in October 1871, having found - White suggests - that working with his brother was less enjoyable than it had been earlier. Frank had also undertaken other railway construction contracts in Pennsylvania and Ontario with other partners, in the course of which he managed the laying of many miles of track. But in doing so he acquired significant debts. By March 1873, Walter was actively helping to mitigate these, in part because he had co-signed some of the bank loans. Frank was saved, but his career as a contractor was effectively over - to his great disappointment. In White's view, the major problem was that Frank could never keep a job on schedule and the delays that occurred added to his costs.

By 1875 Frank had returned to consulting, doing mostly inspections and post-contract arbitration. But in October of that year, he was quite unexpectedly appointed engineer to the City of Toronto, with primary responsibility for street paving and sewer construction. The problem in this case was that, while he knew civil engineering, he was not used to being an employee or having politically elected people tell him what to do. He remained a consultant and put together several contracting proposals, taking time out from his regular work to pursue these projects. The city fathers were not impressed. He was freed from them in June 1880 when he was appointed chief engineer of the Intercolonial Railway, with the job of sorting out contractors" claims that had remained unsettled since the line's completion four years earlier. He was able to have his son, Cuthbert, appointed as his secretary. He travelled by overnight train between his home in Toronto and his office in Ottawa on a regular basis. But the pace of his life and work, as well as financial problems and Cuthbert's death from tuberculosis in August 1882, contributed to his own sudden death a month later at the age of 61 during one of these train trips. It fell to Walter, as executor, to settle Frank's business affairs and to provide for his young family. White concludes that..... "vain and proud Frank Shanly may have been, but he was undoubtedly and honourable man. His word was good.....If there is one sentiment that stands out in the letter of condolence Walter received from Frank's colleagues it is that Frank was admired for his integrity...."

Walter retained his seat in the House of Commons during most of the Hoosac years. His second defeat - in 1874 - coincided roughly with the end of the project. Consulting work was rare for him during these years but, when they were over, he undertook more of it - by necessity - since contracting had lost any appeal it may once have had. Consulting also gave him independence. In 1885 he re-entered politics, winning back South Grenville in a by-election. He retained the seat in 1887 but retired from politics before 1891 election.

Of particular interest to the Engineering Institute of Canada is Walter's part in the passage through the House of Commons of the charter incorporating the Institute's predecessor, the Canadian Society of Civil Engineers during the first months of 1887. The June 1937 issue of the Engineering Journal celebrating the 50th anniversary of the founding of CSCE reported that.... "The charter was carried through Parliament by one of the vice-presidents, Walter Shanly, M.P., and received Royal sanction June 23rd, 1887." In the years since then, Walter has been given varying degrees of credit for the passage of the CSCE bill. But the evidence sited by Richard White suggests that he did little more than introduce it. Given Walter's views on professionalism in engineering, White also expresses surprise that he took only a small part in the founding and management of the Society itself. He had, however, passed his 70th birthday in 1887 and was winding down his professional and business careers. Yet the reports of the annual meetings in the late 1890s indicate that he was still taking an active part in the CSCE discussion on professional status.

"Such is the curse on those who live through changing times".

As Walter's career wound down, he turned to historical research as his principal activity. He wrote about military affairs and the Loyalist settlers in Canada. He also wrote about his family's past although, with the exception of brother Frank and half-sister Ellen (Nell), he had not been close to his own or to the younger generations of it. He made his home in Montreal and died there on 17th December 1899 at the age of 82.

Richard White identifies two main themes in his narrative. He does this for good reasons - and, up front, in the Preface to his book. The first is that during the Union period before Canadian Confederation there was..... "a much more mature and respectable (civil) engineering profession than historians have heretofore recognized." It was not formally organized until 1887 and it predated the profession - based on mechanical and other disciplines as well as the civil one - that emerged from the industrialization of the later 19th century. The second is that members of the old landed gentry who emigrated from the British Isles to Canada during that same century struggled to make the transition....."to the culture of modern industrial capitalism." These themes, White maintains, support his thesis that the brothers were indeed gentlemen engineers and that they were gentlemen before they were engineers. But White also says, in the last paragraph of his book...."the story of Frank and Walter Shanly is not a happy story. It may be one of accomplishment, but it is not one of fulfillment. Neither Frank nor Walter ended his life in circumstances he would have chosen..... (Their) unfulfillment and thus their tragedy comes not so much from their financial failures as from their maladaptation. Like their father, they were most at home in the generation from which they came. Such is the curse on those who live through changing times.

So this book raises two much broader questions. First: how well have immigrant engineers as a group adapted to the Canadian environment? And second: how well have Canadian-born engineers adapted to changing times? But it also raises a third question: now that we have two substantial works on the Shanlys, who's next?

Reviewed by Andrew H. Wilson
Past President, EIC, Nepean, ON.

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Richard White's book was published with the help of a grant from Humanities and Social Sciences Federation of Canada, the Canada Council for the Arts and the Ontario Arts Council. It retails for $60. Order enquiries to the U of T Press at 5201 Dufferin Street, North York, Ontario, M5H 5T8.

Véhicule tout-terrain amphibie de l'écurie « ÉTS »: des étudiants se préparent à la compétition de Mini Baja

Montréal - le 10 mai 2000. Une équipe d'étudiants de l'ÉTS participera à la compétition 2000 Mini Baja East les 11, 12 et 13 mai prochain au Mont Chanteclerc à Sainte-Adèle où elle se mesurera à 37 autres équipes provenant d'universités canadiennes et américaines. Contrairement à ce que son nom peut laisser imaginer, un Mini Baja n'est pas un petit génie sorti d'une lampe magique - bien qu'une bonne dose de génie soit utile à sa conception - mais plutôt un véhicule tout-terrain amphibie faisant chaque année l'objet d'une compétition régionale de la prestigieuse Society of Automotive Engineers (SAE).

Pour les participants, le défi consiste à concevoir et à construire en équipe un véhicule tout-terrain capable d'affronter l'eau et les terrains les plus accidentés. « Cette compétition propose un projet stimulant qui comporte des tâches de planification et de fabrication propres à l'introduction de nouveaux produits industriels sur le marché » explique René Legault, Directeur de Recherche et Développement chez Paradox Security Systems et diplômé de l'ÉTS, qui est l'un des co-organisateurs de l'événement. « General Motors, l'un des principaux commanditaires de l'événement, en profitera d'ailleurs pour organiser un souper et faire sa campagne de recrutement auprès de ces futurs ingénieurs » ajoute-t-il. On estime qu'il faut un budget d'environ 30 000 $ pour organiser cette compétition et coordonner le travail des nombreux bénévoles. Parmi les autres commanditaires principaux, on retrouve SAE, Briggs & Stratton, Honda, l'ÉTS, Paradox Security Systems et Novabus.

Pour l'édition 2000 du Mini Baja, chaque équipe a reçu un moteur de 10 Hp de la Briggs & Stratton Corporation au mois de février dernier. Ce moteur ne doit subir aucune modification. Toutefois, dans le respect de quelques règles strictes de conception et de sécurité, les étudiants ont le champ libre pour la conception de plusieurs éléments du véhicule et pour le choix des matériaux. Dirigée par Hugues Maltais, finissant en génie mécanique, l'équipe de l'ÉTS compte 10 membres qui travaillent depuis juin dernier à la conception du châssis de leur Mini Baja. L'équipe a repris le design du véhicule utilisé lors de la dernière compétition - design qui a déjà fait ses preuves - en y apportant quelques corrections. Cette transmission des connaissances d'ex-participants du Mini Baja aux nouveaux participants permet d'améliorer sans cesse les performances du véhicule.

Échelonnée sur trois jours, la compétition comporte des épreuves statiques et dynamiques ainsi qu'une course où les véhicules doivent effectuer le plus grand nombre de tours en 4 heures sur un parcours accidenté créé spécialement pour l'occasion au Mont Chanteclerc. Les épreuves sont destinées à mesurer l'endurance, la force, la manœuvrabilité sur le terrain et dans l'eau, la suspension, l'accélération et le freinage. L'une de ces épreuves consiste à remorquer un autobus Novabus en position neutre sur une distance de 40 pieds !

La compétition Mini Baja a lieu trois fois par année en Amérique du Nord dans trois régions différentes : Ouest, Centre Ouest et Est. Seule la compétition de l'Est exige des participants qu'ils conçoivent un véhicule amphibie. Par ailleurs, à tous les trois ans, Montréal se retrouve l'hôte du Mini Baja. En 1999, l'Université de Sherbrooke a remporté la palme à la compétition de l'Est et l'équipe de l'ÉTS s'est classée parmi les 10 meilleures équipes. L'ÉTS participe également à la compétition dans le Centre Ouest qui rassemble plus de 100 participants chaque année; elle s'y est classée 3e sur 102 à la dernière compétition. Outre le prestige rattaché à cet événement, les participants ont l'occasion de mettre en pratique leurs apprentissages, de démontrer leur savoir-faire et de rencontrer des employeurs potentiels.

Hugues Maltais est confiant que le véhicule de l'ÉTS a toutes les chances de se classer parmi les meilleurs à cette prochaine édition du Mini Baja. Nous espérons que le génie - dans tous les sens du mot - sera au rendez-vous pour lui et pour ses co-équipiers à Sainte-Adèle!

...... And we moved to the U.S.

After almost 20 years in Canada, I moved with my family to the U.S. on an offer I could not refuse. The pay was good, and in US $ which by itself gave a 40% raise. My company was in need of skilled manpower and offered many side benefits, like a bonus, generous relocation allowance and a challenging work environment. Yes, there was a drawback as well, and that was the small town setting where we moved to in the Midwest. After living in a cosmopolitan metropolis like Montreal with such cultural diversity, the Midwest seems isolated.

My daughter joined a large local public high school with many nice teachers. She made friends fast. She was an instant hit at school for knowing French so well.

Surprisingly, petty crime is very rare. It is not uncommon to see unlocked cars in shopping centers. Police are generally quite friendly and helpful. People hold doors open if they see somebody coming. Even city clerks smile!

There is a tremendous explosion of work all around. Close to 0% unemployment in some midwestern towns is not uncommon. The pay has also gone up substantially because of competition. Job turnover is tolerable, as people who work here need to change town or state to get a better position, and many are tied to the local towns through birth or family attachments. Generally people are religious and church-going. Family is the main center of family life. So, at night there is little traffic in the downtown areas as there is virtually no nightlife.

I moved from Canada to U.S. for a variety of reasons, which are:

- **Lack of opportunity in Canada** - There is a greater opportunity to grow in the U.S.
- **Better pay** - I was getting tired of the 2-3% pay hikes and the pay scale was nothing to be proud of in the first place. Moreover, currency conversion rate makes the pay here even more lucrative.
- **Economic stability** - Instability directly affects the economic health of people. Generally, real estate (in the form of a home) is the main source of savings for most people. If real estate values plummet, so do people's savings. We were concerned about our future savings.
- **Comparatively warmer climate** - Though we moved south a few degrees in latitude, it is still cold though not as much as Montreal.
- **Less crime** - A much better place to bring up your children. However, it gets suffocating for adults after a few months and a short pilgrimage to a larger city often helps.

I wonder sometimes whether my move to U.S. really brought me the pot of gold at the end of the rainbow. Income tax is not that low compared to Canada. Medical and dental insurance is something we pay for from our pockets. We also pay a part of the doctor's visit fee. Medicines are somewhat subsidized through insurance, but they are often more expensive than Canada. However, medical service is excellent. One does not wait long even at a hospital emergency centre. So, for a normal healthy adult there is more to gain, but it is not so for somebody who needs constant medical care. Canada is still a much cheaper place.

As a working engineer, my future growth depends on the prospects and viability of the company where I work. In that sense, I am more optimistic that I made the right decision. I also work at the cutting edge of technology, which enhances my skills. People say work in U.S. is very competitive and strenuous. This may be true in the big cities; but in the Midwest, life is comparatively relaxed and less strenuous.

We still do miss our friends, ethnic diversity and the old familiar places in Canada.

Satya Roy

Mid-West, USA

Subject: Moral of the week

One day an expert in time management was speaking to a group of business students and, to drive home a point, used an illustration those students will never forget.

As he stood in front of the group of high powered overachievers he said,

"Okay, time for a quiz."

Then he pulled out a one-gallon, wide-mouth Mason jar and set it on the table in front of him. He then produced about a dozen fist-sized rocks and carefully placed them, one at a time, into the jar. When the jar was filled to the top and no more rocks would fit inside, he asked, "Is this jar full?"

Everyone in the class said, "Yes."

The expert said, "Really?"

He reached under the table and pulled out a bucket of gravel. Then he dumped some gravel in and shook the jar causing pieces of gravel to work themselves down into the space between the big rocks. He asked the group once more, "Is the jar full?"

By this time the class was on to him.

"Probably not," one of them answered.

"Good!" he replied.

He reached under the table and brought out a bucket of sand. He started dumping the sand in the jar and it went into all of the spaces left between the rocks and the gravel. Once more he asked the question, "Is this jar full?"

"No!" the class shouted.

Once again he said, "Good."

Then he grabbed a pitcher of water and began to pour it in until the jar was filled to the brim. Then he looked at the class and asked, "What is the point of this illustration?"

One eager beaver raised his hand and said, "The point is, no matter how full your schedule is, if you try really hard you can always fit some more things in it!"

"No," the speaker replied, "that's not the point. The truth this illustration teaches us is: If you don't put the big rocks in first, you'll never get them in at all."

What are the 'big rocks' in your life? Your children....Your loved ones.... Your education....Your dreams....A worthy cause...Teaching or mentoring others...Doing things that you love....Time for yourself.....Your health....Your significant other.

Remember to put these BIG ROCKS in first or you'll never get them in at all. If you sweat the little stuff (the gravel, the sand) then you'll fill your life with little things you worry about that don't really matter, and you'll never have the real quality time you need to spend on the big, important stuff (the big rocks). So, tonight, or in the morning, when you are reflecting on this short story, ask yourself this question: What are the 'big rocks' in my life?

Then, put those in your jar first.

Bob McLoud

Markham, ON

Golden Rule:

The man (or woman) with the gold, ...rules.

Managing Transformer Overload - Smart Relays

by Dave Fedirchuk and Curtis Rebizant
APT Power Technologies, Winnipeg, MB

Abstract

This article provides an overview of a smart relay for transformer protection, monitoring and overload control based on the IEEE C57.91-1995 standard. Application of this IEEE standard with a suitable relay enables adaptive overload, automated load shedding and predictive overload early warning system functions to be integrated into the protective relay. The standard is introduced and the related functions and their applications are then described.

Sommaire

Cet article fournit une vue d'ensemble à propos d'un relais intelligent servant à la protection, la surveillance et au contrôle des surcharges des transformateurs, le tout selon la norme C57.91-1995 de l'IEEE. L'application de cette norme dans un relais approprié permet d'intégrer, dans le relais protecteur, des fonctions de surcharge adaptée, de délestage automatisé et de prédiction préventive de la surcharge du système par une alerte. Après avoir discuté de la norme et des fonctions qui en découlent, cet article décrit les applications reliées au relais intelligent.

1.0 Smart Relays - what they do

Power utilities have for along time relied on protection relays (electromagnetic and first-generation digital relays) to perform only a single isolated task - fault protection. This was for a number of reasons but mainly due to limited processing power. With the advent of second-generation digital relays using powerful high-speed digital signal processors (e.g. DSPs), the protective relay is able to process the usual protection functions safely and effectively with processing overhead to spare. This additional processing capacity permits the relay to do more than just provide standard protection. These digital relays combined with a Windows-driven relay setting environment provides increased input/output capability, digital fault recording and asset management functionality in powerful yet simplified solution. Such asset management functionality allows protection relays, for example, to provide transformer temperature and overload monitoring. This article discusses the use of a “smart” relay that provides both fault and overload protection of a power transformer.

Transformers are one of the more costly pieces of equipment found in a utility's inventory (see cover photo). De-regulation and on-going business dynamics continuously pressure utilities to do more with less. This creates a growing need for tools to assist in not only transformer protection but the intelligent monitoring of their activities, status and history - smart relays fit the bill. Sometimes overcurrent relays are set to provide fault protection and also provide some level of overload protection. In many cases, the overload aspect of transformer operation is handled by Control Center load dispatchers as this function is too complex for most simple overcurrent relays to effectively handle.

2.0 Basis for Overload Detection

The smart transformer relay framework for overload management is already defined by the IEEE C57.91-1995 transformer load standard. This transformer standard presents the terms that define the transformer “hot-spot” calculation. With information from the top-oil, ambient temperature, current and voltage transducers inputs, the smart transformer relay is able to provide a unique asset management functionality. This functionality includes overload tracking with the temperature (adaptive overload), automated load shedding based on temperature and/or current levels and predictive overload early warning. Combined with loss of life estimation, the smart transformer relay provides protection, monitoring and control for the transformer in one integrated box.

The cornerstone of the smart transformer relay is the ability to model the transformer behavior by an acceptable method. The 'hot spot' temperature - indicated by the 'winding temperature' gauge - is a value that warns of insulation deterioration at some point in a transformer. It is recognized as the single best indicator that a transformer is in an overload state. The calculation method is the subject of a recent IEEE Standard (Guide): C57.91-1995 [1].

$$\frac{dL}{dt} = e^{(39.164 - 15000/(T_{hs} + 273))} \qquad (1)$$

where L is the accumulated loss of life of the cellulose insulation, in per unit and T_{hs} is the hot-spot rise temperature. If T_{hs} = 110°C then dL/dt is 1.00. As a rule of thumb, the rate doubles for every 7°C rise in T_{hs}.

The IEEE standard [1] indicates 180,000 hours or 20.6 years is the normal life (meaning normal solid insulation life) based on a continuous operation at the design hot-spot temperature of 110°C. It is related to the loss of tensile strength or degree of polymerization retention of the solid winding insulation (page 10 of the Standard). The above nonlinear formula relates the rate of loss of life to other values of hot spot temperature as in Table 1.

Note that operation at the 'oil bubbles' condition is thought to be acceptable for a short time, because the bubbles will re-dissolve when the oil cools. Taking this basic model and implementing it in a smart transformer relay creates a wide range of unique protection, monitoring and control devices in one integrated platform (Figure 1).

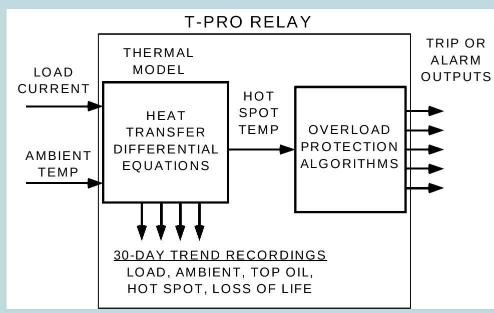

Figure 1: Smart Transformer Relay Model

Table 1: Rate of loss of life to other values of hot spot temperature

Hot Spot Temp. (°C)	Rate of Loss of Life relative to normal
110 (design value)	1
117	2
124	4
131	8
139 (oil bubbles?)	16
147	32

3.0 Adaptive Overload

With the IEEE standard, smart transformer relays are able to detect overload conditions based on calculated hot spot temperature and react in an intelligent manner. By their nature, utilities tend to be conservative so transformer loading is often setup to utilize the transformer at a moderate loading level (e.g. 70% to 120% of nameplate load set as overload limit). There are, however, large savings to be realized by increasing transformer load in a controlled low risk manner thus improving utilization of these transformer assets.

If you have a known overload threshold at ambient temperature, then you can adjust the overload setting based on three approaches: summer/winter setting, ambient temperature and loss of life.

3.1 Approach 1: Summer/Winter Settings

Referring to Figure 2, one can assume a worst-case summer temperature and a worst-case winter temperature, and manually change the relay pickup settings accordingly. Of course, the ability to do this through a communication link is very convenient.

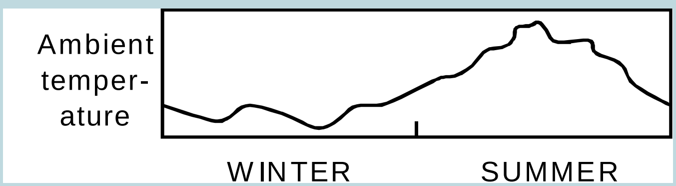

Figure 2: Summer/Winter Settings

3.2 Approach 2: Ambient Temperature

The 'coarse' summer/winter approach above can be made automatic by using a relay and an ambient temperature probe (Figure 3) to sense ambient temperature information. The adaptive pickup levels are defined by the curves of Figure 4. For example, if

- Ambient temperature is 30^{o}C, and
- Rate of loss of life is to be limited to 'normal' or 1 times, i.e. a hot spot temperature of 110^{o}C,

then the pickup is automatically set to 1.0 per unit current. If the ambient temperature is -10^{o}C then the pickup adjusts to about 1.3 per unit. If one allows higher rate of loss of life, for a short time, then higher loads can be tolerated, that is, the inverse-time curve moves upward.

Figure 3: Ambient Temperature Probe

3.3 Approach 3: Loss of Life

In this approach, the overloading condition is sensed as overtemperature rather than as overcurrent (Figure 5). This idea is closely related to the 'emergency overloading' guidelines of the Standard [1]. In other words, the principle is that a transformer can be loaded beyond its rating if one pays close attention to the effect of hot spot temperature on the loss of life. Inverse-time over-current can still be used beyond 2 per unit current, for fault protection.

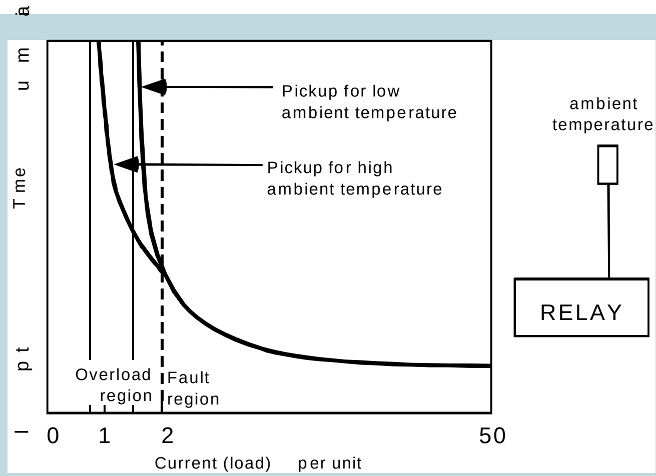

Figure 4: Adaptive pickup level for an inverse-time overcurrent relay

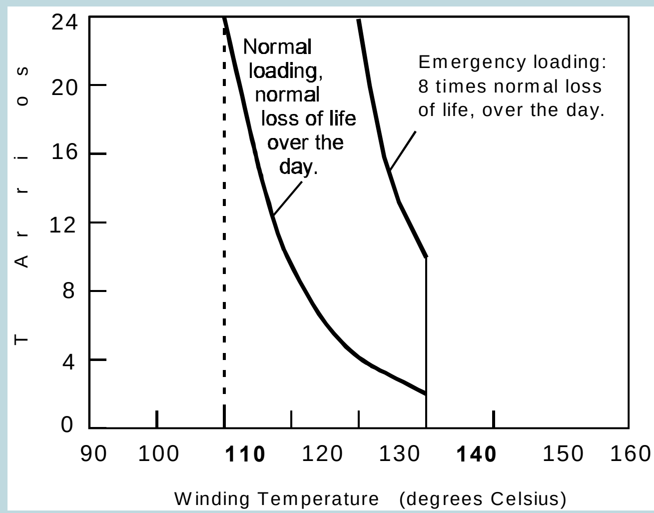

Figure 5: The inverse-time overtemperature relay characteristic

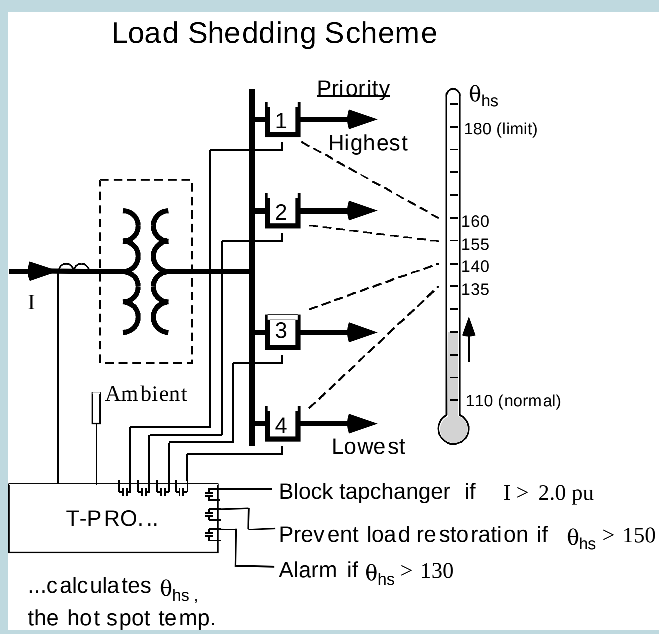

Figure 6: Transformer Relay - Load Shedding Model

4.0 Priority-Based Automatic Load Shedding

Yet another application of the IEEE transformer loading standard with a "smart" relay is the ability to monitor both the transformer's current and/or temperature and set multiple prioritized overload levels for alarm or trip. This gives the utility the ability to provide preferential service to customers and avoid unnecessary full-load transformer trips. In addition, the tapchanger can be blocked if current is above a user-defined setting and prevent load restoration if hot-spot temperature is greater than a user-defined level (Figure 6).

4.1 Transformer Load Management - BC Hydro Example

BC Hydro's Northfield Substation Project (located on Vancouver Island) has two identical 30/40/50//56 MVA, 138/25 kV Canadian General Electric transformers. In conjunction with these transformers they are using two T-PRO relays from APT Power Technologies with ambient and top-oil temperature probes. One T-PRO is used for transformer protection and hot spot temperature monitoring and the other T-PRO is used for transformer hot spot temperature monitoring only. The purpose is to detect a transformer overload condition that might occur under rare contingencies, then initiate an alarm and staged load shedding of feeders.

In the first T-PRO application, the relay is used for differential protection and load shedding with top-oil and ambient temperature inputs. The purpose is to detect when the transformer overload condition occurs and then initiate an alarm back to the Control Center and to subsequently shed feeders sequentially if the overload condition persists. Additionally, T-PRO's overload level detectors blocks tap changer control. Load restoration is blocked until load drops to a certain level then is restored manually by the operators.

The second T-PRO application duplicates the overload protection function of the first.

5.0 Predictive Overload System

Moving one step ahead of standard relay trip and alarm actions is the ability to predict when overload will occur and provide a 30 and 15 minute warning back to the Control Center where preventive load adjustment may be possible.

There are two approaches to monitoring the transformer overload using:

- Excessive hot spot temperature
- Excessive loss of life

The first approach, hot spot temperature early warning, has the hot spot temperature being calculated into the future every time step (e.g. five seconds) under the assumption that the load current and ambient temperatures do not change (Figure 7). If this calculation indicates that the hot spot temperature exceeds its TRIP setting (user-defined), then a 30 and/or 15 minute warning alarm is activated. Further implementation has a time-to-trip option over a SCADA communication channel (e.g. Modbus or DNP 3).

The second predictive overload monitoring approach uses an excessive loss of life warning. This overcomes a difficulty with simple over-temperature as an indication of overload. As an example, suppose the hot-spot temperature trip setting is 140°C. If the temperature hovers at values just below that level, then there will eventually be unacceptable damage to the cellulose insulation, but no trip will occur (Figure 8). Also, if the temperature briefly exceeds the setting but then falls back to normal levels, a trip should not occur, but will (Figure 9).

These reliability and security issues can be overcome by using the "loss of life" concept. By providing a predictive warning (e.g. 30 and 15 minutes warning) back to a utilities control center for load dispatch where corrective action can be taken.

5.1 Predictive Overload - Manitoba Hydro Whiteshell Example

Manitoba Hydro's application of predictive overload involves a Westinghouse step-up 115kV to 230kV transformer with a series phase shifting unit. A previous disturbance in the Whiteshell area of Manitoba resulted in the overcurrent relay pick-up and trip of the main transformer. If the overcurrent relay had a higher trip setting and more time before tripping, then Manitoba Hydro load dispatchers may have been able to change the load and prevent the overcurrent trip.

Using a T-PRO relay, Manitoba Hydro is able to send an alarm through their Modbus SCADA system indicating the time left before tripping. This provides the operators with an early warning indictor that allows them to respond to overload condition 30 and 15 minutes in advance. The overcurrent relay can still be set to trip in fault overcurrent conditions, typically about 200% of nameplate capacity, while allowing the T-PRO's TOEWS© (transformer overload early warning system) application to provide protection against overloads. The predictive overload system gives the operators an opportunity to adjust the system prior to damaging transformer overload conditions.

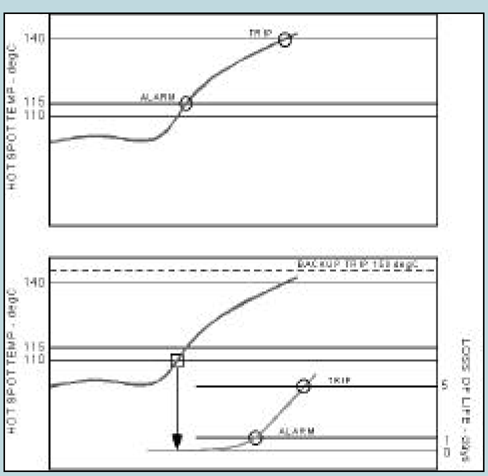

Figure 7: Simple Overload

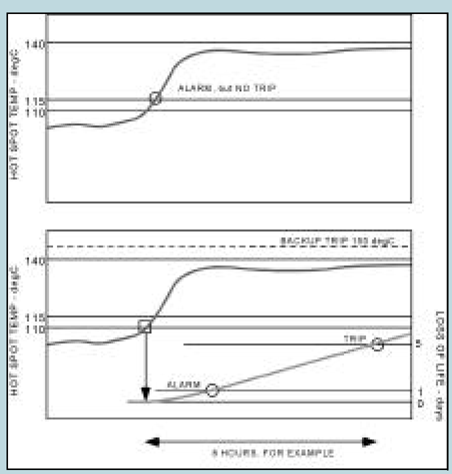

Figure 8: Sustained Moderate Overload

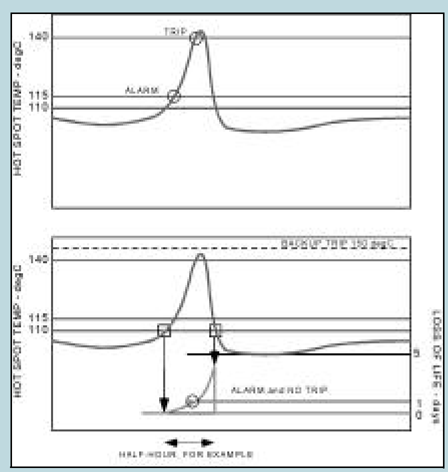

Figure 9: Short-Time Severe Overload

6.0 Conclusion

The ability to protect, monitor and control utility transformer assets in one integrated platform is now possible with improved processing power and simplified Windows-driven interfaces. IEEE transformer loading standards provide the framework by which smart relays can include adaptive overload based on temperature, automated load shedding and predictive overload early warning. Transformer overload issues are becoming more critical as market demands change and utility systems are pushed harder. In the end, utilities are able to provide a secure reliable protection system that also incorporates overload monitoring and control. This ensures minimal impact on the end-user and manages transformer-loading risk on the transformer with the potential for introducing economic benefits by improving transformers utilization.

7.0 Acknowledgments

Special acknowledgment to Manitoba Hydro and BC Hydro for their contribution to the examples. Also, acknowledgment to Dr. Glenn Swift for his insightful comments during the preparation of this article.

8.0 References

[1]. IEEE Standard C57.91-1995 IEEE Guide for Loading Mineral-Oil-Immersed Transformers.

[2]. Swift, G and Zhang, Z, “A Different Approach to Transformer Thermal Modeling,” IEEE Transmission and Distribution Conference, New Orleans, April 12-16, 1999.

[3]. IEC (International Electrotechnical Commission) Standard 354 Second Edition, 1991-09, “Loading guide for oil-immersed power transformers,” pp. 143-145.

About APT Power Technologies: APT Power Technologies (APT) has been supplying advanced technology products to power utilities for 15 years. Its products are used in the power industry for protection, monitoring and control solutions. For further information, visit the website at:

www.aptpower.com

About the Authors

Dave Fedirchuk received his B.Sc. degree in electrical engineering from the University of Manitoba in 1972.

Since graduating, Dave has spent 22 years with Manitoba Hydro in the System Performance group performing relay settings and disturbance analysis. For the last 5 years Dave has been working with APT Power Technologies as a Product Manager.

Curtis Rebizant received his B.Sc. degree in electrical engineering and his MBA from the University of Manitoba in 1986 and 1996 respectively.

Curtis has worked in international CAE firms specializing in electrical/electronic system modeling and high-voltage equipment design. He is currently Marketing Manager at APT Power Technologies.

Power Team Manitoba

Imagine that you work for a local engineering firm, and you need a left-handed monkey wrench for completion of a rush project. Where would you look for this uncommon, esoteric tool: the yellow pages? The Web? Canadian Tire? Well, in Winnipeg it would make sense to run through your mental list of other engineering organizations that might have this tool. The chances are you could arrange to borrow such a device by making a few phone calls.

There's just something about the Winnipeg milieu that seems to foster cooperation - a lot to do with both population size and the diversity of activities here. Winnipeg has a population of about 600,000 which is just about optimum in the sense that there are perhaps a hundred or so working electrical power engineers, and the city is small enough that regular **IEEE Power Engineering Society** luncheon meetings are well-attended.

What about 'diversity'? Of course a larger centre, like Chicago, has lots of diversity. But Winnipeg is just large enough that there is sufficient diversity. In the electric power area we have a major utility bigger than most American utilities: **Manitoba Hydro**. And a second utility: **Winnipeg Hydro.** And 'heavy equipment' transformer manufacturers: **Pauwels Canada Inc**. and **Carte International Inc.** And a 'light equipment' protection relay and disturbance recorder manufacturer: **APT Power Technologies**. You could call **RTDS Technologies Inc.** a 'medium-weight equipment' manufacturer of digital power system simulators. And an international consulting firm: **Teshmont Consultants Ltd**. And a major research operation: **Manitoba HVDC Research Centre** ('The Centre'). And a generator of engineering graduates and research: the **University of Manitoba** (a 'transformer' of technologically-inclined high-school students into engineers, and into advanced-degree holders).

In an attempt to encourage the Power Team Manitoba idea, a “link” Web site has been started. It's still embryonic (prototypical?), but take a look:

www.aptpower.com/ptm/

IEEE News Flash

Vijay Bhargava Elected Fellow Of The Royal Society Of Canada

Vijay Bhargava has been elected a Fellow of the Royal Society of Canada / La Societe royale du Canada for his substantial theoretical contributions to the field of third generation wireless communications systems. Vijay is a Professor at the University of Victoria and is a Past Director of IEEE Region 7 (Canada).

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On the occasion of the start of the Third Millennium, IEEE presented 3000 special awards to its volunteers from all over the world. The following Canadian volunteer members received their awards at various meetings over the year. **Congratulations to one and all! And Thanks.**

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Le congrès canadien 2001 de génie électrique et informatique prévoit un forum pour la présentation de recherche et de développement en génie électrique et informatique au Canada et à travers le monde. Des présentations sont attendues, en français ou anglais, sur les sujets suivants :

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Avis d'acceptation envoyés :	avant vendredi le 19 janvier 2001
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