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Menu

- High bit rate optical communications
- Fiber-Wireless Solution for Broadband Multimedia Access
- Call Admission Control Schemes in Non-Cellular Wireless
- Development of IEEE / ACM Software Engineering Curricula

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(i) Canadian members of IEEE;
(ii) Canadian members of the profession and community who are non-members of IEEE;
(iii) The associated Canadian academic (i.e. universities, colleges, secondary schools), government and business communities.

To ensure that the ***IEEE Canadian Review*** has the desired breadth and depth, editors are responsible for screening articles submitted according to the following general themes:

1- National Affairs	4- Education	7- Computers
2- International Affairs	5- Power	8 - Electronics
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Quelques mots finales du rédacteur en chef

Vijay K. Sood, Hydro-Québec

Félicitations à tous. C'est la cinquantième édition de la revue canadienne de l'IEEE. C'est tout un exploit! Nous sommes partis de loin. Pour ceux qui ne sont pas familiers avec l'historique de la revue canadienne, la page qui suit dresse un bref portrait de son historique et rend hommage aux pionniers qui ont rendu possible un tel magazine. J'ai bien hâte aux prochaines 50 éditions de ce jeune magazine.

Maintenant, dans un autre ordre d'idées, c'est avec des émotions nuancées que j'écris ma dernière colonne en tant que rédacteur en chef de la revue canadienne de l'IEEE. J'ai exprimé mes remerciements dans le numéro précédent. Une partie de moi est très heureuse de ne plus avoir à porter le fardeau de la rédaction. L'autre partie de moi va s'ennuyer du contact personnel que j'ai eu avec vous, les membres de IEEE Canada. Toute bonne chose a une fin, et comme on dit, c'est la vie.

La prochaine équipe de rédaction est fin prête. Laissez-moi leur souhaiter "Bon voyage" et bons succès. Je peux maintenant prendre une bonne bière froide et admirer le plafond. "Ah! Est-ce que ce recoin brunâtre a besoin de réparation?" Bien sûr, mon épouse est bien heureuse de revoir son mari errant faire des travaux dans la maison et le jardin. Je vais peut-être avoir le temps de regarder les nouvelles et de rire de nos politiciens. J'aurai peut-être une dépression nerveuse en suivant les grandes fluctuations du marché boursier. Ou même mieux, je pourrai voir une partie ou deux… ou trois… Les choix sont infinis.

Alors, adieu à vous tous!

Cover picture / *Photo de couverture*

While the very first issue of the CR may look like it's "a piece of (a) cake," producing it was far from easy. More recent CR editors have still spent incredible hours eliciting, editing and writing articles, but at least technology has eased the production challenges. Back in 1988, illustrations were usually still handdrawn. Photos had to be manually converted to half-tones—what are those you ask? Platforms were not compatible ... the list goes on and on. So ... Bravo to all the earlier editors!
Many Thanks, Vijay

A few final words from the Managing Editor

Congratulations to you all. This is the fiftieth issue of the **IEEE Canadian Review** (CR). A milestone! An achievement. We have come a long way, and for those of you who are unfamiliar with CR history, the next page provides a short history of the CR and a tribute to those pioneering individuals who brought it to fruition. I look forward to the next 50 issues of this fledgling magazine.

And now for something completely different. It is with mixed feelings that I write my last column; yes, this is my final column as Managing Editor of the IEEE Canadian Review. I did my appreciation column in the previous issue so I do not have to do that anymore. One side of me is very happy that I will not have this burden to carry any more. The other side of me will miss the personal contact that I had with you, the members of IEEE Canada. All good things must come to an end one day, and it is, as they say in French, "C'est la vie".

The next editorial team is rarin' to go. So let me wish them "Bonne voyage" and send them on their merry way. Let me find a cold beer to relax and admire the ceiling. "Ah! Does that brown patch over there need my attention?" And, of course, my wife is looking forward to having her errant husband back in the fold doing something useful in the garden and house. Maybe, I will have time to catch the news and have a mused laugh at the Canadian political scene from the capital, or have a nervous breakdown watching the exuberant fluctuations of the stock market. Or better still, catch a game or two ... or three.... The choices are endless.

So, Adieu all!

Contents / *Sommaire*

The IEEE Canadian Review - how it all began…

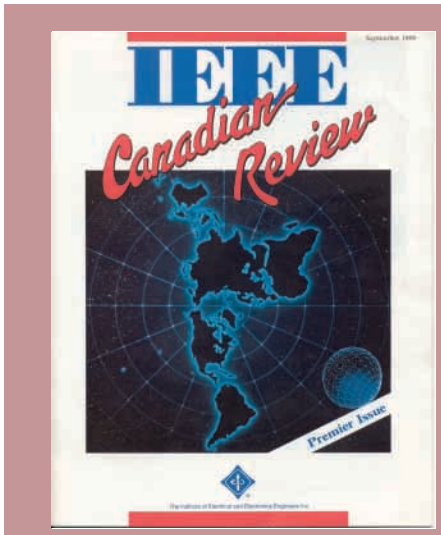
It all started with a conversation with **Cam Blachford** in 1988 - he had just become president of the Canadian Society of Electrical Engineering (CSEE), and I had just become the IEEE Region 7 director. The background for that conversation was as follows. The CSEE had been created 12 years before as a constituent society of the Engineering Institute of Canada (EIC) with a journal, a small number of members and very little in the way of local activities. IEEE Region 7 had been in existence for 85 years with virtually all of its member services provided from IEEE in the US, except for a small newsletter which was mailed from the IEEE Region 7 office in Thornhill, just north of the Toronto city boundaries. The Canadian IEEE bi-annual regional conferences in Toronto and Montreal were going under and **Vijay Bhargava** was starting up the **Canadian Conference on Electrical and Computer Engineering** for the CSEE.

Cam and I were continuing the perennial discussion of that era - how should a learned society for electrical, electronics, and computer engineers exist in Canada, given the long history of the EIC which had never attracted many "electricals" because of the pervasive influence of the then "US centric" IEEE. We each believed that the organization we served should be the only one in town. The choices appeared to be, very small and Canadian, or big and American - the other choice, merging together, was not a realistic option at that time, but the seeds were being sown. I had started to promote the use of the name IEEE Canada as an alternative name for IEEE Region 7, but I realized that the "name" was not enough. I believed that we needed a truly Canadian, high quality magazine for all Canadian IEEE members - to provide a home grown member service and the correct image of our country-wide organization to our members and the public at large. The original mission statement that appeared in the first issue spelled out that belief and remains unchanged today.

Richard Marceau, first Editor of CR Oshawa, ON

The concept of the **IEEE Canadian Review** had been set. The next step was to find the "right person" to help me make the concept a reality - text, pictures, layout on high quality paper, etc. Who would be the initial editor? Again, the requirements were clear in my mind - a volunteer who was obsessive in vision, quality, and detail, with publication experience and proudly Canadian in both languages. I knew of only one such individual, a volunteer with the Montreal Section who produced conference proceedings for IEEE Montreal Conferences Inc. (MCI). His name was **Richard Marceau**. We got together after various MCI and Region 7 meetings and discussed ideas and eventually specific plans, typically in time slots from 10 p.m. to 1 a.m. - **he was as crazy as I was!** But in the space of half a dozen clandestine meetings over about half a year, the first issue was conceived, developed, refined and mailed to all some 15 thousand Canadian members in the Fall of 1988. Richard enlisted the help of volunteer associate editors and the expertise of a Montreal-based printing company who provided guidance on specific layouts and materials. By the way, at the time that our magazine was created, it was against IEEE policy for Regions to have magazines; they were only permitted for Technical Societies. A couple of years later, IEEE USA's "Today's Engineer" was born.

Our premier issue was funded in part by a special $5,000 grant from "IEEC. Inc." - which evolved four years later into the **IEEE Canadian Foundation.** Speaking of funding, we knew that we wanted our new magazine to have a bilingual component but we were conscious of the potential costs and our limited financial resources. We decided to proceed slowly and carefully. All issues would have abstracts of feature articles in both languages and we would seek articles in either language as well as advertising to generate income. Issue #1 had abstracts in both languages, #4 contained the first full page advertisement, #5 carried the first full article in French, and so the magazine developed. Issue #24 was the first one edited by **Vijay Sood** - whose opening remarks started with "It is with apprehension that I take over the helm at the IEEE Canadian Review magazine for the next two years…" That was in 1996 and Vijay has remained at the helm for 37 issues over a decade! Vijay made a break with the past with #34 - a change in font and format for the magazine's name - the original look is shown in the reproduction of the first issue cover on this page.



First issue of the IEEE Canadian Review in September 1988.

In between Richard and Vijay, three other editors added their contributions, **Tony Eastham, Theo Wildi, and Paul Freedman**. These five dedicated volunteers, together with a large number of associate editors, have served with distinction and made that initial concept become the member service that Canadian IEEE members consistently rate as their ***most valued benefit from IEEE Canada*** - my thanks to all of you for making that dream come true.

Bob Alden, LF-IEEE, FEIC,
1988-89 Region 7 Director
Toronto, ON

Some comments from the other editors....

I took over from founding CR Editor, Richard Marceau in 1990 -- was it really 15 years ago? A lot of work I recall, but very satisying. The big issue in those days was the merger of CSECE and IEEE Region 7. I feel proud to have had a role in this, as I know IEEE Canada continues to serve Canadian EEs well! Congratulations to all who have carried the CR torch forward to its 50th issue.

Tony Eastham
1990-91 Region 7 Director
Hong Kong

The IEEE is a big family of friendly people who enjoy sharing their knowledge. The IEEE Canadian Review, launched by Bob Alden, epitomizes this attitude. I found it a real privilege and challenge to act as Editor during two short years.

Theo Wildi,
former Editor of CR
Quebec City, QC

Everyone profits when we become part of something larger than ourselves. I salute our past editors, the authors with whom I worked, Vijay Sood who took over the reins when I stepped down, and lastly our IEEE Canada readers. May you always find something to take away from each issue!

Paul Freedman
former Editor of CR
Montreal, QC

It was an exhilarating challenge all the way. Thanks for the great ride and Au Revoir.

Vijay Sood
Editor of CR, 1996-2005
Montreal, QC

Newslog Editor

Rédacteur des Coupures de presse

Alexandre Abecassis is a patent agent trainee in Montreal at Ogilvy Renault, Lawyers and Patent and Trade-mark Agents.

Alexandre Abecassis travaille à Montréal chez Ogilvy Renault, Avocats et 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 alexandre.abecassis@ieee.org

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MONTREAL, QC, Jan. 21, 2005. Mindready Solutions has announced one of its largest embedded software projects, an IP-over-1394 communication software running on a low level API for use in satellites. The software enables IP communications over IEEE1394/ Firewire bus as well as IEEE1394 bus management. The software is fully redundant, features a small footprint, error reporting for fault tolerance management and is highly efficient in terms of communication performance and processing power requirements.

MONTREAL, QC, Feb. 1, 2005. CMC Electronics has received confirmation from Air China that its high gain satellite communication antenna system has been selected for some of its cargo planes. The system virtually eliminates multi-path interference and allows simplified installation. It enables applications ranging from intranet virtual private network (VPN) access for crews to multi-channel voice services and fast e-mail for passengers.

MISSISSAUGA, ON, Mar. 2, 2005. Elliptic Curve Cryptography (ECC), a strong, efficient public key cryptosystem will soon become the standard to protect US government communications. On February 16, 2005, the National Security Agency (NSA) presented its strategy and recommendations for securing US government sensitive and unclassified communications. The only public key protocols presented were ECMQV and ECDH for key agreement and ECDSA for authentication.

MONTREAL, QC, Mar. 3, 2005. Hamadou Saliah-Hassane, professor at TELUQ, has received an Achievement Award at the International Network for Engineering Education and Research (iNER) conference in Taiwan. More precisely, the award has been awarded For Research and Innovations in On-Line Laboratories and for Accomplishments in Advancing International Engineering Education.

MONTREAL, QC, Mar. 3, 2005. BlueTree Wireless Data, a leading provider of commercial and industrial wireless modems for the M2M market has announced a new wireless modem product. The new wireless modem provides a GPS position of the modem over a wireless network to a host server and as well as to a mobile computer that is attached to the modem with off-the-shelf or custom mapping software. The new modem also manages the reporting of GPS data when in and out of wireless coverage to ensure that customers have accurate tracking data.

LONGUEUIL, QC, Mar. 23, 2005. D-Box technology's "Quest" armchair, a 100% synchronized innovation, that allows home entertainment fans to experience every movement on the screen before them, has been listed in the 39 "Hottest Products on the market" by the magazine Popular Science in its April 2005 edition.

MONTREAL, QC, 31 mars 2005. Patrice Renaud, professeur à l'Université du Québec en Outaouais et affilié au Centre de recherche Fernand Séguin et à l'Institut Philippe Pinel de Montréal a reçu le second prix du concours Innovation Recherche organisé par l'Association de l'Industrie des Technologies de la Santé pour le projet "Modification du comportement à l'aide de la vidéo-oculographie immersive".

MONTREAL, QC, Apr. 4, 2005. Nstein technologies today announced that is was chosen by Industry Canada in the framework of a pilot project to assess technology solutions for its SourceCAN e-marketplace, enabling the company to demonstrate the attributes of its technology platform. SourceCAN is an e-marketplace that matches Canadian products and services with thousands of business opportunities posted by domestic and foreign corporations and governments.

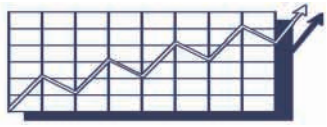
QUEBEC CITY, QC, Apr. 6, 2005. Lyrtech has announced that it has signed a 360k$ contract with Alcatel Space to develop and provide the traffic generator for the validation model of an ultra-fast onboard processor for meshed packet networks. Lyrtech provides, inter alia, DSP/FPGA development platforms.

TORONTO, ON, Apr. 12, 2005. Tri-Vision International today announced that it has licensed its US Patent 5,828,402 to Pioneer Corporation of Japan. The license covers all products within the scope of the digital television receiver. The license is valid through the expiration of the patent in 2016 and requires that both parties keep the terms of the license confidential.

VICTORIA, BC, Apr. 14, 2005. Student Vote BC is underway in 350 schools across British Columbia. It is expected that 100000 students will vote on May 16, 2005. This non-partisan parallel election program aims to build a habit of participation among students under the voting age.

RESEARCH TRIANGLE PARK, NC, Apr. 18, 2005. Harris Corporation has introduced a combined video networking and microwave solution. The solution offers global video network operators, public safety agencies, flexibility and reach to transport conventional and digital video, audio and data traffic across common carrier and studio transmitter link environments.

WATERLOO, ON, Apr. 19, 2005. Research In Motion (RIM) and Microsoft have announced a product collaboration and joint marketing agreement to extend enterprise instant messaging (IM) and presence to Blackberry(R) subscribers. The solution is based on Session Initiated Protocol (SIP) and SIP for Instant Messaging and Presence Leveraging Extensions (SIMPLE) standards.



Fiber-Wireless Solution for Broadband Multimedia Access

by *Stephen Z. Pinter and Xavier N. Fernando*
Ryerson University, Toronto, ON

Abstract

The increasing demand for high-capacity multimedia services in real-time demands wireless broadband access. In order to meet this demand, a fiber based wireless access scheme using radio-over-fiber (ROF) technology can be used and is discussed in this article. Fiber based wireless (Fi-Wi) access schemes effectively combine the high capacity of optical fiber with the flexibility of wireless networks. This approach enables rapid deployment of micro cells in cellular radio networks for capacity enhancement. Furthermore, a single sub-carrier multiplexed ROF link can support wireless LAN, cellular radio, and CATV services simultaneously. ROF technology can also transmit millimeter radio waves to the surrounding neighborhood for LMCS type systems. The focus of our research group ADROIT is to investigate various issues in this scenario such that ROF becomes a feasible technology to provide a cost-effective, high performance solution for broadband access. We have devised a system identification technique for a concatenated fiber-wireless channel, and have proposed various compensation schemes to equalize the time varying linear wireless plus static nonlinear optical channel. Another of our projects focuses on supporting both cellular CDMA and IEEE 802.11 signals over the fiber-wireless channel. We have also performed various experimental studies on the ROF approach and have been working with optical and electrical signal processing for performance improvement. This article provides an overview of ADROIT research and presents some noteworthy results.

Sommaire

La demande croissante pour des services multimedia temps réel de haute capacité exige un accès sans fil à large bande. Pour répondre à cette demande, un procédé d'accès sans fil sur fibre optique utilisant la technologie radio-sur-fibre (RSF) peut être utilisé et sera discuté dans cet article. Les procédés d'accès sans fil basés sur fibre (Fi-Wi) combinent la haute capacité de la fibre optique à la flexibilité des réseaux sans fil. Cette approche permet le déploiement rapide de micro-cellules dans les réseaux cellulaires pour l'accroissement de capacité. De plus, un simple lien RSF sous-porteur multiplexé peut supporter des services de réseau local sans fil, radio cellulaire, et câblodistribution simultanément. La technologie RSF peut aussi transmettre des ondes radio millimétriques pour des systèmes de télécommunications multipoints locaux. La cible principale de notre groupe de recherche ADROIT est l'investigation de divers sujets dans ces scénarios de façon à ce que la RSF devienne une technologie pouvant fournir une solution à haute performance et rentable pour l'accès à large bande. Nous avons conçu une technique d'identification de systèmes pour un canal fibre-sans-fil concaténé, et avons proposé plusieurs procédés de compensation pour égaliser le canal optique en variance temporelle linéaire sans fil et nonlinénaire statique. Un autre de nos projets se penche sur le support de signaux AMRC (CDMA) et IEEE 802.11 sur canaux fibre-sans-fil. Nous avons aussi réalisé plusieurs études expérimentales sur l'approche RSF et avons travaillé avec du traitement de signal optique et électrique pour accroître la performance. Cet article fournit un exposé des recherches de l'ADROIT et présente certains résultats significatifs.

1.0 Introduction

Over the past decade there has been substantial progress in the areas of wireless and optical communications. The driving force behind this advancement has been the growing demand for multimedia services, and hence broadband access. Present consumers are no longer interested in the underlying technology; they simply need reliable and cost effective communication systems that can support anytime, anywhere, any media they want. As a result, broadband radio links will become more prevalent in today's communication systems.

Furthermore, new wireless subscribers are signing up at an increasing rate demanding more capacity while the radio spectrum is limited. To satisfy this increasing demand, the high capacity of optical networks should be integrated with the flexibility of radio networks. The Advanced Radio-Optics Integrated Technology Research Group (ADROIT) at Ryerson University concentrates on this integration; this leads us to the discussion on the fiber-based wireless access scheme using radio-over-fiber (ROF) technology. ROF refers to a fiber optic link where the optical signal is modulated at radio frequencies (RF) and transmitted via the optical fiber to the receiving end. At the receiving end, the RF signal is demodulated and transmitted to the corresponding wireless user. By implementing the above technique, ROF technology is able to alleviate the increasing demand for high-bandwidth services through the implementation of micro/pico cellular architectures. The primary focus of the ADROIT research group is to investigate (optical and electrical) signal processing strategies that can provide a cost-effective, high performance solution for high-speed fiber based wireless access.

2.0 Radio-Over-Fiber for Fi-Wi Systems

The fiber-wireless solution for cellular networks is shown in Figure 1 (the fiber-wireless downlink). This solution increases the frequency reuse and enables broadband access by providing a micro/pico cell scenario for cellular radio networks. The mirco/pico cell scenario is possible through the use of radio access points-RAP in Figure 1. These inexpensive low power RAPs provide wireless access instead of conventional base stations. It is important to keep the RAPs complexity and cost at a minimum in order to allow for large scale deployment. By doing so, a large cell can easily be split into smaller cells by dispersing RAPs throughout. These robust RAPs are connected to the central base station via the ROF links.

2.1 The Radio-Over-Fiber Technology

In any RF communication system, the baseband information is modulated to a suitable carrier frequency. Both the modulation scheme and the carrier frequency are predetermined (Figure 2). For example, QPSK (with CDMA) is used at 900 MHz in IS-95 cellular radio system and OFDM at 2.4 GHz is used in IEEE 802.11 wireless LAN. The purpose of the ROF link is to provide a transparent, low distortion communication channel for the radio signal for antenna remoting.

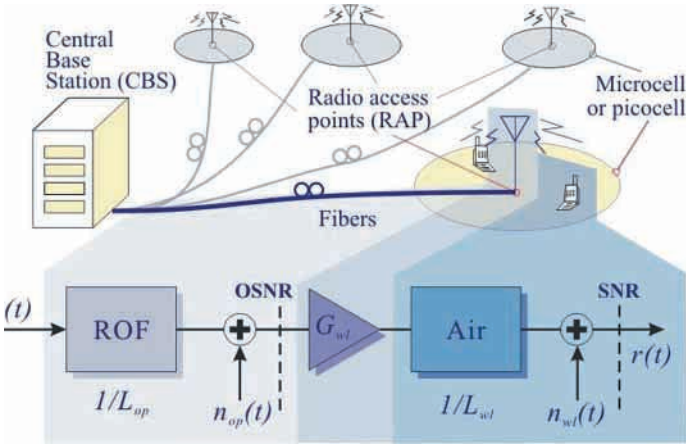


Figure 1: ADROIT fiber-wireless solution for cellular radio networks

Laser diodes can be directly modulated up to several GHz of radio fre-

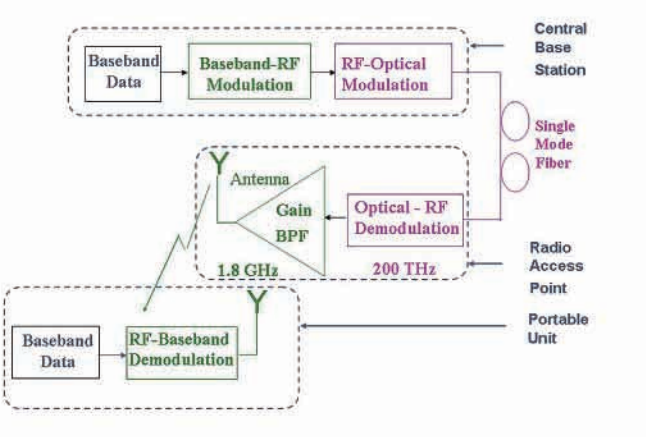


Figure 2: Two types of modulation involved with the radio-over-fiber approach

quency depending on their resonance frequency. Up to several GHz directly modulated ROF transceivers are commercially available. At higher frequencies, external modulators such as the Mach-Zehnder interferometer should be used.

ROF transmission offers many advantages in wireless systems, some of which are:

- Huge bandwidth that enables multiplexing several radio channels; each radio channel may belong to a different system such as wireless LAN and cellular radio,
- Ability to use existing dark/dim fibers to transmit the radio signal (dim fiber can be used with WDM techniques),
- Inherent immunity to electromagnetic interference, and
- Allowing for transparent operation because the RF to optical modulation is typically independent of the baseband to RF modulation.

ROF also allows for easy integration and upgrades since the electrical to optical conversion is independent of baseband to RF modulation format. Conventional transmission mediums such as copper coaxial may not be completely replaced by optical fiber, but in applications where factors such as RF power loss, future system upgrades and transparency are considered, fiber is regarded as the most practical and efficient medium. Even though the prospects of ROF are substantial, there is still plenty of research to be carried out in this area before widespread deployment can be considered.

Table 1: Myths and realities of fiber-wireless access

The Myth	The Reality
Optical fiber is mostly useful to transmit digital (SONET) type data carrying voice (telephony) signals.	Not true. Optical fiber is an excellent wideband channel and any broadband (analog or digital) signal can be transmitted via fiber with very low distortion. Analog transmission has been widely used in CATV systems.
Optical access networks means running fiber to every house (fiber-to-the-home, FTTH). This is too expensive and will not materialize in the near future.	Not necessarily. There is plenty of dark (unused) and dim (partly used) fiber running in our neighborhood in most major cities. These existing fibers can dramatically enhance the access network capacity with the Fi-Wi approach.
Optical and wireless networks are independent.	Access networks can be effective combinations of both optical and wireless techniques. This combination supports mobility as well as broadband access.
Optical fiber may be useful to transmit millimeter waves which otherwise can't be transmitted cost effectively.	Even at 900 MHz, 1800 MHz and 2400 MHz frequencies radio-over-fiber technology is cost effective; see the Sydney Olympics example below.
Only few isolated researchers work in this area.	There are commercial products available for Fi-Wi networks and even books have been written on the technology [3]. Also see the Sydney Olympics example below.

2.2 Supporting Multiple Wireless Standards

Studying the effects of transmitting multiple wireless standards over a single ROF link can be very beneficial. Today, 3G wireless technologies have a bit rate of more than 2 Mbps and wireless local area network (WLAN) technologies can provide a bit rate as high as 54 Mbps with IEEE 802.11. The integration of these two technologies can increase the bit rate available for applications, while maintaining reasonable mobility for end users.

Some work in this area has been done in [1] where the transmission of multiple wireless standards over an ROF network is investigated; however, the knowledge in this area is still limited. Currently, we concentrate on the different issues of supporting both cellular CDMA and IEEE 802.11 type Wi-Fi signals over the fiber-wireless system. This can be done either in a sub-carrier multiplexed [2] or baseband plus ROF manner. Although the fiber has several GHz of bandwidth, the cross coupling due to nonlinearity impairs system performance and our focus is to quantify it and to find feasible solutions.

2.3 Issues with the Fi-Wi System

Several observations can be made from Figure 1. First, signal processing should not be done at the RAP for cost considerations. Therefore, compensation should be done at the portable unit or at the central base station. By performing most of the signal processing at the central base station, i.e. by asymmetric distribution of the complexity, the cost can be shared by many users and therefore helps reduce overall system cost. Second, the compensation of the concatenated fiber-wireless channel should be handled jointly. This is a challenging task because of the time varying multipath wireless channel in series with the nonlinear optical channel. Furthermore, the uplink and downlink require different solutions. Third, it is desirable not to modify the portable units because of the ROF link. In other words, the portable unit should not be aware of the existence of the ROF link. This makes seamless roaming between fiber-based and conventional wireless systems possible.

One of the major issues with ROF is the nonlinear distortion of the optical link. This is due mainly to the laser diode (and partly to the high-gain RF amplifier at the optical receiver), and is most dominant in a multiuser environment. Several approaches have been proposed to characterize and solve the problem of nonlinear distortion. In [4], the authors demonstrated how external light injection into a directly modulated laser diode can be used to enhance the linear performance of a multi-channel ROF system operating at a frequency of 6 GHz. In [5], low-cost predistortion circuits able to compensate second- and third-order laser distortions in multiservice ROF industrial systems were developed. Another approach mitigated the nonlinear distortion in the network layer [6].

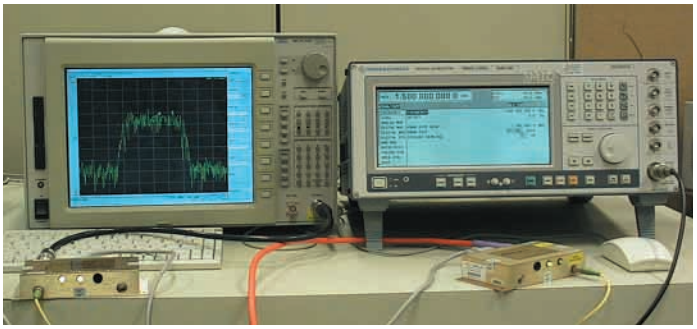


Figure 3: ROF experimental setup. In this photo, a Rohde & Schwarz signal generator sends a WCDMA RF signal through the ROF link and into the Tektronix WCA380 wireless communication analyzer

3.0 ADROIT Solutions for the Issues

3.1 Nonlinearity Compensation

An adaptive baseband model for the ROF link was developed and two different predistortion schemes for the nonlinearity were proposed; one is currently being implemented in an FPGA platform. With the first scheme, the predistortion is done using a look-up table. In the second scheme, higher order adaptive filters are trained to inverse model the ROF link. With both of these approaches, simulation results show good performance improvement, but sometimes requiring a power back off.

Asymmetric compensation is a scheme that allows for most of the signal processing to be done at the central base station. This is achieved by doing predistortion for the downlink and post compensation for the uplink [7]. The issues associated with this asymmetric arrangement are discussed in detail and a unified analysis carried out in [7].

3.2 Estimation and Equalization

Even though ROF provides an excellent broadband link allowing for the communication of several channels, the wireless channel introduces inter symbol interference (ISI) at high bit rates. Along with the nonlinearity, available linear dynamic range becomes a major concern, especially in the uplink. A large linear dynamic range is required in the uplink, where the received signal first travels through the wireless channel (resulting in path losses, fading and shadowing) before entering the optical fiber. Several researchers (for example [8]) address the issue where rapidly fading dispersive linear channels are estimated and equalized. However, in the Fi-Wi system, the ISI is coupled with the nonlinear distortion of the optical link, thereby demanding nonlinear channel estimation and equalization techniques.

3.2.1 Estimation

In order to limit the effect of nonlinear and ISI distortions, estimation, and subsequently equalization, of the concatenated fiber-wireless system should be done. Estimation of the concatenated fiber-wireless channel is an important step towards equalization of the linear channel and linearization of the nonlinear channel. In our estimation algorithms we always consider both wireless channel noise and optical channel noise (quantum, thermal and relative intensity) which are shown in Figure 1 as $n_{wl}(t)$ and $n_{op}(t)$, respectively.

A complete identification of the ROF uplink has been performed in [9] for a single user environment. Expanding identification to a multiuser environment is currently being studied; simulations yield promising results. The wireless channel was identified using correlation analysis, and the nonlinear link was identified using a least squares polynomial fit. It should be noted that our identification was performed using multiple maximal-length pseudonoise (PN) sequences. This is a major advantage because multiple PN sequences are already widely used in spread spectrum communications.

3.2.2 Equalization

Once the channel is estimated, an appropriate equalizer must be devised for the compensation of the linear and nonlinear parts. The fiber-wireless uplink is a Wiener system and therefore a Hammerstein type decision feedback equalizer (DEF) was developed to compensate for it. This equalizer compensates for the linear and nonlinear distortions separately. This modular architecture is attractive for commercial implementation. The receiver consists of a polynomial filter, which inverse models the optical link, and a linear DFE arrangement that compensates for the wireless channel dispersion. The DFE filter parameters were optimized and performance analysis was carried out.The Hammerstein type equalizer discussed above was implemented for a single user. Currently, ADROIT is working on expanding equalization to a multiuser environment.

3.3 Noise Characterization and Cancellation

From Figure 1 it is observed that there are two signal to noise ratios involved in the fiber-wireless system. The optical noise (n_{op}) will be dominant if the fiber is too long and the wireless channel noise (n_{wl}) will be dominant if the radio cell is too large. The cumulative SNR will be smaller than the smallest SNR. This issue is discussed in detail in [10]. The optical SNR deteriorates with wideband RF signals; this becomes an issue in emerging 4G systems that opt for WCDMA type wideband RF signals. ADROIT has also been working on improving the SNR performance of the Fi-Wi system.

Relative intensity noise (RIN) plays an important role in analog fiber optic links. This is especially true with ROF applications because the SNR at the remote antenna end is critical for system performance. Conventionally, the RIN is taken to be proportional to the square of the mean optical power; however, it has been shown that RIN also depends on the modulation index. An improved mathematical expression for the dynamic RIN was derived from fundamental principles and as a function of the modulation index as well. This is a fundamental contribution and will most likely change the way ROF links are analyzed.

4.0 Some Numerical Results

The research results presented herein discuss the BER performance of the ROF link under various conditions[1].

Figure 4 shows the relationship between average BER and fiber length when the RF bandwidth is 5 MHz (WCDMA) and 1.25 MHz (IS-95). A single active user is considered and the radio cell radius is 2.5 km. It can be seen that for both cases as the fiber length increases, the average BER gradually increases as well. This is expected because, as the fiber length increases, signal attenuation in the fiber increases and this decreases the SNR in the ROF link. This phenomenon gives slightly different results depending on the RF bandwidth. For example, with 5 MHz RF bandwidth, the noise collected in the ROF link is high because of the high noise bandwidth. However, WCDMA has larger spreading gain and generally it will give a low BER compared to an IS-95 signal.

In Figure 4, because of the above contradicting issues, there is a crossover of the two curves that happens at a fiber length of approximately 10 km. This occurs because at short fiber lengths the spreading gain dictates the BER and therefore the WCDMA signal with bandwidth 5 MHz performs better. At the other end, when the fiber length is longer, the limiting factor is the optical signal to noise ratio. In this case, the 5 MHz system performs worse because it collects more optical noise (nop).

The relationship between average BER and the radio cell radius for 1, 2, 5 and 10 users is shown in Figure 5. In this simulation the fiber length was fixed at 5 km. Overall, as expected, the average BER increases with radio cell radius and added users. At larger radio cell radii, the average BER is less dependant on the number of users, however, at small radio cell radii, the spread between the average BER for 1 user and 10 users is fairly large. The BER floor depends on the fiber length and optical-electrical conversion losses.

5.0 Conclusions

The projected impact of implementing ROF schemes is substantial. The deployment of optical fiber technology in wireless networks provides great potential for increasing the capacity and QoS without largely occupying additional radio spectrum. From the aforementioned benefits it is obvious that ROF technology will become ubiquitous in today's communication industry. The research performed by ADROIT will definitely help to provide a cost-effective, high performance solution for present and future high-speed fiber based wireless access systems.

6.0 Acknowledgement

The authors are grateful to Faizal Karim for providing some of the simulation results and Roland Yuen for some figures.

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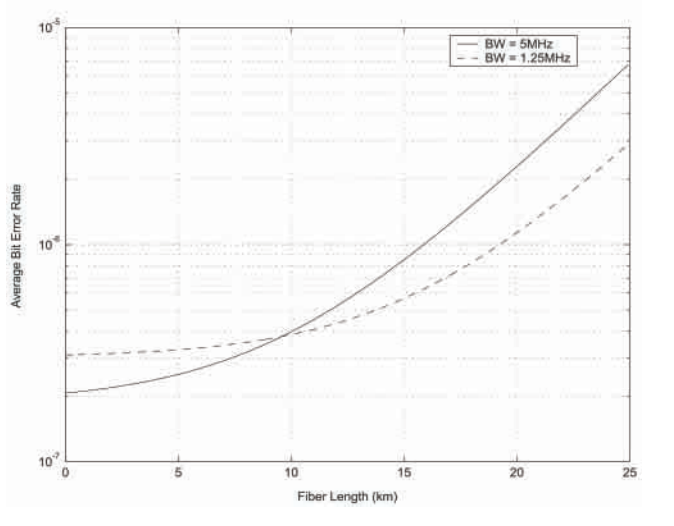

Figure 4: Average BER performance with fiber length.

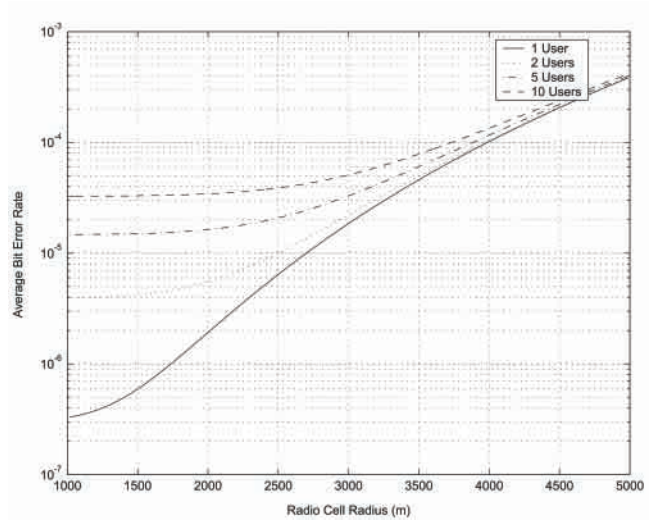

Figure 5: Average BER performance with radio cell radius.

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Application Example - Sydney Olympics

The BriteCell™ fiber optic-based mobile communication system designed by Tekmar Sistemi was installed for the Sydney 2000 Olympics in order to handle the massive wireless traffic (especially at the opening and closing ceremonies).

On the opening day of the Olympics, over 500,000 wireless calls were made from Olympic Park venues. In the minutes leading up to the opening ceremony, over 175,000 calls were made by the 110,000 spectators in the sold out stadium.

Some vital features of the BriteCell™ ROF system installation were:

1. Support for dynamic allocation of network capacity.
2. Support for 3 GSM operators.
3. Support for both 900 MHz and 1800 MHz cellular networks.
4. More than 500 remote antenna units (RAPs) were deployed.
5. Multiple layers of wireless in-building and external pico cell coverage systems were installed.
6. System was able to support the equivalent of 75% of Sydney's average central business district traffic.

Source: Fiber Optics Business, Nov. 2000.

About the authors

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FACTS - Modelling and Simulation in Power Networks

Authors: Enrique Acha, Claudio R. Fuerte-Esquivel, Hugo Ambriz-Pérez and César Angeles-Camacho

Publisher: J.Wiley & Sons.

ISBN: 0-470-85271-2

Year of publication: 2004

No of pages: 403

by *Vijay K. Sood*
Concordia University, Montreal, QC

The subject of flexible ac transmission systems (FACTS) is receiving considerable interest in recent years. The recent blackouts in many power systems around the world have focused attention in this topic. In response to this interest, this book is another attempt by academia to demystify and and explain the controllers that comprise the topic of FACTS.

The book is a compilation of the work undertaken in the past ten years by Professor Enrique Acha from the University of Glasgow, Scotland and some of his Ph.D. students, who have now returned to their native Mexico in pursuit of their careers.

The book commences with a short introduction to FACTS controllers in Chapter 1. It provides also the *raison d'être* for the book since it becomes necessary to develop new mathematical models for the modelling of power systems with these new electronic controllers. At the same time the writing of new software for power flow analysis with these equipment is needed.

An explanation of the mathematical models is needed. Chapter 2 therefore tackles the important task of building the mathematical models for the most common types of FACTS controllers. First, the controllers based on thyristors (such as SVC and TCSC) are discussed, followed by controllers based on Voltage Source Converters (such as STATCOM and UPFC).

Chapter 3 deals with the modelling of the traditional and mundane transmission system components such as transmission lines, transformers and generators.

Chapter 4 then leads onto the Conventional Power Flow methods. A short description of the Newton-Raphson method is included, and students will find this very useful. A listing of a Matlab code is provided for a five-bus test network which formulates the basis of all work later on in the book. The power flow problem is solved to determine the steady-state complex voltages at all buses in the network, from which the active and reactive power flows in the network are derived.

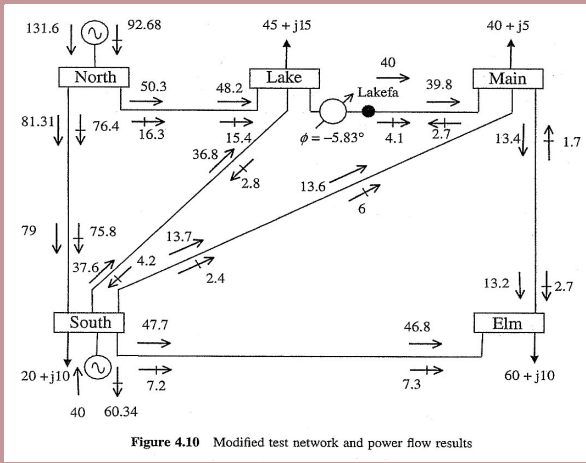
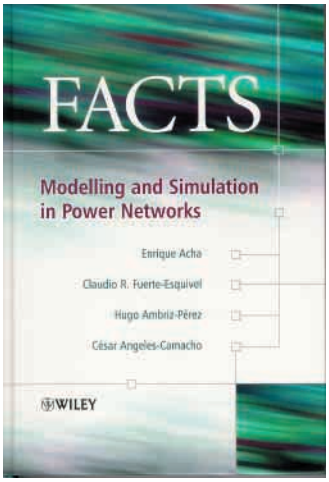


Figure 4.10 Modified test network and power flow results

Chapter 5 discusses the Power flow including FACTS controllers. Amongst the FACTS controllers discussed are SVC, TCSC, STATCOM, UPFC and HVDC-VSC; these are the five most common and significative applications of FACTS controllers. Each controller is modeled with Matlab and the listing of the code is supplied; unfortunately it is not supplied in electronic format which could have been much more practical. Using the benchmark 5 bus network (originally from Stagg and El-Abiad's book published in 1968: Computer Methods in Power System Analysis), each controller application is tested and the power flow results are provided. This was a most useful chapter and highly readable.



Chapter 6 moves from where chapter 5 ended, and the authors provide a three-phase power flow in the phase frame of reference since the study of unbalanced transmission systems is very essential for FACTS controller applications. Again the Matlab code is provided and results are available for comparison cases.

Chapter 7 deals with Optimal Power Flow (OPF) using Newton's method. This is major chapter and deals with representation of the tap changing transformer, phase shifting transformer and all the five major FACTS controllers described earlier.

Chapter 8 is devoted Power Flow tracing. With the new era of deregulation and unbundling of transmission services, a scenario exists where electrical energy trading is performed.

There are a number of Appendices which provide Jacobian elements, Gradient and Hessian elements for OPF and Matlab codes for OPF using Newton's method.

Overall, the book is very well written. Diagrams are generally clear and well laid out. The references are adequate and provided after each chapter. The book is destined to become a classroom text book and will be extremely useful for planning engineers at utilities and consultants alike. My one regret is that the Matlab codes were not also electronically available on a CD-ROM so that the code could have been tested; perhaps the authors or publisher will make a note of that and provide them via the internet to interested readers. I certainly recommend this book to all power system planning engineers and students who wish to follow careers in this area.

Nomenclature:

SVC - Static Var Compensator

TCSC - Thyristor Controlled Series Capacitor

STATCOM - Static Compensator

UPFC - Unified Power Flow Controller

HVDC-VSC - High Voltage DC transmission system based on Voltage Source Converter

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High bit rate optical communications: Limitations and perspectives

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Abstract

Motivated by the world's growing need for communication bandwidth, progress is constantly being reported in building newer optical fibers that are capable of handling the rapid increase in traffic. However, building an optical fiber link is a major investment, one that is very expensive to replace. For example, the optical fiber cables that were installed during the early 80's consist of millions of kilometers of "standard" single-mode fiber (SSMF) around the globe. Since old optical fibers cannot be easily replaced with newer ones, innovative methods of exploiting the available bandwidth are crucial. Even today, standard single-mode fibers are substantially cheaper than the more advanced ones. The present document illustrates the constraint of the need to increase the fiber based transmission bit rate without being obliged to undertake significant infrastructural changes.

Sommaire

Motivé par le besoin mondial croissant en termes de bande passante de communication, un progrès continu est rapporté dans le domaine de la mise en œuvre de nouvelles fibres optiques permettant de faire face à l'augmentation rapide du trafic. Cependant, établir un réseau de fibres optiques est un investissement important. Par conséquent, il n'est rentable de remplacer ce réseau. Par exemple, les câbles à fibres optiques qui ont été installés pendant au début les années 80s comportent des millions de kilomètres de fibres standard monomodes (SSMF) autour du globe. Du fait que les vieilles fibres optiques ne sont pas rentablement remplaçables par des nouvelles, des méthodes innovatrices d'exploiter la bande passante existante sont primordiales. Jusqu'à présent, la fibre monomode standard est significativement moins chère que les nouveaux produits. Le présent document illustre la contrainte de la nécessité d'augmenter le débit binaire fourni par la fibre sans être obligé d'entreprendre des changements d'infrastructure importants.

1.0 Background

The goal of an optical fiber communication system is to transmit the maximum number of bits per second over the maximum possible distance with the fewest errors. A typical digital fiber optic link is depicted in Figure 1.

Electrical data signals are converted to optical signals via a modulator. A "1" is transmitted as a pulse of light while a "0" has no light output. This modulation is referred to as the "ON-OFF keying" and has three formats as shown in Figure 2.

The NRZ format is the most commonly used since it requires less bandwidth. It is worth noting that the RZ format has the advantage to allow easier implementation of time recovery in case of long sequences of "1's".

The number of "1's" and "0's" transmitted per second determines the speed of the link (bit rate). Glass optical fibers have a wide transmission window over which a number of optical signal channels may be transmitted simultaneously by wavelength division multiplexing (WDM).

The power of all the channels combined is boosted by an optical amplifier before being launched into an optical fiber. The launched power generally compensates for the fiber transmission loss of a given fiber stage (span). After each span, the signals are amplified by an optical line amplifier (e.g., Erbium doped fiber amplifier), or by a repeater. Since the transmission fiber is a dispersive medium, implying that pulses spread as they travel through the fiber, some form of dispersion compensation is applied at each repeater stage. At the receiving end of the link, the WDM optical signal is de-multiplexed. Each channel is optically pre-amplified and then detected by an optical-to-electrical (O/E) converter (e.g., a photodiode). A decision circuit identifies the "1's" and "0's" in the signal. An optical filter can be inserted before the O/E converter to filter out amplifier noise.

2.0 Limitation factors

The need for high-speed data transmission has enhanced the use of optical communication systems, which have experienced a rapid evolution during the last decade. New system concepts including dense wavelength division multiplexing (DWDM) and optical time division multiplexing (OTDM) have multiplied the transmission capacity of an optical fiber. Especially WDM provides a straightforward way to upgrade the capacity of the existing fiber lines. Even though the above advancement, there is a major impairment that restricts the achievement

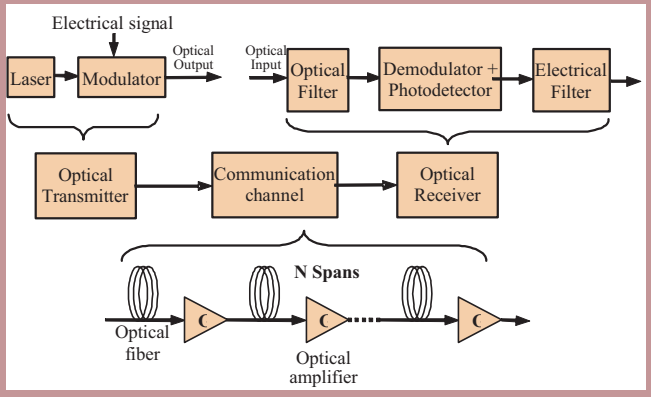

Figure 1: A typical digital fiber optic link

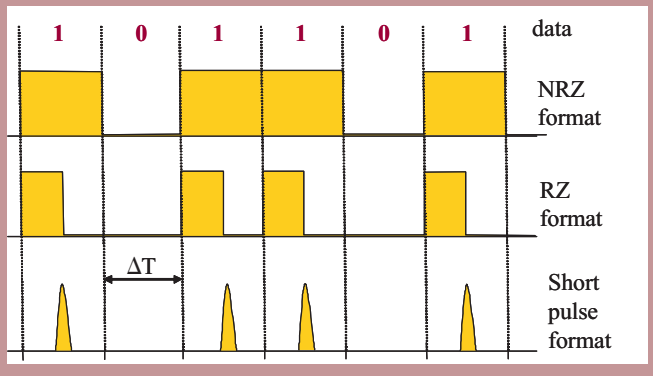

Figure 2: RZ, NRZ and pulse format, T: bit interval

of higher bit rates with standard single mode fiber is chromatic dispersion. This is particularly problematic for systems operating in the 1550 nm band, where the chromatic dispersion limit decreases rapidly in inverse proportion to the square of the bit rate. Chromatic dispersion (CD) and polarization-mode dispersion (PMD) can cause the creation of Inter-Symbol Interference (ISI) which is a major obstacle to reliable high speed data transmission over optical fibers. As both CD and PMD originate in the optical domain, the most effective compensation schemes use optical equalization. Nonetheless, electrical equalization schemes are also being widely considered because they offer several potential advantages, including compactness, flexibility and low cost.

Moreover, non-linear effects arise when the pulse is shorter such as the case of moving from 10 to 40Gbit/s. Thus, we face a major limitation factors for high bit rate transmission: dispersion and the presence of nonlinear effects. It is very desirable to make both factors cancel one another. In this spirit, some researches lead to what is referred to as the "solitons". Initially, these special forms of optical signals are designed to balance the chromatic dispersion and the Kerr nonlinearity of the fiber.

3.0 Fiber Impairment

3.1 Attenuation

Attenuation in fiber occurs due to absorption, scattering and radiative losses of the optical energy. Absorption losses are caused by atomic defects in the glass composition, intrinsic absorption by atomic resonance of fiber material and extrinsic absorption by the atomic resonance of external particles (like OH ion) in the fiber. Scattering losses in fiber arise from microscopic variations in the material density and from structural inhomogeneities. There are four kinds of scattering losses in optical fibers namely Rayleigh, Mie, Brillouin and Raman scattering. Radiative losses occur in an optical fiber at bends and curves because of evanescent modes generated.

3.2 Signal distortion

3.2.1 GVD / PMD

Dispersion has two major forms: chromatic and polarization mode (Figure 3). The former (Figure 3b) is the phenomenon by which different frequencies travel through a fiber with different group velocities, while the latter (Figure 3a) represents a velocity difference between the two orthogonal electric field components inside the fiber. Unlike Polarization Mode Dispersion (PMD), chromatic dispersion or Group Velocity Dispersion (GVD) increases linearly with the fiber length. The GVD is governed by material properties (the dependence of the fiber material refractive index on the light frequency) and waveguide dispersion (wherein Maxwell's equations yield different β's for different frequencies depending upon the fiber dimensions). It is quantified by a Dispersion Parameter, $D(\lambda)$, which measures the time delay introduced between light at different wavelengths while propagating through a fiber with a length L ($\tau_{delay} = D(\lambda)\,\Delta\lambda L$, where D =17 ps/nm-km in the 1550 nm communication window). PMD on the other hand is caused by the removal of circular symmetry in a fiber due to external factors like temperature, mechanical stress etc. It is a random process and hence the group delay it produces (τ_{PMD}) is proportional to the square root of the propagation distance. The fraction of the total power contained in one of the polarizations (γ) basically governs how bad the PMD is. The overall effect of both GVD (Figure 4) and PMD is the broadening of pulses propagating through the fiber and this result in Inter-Symbol Interference (ISI) [1] as pointed out in Figure 4. Indeed, what we presented in Figure 3, is not the actual signal. In reality it deals with the envelope of the transmitted pulses. However, the actual signal looks like what we point out in Figure 4. ISI leads to closing of the eye at the output that in turn causes higher bit error rates and increases input power requirements.

3.2.2 Non linear optical effects

The refractive index of silica has a weak dependence on the optical intensity I (optical power per effective area in the fiber) and is given by: $n = n_0 + n_2 I = n_0 + n_2 P/A_{eff}$ where n_0 is the normal refractive index of the fiber material, n2 is the nonlinear index coefficient, P is the optical power and A_{eff} is the effective cross-sectional area of the fiber. In silica, the value of n_2 ranges from 2.2 to 3.4 x10^{-8} $\mu m^2/W$. This nonlinearity in the refractive index is known as Kerr nonlinearity, and results in a carrier-induced phase modulation of the propagating signal, called the Kerr effect. It can cause self-phase modulation (SPM), cross-phase modulation (XPM) and four-wave mixing (FWM).

3.2.2.1 Self-Phase Modulation (SPM): Because the local refractive index is a function of the optical intensity of the propagating signal, the mode propagation constant becomes dependent on the optical intensity also. The power dependent propagation constant, β, can be written as $\beta = \beta + \gamma P$, where β is the mode propagation constant which is derived by assuming a constant refractive constant. The nonlinear coefficient γ is defined by $2\pi n_2/(A_{eff}\lambda)$. Since this nonlinear phase modulation is self induced, the nonlinear phenomenon responsible for it is called SPM. As phase fluctuations translate into frequency fluctuations, SPM causes frequency chirping of the optical pulses, which presents a source of error.

3.2.2.2 Cross-Phase Modulation (XPM): In WDM systems, where several optical channels are transmitted simultaneously inside an optical fiber, the nonlinear phase shift for a specific channel depends not only on the power of that channel but also on the power of the other channels. Moreover, the phase shift varies from bit to bit, depending on the bit pattern of the neighboring channels. This nonlinear phenomenon is known as XPM. Like SPM, XPM may lead to erroneous reception of the transmitted bits sequence.

3.2.2.3 Four-Wave Mixing (FWM): FWM is a third order nonlinearity in silica fibers, caused by the third order nonlinear susceptibility of silica. FWM resembles inter modulation distortion in electrical systems. If three optical fields with carrier frequencies f_1, f_2, *and* f_3 are propagating simultaneously in a fiber, the fiber nonlinearity causes them to mix, producing a fourth inter modulation term that is related to the other frequencies by the relation $f_4 = f_1 \pm f_2 \pm f_3$. FWM is an additional source of ISI.

4.0 Electronic Dispersion Compensation

4.1 Pre-compensation

Pre-compensation schemes are based on the idea of modifying the characteristics of the input pulses at the transmitter before being launched

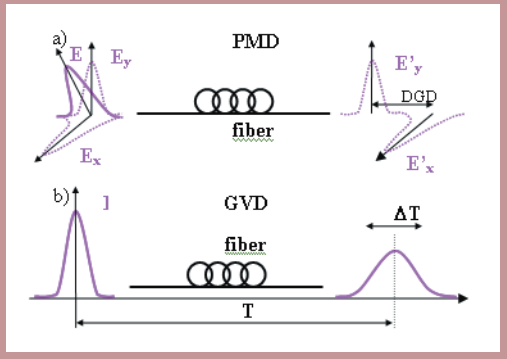

Figure 3: a) PMD: Polarisation mode Dispersion, DGD: Differential Group Delay, E: input field, E': output field, Ex: x-component of the field, b) GVD: Group Velocity Dispersion.

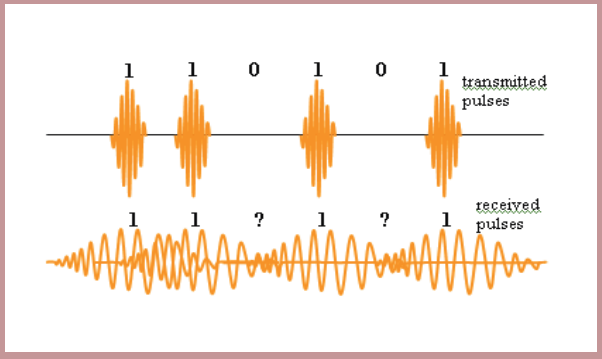

Figure 4: The overall effect of both GVD and PMD.

into the optical fiber so that the dispersion negates the applied pre-compensation and an undistorted signal results at the receiver.

4.1.1 Alternative coding techniques

Instead of using the conventional On-Off Keying (OOK) to modulate the light signal, several other modulation schemes have been developed that offer a substantial increase in the transmission distance. In one approach, referred to as dispersion-supported transmission, the frequency shift keying (FSK) format is used for modulating the light signal [2]. The FSK signal is generated by switching the laser wavelength by a constant amount $\Delta\gamma$ between '1' and '0' bits without changing the amplitude of the modulated signal. Due to chromatic dispersion, the two wavelengths travel at different speeds inside the fiber. As a result, the chromatic dispersion converts the FM signal into a three-level signal that can be decoded in the receiver. The wavelength shift is chosen so that the time delay, Δt, between the '1' and '0' bits is equal to one-bit duration.

Another approach for increasing the reach of the system depends on utilizing modulation formats that further reduce the bandwidth of the optical signal, as compared to the standard OOK technique. One such approach makes use of duobinary coding, which reduces the signal bandwidth by approximately 50%. In their simplest form, duobinary signals are created by low pass filtering of the electrical signal to reduce its bandwidth, while generating controlled inter symbol interference. Since the detrimental effect of the chromatic dispersion depends on the signal bandwidth, the system reach can be improved substantially [3-7]. Experimental results have shown that 10 Gb/s duobinary-coded systems, operating in the 1550 nm band can have a reach in excess of 200 km, as compared to the 80 km limit of conventional OOK systems [3]. Combining duobinary coding with prechirping increases the system reach even further. In [4], a distance of 277 km has been achieved using that technique. An additional advantage of duobinary coding is its reduced sensitivity to higher order PMD which is a direct result of their reduced bandwidth.

4.1.2 Prechirping Techniques

Prechirping is the process of appropriately phase modulating the light carrier in order to compensate for the pulse width broadening that would otherwise result from the chromatic dispersion of the optical fiber. In the 1550 nm band, conventional optical fibers suffer from anomalous dispersion; that is, longer wavelengths have a lower group velocity than shorter wavelengths. In this case, the spreading of the bit into adjacent slots can be delayed by making the light in the leading edge of the pulse of longer-than-average wavelength and that in the trailing edge of the bit to be of shorter-than-average wavelength (Figure 5). As a result, the pulse initially becomes narrower as it travels along the fiber, which means that the allowable transmission length for a system with prechirp is greater than that of a system with an ideal external modulator. However, further transmission causes the pulses to broaden again and intersymbol interference results.

Several techniques have been proposed to prechirp the transmitted signal. One simple way is to add phase modulation by the use of an unbalanced Mach-Zehnder amplitude modulator. However, this technique achieves only modest gains [8]. Another method is to frequency modulate the laser to provide chirp in the optical signal that is entering an external modulator [9]. With this technique, the experiments in [10] demonstrated a penalty-free 10 Gb/s NRZ transmission over 100 km of SSMF at 1550 nm.

4.2 Post-compensation Techniques

4.2.1 Error Correction

For high-speed optical fiber communication, the data transmission reliability can be degraded by some or all of the system impairments, mentioned earlier, resulting in a quality of service that is lower than that demanded by the system specifications. In this case, the transport protocol of the network can be manipulated to compensate for the loss in performance. The two common schemes for improving the reliability of the system are automatic repeat request (ARQ) and forward error correction (FEC). The ARQ scheme is based on using a feedback channel between the receiver and the transmitter to request a message retransmission in case errors are detected. Since each retransmission adds at least one round trip time of delay, ARQ may not be adequate for applications that require low latency. FEC avoids the shortcomings of ARQ which makes it more suitable for high-speed optical networks that require short delays.

For FEC techniques, redundant information is transmitted along with the original data. The redundant information is used to check the integrity of the transmitted data and correct the received errors. Typically, the overhead that is added to the transmitted data is kept small, so that the FEC scheme does not require much additional bandwidth, and thus, remains efficient.

Although FEC does not compensate for ISI by itself, it can be used to complement other dispersion compensation techniques. In [5], polarization scrambling was combined with FEC and electronic equalization in the receiver so as to mitigate the PMD. The idea is to accelerate the PMD dynamics by polarization scrambling so that the bad PMD constellations can affect only a limited number of bits per FEC frame. Then, these few errors can be corrected by the FEC scheme.

4.2.2 Electrical Equalization

Although the term equalization derives from linear filter theory, it now applies to any scheme aimed at compensating for the effects of a dispersive channel. Equalizers are classified into three general types [14]. One is based on the maximum-likelihood sequence estimation (MLSE) criterion which provides the best performance. The second type is based on the use of linear filters with adjustable coefficients. The third type uses the previously detected symbols to subtract the ISI in the present symbol being detected; thus, the name decision-feedback equalizer (DFE).

4.2.2.1 Maximum Likelihood Sequence Estimation (MLSE)

MLSE is the optimum detection technique. It is based on the correlation of a complete distorted signal sequence with estimates of all the possible sequences over many time slots. The selection of the sequence with the maximum correlation, usually done with the Viterbi algorithm, determines the decision for the actual bit. The Viterbi algorithm has the disadvantage of imposing a heavy computational burden. Indeed, the MLSE has a computational complexity that grows exponentially with the length of the channel time dispersion. If the size of the symbol alphabet is M and the channel dispersion spans L symbols, the Viterbi algorithm computes ML+1 for each newly received symbol. However, for many channels of practical interest, this kind of computational complexity is prohibitively expensive to implement. Instead, one can resort to much simpler, although suboptimum, equalizers such as linear transversal equalizers and decision-feedback equalizers.

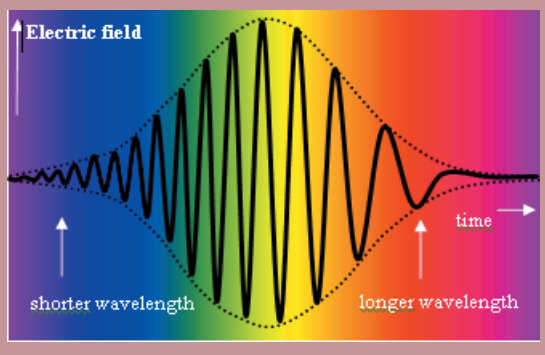

Figure 5: A negatively chirped Gaussian pulse: The instantaneous frequency decreases with time.

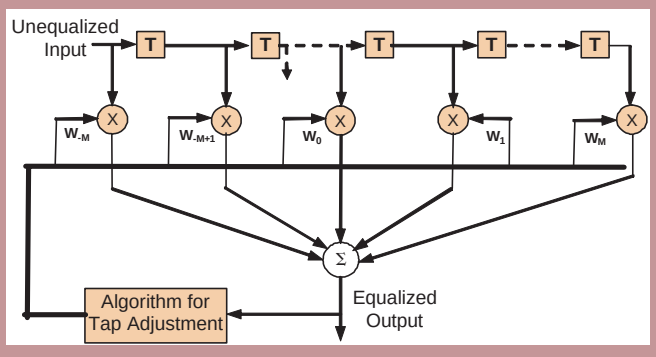

Figure 6: Linear Transversal Equalizer

4.2.2.2 Linear Equalization

The most widely used linear filter for equalization is the transversal (tapped delay line), depicted in Figure 6. Usually, the input signal is assumed to be sampled at T-intervals, where T is the symbol period. Thus, the commonly used name, T-spaced transversal equalizer.

The peak distortion criterion based method and the more recent one based on the mean square error (MSE) criterion are the two popular methods using linear equalization. In the peak distortion criterion, the transversal filter frequency response is adjusted to approximate the inverse of the channel frequency response. The resulting filter is commonly referred to as the zero-forcing equalizer. However, this filter has a serious drawback. If the channel contains a spectral null in its frequency response, the linear zero forcing equalizer attempts to compensate for this by introducing an infinite gain at that frequency. This compensates for the channel distortion at the expense of enhancing the additive noise and poor performance results.

For the MSE criterion based method, the taps of the equalizer are adjusted to minimize the mean square value of the error signal which is the difference between the correct symbol and the output of the equalizer. The main difference between the MSE criterion and the peak distortion criterion is that the noise at the input of the equalizer is also considered to avoid any excessive noise enhancement. As a consequence, the MSE criterion attempts to achieve a compromise between the cancellation of the ISI and noise enhancement.

4.2.2.3 Decision-Feedback Equalization

Unfortunately, linear equalizers in not very efficient for channels suffering from serious ISI. The decision-feedback equalizer (DFE), which is the most popular nonlinear equalizer for severe fading channels, requires a lower computational effort. As depicted in Figure 7, it consists of two filters, a feedforward (FF) filter, and a feedback (FB) filter. The FF filter is identical to the linear transversal equalizer; usually, a FSE is used. The FB filter has, as its input, the sequence of decisions on previously detected symbols. Functionally, the FB filter is used to remove that part of the ISI from the present estimate caused by previously detected symbols. Typically, the MSE criterion is used for the optimization of the equalizer coefficients. The performance characteristics of the DFE are summarized as follows [6]:

- The feedback section does not exhibit any noise enhancement, since it operates on noise-free decisions.
- The combined impulse response of the channel and the FF section can have nonzero samples following the main pulse; that is, the FF equalizer does not need to approximate the inverse of the channel characteristics, and so avoids excessive noise enhancement and sensitivity to the sampler phase.
- Since the feedback section operates on symbol decisions, the feedback section taps are baud-spaced.
- The required number of feedback taps equals the channel's maximum delay spread. However, when an incorrect decision is fed back, the DFE output reflects this error for the next few symbols, because the incorrect decision traverses the feedback delay line. As a result, there is a greater likelihood of more incorrect decisions following the first one, i.e., error propagation. Fortunately, the error propagation in a DFE is usually not catastrophic. Under typical channel conditions, errors occur in short bursts that degrade the performance only slightly.

5.0 Solitonic transmission

The techniques covered above are limited to the compensation of dispersion. Given that dispersion is not the only source of ISI, nonlinearity should be taken into account in high bit rate communications. Instead of handling nonlinearity alone as the case of predispersation, it is more convenient to eliminate or at least to reduce both effects at once. The idea consists of mutually balancing the effects of dispersion and nonlinearity [7].

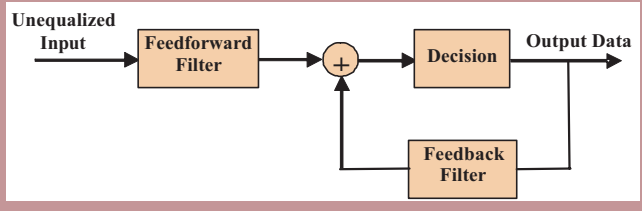

Figure 7: DFE structure

Solitons are understood as arising from a balancing of the chromatic dispersion and the Kerr nonlinearity of the fiber [7]. While solitonic transmission presents a very attractive technique for providing high-speed long-distance communication, there are some serious difficulties to overcome before reaching the commercialization stage of amplified solitonic systems. The Gordon-Hauss effect is one of these problems. It is induced by the mixing of the signal and the Amplified Spontaneous Emission (ASE) noise generated by the Erbium-Doped Fiber Amplifiers (EDFAs). We recall that this amplifier is used to balance the attenuation inherent to solitonic communication systems. During propagation, signal mixing and ASE noise distort the soliton shape and lead to timing jitter. As a consequence, the Bit Error Rate or Ratio (BER) is increased. The BER is defined as the ratio of the number of erroneous bits received to the total number of bits transmitted.

6.0 Discussion

Although equalization is very well known in lower rate communication systems, its potential in Gb/s optical communication has not been fully exploited yet. The main obstacle lies in the very high speed implementation requirements which limit the available options for implementation. The effectiveness of linear equalizers, which are the simplest and most amenable to high speed implementation, is limited by the fact that direct detection receivers convert the distortion that results from chromatic dispersion, which is linear in the optical domain, into a nonlinear distortion that is difficult to cancel. Although nonlinear techniques such as decision feedback equalizers and maximum likelihood sequence estimation can substantially improve the dispersion-limited reach, their implementation remains the main challenge at high data rates.

Duobinary modulation, principally driven by its advantage of the reduced bandwidth, compared to conventional NRZ OOK modulation, and the ability to use a conventional direct detection receiver. In principle, electrical pre-equalization can also be applied to other modulation formats for potential improvements, albeit at the cost of more complex transmitters and receivers.

All these techniques do not handle nonlinear effects, which are serious sources of errors in the framework of high bit rate communications. Besides, solitonic transmission is a totally different compensation technique, that is in theory largely more powerful than the previously mentioned techniques. The power of the latter lies in its ability of making two sources of signal distortion, namely dispersion and nonlinear effects to cancel each other. The major drawback of this technique is the technological difficulty of implementing soliton like pulses. As technologies progress, it would be possible to implement the solitonic transmission compensation with ease, leading to a blooming of high bit rate communications.

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Highlights from IEEE Canada Region 7 Spring Meeting in Saskatoon, May 2005

Various **IEEE Canadian Foundation Awards** were presented to Section Chairs to take back to their members.

(left to right): Maike Miller (Ottawa), Lawrence Whitby (S. Alberta), Andrew Kostiuk (N. Saskatchewan), Bill Kennedy (President IEEE Canada) Bob Alden (President IEEE Canadian Foundation), Jim Dunfield (Kingston), Keith Brown (Northern Canada Section), Kostas Plataniotis(Toronto) and Ani Gole (Winnipeg).

President Bill Kennedy acknowledges work done by members of the **IEEE Canada Audit Committee.**

(left to right): Bill Kennedy, Danny Wong, Gerard Dunphy, Kash Husain and Vijay Bhargava.

The Development of the IEEE/ACM Software Engineering Curricula

by *Yingxu Wang*
University of Calgary, Calgary, AB.

Abstract

A recent important international effort in software engineering education is the work of the IEEE/ACM Joint Task Force on the development of the Software Engineering Curriculum (JTF-SEC). This paper reports the design and development of the Computing Curricula - Software Engineering (CCSE), and presents the philosophy and insides behind CCSE based on the experience as a member of the committee.

The architecture of CCSE encompasses the guiding principles, curricular models, software engineering education knowledge areas, curriculum design, pedagogy guidelines, professional practice, program implementation and accreditation. The major components of CCSE are the Software Engineering Education Knowledge (SEEK), a formulate guidance for pedagogy, and methodologies for course design and accreditation. Software engineering education in SEEK is categorized into a set of knowledge areas, known as foundations, requirements, design, construction, maintenance, process, quality, and management.

CCSE is featured not only by its knowledge structures, but also by its studies on pedagogy for software engineering. CCSE provide a comprehensive set of principles for curriculum design, methodologies for software engineering course development, and core themes and models of the software engineering curriculum for both directors of software engineering programs and instructors of software engineering courses. It is noteworthy, however, that a number of important areas have not yet been modeled in the CCSE curriculum, such as software engineering notations, measurement and metrics, and theoretical foundations of software engineering.

Sommaire

Un effort international important et récent en enseignement du génie logiciel est celui du groupe de travail conjoint IEEE/ACM sur le développement du Curriculum de génie logiciel (JTF-SEC). Cet article présente la conception et le développement des Curriculums en informatique - génie logiciel (Computing Curricula - Software Engineering, CCSE), ainsi que la philosophie et les dessous du CCSE d'après l'expérience d'un membre du comité. L'architecture du CCSE comprend les principes directeurs, des modèles de curriculums, les domaines de connaissance en enseignement du génie logiciel, la conception de curriculums, les lignes directrices pédagogiques, la pratique professionnelle, les programmes d'implantation et l'accrédiation. Les composantes majeures du CCSE sont les Connaissances en enseignement du génie logiciel (SEEK), une formule d'orientation pédagogique, et des méthodologies pour la conception de cours et l'accréditation. L'enseignement du génie logiciel dans SEEK est catégorisé en un ensemble de domaines de connaissances: fondations, spécifications, conception, construction, maintenance, processus, qualité et gestion.

Le CCSE se caractérise non seulement par ses structures de connaissances, mais aussi par ses recherches sur la pédagogie pour le génie logiciel. CCSE fournir un ensemble exhaustif de principes pour la conception des curriculums, des méthodologies pour le développement de cours en génie logiciel, et des thèmes et modèles centraux des curriculums de génie logiciel pour les directeurs de programmes de génie logiciel et les enseignants. Il est à noter, cependant, qu'un nombre important de domaines n'ont pas encore été modélisés dans le curriculum du CCSE tels la notation en génie logiciel, les mesures et métriques, et les fondations théoriques du génie logiciel.

1.0 Introduction

The recent surge in the creation of software engineering programs and their accreditation has resulted in the development of the Joint IEEE/ACM Computing Curricula - Software Engineering (IEEE/ACM CCSE) [13]. The primary purpose of IEEE/ACM CCSE is to provide guidance to academic institutions and accreditation agencies about what should constitute an undergraduate software engineering curriculum and its implementation.

A curriculum is a well defined process by which the knowledge and skills required for a discipline or a profession can be defined and taught by a number of coherent courses according to a specific degree program.

The IEEE/ACM Joint Task Force on the development of the Software Engineering Curriculum (JTF-SEC) was established in 1998. The definition of software engineering and its implication and extension are discussed in the group.

IEEE defined software engineering as "The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software [12]." The author perceives that:

> "*Software Engineering* is a discipline that adopts engineering approaches, such as established methodologies, processes, architectures, measurement, tools, standards, organization methods, management methods, quality assurance systems and the like, in the development of large-scale software, seeking to result in high productivity, low cost, controllable quality, and measurable development schedule [14, 15]."

The JTF-SEC adopted a set of principles to guide the work on the development of the Software Engineering Education Knowledge (SEEK) and the Computing Curricula - Software Engineering (CCSE). The design philosophy and principles of CCSE are as follows [13]:

- **Basic Knowledge and Skills:** "All software engineering students must learn to integrate theory and practice, to recognize the importance of abstraction and modeling, to be able to acquire special domain knowledge beyond the computing discipline for the purposes of supporting software development in specific domains of applications, and to appreciate the good engineering design."

  "CCSE must support the identification of the fundamental skills and knowledge that all software graduates must possess."
- **Dynamic Curricula:** "The rapid evolution and the professional nature of software engineering require an ongoing review of the corresponding curriculum."

  "Development of a software engineering curriculum must be sensitive to changes in technology, new developments in pedagogy, and the importance of lifelong learning."
- **Professionalism:** "CCSE must include exposure to aspects of professional practice as an integral component of the undergraduate curriculum."
- **Pedagogy and Implementation Support:** "CCSE must include discussions of strategies and tactics for implementation, along with high-level recommendations."

It is recognized that software engineering draws its foundations from a wide variety of disciplines. Although undergraduate study of software engineering relies on many areas in computer science for its theoretical and conceptual foundations, it also requires students to utilize concepts from a variety of other fields, such as mathematics, engineering and project management.

2.0 Sources of IEEE/ACM CCSE

The development of IEEE/ACM Computing Curricula - Software engineering (CCSE) is on the basis of a number of international initiatives and a wide range of educational experiences. The major sources of CCSE are the IEEE/ACM SWEBOK [5], CCCS [9], IS2002 [4], and surveys on international software engineering programs.

2.1 IEEE/ACM SWEBOK

The software engineering body of knowledge (SWEBOK) [5] is developed by an IEEE/ACM joint committee in 2001. SWEBOK provides a comprehensive description of the knowledge needed for the practice of software engineering. The IEEE/ACM JTF-SEC has chosen SWEBOK as one of the primary sources for the development of SEEK

Although CCSE was significantly influenced by SWEBOK, the major difference between SWEBOK and CCSE is that the former is process-centered and the latter is water-fall-model based. In addition, SWEBOK was designed for professionals working in the software industry and CCSE is oriented to undergraduate students in software engineering programs.

2.2 IEEE/ACM CCCS

IEEE-CS and ACM established a task force on Computing Curricula in 1998, that results in the Computing Curricula 2001 (CC2001) [1]. Over the past fifty years, computing has become an extremely broad designation that extends well beyond the boundaries of computer science to encompass such independent disciplines as computer engineering, software engineering, and information systems. In representing this trend, the computing curricula are divided into two volumes known as the Computing Curricula - Computer Science (CCCS) [9] and the Computing Curricula - Software Engineering (CCSE) [13].

2.3 ACM/AIS/AITP IS2002

Related to the international effort on CCCS, the Model Curriculum and Guidelines for Undergraduate Degree Program in Information Systems (IS 2002) is published in 2002 [4], jointly developed by a task force chartered by ACM, the Association for Information Systems (AIS), and the Association of Information Technology Professionals (AITP). IS 2002 is perceived to be useful for both students major in information technology (engineering), and computer engineering [3].

2.4 IEEE/ACM JTF-SEC

The IEEE/ACM Joint Task Force on the development of the Software Engineering Curriculum (JTF-SEC) conducted a survey of international undergraduate programs of software engineering. In this comprehensive survey, 32 programs in North America, Europe, Asia and Australia have been comparatively analyzed. This work forms the empirical foundation and a global view on the design of CCSE and SEEK.

3.0 IEEE/ACM CCSE

The software engineering curriculum is a set of carefully defined programs by which the knowledge and skills required for software engineering as a profession can be defined and taught by a number of coherent courses for a specific degree in software engineering or computer science.

IEEE/ACM Computing Curricula - Software Engineering (CCSE) concentrates on the knowledge and pedagogy associated with a software engineering curriculum. The architecture and the recommended curriculum of CCSE are described below.

3.1 The Architecture of CCSE

The architecture of CCSE is shown in Figure 1. CCSE encompasses (a) The guideline principles and professional practice; (b) Software engineering education knowledge, curriculum models, and curriculum design; and (c) program implementation and assessment, and student outcomes.

As shown in Figure1, the center of CCSE is the Software Engineering Education Knowledge (SEEK) and the recommended curricula on software engineering.

3.2 The Recommended Curriculum

A software engineering program designed based on IEEE/ACM CCSE may be divided into the introductory, core, and completing modules as shown in Table 1, where the recommended courses and their levels in each module are also described.

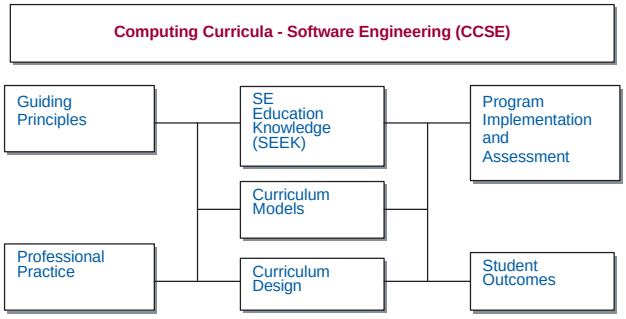

Figure 1: Architecture of CCSE

4.0 IEEE/ACM SEEK

Software Engineering Education Knowledge (SEEK) is a set of core and fundamental knowledge that every software engineering graduate must know [13]. This section describes the architecture of SEEK and the knowledge areas and units modeled in SEEK.

4.1 The Architecture of SEEK

The architecture of SEEK is shown in Figure 2, where 11 knowledge areas have been modeled. Each of these knowledge areas is explained below.

- **A1: Fundamentals**

Fundamentals of software engineering cover the theoretical and mathematical foundations of software and software engineering technologies. This area focuses on engineering design, where mathematics and engineering sciences are applied to optimally convert resources to meet a stated objective [13].

- **A2: Professional Practice**

Professional practice in software engineering is represented by knowledge, skills, attitudes, and professionalism that software engineers must possess. It also includes the areas of technical communication, team working, psychology, and social and professional responsibilities.

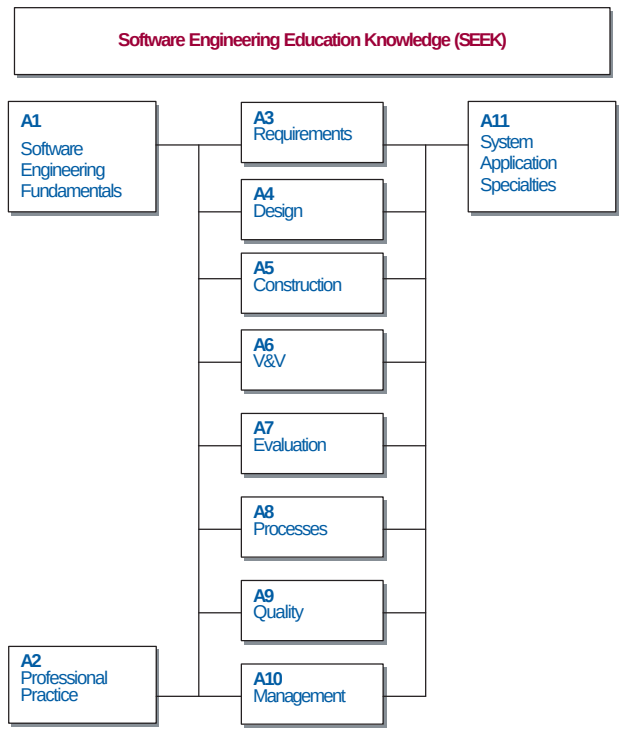

Figure 2: Architecture of SEEK

Table 1: The Recommended Curriculum in CCSE

Cat #	Course Title	Description
1	**Introductory**	
SE101	Introduction to Software Engineering and Computing	A first course in software engineering and computing for the software engineering student who has taken no prior computer science at the university level. Introduces fundamental programming concepts as well as basic concepts of software engineering.
SE102	Software Engineering and Computing II	A second course in software engineering, delving deeper into software engineering concepts, while continuing to introduce computer science fundamentals.
SE200	Software Engineering and Computing III	Continues a broad introduction to software engineering and computing concepts.
CS103	Data Structures and Algorithms	Any variant of CS 103 from the CCCS can be used (e.g., those from the imperativefirst or objects-first sequences).
CS105	Discrete Structures I	Standard first course in discrete mathematics. Taught in a way that shows how the material can be applied to software and hardware design
CS106	Discrete Structures II	Continues the discussion of discrete mathematics introduced in CS105. Topics in the second course include predicate logic, recurrence relations, graphs, trees, matrices, computational complexity, elementary computability, and discrete probability.
MA271	Statistics and Empirical Methods	Applied probability and statistics in the context of computing. Experiment design and the analysis of results.
2	**Core**	
2.1	**Package I**	
SE211	Software Construction	Covers low-level design issues, including formal approaches
SE212	Software Engineering Approach to Human Computer Interaction	Covers a wide variety of topics relating to designing and evaluating user interfaces, as well as some of the psychological background needed to understand people
SE311	Software Design and Architecture	Advanced software design, particularly aspects relating to distributed systems and software architecture
SE321	Software Quality Assurance	Broad coverage of software quality and testing
SE322	Software Requirements Analysis	Broad coverage of software requirements, applied to a variety of types of software
SE323	Software Project Management	In-depth course about project management
2.2	**Package II**	
SE213	Design and Architecture of Large Software Systems	Modeling and design of large-scale, evolvable systems; managing and planning the development of such systems – including the discussion of configuration management and software architecture
SE221	Software Testing	In-depth course on all aspects of testing, as well as other aspects of verification and validation, including specifying testable requirements, reviews, and product assurance
SE312	Low-Level Design of Software	Techniques for low-level design and construction, including formal approaches. Detailed design for evolvability
SE324	Software Process and Management	Software processes in general; requirements processes and management; evolution processes; quality processes; project personnel management; project planning
SE313	Formal Methods in Software Engineering	Approaches to software design and construction that employ mathematics to achieve higher levels of quality. Mathematical foundations of formal methods; formal modeling; validation of formal models; formal design analysis; program transformations
SE400	Software Engineering Capstone Project	Provides students, working in groups, with a significant project experience in which they can integrate much of the material they have learned in their program, including matters relating to requirements, design, human factors, professionalism, and project management
3	**Completing**	
3.1	CCCS 2xx	Intermediate fundamental computer science courses
3.2	Non-technical compulsory courses	
NT272	Engineering economics	This is a standard engineering economics course as taught in many universities.
NT181	Group dynamics and communication	Communication and writing skills are highly regarded in the software industry, but they are also fundamental to success in collegiate careers.
NT291	Professional software engineering practice	Professional Practice is concerned with the knowledge, skills, and attitudes that software engineers must possess to practice software engineering in a professional, responsible, and ethical manner.
3.3	Mathematics courses that are not SE core	-
3.4	Technical (SE/CS/IT/CE) courses that are not SE core	-
3.5	Science/engineering courses covering non-SEEK topics	-
3.6	General non-technical courses	-

- **A3: Requirements**

"Software requirements identify the purpose of a system and the contexts in which it will be used [13]." Requirements play an important role in software engineering since it is the initial conceptual model of a software system. It is noteworthy that requirements for a software engineering project are a moving target. Therefore, treatment of requirements as static items in software engineering courses should be avoided.

- **A4: Design**

System design is the process that creates a conceptual and abstract model of a software system with its architecture and behaviors, which meets users' requirements. System design includes the specification activities of internal interfaces among software components, architectural design, data design, user interface design, and special tool design.

- **A5: Software Construction**

Software construction is a process that implements a system design by composing suitable components on selected platform. This area covers the knowledge on design refinement, component selection, coding, programming languages, tests, and simulation.

- **A6: Software Verification and Validation**

Software verification and validation are processes that ensure the quality of software. The former checks whether an implementation of the system conforms with the specifications of the system; The latter checks whether an implementation of the system meets the customers requirements. In Verification and Validation, both static and dynamic behaviors of a system should be checked.

- **A7: Software Evolution**

"Software evolution provides cost-effective mission support during pre- and post-delivery stages while maintaining acceptable and satisfactory behavior and validity of assumptions [13]." Software evolution may be implemented by a number of planned and coherent releases for a given system. A number of techniques may adopted in this area, such as program comprehension, release planning, changes identification and control, re-engineering, reverse engineering, maintenance review, migration, system trial, and system replacement /retirement.

- **A8: Software Process**

Software process is a set of durable and repeatable practices in software engineering, which cover the whole life-cycle of software development. Software processes can be classified into three categories known as organization, technology, and management. Software process may be perceived as the infrastructure of process-based software engineering. Software engineering process establishment, assessment, and improvement are major knowledge and techniques for software engineering students [14, 15].

- **A9: Software Quality**

Software quality is one of the basic characteristics and requirements in software engineering. It is a pervasive concept that affects, and is affected by all aspects of software development, support, revision, and maintenance. Software quality can be modeled by a set of attributes such as usability, reliability, safety, security, maintainability, flexibility, efficiency, performance and availability. Software quality is not only implemented in code and other work products, but also influenced by software engineering process and environment. Software quality assurance is at the center of software engineering technologies and practices.

- **A10: Software Management**

Software project management covers practices of project planning, organization, and monitoring. Software project management may be implemented by a set of organizational and management processes. The essence of software management is the synchronization of process activities in software engineering [15].

4.2 Knowledge Areas and Units of SEEK

Further detailed description of the SEEK knowledge areas is provided in Table 2 where each knowledge area is refined by a number of units [13]. The recommended load of each area and unit is given by the number of hours for study.

It is noteworthy that although software engineering programs are offered with a wide range variety of loads, the SEEK recommendation is 494 hours in total, which cover 20+ courses in a program.

5.0 Software Engineering Pedagogy

CCSE is featured not only by its knowledge structures, but also by its studies on pedagogy. CCSE provide a comprehensive set of principles for curriculum design, methodologies for software engineering course development, and core themes and models of the software engineering curriculum for both directors of software engineering programs and instructors of software engineering courses.

The task of the Pedagogy Focus Area Group of IEEE/ACM JTF-SEC is focused on curriculum recommendations based on SEEK. The pedagogy of CCSE encompasses the pedagogy guidelines, principles of software engineering curriculum design, curriculum models, international adaptation, and requirement for professional skills in addition to SEEK

5.1 Pedagogy Guidelines for Software Engineering

A set of 18 guidelines has been developed in CCSE for supporting the development of a specific software engineering program. The guidelines as shown in Table 3 can be classified into those for generic pedagogy, curricula designers, instructors, and students.

5.2 Student Outcomes

A set of expected outcomes is specified in CCSE for an undergraduate curriculum in software engineering. Graduates of an undergraduate software engineering program are required to be able to meet the following criteria [13]:

- Work as part of a team to develop and deliver executable artifacts,
- Understand the process of determining client needs and translating them to software requirements,
- Reconcile conflicting objectives, finding acceptable compromises within limitations of cost, time, knowledge, existing systems, and organizations,
- Design appropriate solutions in one or more application domains using engineering approaches that integrate ethical, social, legal, and economic concerns,
- Understand and be able to apply current theories, models, and techniques that provide a basis for software design, development, implementation and verification,
- Negotiate, work effectively, provide leadership where necessary, and communicate well with stakeholders in a typical software development environment, and
- Learn new models, techniques and technologies as they emerge.

5.3 Program Accreditation

It is recognized that, in order to maintain a quality curriculum, a software engineering program should be assessed on a regular basis. The formal assessment and accreditation of a software engineering program may cover the following areas: faculty, curriculum, laboratory and computing resources, students, institutional support, and program effectiveness. Accreditation may be carried out by periodic external reviews of programs. The aim of accreditation is to assure that a software engineering program meets the minimum requirement as adhered to the standard of a certain accreditation organization.

A number of curriculum guidance and accreditation criteria are available from accreditation organizations of a variety of nations and sectors [2, 6, 7, 8, 11]. For example, the IEEE/ACM Accreditation Criteria for Software Engineering may be referred to [17].

6.0 Conclusions

This paper has reported the design and development of the IEEE/ACM Computing Curricula - Software Engineering (CCSE), and presented the philosophy and insides behind CCSE based on the experience as a member of the committee. The history of CCSE development and related resources of CCSE have been reviewed.

CCSE has been developed to encompass the guiding principles, curricular models, software engineering education knowledge areas, curriculum design, pedagogy guidelines, professional practice, program implementation and accreditation.

Table 2: SEEK Knowledge Areas and Knowledge Units

No.	Knowledge Area	Knowledge Unit	Rec'd load (hrs)	
1	Computing Essentials	Computer Science foundations	140	172
		Construction technologies	20	
		Construction tools	4	
		Formal construction methods	8	
2	Mathematical & Engineering Fundamentals	Mathematical foundations	56	89
		Engineering foundations for software	23	
		Engineering economics for software	10	
3	Professional Practice	Group dynamics / psychology	5	35
		Communications skills (specific to SE)	10	
		Professionalism	20	
4	Software Modeling and Analysis	Modeling foundations	19	53
		Types of models	12	
		Analysis fundamentals	6	
		Requirements fundamentals	3	
		Eliciting requirements	4	
		Requirements specification & documentation	6	
		Requirements validation	3	
5	Software Design	Design concepts	3	45
		Design strategies	6	
		Architectural design	9	
		Human computer interface design	12	
		Detailed design	12	
		Design support tools and evaluation	3	
6	Software V & V	V&V terminology and foundations	5	42
		Reviews	6	
		Testing	21	
		Human computer UI testing and evaluation	6	
		Problem analysis and reporting	4	
7	Software Evolution	Evolution processes	6	10
		Evolution activities	4	
		Evolution processes	6	
8	Software Process	Process concepts	3	13
		Process implementation	10	
9	Software Quality	Software quality concepts and culture	2	16
		Software quality standards	2	
		Software quality processes	4	
		Process assurance	4	
		Product assurance	4	
10	Software Management	Management concepts	2	19
		Project planning	6	
		Project personnel and organization	2	
		Project control	4	
		Software configuration management	5	
	Total			494

The Software Engineering Education Knowledge (SEEK), a key component of CCSE, has been elicited by a set of knowledge areas that cover all aspects of software engineering.

CCSE has been featured not only by its knowledge structures, but also by its studies on pedagogy for software engineering. CCSE has provided a comprehensive set of principles for curriculum design, methodologies for software engineering course development, and core models of the software engineering curriculum for both directors of software engineering programs and instructors of software engineering courses. Although CCSE is a comprehensive software engineering curriculum, a number of important areas have not yet been modeled in it, such as software engineering notations, measurement, and theoretical foundations of software engineering [10, 14-16].

7.0 Acknowledgements

CCSE and SEEK are the intermediate results of an international effort carried out by IEEE/ACM JTF-SEC. The author would like to acknowledge the group and a lot of interesting discussions within it on the architecture and pedagogy of the software engineering curricula.

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Table 3: IEEE/ACM CCSE Guidelines for Curricula Design

No.	User	Guideline
1	**Instructors**	Instructors must have sufficient relevant knowledge and experience and understand the character of software engineering.
2	**Designers**	Curriculum designers and instructors must think in terms of outcomes.
3		Curriculum designers must strike an appropriate balance between coverage of material, and flexibility to allow for innovation.
4		Many SE concepts, principles, and issues should be taught as recurring themes throughout the curriculum to help students develop a software engineering mindset.
5		Learning certain software engineering topics requires maturity, so these topics should be taught towards the end of the curriculum, while other material should be taught earlier to facilitate gaining that maturity.
6	**Students**	Students must learn some application domain or domains outside of software engineering.
7		Software engineering must be taught in ways that emphasize its engineering nature.
8		Students should be trained in certain personal skills that transcend the subject matter.
9		Students should be instilled with the ability and eagerness to learn.
10		Software engineering must be taught as a problem-solving discipline.
11		The underlying and enduring principles of software engineering should be emphasized, rather than details of the latest or specific tools.
12		The curriculum must be taught so that students gain experience using appropriate and up-to-date tools, even though tool details are not the focus of the learning.
13		Material taught in a software engineering program should, where possible, be grounded in sound research and mathematical or scientific theory, or else widely accepted good practice.
14		The curriculum should have a significant real-world basis.
15		Ethical, legal, and economic concerns, and the notion of what it means to be a professional, should be raised frequently.
16	**General**	In order to ensure that students embrace certain important ideas, care must be taken to motivate students by using interesting, concrete and convincing examples.
17		Software engineering education in the 21st century needs to move beyond the lecture format: It is therefore important to encourage consideration of a variety of teaching and learning approaches.
18		Important efficiencies and synergies can be achieved by designing curricula so that several types of knowledge are learned at the same time.

INTERNATIONAL CONFERENCE FOR UPCOMING ENGINEERS (ICUE) 2005

The International Conference for Upcoming Engineers (ICUE) is a platform where students and faculty members work together in organizing a conference, and a forum to exchange ideas and promote learning and participation amongst undergraduate students, graduate students and faculty researchers.

After a very successful 3rd annual ICUE, the Steering Committee chaired by **Dr. Sri Krishnan** (Ryerson University) decided to make this a travelling conference in order to benefit students in other regions as well. The steering committee decided that the proposal from University of Windsor IEEE Student Branch was the strongest and hence the planning for the 4th annual ICUE began in December 2005.

The 4th annual ICUE was held in the University of Windsor on May 20th-21st 2005 thanks to the co-operation and support from the University of Windsor's Department of Electrical and Computer Engineering, Ryerson University, IEEE Canadian Foundation, IEEE Region 4, IEEE Toronto Section and IEEE South-eastern Michigan Section. Funding was also received from DaimlerChrysler 3-E Student Activities Fund (Platinum Sponsor), University of Windsor Student Alliance (Platinum Sponsor), JMP Engineering (Gold Sponsor), and the Alumni Association (Silver Sponsor).

The 2-day conference brought together prominent individuals in various fields of engineering and provided students with an opportunity to learn and interact. It consisted of a wireless communication session, automotive session, other technical and non-technical talks by distinguished lecturers, design demonstrations, paper contest, a wine and cheese social and a banquet and awards ceremony.

The wireless communication session had 4 speakers including **Dr. Gerry Chan**, Vice President, Terrestrial Wireless Systems at Communications Research Centre (CRC). The presentations were followed by a panel discussion which allowed the audience to interact with the speakers. The automotive session followed a similar format and included speakers from both industry and academia. Apart from these, there were presentations on various other technical topics such as "Making Mobile Robotics Help People" by **Dr. McIsaac** from University of Western Ontario.

In addition to technical talks, seminars on non-technical topics such as career growth, job search techniques, and stress management were also included. Keynote speaker **Jim Watson**, an IEEE S-PAC National

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Call Admission Control Schemes in Non-Cellular Wireless Network

by *Mohamed Hossam Ahmed*
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Abstract

Radio resource management (RRM) plays a major role in Quality of Service (QoS) provisioning for wireless communication systems. The performance of RRM techniques has a direct impact on each user's individual performance and on the overall network performance. Arriving (new and handoff) calls are granted/denied access to the network by the call admission scheme (CAC) based on predefined criteria, taking the network loading conditions into consideration. This article provides an overview of CAC schemes in special wireless networks, namely, satellite systems, multi-hop/ad-hoc networks, high altitude aeronautical platform station, and hierarchical cellular structure.

Sommaire

La gestion des ressources radio (GRD) joue un rôle majeur dans la fourniture de Qualité de service (QS) pour les systèmes de communication sans fil. La performation des techniques de GRD a un impact direct sur la performance de chaque usager et celle du réseau globalement. Les appels entrants (nouveaux ou transferts intercellulaires) voient leur accès au réseau accordé/refusé par le processus d'admission d'appel (PAA) basé sur des critères prédéfinis, prenant en compte les conditions de charge du réseau. Cet article fournit un aperçu des PAA dans des réseaux sans fil spéciaux tels les systèmes satellites, les réseaux ad-hoc/à plusieurs bonds, les plateformes de stations aéronautiques en haute altitude, et les structures cellulaires hiérarchiques.

1.0 Introduction

Radio resource management (RRM) plays a major role in the Quality of Service (QoS) provisioning for wireless communication systems. As a matter of fact, RRM policies along with the network planning and air interface design determine the QoS performance at the individual user level and the network level as well. RRM techniques encompass frequency and/or time channels, transmit power, and network access in order to control the amount of the assigned resources to each user with the objective of maximizing some function such as the total network throughput, total resource utilization or total network revenue subject to some constraints such maximum call blocking/dropping rate (P_b/P_d) and/or minimum signal to interference ratio (SIR). The performance of RRM techniques has a direct impact on each user individual performance and on the overall network performance. For instance, the allocated transmitter power for a user not only determines the QoS offered to this user but it also affects the interference level that other users receive, and as a result it influences the signal quality of other users.

Radio resources are managed using various schemes that can be grouped in three sets. The first set includes frequency/time resource allocation schemes such as channel allocation, scheduling, transmission rate control and bandwidth reservation schemes. The second set consists of power allocation and control schemes, which control the transmitter power of the terminals and access points. The third set comprises call admission control and network access schemes.

As shown in Fig. 1, arriving calls are granted/denied access to the network by the call admission scheme (CAC) based on predefined criteria taking the network loading conditions into consideration. Traffic of admitted calls is then controlled by other RRM techniques such as scheduling, power control and transmission rate control.

CAC has been extensively studied in wireline networks as an essential tool for congestion control and QoS provisioning. Different aspects of CAC design and performance analysis particularly in the context of broadband integrated service digital network (B-ISDN) based on asynchronous transfer mode (ATM) technology have been investigated in [1]. However, the problem of CAC in wireless networks is more sophisticated due to the unique features of wireless networks such as channel multiple access interference, channel impairments, handoff requirements, and limited bandwidth.

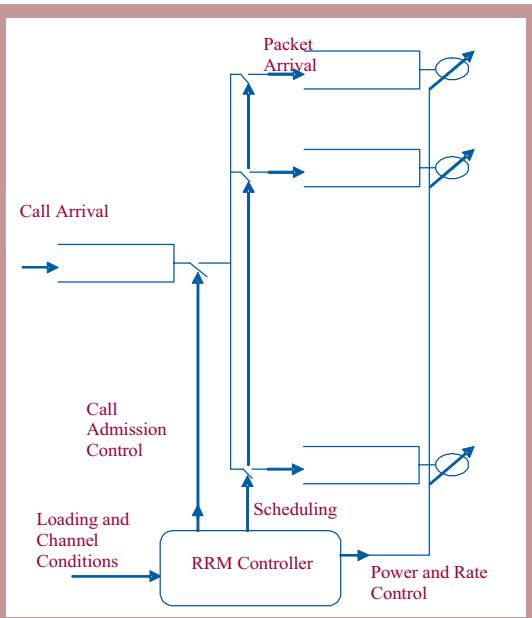

Figure 1: Radio Resource Management Model

CAC schemes developed for cellular wireless networks including second and third generation systems are extensively studied in the literature. Reference [2] includes a comprehensive survey on CAC on wireless cellular networks. This article provides an overview of CAC schemes in special wireless networks, namely, satellite systems, multi-hop/ad-hoc networks, high altitude aeronautical platform station, and hierarchical cellular structure.

2.0 CAC in Satellite Networks

Satellite systems are considered as a complement of terrestrial wireless networks to extend the coverage to large areas with small user density or to areas that can't be covered by terrestrial infrastructure such as large water areas. Satellite systems are also considered for overlapping with terrestrial wireless networks to provide service for high mobile users. However, two main challenges have to be tackled in satellite systems. The first challenge is the large propagation delay that limits the adaptation capability of RRM techniques including CAC schemes. The second challenge is the spectrum partitioning between terrestrial and satellite systems.

In [3], a hybrid system consisting of satellite and cellular coverage is considered. CAC is employed to manage the assignment of arriving calls (new and handoff) to one of the two layers depending on the call type. The admission decision is probabilistic where the admission probability is chosen to minimizes the blocking probability subject to constraints on the dropping probability and average percentage of calls assigned to the satellite coverage given a certain bandwidth partitioning plan. The second constraint is used to represent the consideration of the large propagation delay in the satellite connection. Ordinal optimization, which is a simulation-based optimization technique [4], is used to find the optimum CAC policy which is shown to outperform two known policies, namely, cellular first (CF) and satellite first (SF).

A threshold-based CAC scheme has been proposed in [5]. Call admission is based on resource availability for constant bit rate (CBR), bursty data, and best effort services using double movable boundary strategy for resource sharing over the satellite uplink. The threshold values are adaptive and depend on the traffic conditions to maximize the resource utilization. In order to avoid excess delay in the resource allocation, the CAC and other resource management are processed on board the satellite.

CAC for variable bit rate (VBR) (real-time and non-real-time) and CBR services has been proposed in [6] using a probabilistic measure of the QoS guarantee by estimating the excess demand probability (which measures the probability of the resource unavailability of all admitted calls) in ATM-Satellite network. Unspecified bit rate (UBR) is also considered but without any CAC, i.e. with best effort policy. More description of the signaling and this CAC implementation is provided in [7]. A CAC scheme for voice and data services over low earth orbit satellite (LEOS) system has been proposed in [8]. The admission decision is based on the resource availability with a higher priority to the voice service.

3.0 CAC in Wireless Multihop/Ad-hoc Networks

Multi-hop/ad-hoc wireless networks have fundamental distinctions compared with classical wireless networks. Therefore, introducing novel CAC that takes into consideration the new characteristics is essential for providing acceptable QoS in multihop/ad-hoc wireless networks. These CAC schemes have to consider the lack of infrastructure (for ad-hoc networks), network connectivity, new interference model, traffic routing, decentralized implementation and power/energy limitation.

A framework for call admission in ad-hoc networks has been proposed in [9]. This framework tries to strike a balance between the network connectivity, which is enhanced by admitting more users and the signal quality in terms of the interference level that increases by admitting large number of users. The CAC concept classifies the incoming user as class 1 if (by admitting this user) the number of links will equal one of the critical values otherwise it is classified as class 2. The critical numbers of links, determined by the graph theory, are the ones that increase the connectivity of the existing nodes (users). For instance, when the number of links is equal to $((n/2).\log(n))$ or more, any node can reach other nodes using one or more hops, where n is the number of existing nodes. Class 1 users are admitted if the advantage of increasing the connectivity by admitting those users compensates the degradation in the signal quality due to the potential increase in the interference level while class 2 users are only admitted if the interference level (after admitting the incoming users) is acceptable. The admission decision is made by an appointed node, which is considered as a virtual cluster head.

In [10], a CAC scheme based on bandwidth availability in multihop network has been proposed. On demand routing and bandwidth reservation (at included nodes) are employed to explore the possibility of admitting the new (real-time) call. If no routes could be found such that all nodes in that route can be allocated the required resources in terms of the number of tome slots, the call is rejected. Time slot reallocation is not considered to alleviate the problem of time-slot matching between neighbor nodes.

A threshold-based CAC for wireless multi-hop voice/data network using circuit switching has been presented in [11]. Before admitting a call, the number of calls per circuit (connecting a source/destination pair) is checked whether it is less than a threshold value. Also, the sum of the number in each pair of circuits intersecting at any node is checked to ensure that it is less than another threshold value. The threshold values are chosen to minimize the blocking probability using the ordinal optimization techniques.

The CAC scheme proposed in [12] uses adaptive prioritization schemes and resource availability for burst admission in ad-hoc wireless networks. For instance, services with lower delay tolerance are admitted first, then services with higher delay tolerance, which can be queued until resources become available. Arriving bursts send their requests to the cluster head that manage the resource availability and prioritization scheme. Results show that the proposed scheme outperforms classical non-prioritized burst admission schemes such as first-come-first-serve (FCFS) in terms of P_b.

In [13], a measurement-based CAC has been proposed. When a new call arrives, it first transmits probing packets. The delay incurred by the probing packets is used to determine the service curve, which quantifies the network loading status. The measured service curve is compared by a pre-specified service curve corresponding to the QoS requirements. The CAC scheme accepts the call if the measured service curve is above the universal service curve; otherwise the call is rejected.

Three CAC schemes for ad-hoc wireless local are networks (LANs) have been proposed in [14]. The master device (node) decides whether to admit the arriving call based on the total amount of resources and estimated aggregate link utilization by all existing users. The three schemes differ mainly in the estimation technique of the aggregate link utilization taking into account the burst nature of the traffic. The first scheme uses the sum of the peak rates of different users as an estimate of the aggregate link utilization. Although this scheme is very simple and can guarantee a low packet loss rate, the conservative estimate leads to a very high blocking rate (up to 50%). The second and third schemes use the effective bandwidth technique to estimate the link utilization. The probability of the aggregate link utilization is approximated using the Hoeffding bound [15] and Gaussian distribution in the second and third schemes respectively. Results show that when a low packet loss rate is required, the Hoeffding bound based scheme can maximize the aggregate utilization better than the Gaussian distribution based scheme. On the other hand, the Gaussian distribution based scheme is more effective in reducing the locking rate if a high packet loss ratio can be tolerated. A similar strategy is used in [16] for mobile ad-hoc networks (MANETs). The aggregate link utilization is estimated based on the number of nodes sharing the link and a utilization factor determined empirically (by simulation). However, it should be noticed that the utilization factor value is sensitive to many systems parameters and it has to be determined for each particular network configuration.

4.0 CAC in HAAP Station

High altitude aeronautical platform (HAAP) has been proposed to combine the advantages of terrestrial and satellite systems while avoiding most of the disadvantages of both systems [17]. As shown in Fig. 2, HAAP provides the advantage of covering large areas with minimum infrastructure and having centralized system control and global information. Nevertheless, the transmitted power in the downlink is significantly limited compared with terrestrial wireless networks.

Two power-constrained SIR-based CAC schemes have been proposed for downlink admission in [18]. The first algorithm restricts the maximum transmitted power per base station (BS) while the second scheme restricts the maximum total transmitted power. It is clear that the second algorithm is more efficient and causes less blocking due to the statistical multiplexing. In both algorithms the call is only admitted if the SIR constraints of all users in all cells can be satisfied without violating the maximum power constraint.

Due to the availability of global information at the HAAP station, it is feasible to calculate the SIR for all users in all cells. The admission for uplink in HAAP is proposed in [19]. The CAC scheme admits the incoming call if the SIR constraints at all BS are met. The SIR is checked by calculating the total received power at all BSs.

5.0 CAC in hierarchical cell structure

Hierarchical network structure consists of two or more tiers (macro-cells, micro-cells, pico-cells, etc.) as shown in Fig. 3. In this case, CAC schemes do not only decide whether to admit the incoming call but also direct the incoming calls to the proper layer. In [20], two algorithms have been proposed. The first one, called Uniform Call Admission (UCA), directs all calls (voice or data, new or handoff) to micro-cells first. If no channels are available in the micro-cells, the incoming call is then redirected to the corresponding macro-cells. Unlike UCA, the second algorithm, called Non-uniform Call Admission (NCA), directs data calls to macro-cells first and if all channels in the macro-cells are occu-

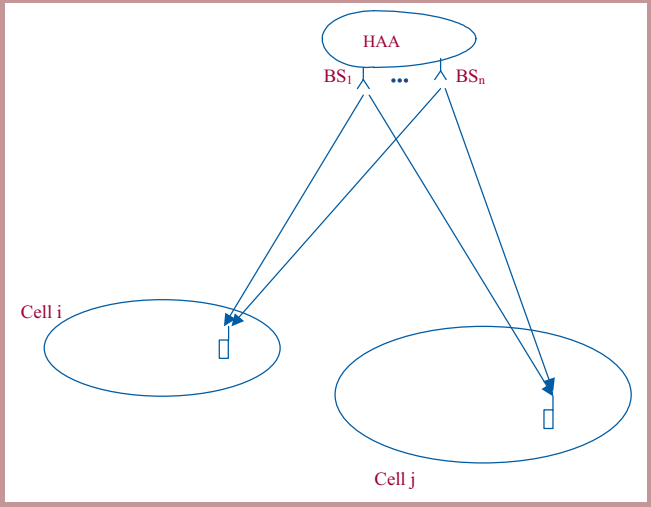

Figure 2: High altitude aeronautical platform (HAAP) system

pied the data call is then redirected to micro-cells. Voice calls are handled as in UCA. This is based on the assumption that data calls residence time is much larger than the voice calls residence time. Results show that UCA algorithm outperforms NCA algorithm in terms of the blocking and dropping probabilities.

A CAC scheme has been proposed in [21] to maximize the system capacity while maintaining an upper bound of the outage probability and blocking probability in hierarchical cell structure. The spectrum is reused in different layers (micro-cells and macro-cells) using a special pattern to minimize inter-layer interference as explained in [22]. Modified linear programming techniques used to solve the optimization problem and find the maximum loading factor in cell layer.

CAC in code division multiple access (CDMA) hierarchical cell structure is considered in [23]. While the admission of the arriving call in micro-cells is based on the interference level in the home cell, the admission of incoming calls in macro-cells is based on interference level in the home cell as well as the adjacent cells. This is because the propagation model in the macro-cell leads to more interference than the Manhattan-model assumed in the micro-cells.

6.0 Conclusions

CAC in special wireless networks has been discussed in this article through a survey of the literature. Different aspects of CAC schemes have been addressed in multihop/ad-hoc wireless networks, satellite networks, high altitude aeronautical platform stations, and hierarchical cellular wireless networks. It has been shown that CAC schemes play a central role in the QoS provisioning.

In future wireless networks, RRM is becoming more challenging because of the anticipated heterogeneous environment taking into account the various access technologies, the broad range of QoS requirements, the amount of available information, and stringent QoS requirements comparable to those of broadband wireline networks. It is anticipated that different networks and access technologies will coexist

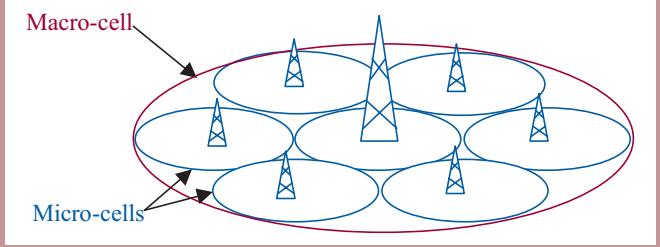

Figure 3: Hierarchical Cellular Structure

in the future wireless networks. Henceforth, fourth generation (4G) wireless networks will encompass third generation (3G) wireless systems (including hierarchical cellular structures) , wireless local area networks (WLAN) such as IEEE 802.11 family and High Performance Radio Local Area Network (HIPERLAN), satellite and high altitude platform networks, ad-hoc wireless networks and broadband wireless access metropolitan area network (MAN) such as IEEE 802.16. Therefore, novel RRM in general and CAC in particular are needed to deal with the anticipated new composite radio wireless environment.

7.0 References

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About the author

Mohamed Ahmed received B.Sc. and M.Sc. in electronics and communications engineering from Ain Shams University, Cairo, Egypt in 1990 and 1994, respectively. He received a Ph.D. in 2001 from Carleton University, Ottawa. From Mar. 2001 to Mar. 2003 he worked as a senior research associate in the department of systems and computer engineering at Carleton University. In April 2003 he joined the faculty of engineering and applied science, Memorial University of Newfoundland, as an assistant professor. He has served as a technical program committee member of various conferences and as a guest editor for the Wiley Journal on Wireless Communications & Mobile Computing. He won the Ontario Graduate Scholarship for Science and Technology in 1997, the Ontario Graduate Scholarship in 1998, 1999 and 2000, and the Communication and Information Technology Ontario (CITO) graduate award in 2000. His research interests include wireless access techniques, resource management in wireless networks, smart antennas and MIMO systems, multi-hop and ad-hoc wireless networks, 3G and 4G wireless systems, and fixed wireless networks. He can be reached at mhahmed@engr.mun.ca.

Letters to the Editor

Subject: Erratum

Dear Editor,

An erratum appeared in the article "On the Cooperative Control of Multiple Unmanned Aerial Vehicles" (pages 15-19) which was published in the IEEE Canadian Review 2004 (Edition CR46). The article should have made due reference to the following scientific proposal on UAV cooperative control that had been officially submitted, prior to publication of IEEE CR 2004, by the authors of the article along with colleague scientists from Defence R&D Canada - Ottawa and the Canadian Forces Experimentation Center of the Department of National Defence of Canada, and from the University of Montreal Center for Research on Transportation. This additional reference is:

M. Lauzon, P. Hubbard, C.A. Rabbath, E. Gagnon, B. Kim, P. Farrell and T. Crainic, "Trusted Uninhabited Vehicle Autonomy Through Time-Constrained Decentralized Model Predictive Control", Project Proposal, Technology Investment Fund Program, Defence R&D Canada, May 2003.

We would appreciate if this erratum could be published in an upcoming issue of the IEEE Canadian Review.

Dr. C.A. Rabbath, Dr. E. Gagnon and Mr. M. Lauzon

Quebec

Subject: IEEE Canadian Review #49 question

Dear Editor,

I have a question regarding a statement in the article "A History of Electric Power Development in Manitoba" (Winter 2005). The article includes the sentence "This was six years before Edison invented the incandescent lamp."

Yet, the following text appeared in the Ottawa Citizen not too long ago:

"Thomas Edison is often credited with the invention of the light bulb, but Torontonians Henry Woodward and Matthew Evans beat him to the switch when they patented a bulb in 1875. When the two couldn't raise enough cash to make their product commercially viable, Edison, who like many others at the time had been working on a similar idea, bought the rights to their patent. Using different techniques and improvements, Edison's bulb was ready for patenting in 1879 and has remained in the spotlight ever since."

Now and then I read conflicting reports on who invented the light bulb. Can you point me to a good article or paper on the light bulb invention story. I would like to understand why there is an apparent lack of agreement on who invented the light bulb.

Dave Hall

Ottawa, ON

Subject: IEEE Canadian Foundation: 2005 IEEE Canada Women In Engineering Prize

Dear Editor,

I am pleased to advise that after careful consideration by the full Board of Directors, the IEEE Canadian Foundation has agreed to award the IEEE Canada Women in Engineering Prize for 2005 to **Jennifer Jessop** of the Winnipeg Section, as nominated by **Jeff Blais**.

This Prize is awarded to a female IEEE Canada member who received her first professional degree within the last ten years and who is active in IEEE activities - value $500. This year, 2005, is the first that the Prize has been awarded.

A framed certificate being prepared by the ICF will be presented to the Prize winner by the Section Chair at a suitable IEEE Section or National Meeting.

Our Treasurer, Luc Matteau, will arrange to forward the funds.

Congratulations!

David Whyte

ICF Grants Committee Chair

Obituaries

Mr. Shoaib A. Khan

5/4/1936 - 2/10/2005

Shoaib Khan was born in Jaunpur, India on May 4, 1936. He received a BS Degree in Electrical Engineering with major in Electric Power from Benaras Hindu University, in Varanasi, India, in 1957.

Shoaib worked from 1957 to 1965 in India with Kaiser Engineers and M.N. Dastur & Co. His experience included engineering, construction and operation of steel, aluminum and power plants. He and Shamim were married in 1960, and they moved to Canada in 1965.

Shoaib had over forty years of experience in power systems engineering, application, and protective relaying for power (hydro, thermal, nuclear), pulp & paper, mining & metals, and chemical plants in North America and overseas. He had worked with Bechtel Corp., SNC LAVALIN, and Sandwell as a specialist in Power Systems and Protection. With Sandwell EPC Inc., he held the position of a Specialist in Power Systems and Protection. He was also engaged in organizing, developing, and teaching courses in power systems and protection. He had authored numerous technical papers on power systems, applications engineering and protection, some of which have been published in IAS/PES transactions and Pulp & Paper Canada.

Shoaib was a senior member of IEEE, a registered engineer with the order of Ingenieurs and the Professional Engineers of Ontario. He was also an active member of IEEE/IAS - PPIC PDS subcommittee. He was a recipient of IEEE Centennial and Third Millennium Medals for achievement in education.

Shoaib had been active with IEEE Education Committee, Montreal Section for over thirty years and was Committee Chairman from 1974 to 1994. Shoaib was also an Auxiliary Professor with the department of Electrical Engineering and a guest lecturer with the Department of Chemical Engineering at McGill University, Montreal.

Shoaib will be remembered by all his colleagues and friends for his dedication to the advancement of applied engineering and hard work and dedication to education in his field of endeavor. He was not only an outstanding engineer, but also a true friend to his colleagues and support to the training of young engineers.

Our prayers go out to the family surviving him, his wife Shamim, his children Sheema, Sheeba and Shakeeb, and grand children Sara and Zeyad.

Professor Éloi Ngandui

Notre collègue et ami **Éloi Ngandui** nous a quittés à l'âge de 43 ans le 22 décembre dernier, après avoir combattu courageusement le cancer.

Originaire du Cameroun, Éloi a obtenu le diplôme de Professeur avec mention honorable de l'École Normale Supérieure de l'Enseignement Technique (ENSET), Université de Douala, Cameroun, en 1987 et les diplômes de maîtrise et de doctorat en génie électrique et génie informatique à l'École Polytechnique de Montréal en 1991 et en 1997 respectivement. Éloi s'est joint au département de génie électrique et génie informatique de l'UQTR en août 1998 après avoir oeuvré comme consultant à l'Hôpital Général Juif de Montréal, chargé de cours à l'UQAC et à l'École Polytechnique de Montréal, et assistant professeur à l'ENSET, Université de Douala.

Éloi s'est taillé une place importante à l'université par son implication soutenue dans la vie universitaire. Éloi a remodelé et modernisé les cours dont il a pris charge et a su donner aux étudiants une formation extrêmement pertinente et recherchée par le milieu industriel. Ses activités de recherche sur la qualité de l'alimentation électrique l'ont amené, lui et ses étudiants, à parcourir les installations de l'université et de nombreuses entreprises de la région. Sa rigueur a été soulignée dans ses publications, qui se sont multipliées avec les années. Il a aussi été un collaborateur hors pair qui a fortement contribué aux succès de la Chaire de recherche Hydro-Québec sur la Puissance et l'Énergie Électrique et du Groupe de Recherche en Électronique Industrielle qu'il a dirigé ces dernières années. Membre du comité de la recherche à l'UQTR, il a contribué au rayonnement de l'université par son implication dans le comité exécutif de la section St-Maurice de l'IEEE, dont il est membre senior depuis 2002, par sa participation dans des comités organisateurs de conférences internationales et comme membre du comité d'édition et éditeur associé du International Journal of Power and Energy Systems de l'IASTED, depuis 2001.

Éloi laisse dans le deuil son épouse Marie-Agathe et ses trois fils Brice, Noël et Franck. Que dieu les bénisse. Il fut un père dévoué qui ne ménageait pas ses efforts pour permettre à ses fils de se développer dans les sports et pour passer au travers des épreuves difficiles.

Pendant son court passage parmi nous à l'UQTR, Éloi s'est fait de nombreux amis et a marqué plusieurs d'entre nous par sa joie de vivre, ses qualités humaines, son dynamisme et son professionnalisme.

Les étudiants, collègues et amis se souviendront d'un grand sportif au sourire radieux et d'une grande rigueur dans tout ce qu'il entreprenait.

The winner of Super Expo-sciences Bell, Quebec final, from 21 to 24 April, 2005 at Université du Québec à Trois-Rivières.

Frédérick Brousseau Gauthier (center), winner of the **IEEE Shoaib A. Khan** Prize (Scholarship of 750 $) in the presence of **Adam Skorek** (right), Chair of Engineering Department at Université du Québec à Trois-Rivières and with **Vijay Sood** (left), Researcher at Hydro-Québec (IREQ). The Khan family was present at the ceremonies.

Title of projet: Moteurs à hydrogène : l'avenir? Collège de Montréal (région : Montréal)

Sébastien Gagnon (centre), lauréat du **Prix IEEE Éloi Ngandui** (bourse de 750 $) en compagnie de Adam Skorek (agauche), directeur du Département d'ingénierie à l'Université du Québec à Trois-Rivières, et de Vijay Sood (adroit), chercheur chez Hydro-Québec.

Titre du projet: Programmation de robots Polyvalente Deux-Montagnes (région : Rive-Nord)

Les lauréat de la Super Expo-sciences Bell, finale québécoise 2005, du 21 au 24 avril, à l'Université du Québec à Trois-Rivières.

IEEE Montreal Conferences Inc names its bursary in honor of Mr. Shoaib Khan

In honor of the long association of **Mr. Shoaib Khan** with IEEE Montreal Section, IEEE Montreal Conferences Inc has decided to name a Bursary presented annually at the **Bell Expo Sciences** exposition for high school students. This bursary is a cash award of $750.00 to be given to the best project in Electrical Engineering.

IEEE Montréal conférences inc. nomme une de ses bourses en l'honneur du Dr. Eloi Ngandui.

En l'honneur de la longue association du **Dr. Eloi Ngandui** avec la Section IEEE Saint-Maurice, IEEE Montréal Conférences inc. a décidé de nommer une bourse présentée annuellement à la **Super Expo-sciences Bell** pour les étudiants du secondaire. Cette bourse est un prix en argent de 750 $ accordé au meilleur projet en Informatique.

IEEE Canada

Awards Presentation - 2 May 2005
Saskatoon, Saskatchewan

Canada Council Awards

J.J. Archambault Eastern Canada Council Merit Award "For bringing IEEE Sections Conference 2008 to Canada, and fifteen years of outstanding service to the IEEE."	 **André Morin**	**Prix du mérite J.J. Archambault est du Canada** "Pour avoir amené au Canada la conférence 2008 des sections IEEE, et pour 15 années de service exceptionnels à l'IEEE."
M.B. Broughton Central Canada Council Merit Award "In recognition of hard work and dedication to the IEEE."	**Ronald H. Potts** 	**Prix du mérite M.B. Broughton centre du Canada** "En reconnaissance de son travail acharné et de son dévouement à l'IEEE."
Ted Glass Western Canada Council Merit Award "For over thirty years of dedicated and remarkable service to IEEE in several capacities."	 **Witold Kinsner**	**Prix du merite Ted Glass- ouest du Canada** "Pour plus de trente années de service devoué et remarquable à l'IEEE l'exercise de plusieurs functions."

Service Awards

Wallace S. Read Service Award "In recognition of hard work and dedication to the IEEE."	**Miro G. Forest** 	**Prix du service Wallace S. Read** "En reconnaissance de son travail acharné et de son dévouement à l'IEEE."
Outstanding Engineering Educator Award "For contributions to Engineering Education and inspirational Guidance of Graduate Students."	 **Konstantin Platiniotis**	**Prix d'éducateur exceptionnel en ingénierie** "Pour contributions à l'enseignement du génie et conseils inspirants aux étudiants gradués."

Medals

Fessenden Medal For pioneering the world's first point-to-multipoint wireless access system"	**Tho Le-Ngoc** 	Médaille Fessenden "Pour avoir tracé la route vers le premier systéme sans fil à accés point à multipoint au monde."
McNaughton Medal "For sustained contributions to electric power systems in Canada and the world, especially for Single Pole Trip and Re-Close operation of High Voltage transmisison lines and Elliptical distance relaying." *The A.G.L. McNaughton Medal is IEEE Canada's highest honour, and it recognizes outstanding contributions made to the engineering profession in Canada.*	 **Andy B. Sturton**	Médaille McNaughton "Pour ses nombreuses contributions aux systémes électriques de puissance, au Canada, et de par le monde, et en particulier les opérations de disjonction et fermeture à pôle unique pour lignes à haute tension, et le relais elliptique à distance." *La plus haut distinction de l'IEEE Canada, la medaille A.G.L. McNaughton, reconnais des contributions remarquable à la pratique de l'ingénierie au Canada.*

EIC Awards, 2005

ENGINEERING INSTITUTE OF CANADA
L'INSTITUT CANADIEN DES INGÉNIEURS

Honours, Awards & Fellowships - Médailles, Distinctions et Fellowships

Presented at the EIC Awards Banquet on Saturday, 5 March, 2005
Seront présenté lors du Banquet de l'ICI le samedi, 5 mars 2005

Awards Presented by Ms. Maja Veljkovic, President of the EIC

Bob Alden and Maja Veljkovic

Sunil Das and Maja Veljkovic

Charles Despins et Maja Veljkovic

Hussain Mouftah and Maja Veljkovic

Masoud Farzaneh and Maja Veljkovic

John Lodge and Maja Veljkovic

Dorina Petriu and Maja Veljkovic

Keith Hipel and Maja Veljkovic

Left: Rajni Patel was unavailable at the Awards ceremony in Ottawa.

Back row: (left to right) Masoud Farzaneh, Keith Hipel and Hussain Mouftah

Seated: (left to right) Sunil Das, Dorina Petriu and Bob Alden

Missing from the photo were Charles Despins, John Lodge and Rajni Patel

For further details, please visit the EIC website: www.eic.ca

Fifty is a significant number. This issue of the IEEE Canadian Review is the fiftieth. This issue also marks **Vijay Sood**'s last as Editor. I have worked with him since 1996 when I was IEEE Canada's Treasurer. One of the reasons we are able to celebrate the fiftieth edition is Vijay's hard work and dedication. On behalf of the IEEE Canada Board, thank you Vijay for a job well done!

In this column, I want to bring you up to speed on the latest successes for IEEE Canada. At the Spring Meeting in Saskatoon, the revised bylaws were passed and they have now been sent to RAB for final approval. That approval should occur during the June Board Series in Chantilly, VA. Lots of hard work went into getting the bylaws ready for the Spring Meeting. I would like to recognize three individuals, although others were involved. **Cathie Lowell**, the Region Administrator, put together the first draft that allowed **Mo El-Hawary**, the Past President, to produce the penultimate draft. Finally, **Ray Findlay**, Director Emeritus, reviewed the final draft that was presented to the IEEE Canada Board in Saskatoon.

As part of the new governance system for Region 7 the Audit Committee met in Saskatoon and reviewed how your money is spent. The Audit Committee's recommendations will be forwarded to the Executive Committee for implementation.

One of IEEE Goals is to craft relationships with provincial licensing bodies. We have had interest from New Brunswick, Manitoba and Saskatchewan. We will continue to work with these organizations to make IEEE educational programs available to them and their members. This will increase IEEE's exposure to Canadian Professional Engineers.

Two Sections celebrate their fiftieth anniversary this year. Northern Canada celebrated their anniversary in March and Kingston will celebrate theirs in June. Also in June, the Nelson River HVDC project will be recognized as an IEEE Milestone. Plans are underway for the dedication ceremony in Winnipeg on June 3rd.

Finally, this is the year Region 7 elects a Director-Elect. The Steering Committee interviewed seven candidates and selected three. The three candidates addressed the IEEE Canada Board in Saskatoon on the topic "What I will do for IEEE Canada." This was followed by a question-and-answer period. Two other Region 7 members have expressed an interest in the Director-Elect position and are trying to run as petition candidates.

Summer is fast approaching and I wish you lots of summer fun. Please come back in September refreshed and ready to further IEEE Canada's Goals for 2005.

W.O. (Bill) Kennedy, P.Eng., FEIC
IEEE Canada & Region 7 - Director/Président,
Calgary, AB
w.kennedy@ieee.org

Cinquante est un chiffre important. Cette édition est la cinquantième de Canadian Review. Elle est également la dernière de **Vijay Sood** en tant qu'éditeur. J'ai travaillé avec lui depuis 1996, lorsque j'étais le Trésorier de IEEE Canada. Son dévouement et son travail acharné font parties des raisons pour lesquelles nous pouvons célébrer cette cinquantième édition. Au nom du conseil de IEEE Canada, Vijay, merci pour tous le travail accompli.

Je veux prendre l'occasion de vous informer des derniers succès de IEEE Canada. À la Réunion Printanière à Saskatoon, les lois et règlements révisés ont été adoptés et ont été envoyés au RAB pour leur approbation finale. Cette approbation devrait être obtenue lors du conseil de direction de juin à Chantilly, VA. Beaucoup de travail a été accompli afin que les lois et règlements soient prêts pour la Réunion Printanière. Je voudrais reconnaître le travail de trois des principaux instigateurs de ce succès, quoi que bien d'autres aient collaboré à ce project. **Cathie Lowell**, administratrice de la Région a préparé la première version, ce qui a permis à **Mo El-Hawary**, président sortant, de réviser celle-ci pour que **Ray Findlay**, directeur émérite, finalise les lois et règlements qui ont été présentés au Conseil de Direction de IEEE Canada à Saskatoon.

Le comité de vérification, en tant que parti intégrante de la nouvelle structure de gestion, a revu, lors de la rencontre de Saskatoon, l'utilisation de vos fonds. Les recommandations du comité de vérification seront présentées au comité exécutif pour leurs implémentations.

Un des buts de IEEE est d'établir des liens avec les organismes d'accréditation provinciaux. Nous avons reçu une réponse favorable du Nouveau-Brunswick, du Manitoba et de la Saskatchewan. Nous continuerons de travailler avec ces organismes afin que les programmes de formations de IEEE leurs soient disponibles ainsi qu'à leurs membres. Ceci va permettre d'accroire la visibilité de IEEE auprès des Ingénieur(e)s Professionnel(e)s Canadien(ne)s.

Deux sections célèbres leur cinquantième anniversaire cette année. Northern Canada ont célébré leur anniversaire en mars, et Kingston vont célébrer le leur en juin. Également en juin, le projet "Nelson River HVDC." sera reconnu comme étape importante pour IEEE. Les préparatifs sont en cours pour la cérémonie de dédicace à Winnipeg le 3 juin.

Finalement, cette année, la région 7 élit un Président Désigné. Le comité exécutif a interviewé sept candidats et a retenu trois candidatures. Les trois candidats ont présenté au conseil d'administration une dissertation sur le thème: "Que vais-je faire pour IEEE Canada?". Ces présentations ont été suivies d'une période de questions et réponses. Deux autres membres de la région 7 ont exprimé leurs intérêts pour la position de Président Désigné et préparent des pétitions en ce sens.

Je vous souhaite beaucoup de plaisir durant l'été qui approche à grand pas. Au plaisir de vous revoir en septembre reposé et prêt à continuer la réalisation des buts de IEEE Canada pour 2005.

Continued from page 21

Speaker, discussed career growth and how to get ahead in the engineering fields in a presentation called "In Search of Diamonds." To give attendees a historical perspective of the profession, **Jim Rautio**, president of Sonnet Software, in Syracuse N.Y., spoke on the life of James Clerk Maxwell, a Scottish physicist who did pioneering work in electromagnetism and the kinetic theory of gases.

ICUE 2005 was advertised through various IEEE newsletters, communities, mailing lists and was also linked to the IEEE Canada and Region 4 websites. As a result ICUE 2005 generated interest across the borders and we received technical papers from USA, India, Bangladesh, Australia and Canada. A total of 85 students registered, 25 papers were displayed and 8 design demonstrations were presented during the conference.

The following were recognized by awards:

1st Best Paper:

- "Lab on the Web" by Srdjan Pepic, Ian J. Sin Kwok Wong, Paramjit Pawan (University of Toronto)

2nd Best Paper:

- "The Autonomous Rover Project" by Mohamad El-Sadek, Kenny Ma, Akram Nafee, Mohammad Tariq Rafique (University of Toronto)

3rd Best Papers:

- "Crosstalk in add/drop multiplexing with phase masked fiber Bragg Grating" by Ms Hatice Kosek (Ryerson University)
- "Budget Management Algorithms with Gate-Sizing and Other Low-Power Applications" by Kevin Banovic (University of Windsor)

Best Design Project:

- "Integrated Radio Electric Guidance Package" by Adrian Tang, Charles Prosper (Ryerson University)

The organizing committee appreciates the time and interest of all the participants, speakers and supporters who helped in making ICUE 2005 a success. More information about this conference can be found at www.icue.ca.

Apurva Jain

ICUE 2005 Chair

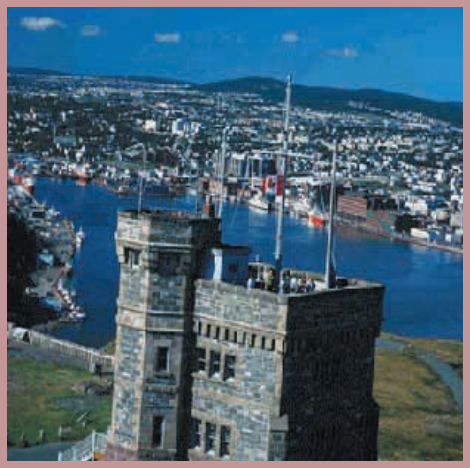
The IEEE Engineering Management Society's Annual International Engineering Management Conference

IEMC 2005

A Strategic View of Engineering and Technology Management

11 - 14 September 2005

Fairmont Hotel, St. John's, Newfoundland, Canada



IEMC brings together engineering and management professionals, and academics from around the world. This year we are very pleased to be hosting IEMC05 in St. John's, Newfoundland, Canada. St. John's blend of old and new extends far beyond old world charm and modern, world-class facilities. The location of such engineering "firsts" as the first transatlantic cable and receipt of the first transatlantic wireless communication, it is particularly appropriate for an engineering management conference. St. John's is also the headquarters and nucleus of leading edge multi-billion dollar resource development projects in mining and offshore oil/gas. Non-stop flights from various cities in Canada, from London's Heathrow and from New York/Newark make St. John's very accessible.

We encourage attendance from engineers, managers, business and management consultants, academics and researchers. IEMC is a forum for the exchange of ideas, experience, theories, and knowledge between all persons involved in engineering management.

IEMC's Technical Program runs Monday through Wednesday, September 12-14, 2005 and includes a wealth of topics such as:

- Rebuilding from Devastation
- Environmental Management
- Supply Chain Management
- Quality Management & Six-Sigma
- Building & Managing High Performance Teams
- Knowledge Management
- Technology/Innovation Management

As a precursor to the conference, the following tutorials are being offered on Sunday, Sept. 11, 2005

Tutorial	Duration
Getting Your Point Across: Essential Communications for Engineers	1 day
How the West Was Lost: A Workshop for Managers on Statistical Process Control	½ day*
Leading an Effective Engineering Organization	½ day
New Trends in Project Management	½ day*
So You Want to be an Entrepreneur/Management Consultant	½ day

(* = morning tutorial sessions)

Online registration

and other information can be found on the conference website: **http://www.iemc2005.org**

or email us at: **info@iemc2005.org**

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CANADA

IEMC is the annual Conference of the IEEE Engineering Management Society
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CCECE 2006 - CCGEI 2006
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La technologie pour un monde meilleur

Conférence Canadienne de génie électrique et informatique

7 au – 10 mai 2006, Centre des Congrés d'Ottawa, Canada

http://ieee.ca/ccece06/

APPEL DE SOUMISSION D'ARTICLES

La conférence canadienne de génie électrique et informatique 2006 de l'IEEE offre un tribune pour la présentation de travaux de recherche et de développement en génie électrique ou informatique provenant du Canada et du monde. Des communications en français ou en anglais sont sollicitées sur des sujets qui incluent, mais ne sont pas restreints à ceux mentionnés ci-dessous :

- Architectures avancées d'ordinateurs
- Electronique analogique et numérique
- Intelligence artificielle
- Réseaux et systèmes informatiques
- Théorie du Contrôle et applications
- Traitment numérique des signaux
- Circuits, Systèmes et ITGE
- Interaction human-machine
- Traitment de l'image et de la parole
- Instrumentation et mesure
- MEMS et Nanotechnologie
- Réseaux neuronaux et logique floue
- Reconnaissance de formes
- Fiabilité des systémes de puissance
- Systémes à opération en temps réel
- Micro-ondes et RF
- Télédétection, capteurs et dispositifs
- Apprentissage, affaires, et commerce électronique
- EMC & EMI
- Systèmes à base d'agents et sur Internet
- Eléctromagnétisme & Antennes
- Ingénierie biomédicale et bioinformatique
- Communications et systèmes sans fil
- Bases et exploration de données
- Machines et entraînements électriques
- Ingénierie de la haute tension
- Calculs de haute performance
- Systèmes intelligents
- Microélectronique et Optoélectronique
- Informatique mobile
- Systémes optiques et photoniques
- Électronique de puissance
- Robotique et mécatronique
- Sécurité, confidentialité et fiabilité
- Génie logiciel
- Production de l'énergie et énergies renouvelables
- Réalité virtuelle et Nouveaux médias

1.0 Soumission d'articles

Veuillez soumettre électroniquement un résumé de votre article, d'environ 300 mots, au site web:

http://ieee.ca/ccece06 au plus tard le décembre 2005.

2.0 Soumission de propositions pour organiser des sessions spéciales

Pour soumettre une proposition visant à organiser une session spéciale, veuillez contacter Dr. Voicu Groza (vgroza@ieee.org), au plus tard le 4 décembre 2005.

3.0 Soumission d'ateliers et de tutoriels

Pour soumettre une proposition visant à offrir ou à organiser un atelier ou un tutoriel, veuillez contacter Mr. George Yee (g.m.yee@ieee.org), au plus tard le 20 janvier 2006.

4.0 Compétition de catégorie étudiante

Si l'auteur principal d'un article soumis à la conférence est un étudiant, cet article sera inclus automatiquement dans la compétition de catégorie étudiante.

5.0 Dates limites à noter

Soumission de résumés d'articles: ..... le dimanche, 4 décembre 2005

Soumission de propositions pour sessions spéciales: ..... le dimanche, 4 décembre 2005

Soumission d'ateliers, tutoriels: ..... le vendredi, 20 janvier 2006

Notification d'acceptation d'un article: ..... le dimanche, 5 février 2006

Version finale d'un article et enregistrement d'auteurs: ..... le vendredi, 24 février 2006

6.0 Expositions

Pour louer un espace d'exposition, veuillez contacter le président du comité organizateur de cette activité, Dr. Jasmin Roy (jasmin.roy@crc.ca), au plus tard le 7 avril 2006.

IEEE Canada

CCECE 2006

Technology for a Better World

19th Annual Canadian Conference on Electrical and Computer Engineering

May 7 - 10, 2006, Ottawa Congress Centre, Ottawa, Canada

http://ieee.ca/ccece06/

CALL FOR PAPERS

The 2006 IEEE Canadian Conference on Electrical and Computer Engineering provides a forum for the presentation of electrical and computer engineering research and development from Canada and around the world. Papers are invited, in French or English, including but not limited to the following topics:

- Advanced Computer Architecture
- Analog & Digital Electronics
- Artificial Intelligence
- Computer Networks & System
- Control Theory & Applications
- Digital Signal Processing
- Electronic Circuit and VLSI
- Human-Machine Interactions
- Image & Speech Processing
- Instrumentation & Measurement
- MEMS & Nanotechnology
- Neural Networks & Fuzzy Logic
- Pattern Recognition
- Power Systems Reliability
- Real-Time Embedded Systems
- RF & Microwaves
- Remote Sensing, Sensors and Devices
- E-Learning, E-Commerce, E-Business
- EMC & EMI
- Agent-Based & Internet-Based Systems
- Electromagnetics & Antennas
- Biomedical Engineering & Bioinformatics
- Communications & Wireless Systems
- Database & Data Mining
- Electrical Machines & Drives
- HV Engineering
- High-Performance Computing
- Intelligent Systems
- Microelectronics & Optoelectronics
- Mobile & Pervasive Computing
- Optical Systems & Photonics
- Power Electronics
- Robotic & Mechatronics
- Security, Privacy & Trust
- Software Engineering
- Power systems & renewal Energy
- Virtual Reality and New Media

1.0 Regular Paper Submission:

Please submit a 300-word abstract of your paper to the Technical Program Committee using the on-line submission process on our web site at http://ieee.ca/ccece06 before December 4th., 2005.

2.0 Special Sessions Proposal Submission:

Proposals for special sessions must be received by December 4th., 2005. Please contact the Technical Program Co-Chair at vgroza@ieee.org

3.0 Workshop and Tutorial Submission:

Workshop and tutorial proposals must be received by January 20th, 2006. Please contact the Workshop / Tutorial Chair at g.m.yee@ieee.org

4.0 Student Paper Competition:

If the first author of a paper submitted to the conference is a student, that paper will be automatically considered for Student Paper Competition.

5.0 Important Dates

Paper abstracts must be received by: ..... Sunday, December 4th, 2005
Special Session proposals must be received by: ..... Sunday, December 4th, 2005
Tutorial / workshop proposals must be received by: ..... Friday, January 20th, 2006
Notification of acceptance will be sent out by: ..... Sunday, February 5th, 2006
Final papers and author registration must be received by: ..... Friday, February 24th, 2006

6.0 Industrial Exhibits

To rent exhibit space at the conference, please contact the Sponsorship / Exhibition Chair Dr. Jasmin Roy at: jasmin.roy@crc.ca before April 7th, 2006.