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Guitar master class via IPv6 at CRC

June 8, 2011, saw some major Internet players piloting IPv6 for the day, in an effort to prompt others in the business to prepare for the upcoming transition from IPv4. With the proliferation of web-enabled devices, the world has exhausted its supply of Internet Protocol (IP) addresses under the IPv4 format of 32 bits. IPv6 addresses are 128 bits long, so the permutations will provide a vast quantity of unique IP addresses.

At the Communications Research Centre (CRC), staff from both the Broadband Applications and Demonstration Laboratory (BADLAB), and IT unit worked together to establish two IPv6 web sites, along with supporting Domain Name System (DNS) servers and network infrastructure, visible from IPv6 equipped workstations around the world. Posted for June 8, the site www.ip6.crc.ca was a clone of CRC's IPv4 web site (www.crc.gc.ca), while the site beta.ip6.crc.ca highlighted projects from the BADLAB. The June 8 demonstration was another step toward deployment of IPv6 throughout CRC.

Traffic for CRC's IPv6 Day websites was routed through CRC's connection with the Federal GigaPOP, and then through CANARIE (Canada's advanced research and innovation network) to other IPv6 participating networks. The BADLAB has been running IPv6, alongside IPv4, for some time using an IPv6 address block assigned by CANARIE.

CRC took part in a global summit on IPv6 in 2002. The event was enabled by ISABEL, a real-time collaborative working environment. Based on advanced video-conferencing features, ISABEL allows multiple locations to work together through video, audio and a shared workspace with interactive applications, all done via advanced broadband networks such as CANARIE.

CRC's involvement in ISABEL continues today. On June 16 from CRC's BADLAB, University of Ottawa professor and member of the Canadian Guitar Quartet Julien Bisaillon taught a virtual guitar master class to a university guitar student located at the Liceu Grand Theatre in Barcelona, Spain, and to three other students at *Universidad Politécnica*

CRC's New President: Dr. Jean Luc Bérubé

The Communications Research Centre (CRC) has a new President: Dr. Jean Luc Bérubé. He served as Vice-President of CRC's Broadband Network Technologies branch, and most recently, acted in the position of President after Dr. Veena Rawat retired from the federal government in early 2011.

Before joining CRC, Dr. Bérubé was Senior Manager of Field Application Engineering at Altera Corporation, and prior to that, Senior Field Applications Engineer and Market Development Manager for Motorola Semiconductors. He also worked at Nortel Networks and Canadian Marconi Company.

Dr. Bérubé holds a BSc in Electrical Engineering from the University of New Brunswick (UNB), an MScA (Génie électrique) from Montréal's École Polytechnique, and a PhD in Electrical Engineering, also from UNB.

"I look forward to working with everyone at CRC, as we work together to ensure the organization continues to be a relevant organization and an excellent research centre, focusing on the impact we can have for our stakeholders," says Dr. Bérubé.

University of Ottawa professor Julien Bisaillon teaching guitar master class, virtually, to students in Spain (on screen)

de Madrid. The class was part of the third European Network Performing Arts Production workshop sponsored by Terena, a forum to foster the development of Internet technology. The three participating sites ran the ISABEL application and connected via IPv6.

CRC-DVBDetect enables mobile reception of HD television via DVB-T

Researchers at the Communications Research Centre (CRC) have invented a breakthrough technology for the delivery of mobile television: CRC-DVBDetect. This advanced detection algorithm, incorporated into a mobile receiver, enables mobile reception of high definition television (HDTV) broadcast signals initially intended for fixed receivers.

While this development could potentially influence technologies in North America's ATSC family of standards, the impact in Europe, where broadcasters follow the DVB family of standards, is expected to be felt immediately.

Providing mobile TV services in Europe is more complex and costly than in North America. European broadcasters must send two separate signals – one to deliver fixed, terrestrial reception to the home (DVB-T) and another to serve handheld and mobile devices (DVB-H). This requires two separate transmitter infrastructures and separate radio frequencies.

"Broadcasters will not put millions of euros into a separate infrastructure without knowing if there's a market for mobile TV," says Louis Thibault, manager of CRC's Advanced Audio Systems group that developed CRC-DVBDetect. "For the time being, they cannot justify investing in DVB-H infrastructure. They are just finishing the deployment of DVB-T."

In North America, the stream of bits that represents a television signal – the bit payload – may contain a stream for fixed, terrestrial reception in the home (ATSC) and a stream for mobile, handheld reception (ATSC-M/H). Both modes are delivered using the same transmitter and the same frequency. While the equipment needed to generate the mobile stream costs in the order of $100,000, the North American standard is far more economical from a transmission equipment standpoint.

In recent years, CRC built up considerable expertise in the digital audio broadcasting (DAB) system. CRC researchers have applied their DAB expertise to other telecommunications systems employing the same modulation method, such as DVB that is employed in Europe. The resulting advanced detection algorithm, CRC-DVBDetect, enables mobile reception of HDTV broadcast signals initially intended for fixed receivers. The research team hopes to develop a similar algorithm to allow mobile reception of the terrestrial ATSC signal in North America.

How CRC-DVBDetect works

CRC-DVBDetect is simply an extra module – an algorithm – added to a DVB-T receiver. A CRC-DVBDetect-enabled receiver is capable of capturing and detecting on the move DVB-T signals initially targeting fixed receivers in the home.

Using computer simulation, Thibault's team measured vehicle speed and resulting quality of service delivered, first via a conventional DVB-T receiver, then via a CRC-DVBDetect-enabled DVB-T receiver. When a vehicle reaches 80 km/h, the quality of service delivered by conventional receivers degrades. Mobile receivers equipped with CRC-DVBDetect can travel at twice this speed, 160 km/h, and still receive quality service. Dr. Liang Zhang, one of the inventors of CRC-DVBDetect with Dr. Zhihong Hong, explains how.

"When a mobile receiver is on the move, all the frequencies of the radio signal it receives are shifted in a random manner depending on the direction and speed it is traveling relative to the source. This is called the Doppler effect," Dr. Zhang says. "Our technology estimates the Doppler-induced distortions to the signal and cleans it up. The cleanup takes place prior to demodulating the signal and performing the error correction, so we are reducing the transmission bit error rate to quite a low value."

Broadcasters don't have to deploy a separate infrastructure for mobile receivers, and manufacturers incorporating CRC-DVBDetect can keep 80 to 90 percent of their current fixed receiver design. What's more, as Thibault points out, this development opens the door to a new approach to broadcast standards setting.

"Five years ago, deploying this new technology into a receiver would not have been possible because the signal processing capability at an affordable cost was not there," says Thibault. "But with the number-crunching capabilities of chip sets doubling every 18 months, complex algorithms can be incorporated in receivers in a cost effective manner, so we are no longer forced to define two standards, one for fixed and one for mobile reception."

Origins and adaptations of the algorithm

In recent years, as DAB technology was introduced in different parts of the world, CRC built up considerable expertise in the system, which uses orthogonal frequency division multiplexing (OFDM), a modulation method that's common in many telecommunications systems. Thibault and his colleagues are extrapolating their DAB expertise to other technologies employing OFDM, such as DVB.

Another OFDM-based system is 3GPP-LTE (3rd Generation Partnership Project, Long Term Evolution), the latest standard in mobile telecommunications networks. Thibault's team is working on adapting their OFDM Doppler mitigation algorithm to 3GPP-LTE to improve mobile reception. In addition, cleaning up Doppler distortion will allow increased throughput, enabling the use of a higher order modulation constellation and/or lower error protection code rate, and resulting in increased spectral efficiency of 3GPP-LTE for mobile reception.

As for the ATSC standard, Thibault hopes to develop a similar algorithm to allow mobile reception of the fixed terrestrial ATSC signal in North America.

"Up to 25 percent of the ATSC bit payload, or 5 megabits per second [Mb/s], is reserved for mobile," says Thibault. "If we could come up with a Doppler mitigation technique that would allow you to receive the fixed terrestrial signal on your mobile device, those 5 Mb/s would not have to be sacrificed and this could improve your picture quality both at home and on your mobile/handheld receiver."

Thibault looks forward to working with a receiver manufacturer to build a prototype incorporating the patent-pending CRC-DVBDetect. When its sister product, CRC-DABDetect (the subject of a future *Eye on Technology* article), was implemented in a receiver, it produced test results that practically mirrored those of computer simulation.

For more information on CRC-DVBDetect, contact Louis Thibault, Research Manager of CRC's Advanced Audio Systems group, at 613-990-4349 or louis.thibault@crc.gc.ca.

Update on audio loudness

The front page story of the Communications Research Centre's (CRC) *Eye on Technology* Issue 10 details the development of the CRC loudness meter, chosen as the international standard by the International Telecommunication Union - Radiocommunication Sector (ITU-R) as a key technology to solve the problem of annoying loudness variations between TV programs and commercials, as well as between TV stations.

Since that story ran, the ITU-R has published its recommended target loudness level (2010), commercial products implementing the loudness meter standard have become increasingly available, and key organizations in the broadcast industry continue to update their recommended practices or regulations to incorporate the use of the meter.

In Europe, for example, the European Broadcasting Union issued loudness control recommended practices in August 2010.

In North America, the Advanced Television System Committee (ATSC) sets standards for digital television. ATSC issued a recommended practice for providing consistent loudness levels in 2009, but as of March 2011, it's moving toward a regulation rather than a recommended practice, given legislative changes in the United States. Once adopted, the U.S. television industry will have one year to implement the ATSC loudness regulations.

In Canada, the Canadian Radio-television and Telecommunications Commission (CRTC) recently held a public consultation on loud TV ads; they received over 7300 submissions. To aid in the CRTC's overall examination of the issue, the CRC submitted the technical report: *A Status Report on Loudness Control Technologies and Standardization for Broadcasting.*

The report explains the intricacies of the issue, from a summary of the main characteristics of the human ear as they relate to loudness, to the audio signal properties of digital television, such as dynamic range compression. The process followed by the ITU-R in selecting and validating its chosen loudness meter is covered in the document, as are regulations and legislation in other jurisdictions. A comprehensive listing of commercial loudness meters is also provided.

The authors of the report, from CRC's Advanced Audio Systems group, know full well the complexities of the issue, having participated in the ITU-R's testing and validation process that produced the international standard. And they continue to provide expertise that is advancing the standard.

"The CRC has contributed significantly to recent developments, including the addition of a gating method to the loudness algorithm, to factor out the silent and very low level signal from the loudness calculation," explains Louis Thibault, Advanced Audio Systems Research Manager. "This ensures accurate loudness readings when measuring audio containing extended silence or quiet passages."

CRC has also contributed to the development of both a short-term loudness meter and a momentary loudness meter to assist recording engineers in program production. In addition, Dr. Scott Norcross was appointed Chair of the ITU-R Rapporteur Group on Loudness Metering in spring 2009, a distinguished honour that recognizes CRC's important role in loudness meter standard development.

To read the full *Status Report on Loudness Control Technologies and Standardization for Broadcasting*, visit the CRTC's website at http://crtc.gc.ca/eng/publications2.htm or the CRC's website at www.crc.gc.ca/en/html/crc/home/info_crc/publications/loudness_crtc_2011.

For more information on CRC's Advanced Audio Systems group, contact Louis Thibault at 613-990-4349 or louis.thibault@crc.gc.ca.

2011 Public Service Award of Excellence to Dr. Veena Rawat

(From left to right): Janice Charette, Associate Secretary to the Cabinet and Deputy Minister of Intergovernmental Affairs; Dr. Veena Rawat; Richard Dicerni, Deputy Minister of Industry Canada.

Dr. Veena Rawat, who retired as President of Industry Canada's Communications Research Centre (CRC) earlier this year, has been awarded the 2011 Public Service Award of Excellence in the Outstanding Career category. The award is in recognition of her lifelong contribution to telecommunications and to women in leadership roles.

Dr. Rawat served as President of the CRC from 2004 until her retirement from the public service in early 2011. Before joining CRC she served Industry Canada and the Department of Communications in progressive spectrum engineering and spectrum management capacities.

Dr. Rawat was often at the centre of major policy and regulatory decisions, where she navigated complex technical problems and negotiated in international forums to bring new communications services to Canada and other parts of the world. Having earned the respect of her Canadian colleagues and her international counterparts, she established her reputation as a consensus-builder in global negotiations, with a fair-minded yet determined approach.

Dr. Rawat is also known for nurturing others' potential. She championed greater representation of women engineers, both at Industry Canada and beyond. She coached women to accept leadership roles at the international level. She also encouraged other administrations to increase the number of women on their delegations to international meetings, and to accept women in high profile roles.

"We are delighted that Veena's career-long contribution to Canada, and indeed the world, is being recognized with this award," says CRC Executive Vice-President Bob Kuley, who nominated Dr. Rawat on behalf of CRC's senior management team. "She is truly deserving."

Cognitive Femtocells: a new paradigm for personal wireless communications

Femtocells are small cellular base stations already being used to extend mobile service coverage indoors in residential or small business settings by connecting to the Internet via the digital subscriber line (DSL) or cable link. With an operating radius of a few dozen meters, the proliferation of such small radio cells could multiply bandwidth use, but as their density increases, so too does the potential for interference.

A Communications Research Centre (CRC) research team, led by John Sydor, has been studying the capabilities of cognitive radio. They even developed a cognitive radio learning platform, CRC-CORAL, so others can research, design and build WiFi cognitive radio networks.

Sydor's expertise is in demand: in 2010 he was one of 10 experts to demonstrate cognitive radio technologies at IEEE DySPAN 2010. This Institute of Electrical and Electronics Engineers (IEEE) event is the premier conference dedicated to dynamic spectrum access networks. What's more, Sydor was recently a keynote speaker at the June 2011 IASTED International Conference on Wireless Communications, held in Vancouver. IASTED is the International Association of Science and Technology for Development and its annual conference is another regular gathering in the wireless communications world.

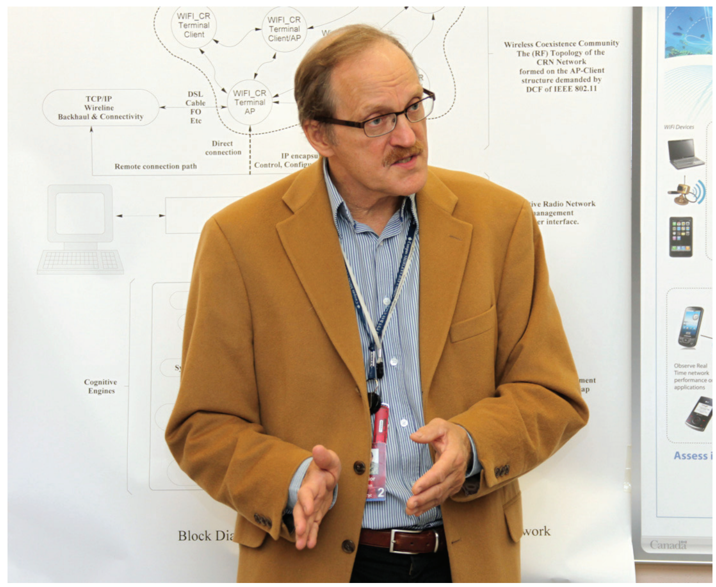
What better time to seek Sydor's insight on the promise of cognitive femtocells, plus the technical and regulatory challenges surrounding this new technology.

Q. What is the scope of the problem? How congested is bandwidth?

A. Cellular telephone companies are continually under pressure to provide new services and as a result, they are using up increasing amounts of scarce bandwidth. In 2008, the average American smartphone user downloaded about 150 megabytes of data per year; by 2015 this figure is projected to be in the order of 7 gigabytes. Smartphone usage is driving the growth in bandwidth demand, which is doubling every 15 months. It is predicted, by sources such as CISCO and a number of LTE equipment providers, that around 2013-2015, we should be experiencing significant congestion on the networks – a point where the demand for bandwidth exceeds the physical capacity of the wireless networks to provide it. So either we come up with new ways to use bandwidth more efficiently, or we limit the capacity of smartphones.

Q. How far out are we from enabling technology like cognitive femtocells and what has to happen to make them a reality?

A. To some degree, cognitive femtocells are already a reality. Some manufactures are equipping femtocell equipment with "self-organizing network" capabilities. This allows home-installed femtocells to automatically coordinate their entry into a cellular network, negotiate spectrum and transmit power constraints with the remote cellular base station, recognize the home user's cellular smartphones and finally, coordinate hand-off between the macrocell and femtocell. These operations are far from being perfected, so there is considerable work that is ongoing toward providing intelligence to femtocells.



John Sydor, Research Manager, Broadband Wireless

Q. What are the technical challenges/concerns?

A. The greatest challenge will be to coordinate the sharing of spectrum between the base station and the femtocell, and then coordinate the sharing of spectrum between femtocells. This last issue is really important because sharing has to be done fairly in a collaborative manner. Maintaining balanced operation among a distribution of femtocells becomes highly problematic since co-channel interference rises rapidly as femtocells are packed into a service area. There's a concern that such coordinated operations can become unstable or operate in a highly inefficient manner. Understanding the complexities that we will be faced with in this wireless balancing act is one of the challenges faced by cognitive radio.

Q. What are the regulatory challenges/concerns?

A. The use of cognitive radio technology will affect our thinking about how we license and use spectrum. Cellular service providers pay for the real estate that allows them to distribute their spectrum to paying customers. If that real estate is now located in your basement, and friends, neighbors, even strangers driving past your house are using your femtocell, should you be entitled to spectrum rights? After all, you are enhancing the use of the service provider's spectrum by having a femtocell and using your power and DSL backhaul bandwidth. It is interesting to note that there are now WiFi network companies that will pay you if your WiFi router supports traffic from other users. It's also interesting to note that with the demand for more spectrum, cellular service providers have been toying with the idea of shared spectrum they can use in a dynamic, equitable manner. Such thinking brings us into the realm of cognitive management of spectrum resources. The pervasiveness of the wired IP network and our ability to interconnect radio sensors now makes it conceivable to charge for spectrum on a per-use basis, or even penalize users creating excessive interference. Such technical capabilities will present us with a totally new regulatory perspective regarding spectrum use and rights.

Q. What are the international standards and regulatory bodies doing?

A. Many of the evolving cellular standards such as LTE advanced are standardizing technical features that will allow collaboration and interference control within and between LTE systems, including LTE femtocells. Some standards, such as the SCC41, are even more advanced: for example, specifying protocols, coexistence policies, and signaling methodologies that will standardize approaches toward implementing cognitive radio in successively smaller radio cells and ultimately, femtocells. Within the ITU-R there are agenda items on cognitive radio, some proposed by Canada, that support exploratory work and encourage member nations to test and qualify cognitive radio system concepts. So both standards and regulatory groups recognize the issues that we will be facing and the need to apply cognitive radio to alleviate these problems.

For more information on CRC's cognitive radio research, contact John Sydor at 613-998-2388 or john.sydor@crc.gc.ca.

DTV-TG meets at CRC

CRC hosted the spring meeting of the Canadian Digital Television Technology Group (DTV-TG). The association provides decision makers in industry and government with the technical information they need to plan for the roll-out in Canada of all forms of DTV. This involves collaborative research by specialized working groups investigating 3DTV, digital audio, advanced coding and transmission, new technology platforms for mobile TV, and more. Broadcasters, distributors and carriers, equipment manufacturers, consumer electronics companies, research institutes, government departments and agencies, universities and industry consultants all make up DTV-TG, so the association has a broad range of expertise at its disposal.

A number of researchers in CRC's Broadcast Technology Research branch presented their findings to the DTV-TG meeting: Gilles Gagnon presented results of a mobile DTV trial and the ATSC next generation broadcast television initiative; André Vincent presented a study on video codec concatenation; Scott Norcross presented the latest developments on the standardization of the audio loudness meter; and Liang Zhang presented new Doppler mitigation technologies developed at CRC for mobile orthogonal frequency-division multiplexing receivers.

Digital TV transition poised to liberate spectrum — a retrospective

The history of high definition television (HDTV) and its connection to the 700 MHz spectrum band – anticipated for auction in 2012 – is an intriguing tale of two sectors seeking the same spectrum, of competitive interests striving for success then joining forces in collaboration, of game-changing innovation along the way, and of the collaborators' ultimate triumph.

It's a story witnessed first-hand by the Communications Research Centre (CRC), a key player in the research and development facilitating Canada's transition to the North American-wide Advanced Television Systems Committee (ATSC) HDTV standard.

North America's move to HDTV started in the mid-1980s in the United States, not long after the introduction of mobile phones. A key mobile player wanted the Federal Communications Commission (FCC) to free up spectrum assigned to broadcasting because, in its view, the broadcasters were not fully utilizing it.

But the National Association of Broadcasters had HDTV on its radar screen, and spectrum was a required resource to make HDTV a reality. The broadcasters invited their Japanese counterparts to Washington for a demonstration of their HDTV system. Legislators were wowed, not only by what they saw, but by the potential for an American HDTV system to fuel domestic manufacturing.

Officials formed the Advisory Committee on Advanced Television Services (ACATS), and it launched a competition for the best system. Along the way, one competitor simulated an all-digital system. This capability to connect with computers moved the bar higher in the competition. When the first round of testing produced no clear winner and ACATS called for more tests, participants decided to work together on a collaborative proposal. The resulting "Grand Alliance" proposal featured the best of their individual systems, including a transmission system that modulates the signal as a data stream into the 6 MHz TV channels of the VHF/UHF TV broadcast bands. In 1996, the FCC declared the Grand Alliance system the new standard. Industry Canada adopted the standard in 1997.

"The work of the ATSC and of ACATS, to which CRC contributed, led to the adoption of a 6 MHz HDTV digital system," explains Bernard Caron, Vice-President of CRC's Broadcast Technology Research branch. "The fact that this system can operate in 6 MHz channels and accommodate more TV signals than the conventional analog NTSC system can provide for more efficient use of the spectrum, and free a portion of the broadcast band that the Department is planning to auction to increase wireless broadband."

Throughout the development of the standard, CRC supported Industry Canada by representing Canada at technical committees developing the new system, demonstrating HDTV to the public – a North America first in 1988 – to gauge interest, providing the technical parameters for digital TV channel allocation, advising the Canadian broadcasting industry on the implementation of the standard, and helping several Canadian manufacturers adapt their equipment to digital TV. Advising industry involved building Canada's first HDTV station in 1998, with funding from Industry Canada and in-kind contributions from the industry.

And CRC's Advanced Television Evaluation Laboratory (ATEL) conducted the subjective testing to ensure HDTV would offer a significant enough improvement in video quality to merit the adoption of a new standard – a contribution that was deemed worthy of an Emmy award by the National Academy of Television Arts & Sciences in 2009.

"The work we are doing now in mobile TV is similar," adds Caron. "We are contributing to the new standard for the department and new parameters for channel allocation, plus we are advising broadcasters and offering our support to industry."

With some information from HDTV: The Engineering History

Friends of CRC help maintain a link with past achievements

The Friends of the Communications Research Centre Canada (CRC) is an association of alumni and others who have an ongoing interest in the CRC. The organization was formed in 1994 on the advice of then CRC President Jacques Lyrette. After establishing its mandate, the volunteers set to meeting their first objective: to help CRC maintain a link with its past history and achievements.

One of the charter members, Doris Jelly, recalls the inception of the Friends' website, www.friendsofcrc.ca.

CRC receives NAB Innovation Award

The National Association of Broadcasters (NAB) recognized the Communications Research Centre (CRC) with the Technology Innovation Award 2011 at the NAB show in Las Vegas in mid-April.

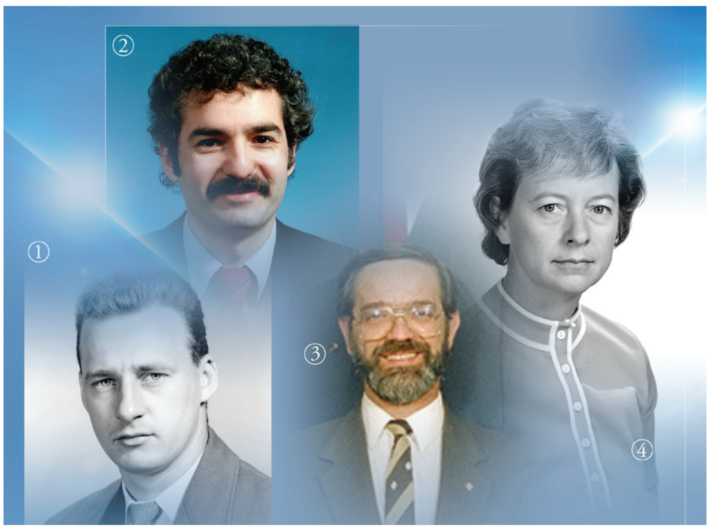
NAB's Technology Innovation Award recognizes participating organizations that exhibit advanced research and development projects in communications technologies which are not yet commercialized. Another well respected research organization, NPR Labs of the U.S., was also recognized.

NAB President Gordon Smith presented the award at the NAB technology luncheon. Research scientist Dr. Yiyan Wu accepted the honour on behalf of CRC. Among the technologies cited by Smith were the CRC loudness meter, its 2D-to-3D conversion technology and the CRC FM TwoO Android App – the first FM-RDS radio application to be distributed on the Android™ market.

Coverage of the awards presentation is on CRC's website.

"We were going to put it in a notebook, but the technology was changing. Now there's a whole website," says Jelly. "There's a lot of material there being accessed worldwide."

The early days of the Defence Research Telecommunications Establishment (DRTE), precursor of the CRC, are documented on the Friends' website. Some of CRC's successes in satellite communications are also chronicled, but as CRC expanded its capabilities to terrestrial wireless, multimedia, broadcasting and broadband networks, fewer stories are featured. Current and recent R&D efforts are covered on CRC's website (www.crc.gc.ca), while the Canadian Space Agency (CSA) website (www.asc-csa.gc.ca) contains a wealth of information on satellites and other space hardware.



Several friends of CRC: Don Muldrew, 1; Dr. Malcolm Vant, 2; René Douville, 3; Doris Jelly, 4

Finding and filling in gaps, plus updating their website, are on the top of the Friends' to-do list. The long-retired members are looking to newer retirees to lend a helping hand.

The Friends are proud of their success in ensuring the history of the Alouette I Satellite Program is not forgotten. It was officially declared an event of national historic significance in 2010. Now they want to ensure other feats are not overlooked, and the behind-the-scenes stories are told.

Hermes, the first satellite to demonstrate the feasibility of direct-broadcast, is one example. The experimental satellite is not only a communications success story – having garnered CRC and NASA an Emmy award – it's a technology transfer success story too.

Hermes was the first to operate in the 14/12 GHz frequency band, so Earth stations in urban areas could receive its signal without interfering with terrestrial communications facilities. Hermes was also the first satellite with enough power to transmit to small Earth stations (1m diameter) at people's homes, so Canadians in rural and remote regions could receive a quality signal.

The Hermes program included interactive Earth stations that turned traditional "audiences" into active participants, enabling telehealth, tele-education and community broadcasting experiments that were later commercialized.

Former CRC Director René Douville was part of the team that designed and built North America's first small terminal to receive a television signal directly from a satellite. While satellite design and manufacturing had progressed since Alouette, the "off-the-shelf" components available did not always meet the exacting specifications of the Hermes team. Douville and his colleagues, for example, built their own (Microwave) Field Effect Transistor Amplifier (FETA) – an integral electronic component on the Hermes satellite and in its Earth stations.

Douville was also instrumental in transferring Hermes technology to Canadian industry. In fact, he championed technology transfer within CRC.

"I was very industry oriented and I encouraged that," says Douville. "The more cross over that can happen, the better."

Douville applied this same principle to knowledge transfer, cycling graduate students through his group.

"I had eight to 10 students in my division of 25 people at any one time," he says. "Some students were hired by CRC; others started companies of their own, including a highly productive Canadian company."

Today, CRC prides itself on both its technology transfer and knowledge transfer track records – using its strong contingent of highly qualified people (HQP) to help nurture new HQP who, in turn, fuel the Canadian economy.

While Hermes is synonymous for advancing communications, Radarsat is renowned for enabling clients with the Earth observation data they need to monitor environmental changes and the planet's natural resources.

Friends' member, Dr. Malcolm Vant, worked on the remote sensing satellite in the early 1980s before CSA was formed. At the time, Vant was working for CRC's radar program, which was sponsored by the Department of National Defence (DND). After designing the DND Synthetic Aperture Radar (SAR) processor for the SEASAT satellite, Vant moved to the design of the ground processor for the Radarsat satellite, which also uses SAR.

Vant, who started his career at Environment Canada working on remote sensing of fresh and sea ice, recalls how Radarsat capitalized on the collective expertise around the table.

"CRC's radar team worked closely with scientists at the Energy Mines and Resources Canada [now Natural Resources Canada] Centre for Remote Sensing in overseeing the design and implementation of the radar sensor and ground segment," explains Vant. "The space experience of the group at CRC that had worked on the Hermes satellite and preceding ones was put to good use."

Along with helping CRC maintain a link with its past history and achievements, the Friends organization aims to facilitate access to the knowledge and experience of retired staff. One way is through CRC's researcher emeritus program, which also started under former CRC President Jacques Lyrette. Don Muldrew is among the original emeritus researchers.

Muldrew started his career before satellites, when long distance wireless communication relied on radio waves reflected off the ionosphere. Alouette and subsequent scientific research programs greatly enhanced researchers' knowledge of the ionosphere, but unexplained phenomena persist even today. Answering these questions remains relevant to understanding radio propagation.

Muldrew, who retired 20 years ago, comes to CRC once a week to keep abreast of developments in the Earth-Space Propagation section and do a bit of research himself. Post-retirement, he started studying some of the unsolved problems he had encountered years and decades earlier.

"Presently, I am looking at ionograms recorded by the Oedipus-C sounder to try and learn something about wave propagation in the Whistler mode near the electron cyclotron frequency," says Muldrew. "[CRC's] Gordon James was the principal investigator for the Oedipus-C rocket experiment."

Reflecting on his career, Muldrew takes pride in knowing that his work has had an impact.

"It feels great to know that the work that I and about another 100 scientists around the world have done using the topside sounders has contributed greatly to our understanding of the ionosphere and to plasmas."

Among the Friends who have worked tirelessly to preserve CRC's history is Doris Jelly. The last 10 years of her career were spent at the Canada Science and Technology Museum (CSTM), collecting the Canadian space story as background for a major space exhibit. She also turned her research into a book, *Canada – 25 Years in Space*.

"What a great assignment for the last 10 years of my career," says Jelly, who had acquired a broad background relevant to the space story working at DRTE/CRC. With contacts all across the country, she knew where to look for artifacts.

"A piece had arrived with a collection of stuff from NRC [National Research Council of Canada] that looked quite like a rudimentary version of the STEM antenna on Alouette," she explains. "Knowing that George Klein had been involved in early development of the concept, I took the piece to him for his comment. He was 84 at the time and not at all well. He saw the piece and his eyes lit up and he exclaimed 'I made that!' Then I sat down with him and recorded an hour of the history of the invention of the STEM, a significant element in the development of Alouette."

In recent years, Jelly volunteered with Graham Booth, who shepherded the Alouette I historic event application through the process. Along with Colin Franklin and fellow Alouette pioneers, Booth and Jelly ensured the plaque was accurate and the unveiling event was a fitting tribute.

One year after the commemorative event, CRC is working with the CSTM to transfer artifacts acquired from Alouette pioneers, and the Friends organization is looking for volunteers to help research the gaps in information on the Friends of CRC website.

For more information on the Friends of CRC, email Friendsofcrc@crc.gc.ca. Benefits of membership include a monthly newsletter and an invitation to their monthly speaker series.

CRC at Spectrum 20/20

Spectrum 20/20 is the premier radio communications event in Canada drawing senior spectrum, radio and telecommunications officials from around the world. Rendez-vous 2011 was held in Ottawa in May with a special focus on wireless broadband.

Jean-Michel Bouffard (left), Research Engineer, Radio Broadcast Systems and Transmission, showcased the CRC FM TwoO Android App, the first FM-RDS radio application to be distributed on the Android™ market. Bernard Doray (right), Research Engineer, Broadband Wireless, demonstrated CRC-CORAL, the world's first Cognitive Radio Networking Platform based on the ubiquitous IEEE 802.11a/g standards (WiFi®). Doray was accompanied by fellow Broadband Wireless Research Engineer Mustapha Bennai, who is not pictured.