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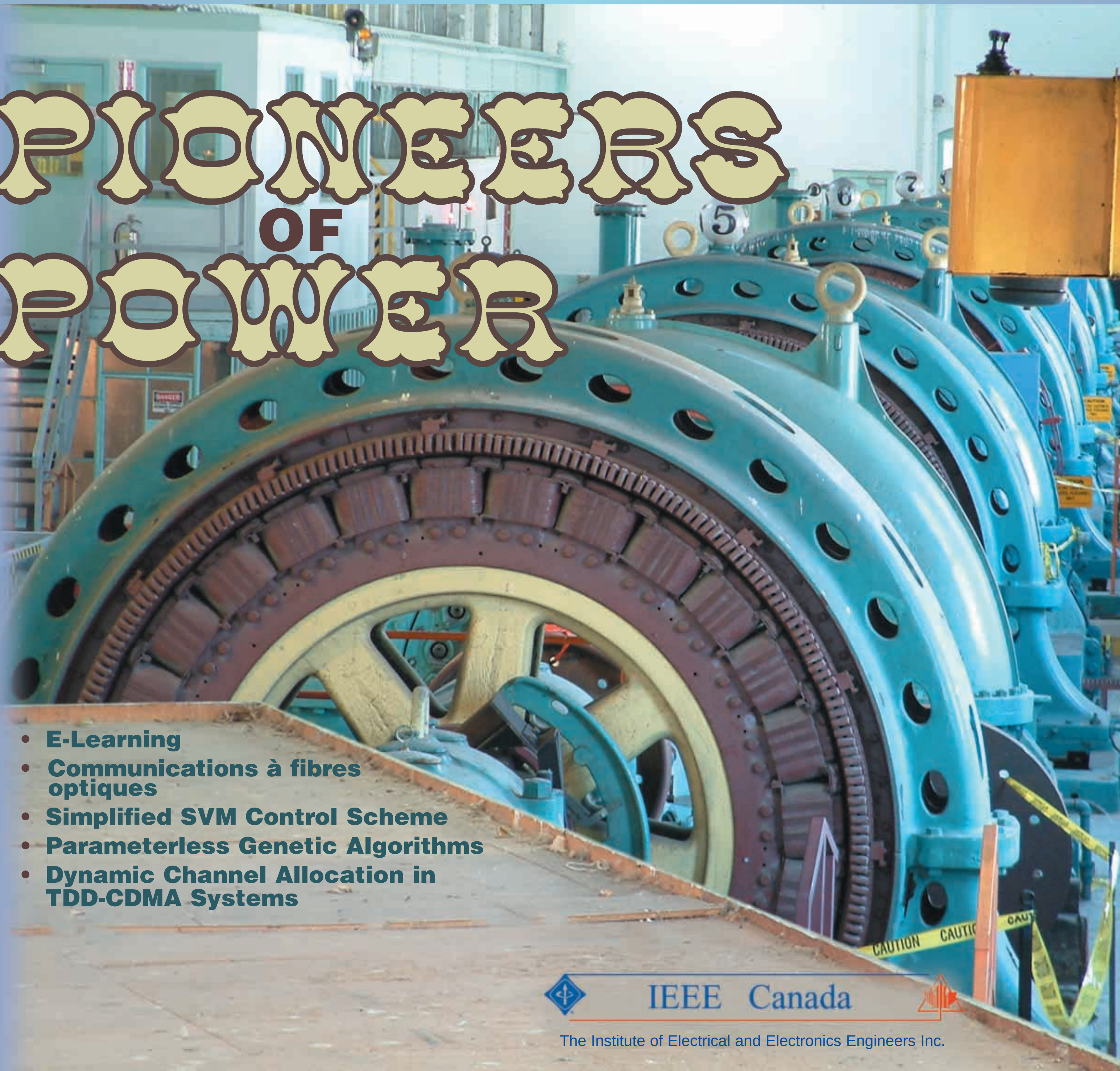

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(ii) Canadian members of the profession and community who are non-members of IEEE;
(iii) The associated Canadian academic (i.e. universities, colleges, secondary schools), government and business communities.

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Quelques mots du rédacteur en chef

Vijay K. Sood, Hydro-Québec

Je suis heureux d'annoncer deux changements au sein de l'équipe de rédaction. Premièrement, j'aimerais saluer **Slawo Wesolkowski** et **Dr. Shaowen Song** et leur souhaiter du succès dans leurs projets futurs. Slawo a été au sein de l'équipe avec moi depuis le tout début et a assumé la charge d'adjoint à la rédaction avec ferveur. Il sera de retour occasionellement, et je continuerai à solliciter son aide. Shaowen a maintenant une jeune famille qui s'agrandit, et a les mains pleines à la maison. Comme je dis toujours, la famille passe en premier. Vous allez me manquer tous les deux. Vous méritez tous les deux une pause. Merci pour votre soutien au cours des dernières années.

Les deux nouveaux adjoints à la rédaction sont **Dr. Alain Zarka** et **Dr. Habib Hamam**. Tous deux ont contribué et m'ont aidé depuis quelque temps déjà à titre non-officiel. Leurs brèves introductions sont quelque part dans cette édition.

Au début du mois de mai, j'ai participé à CCGEI2004 à Niagara Falls. Le comité a travaillé très fort et un record d'assistance a été établi pour la deuxième année consécutive. Mes félicitations à Bob Hanna et à son inlassable équipe. Nous sommes fiers de vous. Nous avons aussi été très heureux d'avoir **Dr. Tom Brzustowski** du CRSNG comme conférencier pour la session plénière.

Cette édition de la revue s'est remplie très rapidement. J'ai eu de nombreux maux de tête pour décider des items à présenter dans cette édition et lesquels publier dans l'édition suivante. On appelle ça le risque du métier. Vos commentaires sont toujours les bienvenus. Je profite de cette opportunité pour vous souhaiter un bel été.

A few words from the Managing Editor

I am pleased to announce two changes in the editorial team. First, I would like to wish both **Slawo Wesolkowski** and **Dr. Shaowen Song** farewell and continued success in their future endeavors. Slawo has been part of the team since the beginning with me and carried the burden of Associate Editor with fervor. He will be back with items occasionally, and I will continue to seek his help. Shaowen now has a growing young family, and has his hands full at home. As I always say, family comes first. I will miss both of you. Both of you need a break. Thank you for your support over the years.

The two new associate editors are **Dr. Alain Zarka** and **Dr. Habib Hamam**. Both have been contributing and assisting me for some time now in an unofficial capacity. Their short introductions are available elsewhere in this issue.

Recently I attended the very successful CCECE'2004 conference in Niagara Falls in early May. The committee worked extremely hard and new attendance records were set at the conference. That makes it two years in a row that a record number of people attended. My congratulations to Bob Hanna and his unstoppable team. You made us proud indeed. We were also very pleased to have **Dr. Tom Brzustowski** of NSERC to be the Plenary Speaker at the Conference. His presentation was thought provoking indeed.

This issue of the CR filled out very early, and it caused me a lot of headaches in the final decision making to leave out items, and push them to the next issue. It is an occupational hazard, and it goes with this job. Your feedback is always welcome. I take this opportunity to wish you all a Happy Summer.

The slippery slope of shortcuts (*why we still need engineers*).
Sent in by Lewis Vaughan and colleagues.

Cover picture / *Photo de couverture*

The IEEE is pleased to recognize the DeCew Falls Hydroelectric Generating Station as a Pioneering Project in distance transmission of electrical energy. The Power Generation Station, located in St. Catharines, Ontario, was the site of a Milestone Dedication Ceremony on May 2nd 2004. Members of the IEEE Hamilton Section, in co-operation with Ontario Power Generation, unveiled a commemorative plaque. Shown in picture is a view of the Generator Hall (see also pages 13 and 23 of this issue).

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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

Veuillez faire parvenir les coupures de presse proposées par e-mail à alexandre.abecassis@ieee.org

CALGARY, AB, Apr. 14, 2004. A web-accessible application designed by Axia, which provides web-based professional development work-space for teachers, has been named “Best Educational Solution for 2003” by the Canadian e-Content Institute. The application provides teachers with guidance, tools and support for creating online content for students in Kindergarten to Grade 12.

TORONTO, ON, Feb. 25, 2004. NTG Clarity Networks has announced that it has been awarded a multi-year technical services contract by a leading Canadian telecommunications service provider to provide training services, which comprise a variety of specialized telecommunications and IP transmission, access and switching technologies to network services and customer services personnel in Canada.

SAULT STE. MARIE, ON, Feb. 4, 2004. Amperion and PUC Telecom have announced that Broadband over Power line (BPL) technology has been deployed in Sault Ste. Marie. The products developed by Amperion allow utilities and service providers to use existing power-line infrastructures to provide high-speed data transport and enhanced utility services economically.

TORONTO, ON, Jan. 28, 2004. Sangoma Technologies, which provides connectivity hardware and software products for Wide Area Networks (WANs) and Internet infrastructure, has provided George Brown College of Toronto with two WAN-related products to enhance the networking curriculum offerings of the school. The first product is a self-contained Wide Area Network which discloses the inner workings of WAN protocols, while the second product enables laboratory staff to set up a cost effective, self-contained Wide Area Network within the confines of a laboratory.

VICTORIA, BC, May 6, 2004. Mint Inc., a Canadian wireless payment company, and Robbins Parking Services, Vancouver Island’s largest private parking operator, have today introduced a wireless “park and pay by phone” service which enables customers to pay for parking using their own digital cell phone. The service will be available at 40 lots.

WATERLOO, ON, May 4, 2004. Web Pearls has announced the launch of a Microsoft Word add-in software which supports government privacy legislation. All businesses engaged in commercial activities must now comply with the Personal Information Protection and Electronic Documents Act (PIPEDA) to ensure that personal information such as names, addresses, dates of birth, etc. are not released in an inappropriate manner. The software will save time by inter-alia quickly analyzing documents for infractions.

MISSISSAUGA, ON, May 3, 2004. Certicom has announced that Research In Motion has licensed a crypto toolkit and Elliptic Curve Cryptography (ECC)-based intellectual property from Certicom. The agreement enables Research In Motion to extend its existing ECC-based security from Certicom in its BlackBerry offerings. Under the agreement, Research In Motion will pay a one-time US$3.5 million Intellectual Property license fee, entitling them to deploy a fixed number of seats. The agreement provides for additional revenue through royalties once Research In Motion exceeds the prepaid number of seats.

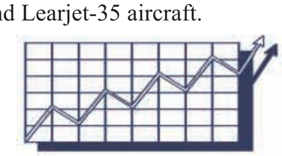
CALGARY, AB, April 30, 2004. Pure Technologies and Physical Acoustics Corporation have announced that they have settled the patent infringement lawsuit between them related to PURE’s patented infrastructure management technology. The lawsuit was pending in the United States District Court for the District of Delaware. The technology uses acoustic techniques, combined with Internet-based data acquisition, transmission and processing, to provide real-time continuous surveillance of large structures such as bridges, pipelines, etc.

MONTREAL, QC, April 29, 2004. Nstein Technologies Inc., has announced the sale of its solutions to a systems integrator for a US government project. Nstein Technologies provides a Global Intelligent Information Management (GIIM) platform for large corporations and organizations.

DARTMOUTH, NS, April 7, 2004. MacDonald, Dettwiler and Associates Ltd has announced that its Information Systems Group has been awarded a contract for approximately $1 million to deliver Remotely Operated Vehicle (ROV) Trainers to the Canadian Navy.

MONTREAL, QC, May 6, 2004. CAE has signed a 10-year services agreement, based on expected simulator usage, with LAN to provide training on Boeing 737-200 and Airbus A320 full-flight simulators beginning this year and on the Boeing 767-300ER commencing in the last quarter of 2005 for a total value, together with third-party revenues, expected to be C$40 million.

MONTREAL, QC, April 29, 2004. CMC Electronics has been awarded an upgrade program in March 2004 to supply its Global Positioning System-based Flight Management System (GPS/FMS) to the Brazilian Air Force for its fleet of C-130, B707, P-95 and Learjet-35 aircraft.



IEEE Canadian Review is pleased to announce a new partnership with **Kluwer Academic Publishers**. This partnership will allow IEEE Canada members to purchase copies of Kluwer books at a 20% discount through the link on the webpage at:

http://ewh.ieee.org/reg/7/canrev/ind_lnks.htm

IEEE Canada — kluwer the language of science

In my last column, I gave an overview of some of my plans for Region 7 over the next two years. In this column, I will report on some of the issues that have been addressed in moving those plans forward.

Membership Development - at the Spring Meeting in Niagara Falls, a Membership Development Retreat was held concurrent with the Region Caucus. MDC Chairs from Region 7 attended along with MDC Chairs from Region 1. The retreat was conducted by Brian Lee, RAB MDC Chair and Mike Binder, Director of Membership Services from Piscataway. Hilmi Turanli, Region 7's MDC Chair, assisted both. The retreat was well received by all attendees. This was the first time the retreat was held outside of Piscataway and the first time it was offered to Section MDC Chairs.

The next step is for the Section Chairs to translate the retreat into increased membership for their Sections. Already in 2004, Region 7 is showing an increase in membership. The April figures were recently released and Higher Grade membership is up 2.7% to 10,137 members. Student membership is up 7.5% to 3,374. Great work! Let's keep working away at increasing our membership.

Now is the time for Sections to look at elevating worthy members to Senior Member. It's easier than you think, because it's all on-line. Next year, a new Fellow category - practicing engineer will be available. It's time to start looking for qualified individuals for this most prestigious of IEEE membership levels.

On another front, the Region Committee reviewed and approved the Governance Report. The Director, Past Director, Director-Elect, Secretary and Treasurer are to come back to the Fall Meeting in Calgary with a firm plan on implementing the Governance structure. The revised Region structure will see more input from the Sections. I want to acknowledge the work that Wally Read and committee of Vijay Bhargava and Ray Findlay, not only in producing the report, but also in conducting the discussion session during the Region Caucus in Niagara Falls.

At the CCECE banquet on Monday, May 3rd, Region 7 presented its awards. On Tuesday morning, Dr. Renato Basisio, the 2004 McNaughton Medalist, presented a lecture on his research. His lecture reviewed some of the research he has lead including the six-port microwave measuring device.

As I write this article, I'm off to Ottawa to help the Ottawa Section celebrate its 60th anniversary. In April, I visited St. Maurice Section to help them celebrate their 50th anniversary. The London Section will celebrate its 60th anniversary later this year. Congratulations to all three sections!

By the time you receive this issue of the Canadian Review, it will be summer and time to relax. However, Fall will come quickly and it will be time to start IEEE activities once again. Have a great summer and I'll report again in the Fall on further progress towards Region 7's goals.

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

Dans mon dernier article, je vous ai fais part de mes objectifs pour la Région 7 pour les deux prochaines années. Le présent article vous présente un suivit des items sur lesquels nous avons travaillés en mettant de l'avant notre plan d'action.

Recrutement de membres - À la Réunion du Printemps à Niagara Falls, une retraite sur l'augmentation des membres de la société a été tenu conjointement avec le Caucus Régional. Les Directeurs de Sections pour le recrutement des membres de la Région 7 étaient présents de même que ceux de la Région 1. La retraite fut dirigée par Brian Lee, RAB Directeur du Recrutement des membres et Mike Binder, Directeur des Services aux membres de Piscataway, aidé de Hilmi Turantli, Président du Comité pour le Recrutement des membres de la Région 7. Les participants ont bien apprécié l'événement. Pour la première fois, la retraite sur l'augmentation des membres était tenue à l'extérieur de Piscataway et offerte aux Directeurs de Section pour le recrutement des membres.

La prochaine étape pour les Directeurs de Sections est d'augmenter l'enrôlement dans leur Sections respectives. Déjà en 2004, la Région 7 a vu une augmentation de ces membres. Les résultats d'avril qui viennent de sortir reflètent une augmentation de 2.7% des membres (Higher Grade) pour un total de 10,137. L'enrôlement des membres étudiants a pour sa part vu une augmentation de 7.5%, pour un total de 3,374 membres. Bon travail! Ensemble nous pouvons continuer à contribuer à l'augmentation de l'enrôlement de nouveaux membres au sein de IEEE.

Il est maintenant temps pour chaque Section de revoir la liste de leur membres et indiquer lesquels se qualifient pour le titre de membres Séniors. Le processus est très simple, le tout étant en ligne. L'an prochain, nous aurons une nouvelle catégorie (Fellow) pour les ingénieurs pratiquants. Dès maintenant, nous nous devons d'identifier les candidats susceptibles de recevoir le titre le plus prestigieux décerné aux membres de IEEE.

Sur un autre front, le Comité Régional a revue et approuvé le Rapport de gouvernance. Le Directeur, le Directeur précédant, le Directeur élu, le Secrétaire et le Trésorier présenteront, à la réunion d'automne à Calgary un plan concret pour l'implémentation de la nouvelle structure de gouvernance. Je voudrais reconnaître le travail de Wally Read et le comité de Vijay Bhargava et Ray Findlay, non seulement pour la production du rapport mais aussi pour avoir guidé la discussion lors du Caucus régional à Niagara Falls.

Au banquet du CCECE, lundi le 3 mai, la Région 7 a conféré ses prix et médailles. Mardi matin, Dr. Renato Basisio, le récipient de la médaille McNaughton 2004, a conduit une lecture sur ses recherches, principalement sur l'instrumentation pour la mesure de micro onde (six-port microwave measuring device).

Au moment d'écrire cet article, je m'apprête à visiter la Section d'Ottawa pour célébrer leur 60ième anniversaire. En avril, lors de mon passage, la Section du St-Maurice célébrait leur 50ième anniversaire. La Section de London célèbrera, quant à elle son 60ième anniversaire. Félicitation à ces trois Sections.

Lorsque vous lirez ces lignes, l'été sera à nos portes, temps pour un repos bien mérité. Par contre, l'automne viendra bien assez vite et avec elle, une foule d'activité avec IEEE. Passez un bon été. Je vous tiendrais au courant à l'automne des progrès obtenus dans la réalisation des objectifs de la Région 7.

E-Learning as a tool of dynamic teaching

by H. Hamam
Faculté d'ingénierie, Université de Moncton, NB

Abstract

Some people believe that when it comes to disseminating information, Internet is the most significant invention since the printing press. Indeed, Internet may present a virtual classroom for teaching and learning as well as a virtual laboratory for research and engineering. For the virtual classroom (Web) to be equivalent to the real one, the virtual teacher (e-learning program) should possess more pedagogical talents than the real teacher who benefits from the direct physical contact with the students in the real classroom. Thus, while electronic learning offers the opportunity of distant education and formation, higher pedagogical performances compared to conventional education are required. In this work, we show how electronic learning can be used to offer fully dynamic courses with efficient interactivity. In function of the interaction of the student with the virtual course, the latter modifies itself automatically in real-time to match the needs of the student and his comprehension level with respect to the given subject. This course dynamism may be ensured by a neural network based algorithm. Rivalry between real and virtual teaching is discussed, challenges are identified and appropriate solutions proposed. Illustrations are given at the end.

Sommaire

Certains croient que quand il s'agit de diffuser l'information, Internet est l'invention la plus importante depuis l'invention de la presse. En effet, Internet peut offrir une salle de classe virtuelle d'enseignement et de formation aussi bien qu'un laboratoire virtuel pour la recherche et l'ingénierie. Pour que la salle de classe virtuelle (Web) équivaille à la classe réelle, le professeur virtuel (programme de formation électronique) devrait posséder plus de talents pédagogiques que le professeur réel qui bénéficie du contact physique direct avec les étudiants dans la salle de classe physique. Ainsi, alors que la formation électronique offre une éducation et une formation distantes, des performances pédagogiques plus élevées, comparées à l'éducation conventionnelle, sont exigées. Dans ce travail, nous montrons comment la formation électronique peut être employée pour assurer des cours pleinement dynamique à interactivité efficace. En fonction de l'interaction de l'étudiant avec le cours virtuel, ce dernier se modifie automatiquement en temps réel pour s'ajuster aux besoins de l'étudiant et de son niveau de compréhension en liaison avec sujet donné. Ce dynamisme dans le cours peut être assuré par un algorithme à base de réseaux de neurones. La rivalité entre les enseignements réel et virtuel est discutée, certains défis sont identifiés et des solutions appropriées proposées. Des illustrations sont données à la fin.

1.0 Introduction

The Interconnected Network (Inter-Network or merely Internet) has been described variously as "the grandest revolution in the capture and dissemination of emerging academic and professional knowledge and information since Caxton developed his printing press"[1], "the invention of the 20th century. The Internet is a world of its own where anything is possible. It has revolutionized communication and our access to information." [2] and "the end of the need to print to paper....the harbinger of an economic, social, and cultural revolution as significant as industrialization and urbanization in the 18th and 19th Centuries....people will not just work differently; they will think differently." [3].

Indisputably, Internet is an outstanding communication tool. People can communicate with anyone who is connected anywhere in the world. The connection is almost instantaneous. The connection does not have to be a one-on-one conversation; you are able to converse with many people at one time. In other words, you can be either the teacher or the student through Internet. However, direct physical contact and natural human interaction are missing. A real teacher (Figure 1) benefits from this natural interaction in the physical classroom to make his course understandable, his arguments convincing and his exercises attractive. For example, during a traditional face-to-face course, the real teacher can use his hands to explain new or difficult concepts, ask and re-ask the students whether they understood, read the faces of the students and reformulate his explanations if necessary … In a virtual classroom offered by Internet, direct physical contact is not available. Thus the virtual teacher (Figure 1 - a Web-based program, …) should compensate for this gap with the assets offered by the electronic learning (e-learning) on Internet.

In the present paper, we limit attention to world wide and publicly accessible e-learning, namely e-leaning on Internet. After providing some definitions, we discuss some potential abilities of e-learning for compensating the absence of direct physical contact between the teacher and the student, the trainer and the trained, the leader and the engineer ... We focus on teaching and learning in this work. Trainings and engineering works will be subject of future publication. In particular, we will discuss how e-learning on Internet can provide dynamism in the course by interpreting the user's actions. After identifying some strong points of face-to-face teaching in traditional classrooms, we propose alternatives offered by virtual teaching. Examples illustrating these solutions are given at the end.

2.0 E-Learning

E-learning has various but similar definitions. We limit ourselves to three of them:

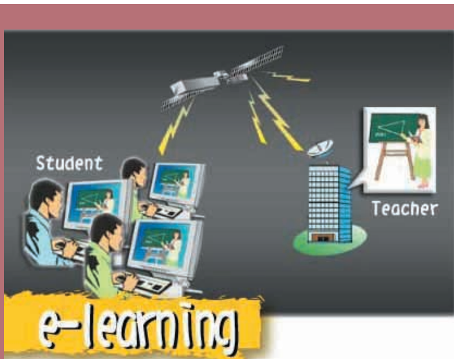


Figure 1: Right: Real teacher (face-to-face learning), Left: virtual teacher (e-learning).

- E-learning is the use of network technology to design, deliver, select, administer, support and extend learning [4],
- E-learning can be defined as instructional content or learning experiences delivered or enabled by electronic technology [5], and
- E-learning is to classroom learning as cell phones are to a pay phone at the bus station [6].

We distinguish two types of e-learning methods. The Web-enhanced e-learning consists of a combination of instructor-led training (face-to-face) with e-learning. However, for the Web fully e-learning, instructions are only available on the Internet. In the present paper, we will focus on the second type, namely the Web fully e-learning.

3.0 Challenges For Virtual Teaching

As mentioned above the virtual teacher should possess more educational talents than the real one. One of the powerful tools that the virtual teacher can use is the popularization of science. This aspect will be treated in details in a future work. We content ourselves here with one example. The virtual teacher can offer a Web page including a science popularization article, for example, on the theory of relativity [7] or on the Big Bang [8]. However such articles present a classical educational tool that is used since the beginning of history of education. Internet in this case is only used as a medium for dissemination of information and not as a platform supporting popularization tools such as scientific simulations, visualization of scientific concepts, animated images, interaction, real time animation, sound clips, … In other words, these tools must be powerful enough to face the challenges resulting from the virtual character of e-learning. In this analysis, we restrict ourselves to the two following challenges.

- Firstly, in a physical classroom, the student can ask questions to understand some points that he missed or to be sure that he correctly understood the talk of the teacher. This option is missing in virtual teaching and presents a serious challenge for this new teaching method. The student appreciates seeing efficient alternatives offered by virtual teaching (next section).
- Secondly, the real teacher may deduce from the student's questions or incorrect answers to some exercises that some points in his explanation during the face-to-face course are not covered or insufficiently detailed or must be reformulated. Questions and errors may be very positive in education since they help the real teacher to pinpoint sources of confusion and therefore to get the possibility to clarify confusing aspects.

These are examples of challenges that virtual teaching through e-learning on the Web should face and provide appropriate alternatives. Let us see in the following section examples of tools that can be offered by e-learning to overcome these challenges.

4.0 Power Of Virtual Teaching

E-learning offers powerful tools that are lacking in traditional learning and formation (face-to-face learning). These tools may make up for the absence of the natural human interaction in a same physical room and at a same time since traditional teaching and learning are linked together in time and space. Indeed, e-learning offer fundamental elements for the popularization of science and engineering such as interaction and animation.

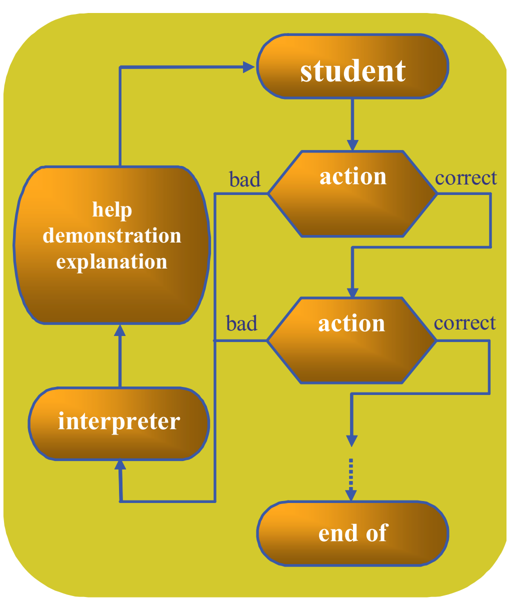


Figure 2: Electronic learning with real-time assistance: supervising the interactions of the user interpreting them to adapt the course to the user's needs and capacity.

One of the assets of e-learning is the possible implementation of multimedia and especially animation. This ability may overcome the first challenge mentioned above. Indeed, there is no doubt that animation provides a strong visual reinforcement of physics as well as engineering concepts. To be more efficient, the animated simulations of scientific phenomena must also include interaction so that the user can formulate his requirements, enter his own data or test himself. This quality may replace the possibility of asking and re-asking questions to the real teacher. All around the world, interactive Web-based animation allows people to visualize even the most difficult concepts of mathematics, computer science, physics, chemistry, telecommunications, etc, to see them and then to understand them. Interactive and especially animated scientific simulations creates real-time correlations between scientific theories and applications that help us visualize, experiment, and interact with the most complex concepts of science and engineering. Without immersing oneself in heavy mathematics, but simply by clicking or dragging a mouse, the user can visually understand difficult concepts, such as photon-atom interaction [9], optical aberrations [10], diffraction [11], fractional Talbot and Lau effects [12] or light injection into an optical fiber [13].

Concerning the second challenge, one of the solutions to meet it is to interpret the responses and the actions of the student (Figure 2). The virtual course should be based on the interaction with the student, the user of e-learning platform, to be sure that he is continuously understanding. In other words before moving to another aspect, the student is asked to interact (reply to questions, move animated elements, draw a curve, check a box, …) or to look for a demonstration. Depending on the actions of the student, the platform can identify whether or not he is understanding or estimate how much he is understanding. His actions may be interpreted by the platform to localize possible confusions or to estimate the degree of difficulty the user is facing.

First, in case of a detected confusion, the platform informs the user about the confusion and then clarifies the situation by a text or a figure or a demonstration … The platform may also change the questions addressed to the user or the kind of interaction to avoid any confusion. This might be performed by a neural network integrated in the e-learning platform.

Second, if, in the light of the user's actions, the platform realizes that the complexity degree of interaction is not presently appropriate to the student, the interaction may be revised (type, difficulty level, …) to match the comprehension level of the user with respect to the concept in question. Demonstrations and figures might be also useful in some cases. The adjustment of the interaction format in function of the user's actions may be performed by a neural network based e-learning platform.

It results that a supervision program interpreting the user's interaction with the e-learning platform is very desirable since it may replace the possibility of asking the real teacher in a face-to-face course. An example will be given in the next section.

5.0 Illustrations

One of the most interesting topologies of communications systems is the Token Ring topology. Avoiding collision and being adapted to fiber networks are two main advantages of this topology. The best way to understand the traffic of packets in a Token Ring canal is to see it (see the concept to understand it). My students provided this statement unanimously. I prepared an interactive and animated Web-based Java Applet to popularize the concept of the Token Ring [14]. The student can freely manipulate the program and build any possible case of traffic including the most complex situations. He can, for example, see what is happening to the Token or to the packet when one of the stations became out of use (Figure 3).

We provided an illustration for the principle of real-time assistance which consists of supervising the interactions of the user with the e-learning platform and interpreting them. This interpretation is used for detecting confusions or for matching the complexity degree of interaction to the estimated comprehension level of the user. We propose an interactive animated Web-based e-learning program for teaching geometrical optics. An animated audiovisual step-by-step curse is offered. The program includes numerous applets offering interaction and animation. One of these applets serves as an audiovisual interactive teaching manual for geometrical optics [15]. For example, one can easily learn

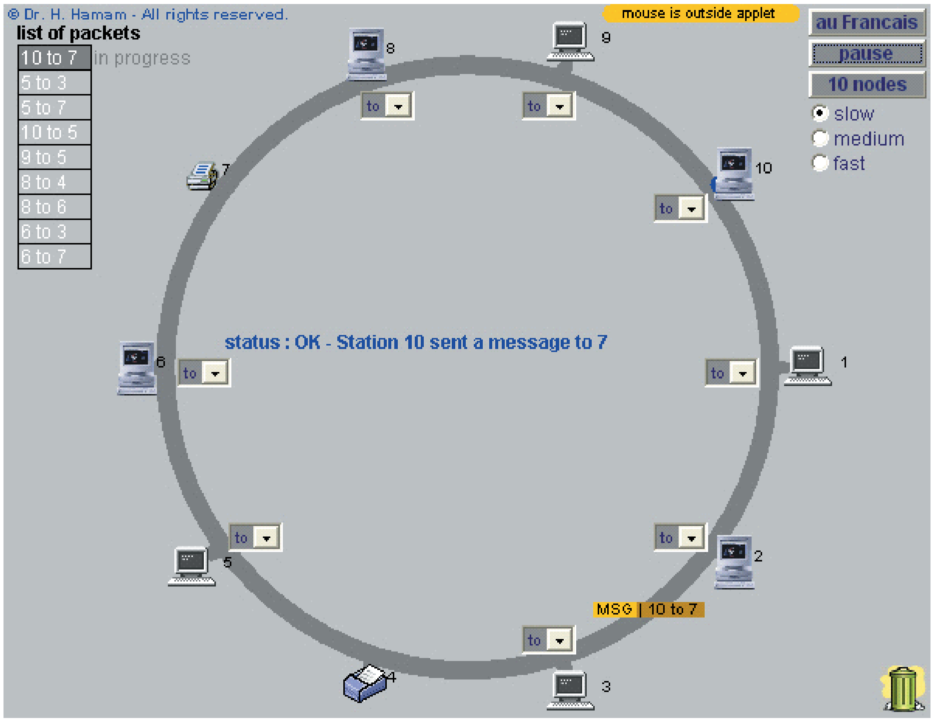


Figure 3: Interactive and animated Java Applet for the Token Ring topology

how to manipulate the three particular rays - parallel, focal and nodal rays - for various systems and for real or virtual objects and images. The applet interprets the manipulations of the user and accordingly offers to him real-time assistance. Several other applets are available [16].

6.0 Conclusion

This article treats some aspects of the rivalry between real and virtual teaching. The real teacher profits from the direct physical contact with the student to identify the needs of the latter, to answer his questions, … The real teacher, by sharing time and space with the student, may make his course dynamic according to the face-to-face interaction with the student.

The virtual course is, by nature, lifeless if the powers of e-learning are not used. We can call for an invisible teacher who should continuously supervise the scene between the Web-based e-learning platform and its user (student). This teacher, who may be a neural system, provides real-time assistance by offering demonstrations, modifying the course, clarify confusing points, asking question progressing in complexity, reminding fundamental aspects and previous explanations, …

In summary, thanks to incessant technological progress that is offering powerful tools to e-learning, the latter may enhance or efficiently replace traditional face-to-face classroom courses.

7.0 Acknowledgment

The author would like to thank the “Faculté des Études Supérieures et de la Recherche (FESR) de l’Université de l’Université de Moncton” for its financial contribution.

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Dynamic Channel Allocation in TDD-CDMA Systems

by Litifa Noor and Alagan Anpalagan
Ryerson University, Toronto, ON

Abstract

Mobile communication systems are increasingly required to accommodate symmetric voice traffic as well as asymmetric data traffic. This paper examines the utilization of frequency band in Time Division Duplex (TDD) mode. Since TDD mode offers the flexibility to support asymmetric channel allocation, it is identified as the preferred access methodology for multimedia traffic, which requires asymmetric channels. We also discuss channel assignment strategies such as Fixed Channel Allocation (FCA), Dynamic Channel Allocation (DCA), and Dynamic Channel Allocation with Adaptive Switching Point (DCA-ASP) that are utilized to fully access the capacity of TDD systems. DCA-ASP provides an efficient allocation of the available resources by shifting the switching point within a transmission frame to accommodate the varying traffic in each direction. Thus, DCA-ASP is a better access methodology compared to FCA and DCA in TDD-CDMA system.

Sommaire

Les systèmes de communication mobile sont de plus en plus utiles pour le traitement du trafic vocal symétrique et asymétrique. Cet article examine l'utilisation de la bande de fréquence dans le mode TDD (Time Division Duplex). Comme le mode TDD peut supporter l'allocation asymétrique de canaux, il est la méthode d'accès privilegiée pour le trafic multimédia. L'article discute des stratégies d'assignation des canaux comme le FCA (Fixed Channel Allocation), le DCA (Dynamic Channel Allocation), et le DCA-ASP (Dynamic Channel Allocation with Adaptive Switching Point). Ces derniers permettent d'exploiter au maximum les capacités des systèmes TDD. Le DCA-ASP permet une allocation efficace des ressources disponibles grâce au déplacement du point d'interrupteur se trouvant dans un paquet de transmission, s'adaptant ainsi à la variation du trafic dans chaque direction. Par conséquent, DCA-ASP est une méthode d'accès supérieure à FCA et à DCA pour les systèmes TDD-CDMA.

1.0 Introduction

The Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA) can operate in two complementary air interface modes: FDD and TDD. Wideband-Code Division Multiple Access (W-CDMA) utilizes FDD, which is designed to support higher mobility and continuous coverage in large cells. FDD is a duplex method where paired frequency bands of symmetric width are assigned to uplink (UL) and downlink (DL) respectively. Alternatively, Time Division-Code Division Multiple Access (TD-CDMA) uses TDD, which is designed to deliver wideband traffic with high degree of asymmetry to low mobile users. TDD is a duplex method where the UL and DL transmissions are carried over the same radio frequency through utilization of synchronized timeslots. Figure 1 shows the utilization of frequency band by both the FDD and TDD modes.

As the mobile domain extends, the target of 3rd Generation (3G) mobile telecommunication systems is to provide a wide range of services, which supports multimedia traffic as well as traditional voice communication. While existing systems have been designed mainly for speech, UMTS is also intended to support wireless multimedia communication such as video and Internet. The nature of the multimedia traffic is different from speech in terms of its appearance in short bursts with high peak data rates and long idle times between consecutive requests. For a network that supports voice and data transmission, Quality of Service (QoS) requirements with respect to transmission error, throughput and delay must be considered. In contrast to voice services, multimedia traffic is highly asymmetric between UL and DL.

Due to the asymmetric traffic characteristics, the utilized communication system must support flexible UL and DL capacity without affecting the overall bandwidth efficiency. The proposed 3G systems support symmetric and asymmetric services where the channel conditions differ depending on the users' locations. Asymmetric channels in FDD systems require assignment of adjustable bandwidths for the forward and reverse links, independent filters, and different data rates, which are practically complex and costly. Alternatively, asymmetric channels in TDD system can be established through software control where the overall capacity of the TDD system is constant, but the UL and DL capacities are adjusted accordingly.

The asymmetric channel allocation makes TDD very attractive for multimedia applications, which require asymmetric channels. The ability to handle asymmetric data and reciprocal nature of TDD channels contribute to the main advantages of using TDD for mobile radio communication. In contrast, synchronization dilemmas and interference problems are considered the limiting factors of TDD systems.

2.0 Physical Channel in UTRA-TDD

The UTRA physical channel consists of TDD frames with duration of 10 ms. Each frame is divided into 15 timeslots that are assigned for either UL or DL transmission. In addition, each timeslot allows for a simultaneous transmission of up to 16 bursts by utilizing distinct spreading codes. The size of the data burst has significant impact on the performance of the network. Large data bursts lead to transmission of redundant data when enough data is not available. Alternatively, small bursts accompany large overhead for physical layer control data.

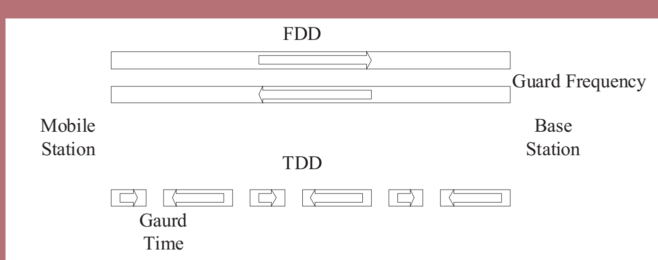

Figure 1: Utilization of Frequency Band by FDD and TDD

The combination of a specific code and a certain timeslot, in each frequency band, is referred to as Resource Unit (RU). Accordingly, 240 RUs are available in each Base Station (BS) on a single frequency. TDD physical channel has a bandwidth of 5 MHz and is located between the frequency range of 2000 MHz and 2005 MHz. Figure 2 indicates the structure of the physical channel within one TDD time frame.

TDD operation mode of UMTS allows highly dynamic and distinct configuration of the physical layer time frame. In addition, UMTS is capable of assigning different physical channel configuration to each connection in order to allow for distinct transmission bit rates with different spreading factors and error connection scheme for several types of services.

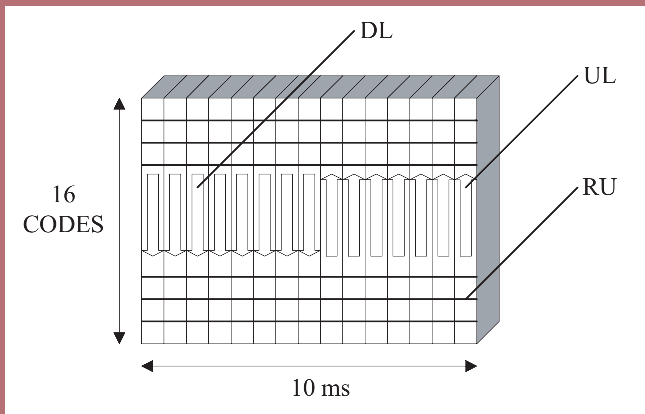

Figure 2: TDD Time Frame

3.0 Channel Assignment Strategies

In contrast to FDD, which utilizes paired frequency bands of symmetric width for DL and UL, TDD is designed to support asymmetric bandwidth allocation. A TDD system provides flexible UL and DL capacity in order to accommodate varying asymmetric traffic in both directions. A switching point indicates the location(s) within a frame where the direction of transmission changes from UL to DL and vice versa. In a TDD system, a timeslot can be utilized for UL or DL transmission in accordance to the traffic ratio. Thus, TDD mode is designed to support optimal management of the available radio resources, which is the fundamental issue in developing access methodologies. Channel assignment strategies that are utilized to access the capacity of the system can be generally categorized as Fixed Channel Allocation (FCA) and Dynamic Channel Allocation (DCA).

3.1 Fixed Channel Allocation (FCA)

In FCA, the number of allocated UL and DL timeslots specifies UL and DL capacities during initialization of the system. Thus, channels are randomly assigned to each connection and switching point movement is not supported during the system operation. Following randomization, if the selected slot is not available, subsequent slots are searched until a free slot is located. Consequently, a new call is blocked when the network fails to locate resources within the available RUs of the TDD frame. Although it can be assumed that interference is spread uniformly over the entire frame and all connections experience similar transmission quality, FCA is not capable of evaluating and adapting to the current connection quality. Thus, FCA cannot support optimal management of the available radio resources.

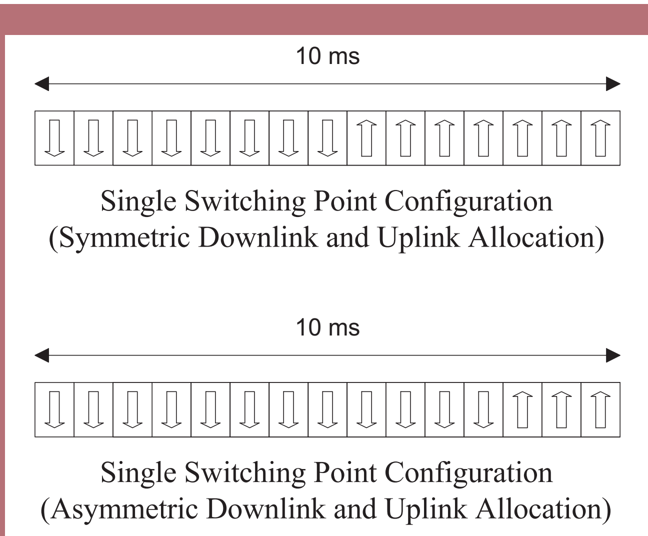

Figure 3: DCA in TDD Frames

3.2 Dynamic Channel Allocation (DCA)

DCA allows the system to utilize the radio resources more efficiently compared to FCA. DCA schemes allow rearrangement of the allocated resources in order to improve connection quality. Thus, QoS is ensured by DCA through assignment of appropriate number of resources. Like FCA, DCA does not support the movement of the switching point. Hence, the number of UL and DL slots is fixed and the switching point is not shifted during transmission. Figure 3 indicates DCA in TDD frames.

Based on channel measurement, DCA schemes assign RUs to the connection, which will likely offer the best available transmission. A simple interference based DCA scheme assigns the Least Interfered Resource (LIR) in DL and UL to the connections. In order to determine that a certain timeslot provides an adequate quality, it specifies a predefined interference threshold for the UL and DL connections. Thus, connections are blocked depending on the interference threshold. The blocking probability of the connections increases with a decrease in the threshold value. Interference based DCA has advantages over FCA in terms of Bit Error Rate (BER) performance. Since DCA reallocates resources with low transmission quality, it offers improved QoS with respect to satisfied subscribers.

4.0 An Interference Based DCA Algorithm

The following algorithm describes an interference based DCA in TDD mode [1].

1. An interference threshold is predefined for speech as well as packet service types. The threshold defines the maximum value below which data or voice is transmitted and received without distortion. In addition, the optimal number of RUs required per frame, for each UL and DL, is parameterized for different services. The parameter enables the system operator to provide distinct packet data services depending on the transmission speed.
2. During initiation of a connection, the mobile terminal measures the signal quality of the local base station. Following, a connection request is transmitted to the BS with the best signal quality. Subsequently, DCA acquires the interference data for each timeslot. For DL the interference is measured at the mobile terminal, while for UL the interference is measured at the base station.
3. DCA compares the interference data with the threshold value. Subsequently, +4 points are assigned to any timeslot with a lower interference level compared to the threshold. Alternatively, -1 point is assigned to the timeslots, which are not considered for the connection.
4. Then, DCA compares the available RUs in the frame with the number required by the service type. An additional 4 points are given to each slot that has the required number of RUs.
5. If the slot contains RUs for only 50 percent of the required capacity, +2 points are assigned. Also, +1 point is given to each timeslot, which is capable of supporting a connection with at least one RU.
6. Finally, the timeslot with the highest score is selected. If both UL and DL allocations are required, DCA must find RUs in both directions.

According to the above algorithm, Step 3 checks the interference level of the timeslot while Steps 4 -6 determine the availability of RUs for the requested service type. DCA makes use of interference limits and RUs requirement parameters of the services in order to allocate radio recourses. By adjusting the interference limit parameters, the system operator can influence the number of blocked calls. RUs requirement parameters enable the system operator to vary the throughput of packet data service. Finally, depending on channel measurements, DCA schemes attempt to assign RUs to the connection, which offers comparatively better transmission quality. Thus, DCA provides enhanced quality of service through appropriate allocation of radio resources.

Furthermore, DCA offers the possibility to allocate resources based on the current connection quality as an additional feature. For speech services, this quality criterion can be the BER of the connection. In the case where the BER is higher than a predefined value, the connection is blocked and a reallocation request is generated and executed. In order to avoid system instabilities, reallocation is permitted after a specific period of steady RU allocation. This is to consider possible failed reallocation attempts when the BER stays above the threshold and limits the dynamic of reallocation.

5.0 DCA with Adaptive Switching Point Strategy (DCA-ASP)

DCA-ASP strategy provides an efficient allocation of the available resources to multimedia traffic. Adaptive Switching Point (ASP) is designed to dynamically adjust the bandwidth to suit the traffic ratio by assigning different number of timeslots for UL and DL. Consequently, the adaptation results in higher throughput. DCA-ASP supports asymmetric services and carries UL and DL allocations with multiple switching points. By placing the switching point within a transmission frame dynamically, a TDD system can provide flexible UL and DL capacity to accommodate varying asymmetric traffic in each direction. Figure 4 indicates multiple switch point configurations in a TDD frame.

The disadvantages associated with the Adaptive Switching Point allocation are comparatively complex resource allocation schemes, and cross mobile interference for overlapping timeslots that are utilized differently in neighboring cells. The interference instances occur due to overlapping timeslot (TS) when, for example, BS1 utilizes TS3 for DL while BS2 uses TS3 for UL as illustrated in Figure 5.

In accordance with the above scenario MS1 is receiving data in TS3. Since MS2 is transmitting on the same slot, MS1 receives interference from MS2, which is referred to as MS-MS interference. In addition, BS2 receives signals from MS2 and interference from BS1, which is transmitting on TS3 in the DL direction. This is referred to as BS-BS interference. The MS-MS and BS-BS interferences that are generated by asymmetric switching point can become a major limiting factor of the TDD mode. In order to eliminate the interference instances, a TDD system requires an effective channel allocation algorithm, which can coordinate TS assignment between base stations in a cellular network. Although the switching point allows an efficient allocation of resources, losses in capacity may occur when time slots in neighbored cells are allocated differently. The loss in capacity results from the interference that takes place between the UL and DL traffic in the corresponding timeslots.

ASP strategy shares the same algorithm as DCA with an additional feature that supports movement of the switching point. ASP follows the steps defined in the DCA. However, if a connection is blocked in Step 3 of the DCA algorithm that was discussed above, the timeslot at the border between the UL and DL is freed up for the connection. Suppose TS0-TS9 are utilized by DL and TS10-TS14 are employed by UL as indicated in Figure 6.

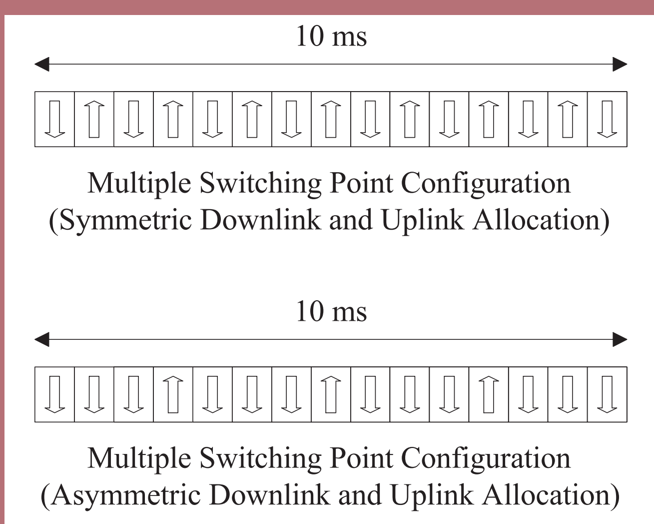

Figure 4: Multiple Switching Point Configuration in a TDD

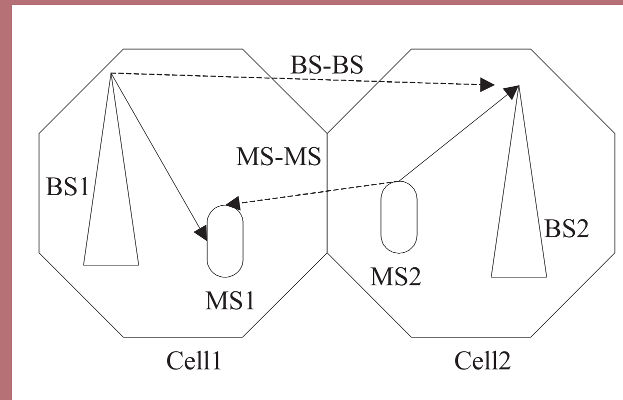

Figure 5: Interference Instance in Overlapping Timeslot (TS3)

Upon the request of a new DL connection, the following five steps are executed [7]:

1. Adaptive switching point utilizes DCA algorithm to allocate resource in DL for the connection. However, the connection is blocked in Step 3 due to high interference in the DL timeslots. Consequently, the slots are marked as unusable.
2. Adaptive switching point attempts to increase the DL capacity by freeing up TS10, which is the subsequent UL timeslot.
3. The connections in TS10, which has been freed up for DL transmission, are reassigned to the next available UL timeslots.
4. If adaptive switching point allocates a suitable UL slot for the existing UL connections, TS10 is utilized for DL and the switching point is relocated.
5. Alternatively, if the adaptive switching point fails to allocate a suitable UL slot for the existing UL connections, the new DL connection is blocked.

Thus, DCA with Adaptive Switching Point increases the total number of satisfied users.

6.0 Conclusion

TDD mode is well suited for multimedia traffic with asymmetric characteristics. With the dominance of unbalanced traffic, optimal management of the available radio resources has become the primary concern in developing radio access methodologies. Channel assignment strategies that are utilized to access system's capacity in TDD are primarily based on FCA and DCA principles. DCA allows the system to utilize the radio resources more efficiently compared to FCA. Dynamic allocation is based on the criteria that offer instantaneous quality of service to the connections. In addition, it allows rearrangement of the allocated resources to increase connection quality in case of a possible impending connection breakdown. DCA-ASP provides an efficient allocation of the available resources by dynamically placing the switching point within a transmission frame to accommodate the varying traffic in each direction. Hence, DCA-ASP is a better access methodology compared to DCA in TDD-CDMA systems.

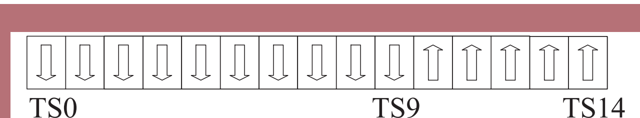

Figure 6: Adaptive Switching Point

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8.0 Acronyms

ASP:	Adaptive Switching Point
BS:	Base Station
BER:	Bit Error Rate
DL:	Downlink
DCA:	Dynamic Channel Allocation
FCA:	Fixed Channel Allocation
FDD:	Frequency Division Duplex
LIR:	Least Interfered Resource
MS:	Mobile Station
QoS:	Quality of Service
RU:	Resource Unit
TD-CDMA:	Time Division-CDMA
TDD:	Time Division Duplex
TS:	Timeslot
UL:	Uplink
UMTS:	Universal Mobile Telecommunication Systems
UTRA:	UMTS Terrestrial Radio Access
W-CDMA:	Wideband CDMA
3G:	3rd Generation

About the authors

Litifa Noor is a 4th year Electrical Engineering student at Ryerson University. Her current research interests include analysis of different channel allocation strategies in TDD-CDMA, synchronization techniques for wideband TDD-CDMA, and digital signal processing for communications. She is the Chair of the IEEE Student Branch at Ryerson University in 2003-2004, and the Organizing Chair of the International Conference for upcoming Engineers, which was held at Ryerson University in May 2004.

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Outstanding student paper awards at the CCECE'2004 Conference in Niagara Falls, May 2004

Four prize winning papers submitted by students were selected at the Conference. Unfortunately, only two students were present to pick up their awards at the Luncheon held on Tuesday 4 May, 2004. The four papers were:

1. A Differential Space-Time Code Receiver using the EM-Algorithm, M. L. B. Riediger, Simon Fraser University,
2. 2-D CMOS based Image Sensor System for Fluorescent Detection, Yasaman Ardeshirpour, McMaster University,
3. Receive Antenna Selection for Space-Time Block Codes, Xiang Nian Zeng, Concordia University,
4. Implementing Task Scheduling and Event Handling in RTOS+, Cyprian F. Ngolah, University of Calgary.

Bill Kennedy (left), President of IEEE Canada presents the award to **M. L. B. Riediger** (center) from Simon Fraser University while Janet Bradley (right) reads the citation. The awards consisted of a plaque and a book generously donated by Alex Greene of Kluwer Academic Publishers, Boston.

Bill Kennedy (center), President of IEEE Canada presents the award to **Cyprian F. Ngolah** (left) from University of Calgary while Janet Bradley (right) reads the citation. The awards consisted of a plaque and a book generously donated by Alex Greene of Kluwer Academic Publishers, Boston.

IEEE Honours Historical Achievement in Electrical Engineering

by Ron Potts, Bob Barnett, Dave Hepburn, Alan Jex, Ed Shadeed and Ted Winch, IEEE Life Members Chapter

Pictures by Eric Harrison

The Institute of Electrical and Electronic Engineers (IEEE) is pleased to recognize the DeCew Falls Hydroelectric Generating Station as a pioneering project in distance transmission of electrical energy. The Power Generation Station, located in St. Catherines, Ontario, was the site of a Milestone Dedication Ceremony on May 2nd 2004. Members of the IEEE Hamilton Section, in co-operation with Ontario Power Generation, unveiled a commemorative plaque which reads:

IEEE Milestone In Electrical Engineering And Computing

DeCew Falls Hydro-Electric Plant, 1898

The DeCew Falls Hydro-Electric Development was a pioneering project in the generation and transmission of electrical energy at higher voltages and greater distances in Canada. On 25 August 1898 this station transmitted power at 22.5 kV, 66 2/3 Hz, two-phase, a distance of 56 km to Hamilton, Ontario. Using the higher voltage permitted efficient transmission over that distance.

May 2004

INSTITUTE OF ELECTRICAL & ELECTRONIC ENGINEERS

The IEEE plaque (left) will be placed alongside the original Ontario Hydro plaque (right) placed in 1998 to commemorate the 100th anniversary of the power plant.

Prior to this significant achievement, transmission lines were no longer than 16 km and operated at much lower voltages. These lower voltages typically meant higher current, much lower efficiency and higher operating costs. The hydroelectric power, generated at DeCew Falls, terminated approximately one mile inside the eastern city limits of Hamilton. It provided electricity to the Hamilton Electric Light & Power Company. This power was used for streetlights, factory operation and within a short time supplied the various electric railways in and around Hamilton.

On July 9,1896, five prominent local citizens known as the "Five Johns", pooled less than $100,000 to form the Cataract Power Company of Hamilton. The idea to harness the power of DeCew Falls and transmit power to Hamilton was proposed by John Patterson. Patterson was one of the first to recognize and implement Nikola Tesla's 1888 invention, "Polyphase Alternating Current". The DeCew Falls Power plant was the first development that provided polyphase power for commercial use over transmission lines to loads in Hamilton 56 km away from the Niagara area. The intake block and part of the original building remain at the original site.

The original four generators (two were installed in 1898 and two in 1903) operated at 66 2/3 Hz. At that time there was no frequency standard. Between 1911 and 1918, six more units were added. The plant output at its peak was 52,000 HP. Presently six units numbered 4 through 9 are on site and units 5 through 8 are operating at 60 Hz.

DeCew Falls plant was the earliest major plant on the Canadian side of the Niagara River diverting water from Lake Erie via the Welland Canal by constructing a 7.6 km canal to the Niagara escarpment just east of DeCew Falls.

Until Sir Adam Beck Plant No.1 was built in 1916, the DeCew Falls plant was operating with the highest head of 83 metres. This is almost the full drop between Lake Erie and Lake Ontario of 100 metres.

The basic design of the plant using a forebay and penstock design with the turbines and generators at the same elevation has endured as distinct from the "dead end" wheel pit design. The DeCew Falls plant remains in operation today whereas all its contemporaries on both sides of the Niagara River generating at 25 Hz have been decommissioned and in most cases demolished.

The milestone proposal and research was accomplished by the Hamilton Life Members Chapter with the support of the Hamilton Section and assistance of Ontario Power Generation personnel.

Photo above: Outside view of the DeCew Falls power plant.

Photo right: Inside view of the generating hall.

For more pictures see the website:

http://ieeesb.mcmaster.ca/~hamilton/milestone/decew.htm

A Simplified SVM Control Scheme for Reduced Switching Losses in Converter-Fed Drives

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Abstract

In this paper we propose a simplified space vector modulation (SVM) control scheme for reduced switching losses in converter-fed drives. This method has some practical advantages when compared to normal SVM. It is characterized by a reduction in switching losses, a lower current harmonic distortion and easier digital implementation. Our approach, which is based on space vector modulation, consists of calculating the duty ratio allocated to each inverter leg. A theoretical analysis is developed and proven based on the results of the experiments.

Sommaire

Dans cet article nous proposons un modèle simple de la commande à modulation du vecteur spatial (SVM) pour minimiser les pertes par commutations dans un convertisseur de puissance. Ce modèle présente des avantages pratiques par rapport au cas classique de la SVM. Il est caractérisé par une réduction des pertes par commutation du convertisseur de puissance, d'une moindre distorsion harmonique du courant et d'une plus simple numérisation pour fins de mise en œuvre pratique. Notre approche, basée sur la modulation de vecteur spatial, consiste à calculer le rapport de commutation alloué à chaque bras du convertisseur. Une étude théorique est développée et validée par des résultats expérimentaux.

1.0 Introduction

Space vector modulation (SVM) has been very popular in the past few years; the technique has gained ground as an effective means of generating PWM vector controlled drives [1, 2]. Space vector modulation offers many advantages, compared to the conventional pulse width modulation (PWM) method [3]. Among these, the key benefits are:

- 15% increase in the maximum line-to-line voltage obtainable, without overmodulation, when compared to conventional PWM with only 87% of the dc link voltage [4],
- Reduced switching losses converter, and
- Reduced harmonic distortion in the current.

With conventional SVM, all three inverter legs switch in any sampling period. To reduce switching power losses, a modification of SVM was developed, which assumes that two out of three inverter legs switch, while one remains without switching. The choice of the leg that does not switch depended on the orientation of the desired voltage reference. The other two inverter legs were then used to construct the desired voltage. The objective was to minimize switching losses.

The theoretical operation principles are described in the following sections. To verify its effectiveness, the proposed scheme was implemented and tested in the laboratory.

2.0 Space Vector Concept

The principle of the space vector is often used to study the behavior of ac machines. It is applied to represent the output voltage of converter-fed drives and to analyze current control methods. This concept makes it possible to represent three-phase quantities (voltages, currents, …) as space vectors [5,6].

Figure 1 shows the equivalent diagram of a typical dc link inverter-fed drive system, where S_A, S_B and S_C denote the switches of the inverter legs A, B and C respectively. For k = a, b or c, while $S_k = 1$, the corresponding upper switch is conducting. In the same way, $S_k = 0$ indicates that the lower switch is conducting. Therefore, the voltage output vector can be represented as a function of the switch states of the inverter denoted as $\vec{V}_i(S_A, S_B, S_C)$.

Consequently, there are eight states $\vec{V}_i$ (i = 0,…,7) available for this vector according to the eight switching positions of the inverter depicted in Figure 2. Of the eight possible states, $\vec{V}_1$ - $\vec{V}_6$ are vectors with magnitude V_d while $\vec{V}_0(0,0,0)$ and $\vec{V}_7(1,1,1)$ are zero vectors. For example, $\vec{V}_1$ corresponds to the switching state (1,0,0). The space vector $\vec{V}_s$ (Figure 3) is then defined as:

$$\vec{V}_s = V_d\left(S_A + S_B \cdot a + S_C \cdot a^2\right) \qquad (1)$$

$$\text{where:} \quad a = e^{j \cdot \frac{2\pi}{3}} \quad \text{and} \quad V_s(t) = V_{s\alpha} + jV_{s\beta} \qquad (2)$$

3.0 Principle Of Space Vector Modulation

According to the above analysis, the reference voltage $\vec{V}_s$ in a certain

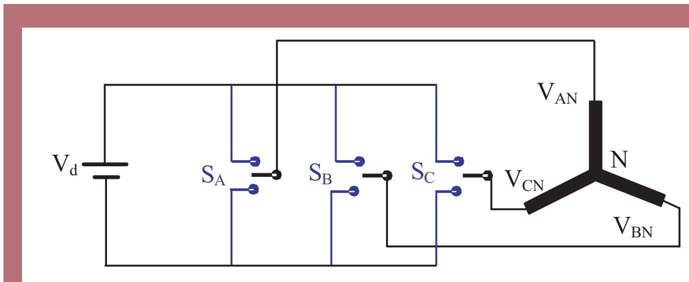
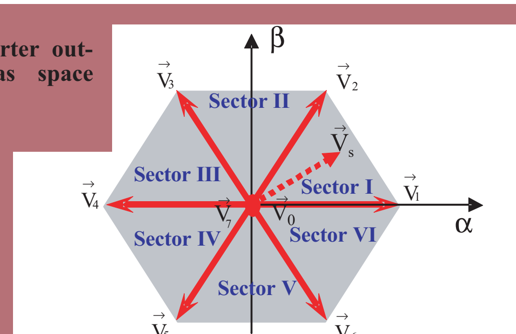


Figure 1: Typical diagram of inverter-fed drive

Figure 2: Inverter output voltage as space vectors



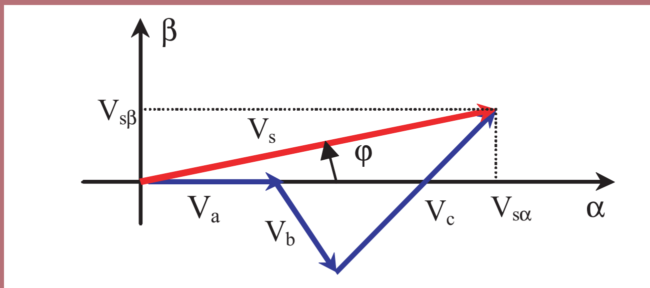


Figure 3: Output voltage as a space vector $\vec{V}_s$ (α – β : stationary coordinate)

sector consists of the two adjacent boundary vectors $\vec{V}_i$, $\vec{V}_{i+1}$ (i=1…,5) and the zero vector $\vec{V}_7$ and $\vec{V}_0$. To obtain the minimum switching frequency of each inverter leg, the switching sequence must be arranged so that the transition from one state to the next is performed by switching only one inverter leg [1]. If, for instance, the reference vector $\vec{V}_s$ is in sector I, the switching mode is as follows: $\vec{V}_0 \Rightarrow \vec{V}_1 \Rightarrow \vec{V}_2 \Rightarrow \vec{V}_7 \Rightarrow \vec{V}_7 \Rightarrow \vec{V}_2 \Rightarrow \vec{V}_1 \Rightarrow \vec{V}_0$.

Figure 4 presents a timing diagram for a sampling period T. For each leg, there are two ON-OFF and OFF-ON transitions. If f_s is the switching frequency for the PWM waveform, where f_s=2/T=2*f, then the switching frequency for three phases will be: f_s = 6 f.

4.0 Proposed Scheme

In this scheme, only one zero vector $\vec{V}_0$ or $\vec{V}_7$ is used in the switching sequence instead of two zero vectors at once. Then, in sector I, the switching mode is as follows (Figure 5): $\vec{V}_0 \Rightarrow \vec{V}_1 \Rightarrow \vec{V}_2 \Rightarrow \vec{V}_0$

In this case, phase C remains without switching and SC is always set on OFF. The switching frequency for three phases under this scheme will be: f_s = 4f. Then, switching converters are reduced by 33.3% compared to the classical SVM, and switching losses can be greatly reduced.

In sector I, the reference vector is composed of voltage vector $\vec{V}_1$, $\vec{V}_2$ and zero voltage $\vec{V}_0$ as illustrated in Figure 6. Hence, it follows for a switching cycle in sector I:

$$\int_0^{T/2} \vec{V}_s \cdot dt = \int_0^{T_1/2} \vec{V}_1 \cdot dt + \int_{T_1/2}^{(T_1/2 + T_2/2)} \vec{V}_2 \cdot dt + \int_{(T_1/2 + T_2/2)}^{T/2} \vec{V}_0 \cdot dt \qquad (3)$$

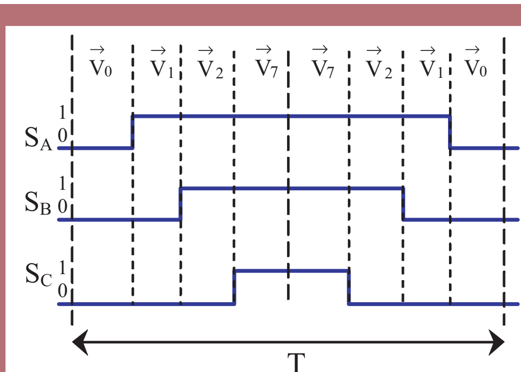


Figure 4: Switching sequence using $\vec{V}_0$ and $\vec{V}_7$

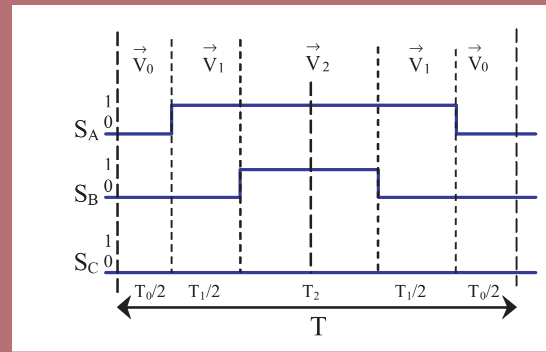


Figure 5: Switching sequence using zero vector only

Where T is the switching period and T_1 and T_2 are the active pulse times for voltage vectors $\vec{V}_1$ and $\vec{V}_1$ respectively. For a sufficiently high switching frequency, the reference space vector $\vec{V}_s$ is assumed constant during a switching cycle. Taking into account that $\vec{V}_1$ and $\vec{V}_2$ are constant and $\vec{V}_0 = 0$, one finds:

$$T\vec{V}_s = T_1\vec{V}_1 + T_2\vec{V}_2 \qquad (4)$$

The reference space vector can be described in stationary coordinate (α,β), as follows:

$$\begin{cases} TV_{s\alpha} = T_1 \cdot \sqrt{\frac{2}{3}} \cdot E + T_2 \cdot \frac{E}{\sqrt{6}} \\ TV_{s\beta} = T_2 \cdot \frac{E}{\sqrt{2}} \end{cases} \qquad (5)$$

From (5) we can obtain:

$$\begin{cases} T_1 = \frac{\sqrt{6} \cdot V_{s\alpha} - \sqrt{2} \cdot V_{s\beta}}{2 \cdot E} \cdot T \\ T_2 = \frac{\sqrt{2} \cdot V_{s\beta}}{E} \cdot T \end{cases} \qquad (6)$$

Thus, for one cycle, SA switches for $\vec{V}_1$ and $\vec{V}_2$ while SB switches for $\vec{V}_2$ only. On the other hand, SC remains without switching. Then, one finds:

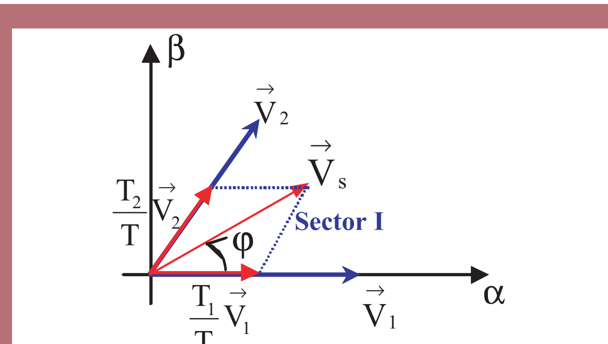


Figure 6: Determination of switching times

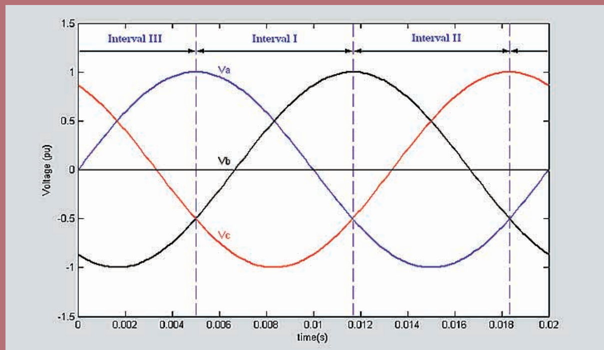


Figure 7: Intervals of 120°

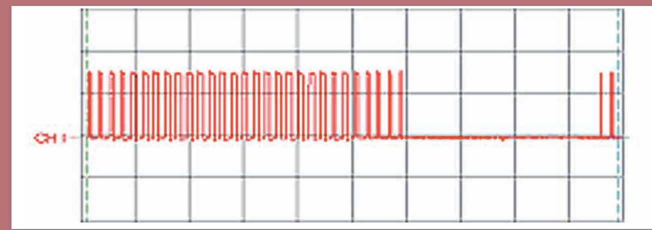


Figure 9: One of the gate control signals

$$\begin{cases} D_a = \dfrac{T_1 + T_2}{T} = \dfrac{\sqrt{6} \cdot V_{s\alpha} + \sqrt{2} \cdot V_{s\beta}}{2 \cdot E} \\ D_b = \dfrac{T_2}{T} = \dfrac{\sqrt{2} \cdot V_{s\beta}}{E} \\ D_c = 0 \end{cases} \quad (7)$$

With 2/3 transformation, we obtain:

$$D_a = \frac{V_a - V_c}{E} \quad ; \quad D_b = \frac{V_b - V_c}{E} \quad ; D_c = 0 \quad (8)$$

where V_a, V_b and V_c are the reference output voltages.

Taking into account the necessary changes in the other sectors, one finds (Table 1):

Table 1: Duty ratio in the 6 sectors

Sectors	Duty ratio
I and II	$D_a = \dfrac{V_a - V_c}{E}$; $D_b = \dfrac{V_b - V_c}{E}$; $D_c = 0$
III and IV	$D_b = \dfrac{V_b - V_a}{E}$; $D_c = \dfrac{V_c - V_a}{E}$; $D_a = 0$
V and VI	$D_a = \dfrac{V_a - V_b}{E}$; $D_c = \dfrac{V_c - V_b}{E}$; $D_b = 0$

According to this analysis, we can take into account only three intervals of 120 ° instead of six sectors of 60 °. These are identified as follows (Figure 7):

Interval I [sectors I II] : Va > Vc Vb > Vc.

Interval II [sectors III IV]: Vb > Va Vc > Va.

Interval III [sectors V VI]: Va > Vb Vc > Vb.

For each I, II and III interval, one of the three inverter phases - C, A and B respectively - remains without switching.

5.0 Experimental Results

Experimental results are presented in this section to demonstrate the validity of the proposed scheme. Experiments were performed on a 1HP induction motor. The motor parameters are listed in the Appendix.

Figure 8 shows the system configuration used in this experiment. The lookup table (EPROM) requires two external control signals: amplitude *Ai* and frequency *Fi*, converted with an A/D and a VCO respectively. An insulated gate bipolar transistor (IGBT) module is used to drive the induction motor. Since the duty ratio is incorporated in the software, the proposed scheme features a simple hardware design.

The fundamental frequency and the amplitude of the output voltage can be changed independently. The transition from one mode to another is without current transients.

Figure 9 shows the gate control signal of one inverter leg when the 33.3% non-switching portion of the inverter leg is clearly visible. This is well confirmed in Figure 9a.

Figure 10a shows the output voltage of one inverter leg and the corresponding sinusoidal current. It can be seen that, normally, the leg is set open in one-third the period compared to classical SVM (Figure 10b). Therefore, switching losses are reduced by 33.3%.

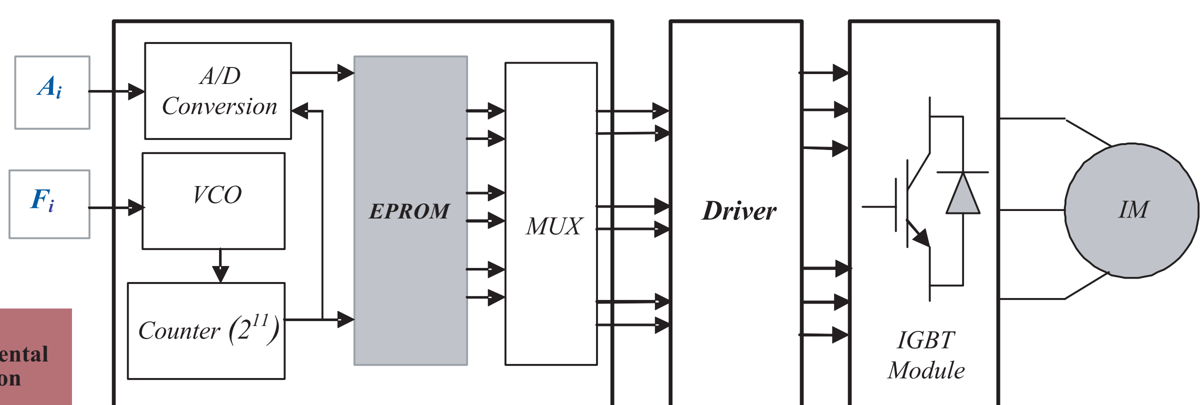
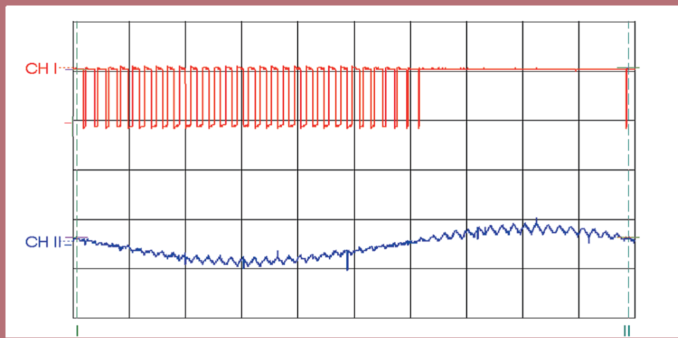
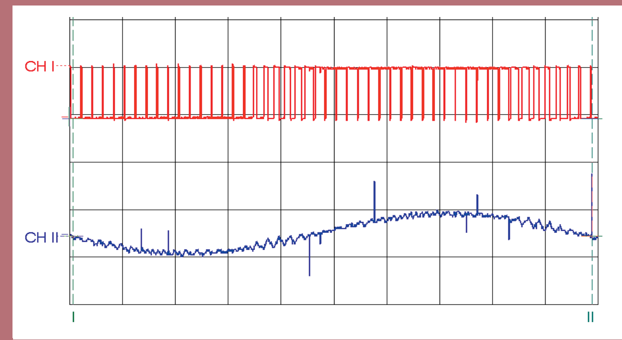


Figure 8: Experimental system configuration



(a)



(b)

Figure 10: Output voltage of one leg and corresponding current
(a) Developed SVM
(b) Classical SVM

6.0 Conclusion

This paper presents a simplified space vector modulation control scheme for reduced switching losses in converter-fed drives. The proposed scheme reduces the switching power losses significantly more than the conventional SVM and gives the same performances, moreover, as those obtained with the SVM technique. The main advantages of the proposed scheme are:

- Only two inverter legs are controlled in each operation interval and the switching losses are reduced by 33.3%, and
- Low cost and easier digital implementation.

7.0 Appendix: Parameters of the motor

Un = 220V, In = 3.6A, Pn = 1 HP,

Nn = 1500 rpm, 3 Phases, 50 Hz.

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Power Converter Handbook - The theory, design and application of power electronics

Author: Andy C. Stevenson
ISBN No: 0-9732855-0-8
Published by: Lazer Graphics
November 2002

Reviewed by: Luc C. Matteau,
LC Matteau Associates, Peterborough, ON

Power conversion as the term implies, is associated with a field of engineering known today as Power Electronics. The specific nature of power conversion covered in this handbook reflects the contributions of many learned engineers and technicians who pioneered the application of power conversion to both rotating and static equipment for industrial and power generation applications in the early years of applying power semiconductors at General Electric (Canada). A few who played a prominent role in these early days are mentioned in the introduction of this handbook.

When the early power converters were designed and installed, there was little history to determine the real reliability and survivability if the equipment over the long term. In the intervening years since the first version of this handbook was developed many interesting phenomena have come to light that explain the long term effect of thermal cycling power semiconductors and what to look for when performing repair and maintenance.

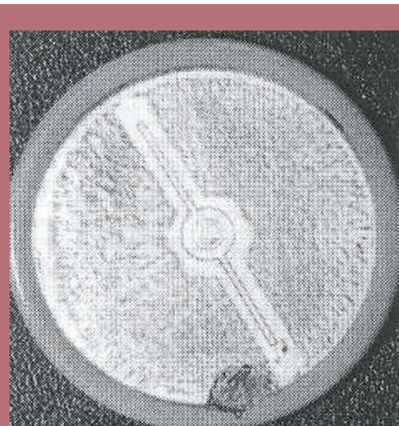
Power Converter Handbook - theory design application provides a guide to power conversion from the basic construction of the P-N junction to the mechanical failure of that junction from excessive thermal cycling over many years. This book is an excellent reference document for both the novice designer and the seasoned professional. It is used in several universities as the course material for teaching this fascinating field of power conversion.

As mentioned earlier, the first chapter of the book outlines basic semiconductor theory to provide an understanding of the various devices that are used in converting power. The known applicable types of devices are defined from the basic two-layer PN junction to the many forms of the four layer (PNPN) junction devices.

The next 3 chapters (Part 2) are devoted to DC Power Converters. An overview (chapter 2) of the basic types of power converters available to the designer is followed by a detailed theoretical discussion (chapter 3) of each type with each circuit equation defined complete with voltage and current waveforms. Chapter 4 discusses DC controlled rectifier in 1, 2 and 4 quadrants operation with respect to the control of power flow. Also in this chapter is a discussion of AC voltage phase control and a practical development of the required design decisions when paralleling many SCR's.

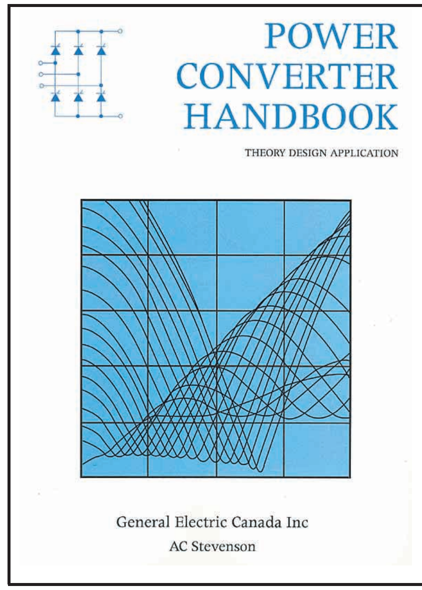
The next 2 chapters (Part 3) discuss thermal and failure analysis in high power thyristors. Thermal analysis (chapter 5) defines the transient and steady state heating of thyristors and then goes on to explain the common cooling systems utilized to keep the thyristor junction below its critical operating temperature.

Failure analysis (chapter 6) provides the design engineer with a practical guide to calculate at the design stage the expected life of the semiconductors in a converter. This chapter is the result of over thirty years of study and observation of failure modes of installed, operating converters and cannot be found in any text book.



CSR Thermal Fatigue

The next four chapters (Part 4) discuss transients, harmonics, power factor and faults that can affect the converter or that are produced by it. Five types of transients (chapter 7) that a converter might see in normal operation are reviewed and solutions to protect the rectifier elements against these are discussed. Chapter 8 looks at effects of harmonics created by the different types of rectifiers on power system and on the load and provides an insight into what steps can be taken to minimize these effects. Chapter 9 defines power factor as a determining the current carrying capacity of the circuit elements connected to the converter. The system designer must take the overall power factor of the connected converters into account when designing the AC feed system.



Chapter 10 looks at the various faults that can occur in a DC bridge converter and discusses the application of protective measures to respond to these faults in order to protect the converter upstream and downstream components. This discussion applies equally to protection of AC phase controlled converters.

The next two chapters (Part 5) discuss the different methods of generating power for AC drives using different converter technologies. Chapter 11 provides a basic discussion of how AC voltage is generated from both rotating machines and static AC-AC converters. Chapter 12 discusses the basic PWM and looks at its use as a DC - 3 phase AC power converter.

The next two chapters (Part 6) discuss the effects that the AC drive can have on its environment. Chapter 13 discusses the effect on the AC line and bridge rectifier side while Chapter 14 looks at the effect of the output inverter on the AC drive motor being controlled. This section provides a practical treatment of problems that can and have faced many designers in the past. This data cannot be found in any text book and as such is a must read before and during the design and installation of any AC drive system.

The final chapter briefly describes the types of drive motors and converter technologies available indicating the strength and shortcomings of each.

In conclusion, this book is an excellent guide for both the novice and seasoned converter designer and is well suited for teaching a course on power converters in electrical engineering. The information is well structured and easy to read. This is a must for your bookshelf if you are or aspire to be involved in power conversion.

Parameterless Genetic Algorithms: Review and Innovation

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Abstract

We present a brief review of Genetic Algorithms (GAs) that do not require the manual tuning of their parameters, and are thus called Parameterless Genetic Algorithms (pGAs). There are three main categories of Parameterless GAs: Deterministic, Adaptive and Self-Adaptive pGAs. We also describe a new parameterless Genetic Algorithm (nGA), one that is easy to understand and implement, and which performs very well on a set of five standard test functions.

Sommaire

Nous présentons un bref examen des algorithmes génétiques (GA) qui n'exigent pas l'accord manuel de leurs paramètres, et nous appelons ainsi les algorithmes de "Parameterless Genetic Algorithms" (pGA). Il y a trois catégories principales des pGAs: PGAs déterministes, adaptatifs et individu-adaptatifs. Nous décrivons également un nouvel algorithme génétique parameterless (nGA), un il est facile comprendre qu'et instrument, et qui exécute très bien sur un ensemble de cinq fonctions standard d'essai.

1.0 Introduction and Review

Introduction. Holland [16] invented the Genetic Algorithm (GA) as an easy-to-use general method for a wide range of optimization problems. The performance of a GA is dependant on a number of factors, including candidate solution representation, and fitness evaluation and manipulation (via crossover and mutation). Both crossover and mutation have parameters (probability of crossover P_c and probability of mutation P_m) that require initialization and adjustment. For a given problem, these parameters, as well as the size of the population of candidate solutions (S), require careful manual optimization, often done through trial and error. Naturally, this diminishes the autonomy of GAs, and renders them much less attractive to potential users, such as engineers, that are not experts in GAs. Parameterless GAs (pGAs) represent an attempt (not yet complete or widely used) to eliminate the need for manual tuning of GA parameters.

1.1 Review. There are two main approaches to the elimination of parameters in GAs: a) Parameter Tuning, and b) Parameter Control.

Parameter tuning involves finding good values for the parameters before the GA is run and then using these values during the GA run. In an empirical study, De Jong [8] discovered a set of parameter values, which were good for the classes of test functions he used (P_c = 0.6, P_m = 0.001, S = 60). Using the same test functions as De Jong, Grefenstette [11] ran a (meta-) GA to find a set of parameter values for another GA (P_c = 0.95, P_m = 0.001, S = 30). As shown, both studies suggest the same low value for P_m (0.001), proposed double-digit values (< 100) for S, and used high (> 0.5) values for P_c. Although none of these two researchers were unable to prove that their sets were optimal for every optimizational task, their results were viewed by many GA users as sound empirically-founded guidelines.

In Parameter Control, one starts with certain initial parameter values; possibly the De Jong or Grefenstette's sets or some amalgamation thereof. These initial values are then adjusted, during run-time, in a number of ways. The manner in which the values of the parameters are adapted at run-time is the basis of Eiben's classification of Parameter Control into three different sub-categories (Eiben et al. [9]). These sub-categories are: (a) Deterministic, (b) Adaptive and finally (c) Self-adaptive. A brief review of published work in these three areas of Parameterless GAs follows.

A. Deterministic Parameterless GAs. In this type of Parameterless GAs, the values of the parameters are changed, during a run, according to a heuristic formula, which usually depends on time (i.e. number of generations or fitness evaluations).

Fogarty et al. [10] change the probability mutation in line with equation (1) - t is the generation number.

$$P_m = \frac{1}{240} + \frac{0.11375}{2^t} \tag{1}$$

Hesser et al. [14] derived a general formula for probability of mutation using the current generation number, in addition to a number of constants used to customize the formula for different optimization problems. Unfortunately, these constants are hard to compute for some optimization problems. In equation (2) n is the population size, l is the length of a chromosome (in bits), and t is the index of the current generation.

$$P_m = \sqrt{\frac{C_1}{C_2}}\frac{\exp((-C_3 t)/2)}{n\sqrt{l}} \tag{2}$$

Both Back [3] and Muhlenbein [17] discovered, experimentally, that $1/l$ is the best value for P_m for (1+l) GAs. A (1+l) GA is an algorithm that sees single parent chromosomes each producing a single child by means of mutation. Hence, the best of parent and child is passed to the next generation. In other studies [4], Back proposes a general formula for P_m, one that is a function of both generation number (t) and chromosome length (l). The formula is presented as equation (3); T is the maximum number of generations allowed in a GA run.

$$P_m = \left\{2 + \frac{l-2}{T-1}t\right\}^{-1} \tag{3}$$

All formulae presented above are variations on a single theme presented symbolically by $1/t$, where t is the generation number. In this theme the probability of mutation is initially very high, but is quickly reduced to a low and reasonably stable value. This agrees with common sense, as most GAs go through a short and frantic period of locating areas of interest on the fitness surface, followed by a lengthy and deliberate exploration of those locales (mainly via crossover). Naturally, random search (and hence mutation) are ineffective methods of exploration of large spaces. This simple fact leads to the incorporation of $1/l$ (and variants) into many formulae for P_m - l is the length of the chromosome which is linked to the dimensionality of the search space.

Not only is the need for manual tuning of P_m eliminated, but the performance of GAs is much improved by the use of time-dependant formulae for P_m. This conclusion is supported by a many studies, including [5].

B. Adaptive Parameterless GAs. In this mode of parameter control, information fed-back from the GA is used to adjust the values of the GA parameters, during runtime. However, (as opposed to self-adaptive control) these parameters have the same values for all individuals in the population.

Adaptive control was first used by Rechenberg [18]. He asserted that 1 every 5 mutations should lead to fitter individuals. As such, he enforced a variable mutation probability that was controlled by the rate of successful mutations in a population. If, at one point in time, the fraction of successful mutations was more than 1/5 then the probability of mutation is decreased and visa versa. Similarly, Bryant et al. [7] increased or decreased the probabilities of crossover and mutation (from initial values) as a function of how much or little those probabilities contributed to the generation of new fitter individuals in a given population: an elaborate credit allocation system was employed and is detailed in their paper.

Schlierkamp et al. [19] focused their efforts on adapting the size of the population. Indeed, they simultaneously evolved a number of populations with different sizes. After each generation, the population with the best maximum fitness is stored in a quality record. After a number of generations, the population with the highest record is increased; all other populations are decreased. In similar fashion, Hinterding et al. [15] ran 3 populations simultaneously. These populations had an initial size ratio of 1:2:4. After a certain pre-specified time interval the populations are halved doubled, or maintained as is, depending on the relative fitness values of their fittest individuals: the best population is doubled in size, while the worst one is halved; the last one is maintained as is. Along the same theme, Harik et al. [13] ran races between multiple populations of different sizes, allocating more time to those populations with higher maximum fitness, and firing new populations whenever older populations had drifted towards suboptimal (search) subspaces.

On a different note, Annunziato et al. [2] asserted that an individual's environment contains useful information that could be used as a basis for parameter tuning. They used a trip-partite scheme in which a new parameter (meeting probability) influences the likelihood of meeting between any two individuals, which (if they meet) can either mate or fight - see section 3.1.3 for details.

C. Self-adaptive Parameterless GAs. These GAs use parameter control methods that utilize information fed back from the GA, during its run, to adjust the values of parameters attached to each and every individual in the population. It was first used by Schwefel [20] in an Evolutionary Strategy (similar to a GA, but using real numbers and matching operators, instead of bit strings, for chromosomes), where he tried to control the mutation step size. Each chromosome in the population is combined with its own mutation variance, and this mutation variance is subjected to mutation and crossover (as is the rest of the chromosome). Back [6] extended Schwefel's [20] work to GAs. He added extra bits at the end of each chromosome to hold values for the mutation and crossover probabilities. At first, the mutation and crossover probability values were chosen at random. Then, these bits were subjected (again, with the rest of the chromosome) to the processes of evolution until, gradually, chromosomes with better probabilities (and better candidate solutions) appeared, and hence dominated the population.

Another way of self-adapting GA parameters, described by Srinivas et al. [21], involves assigning mutation and crossover probabilities to each chromosome, based on its own current fitness and the fitness of the population at large. On the other hand, Arabas et al. [1] defined a new quantity called remaining life time (or RLT). Every new individual is assigned a RLT variable. Each time a new generation is created, the RLT of every individual is updated using a bi-linear formula; how an individual's RLT is updated depends on whether its fitness is less than the average fitness of the current population (or not). Once the RLT of an individual reaches 0, it dies (i.e. is removed from the population).

2.0 Test Functions and Evaluation Measures

2.1 Test Functions. We use exactly the same test functions used in [6] - we restate them here for convenience. This set of test functions have:

- Problems resistant to hill-climbing,
- Nonlinear non-separable problems,
- Scalable functions,
- A canonical form,
- A few uni-modal functions,
- A few multi-modal functions of different complexity with many local optima,
- Multi-modal functions with irregularly arranged local optima, and
- High-dimensional functions.

All test functions have 10 dimensions and use 20 bits/variable except for *f5*, which uses 6 bits/variable.

$$f_1(\bar{x}) = \sum_{i=1}^{n} x_i^2 \quad (4)$$

$$f_2(\bar{x}) = \sum_{i=1}^{n-1} \left(100\left(x_i^2 - x_{i+1}\right)^2 + (1-x_i)^2\right) \quad (5)$$

$$f_3(\bar{x}) = -20\exp\left\{-0.2\sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2}\right\} - \exp\left\{\frac{1}{n}\sum_{i=1}^{n}\cos(2\pi x_i)\right\} + 20 + e \quad (6)$$

$$f_4(\bar{x}) = 10n + \sum_{i=1}^{n}\left\{x_i^2 - 10\cos(2\pi x_i)\right\} \quad (7)$$

$$f_5(\bar{x}) = n - \sum_{i=1}^{n}\left\{\begin{array}{ll} \frac{0.92}{4}(4-x_i) & if \quad x_i \le 4 \\ \frac{2.00}{4}(x_i-4) & if \quad x_i > 4 \end{array}\right\} \quad (8)$$

where x_i is the number of 1 bits in gene *i*.

2.2 Evaluation Measures. In this section we explain a number of statistical measures that we use to evaluate the performance of genetic algorithms. These measures are listed under three headings: reliability, speed and memory load; the measures are defined in the order of their appearance in Table 1.

A. Reliability. Reliability of convergence is essentially the likelihood that the GA is going to converge to an optimal value, within a given number (say 500,000) of fitness evaluations. This following statistic measures reliability.

Percentage of Runs to Optimal Fitness: Each GA was run 30 times. This measure reflects the percentage of runs that were successful in converging to the optimal solution at or before 500 thousand (fitness function) evaluations.

B. Speed. Speed of convergence is essentially the (average) number of fitness evaluations required for a GA to optimally converge. This may be assessed using the following statistical measures.

Ave. No. of Evaluations to Best Fitness, and C.V.: This measure represents the average number of evaluations that are required for a GA to achieve its best fitness value in a run. In cases where the best fitness is 1, it serves as a measure of convergence velocity. Every run produces a different number of evaluations to best fitness. C.V. (Coefficient of Variation) is equal to the standard deviation of that set of evaluations, divided by the average. It is a measure of reliability. Ave. No. of Evaluations to Near-Optimal Fitness: Near-Optimal fitness is defined as a fitness of 0.95. In cases where optimal fitness is not obtained, near-optimal fitness is the next best measure of convergence velocity. This measure is defined in the same way as the preceding measure, except that we substitute near-optimal for optimal.

Average Best Fitness (and S.D.): This is the average of the set of best fitness values achieved in all 30 GA runs. S.D. is standard deviation of that set. Naturally, this is a crucial measure; GAs that are able to achieve a best fitness of 1 (and reliably) are taken seriously; those that return best fitnesses of less than 1 (or 1 but inconsistently) are not as good. Ave. Mean Fitness (and S.D.): This is the average of the set of average fitness values, achieved at the end of the 30 GA runs. S.D. is the standard deviation of that set.

C. Memory Load. This is the amount of memory required, on average, for a GA to achieve optimal convergence. Since the amount of memory correlates with the number of individuals in a given population, we can use population size as a measure of memory load. The following set of measures tackle that issue.

Table 1: Results of Applying nGA to Test Functions f_1 - f_5

nGA	Function 1	Function 2	Function 3	Function 4	Function 5
Percentage of Runs to Optimal Fitness	100%	100%	100%	100%	100%
Ave. No. of Evaluations to Best Fitness C.V.[1]	14345	145980	28873	94640	10413
	18.85	18.34	16.8	40.85	40.64
Ave. No. of Evaluations to Near-Optimal Fitness	4912	15512	9175	90465	6793
Average Best Fitness S.D.	1	1	1	1	1
	0	0	0	0	0
Ave. Mean Fitness S.D.	0.7784	0.51	0.7307	0.6	0.5241
	0.0423	0.0252	0.03	0.04	0.0339
Ave. Mean Population Size to Optimal Fitness	111.78	132.2	121.3	178	114.7
Ave. Max. Population Size to Optimal Fitness	111.78	132.2	121.3	178	114.7
Ave. Mean Population Size to Near-Optimal Fitness	77	117	78.4	178	98.2
Ave. Max. Population Size to Near-Optimal Fitness	77	117	78.4	178	98.2

Ave. Mean Population Size to Optimal Fitness (~ Memory Requirements): In a given run, the size of the population may differ from one generation to the next until (and after) the GA converges to the optimal value (if ever). In one run, the average size of all the populations preceding optimal convergence is called Average Population Size to Optimal Fitness (or APSOF). Every one of the 30 runs may return a value for APSOF. The average value for the set of APSOF values is the Ave. Mean Population Size to Optimal Fitness. Ave. Max. Population Size to Optimal Fitness: For each GA run, the largest population size prior to optimal convergence is stored in a set. The mean of that set is the average maximum population size to optimal fitness. Ave. Mean Population Size to Near-Optimal Fitness: In a given run, the size of the population may differ from one generation to the next until (and after) the GA converges to the near-optimal value of 0.95 (if ever). In one run, the average size of all the populations preceding near-optimal convergence is called Average Population Size to Near-Optimal Fitness (or APSNOF). Every one of the 30 runs may return a value for APSNOF. The average value for the set of APSNOF values is the Ave. Mean Population Size to Near-Optimal Fitness. Ave. Max. Population Size to Near-Optimal Fitness: For each GA run, the largest population size prior to near-optimal convergence is stored in a set. The mean of that set is the average maximum population size to near-optimal fitness. These measures allow GA users to assess the memory requirements for a given GA. The smaller the size of the population required for getting an optimally fit individual the better. This is because smaller populations require less memory. And, memory is a serious concern, still, if one is using large populations for real-world optimization and design problems.

3.0 A New Parameterless GA and Results

The simple Genetic Algorithm (SGA) has been applied successfully in many applications. However, it is not a parameterless GA. In this section, we describe a number of elaborations of the SGA that a) enhance the performance of the SGA, and b) make it into a pGA.

3.1 Stagnation-Triggered-Mutation (STM). The idea behind STM is simple: older individuals stuck at a sub-optimal point on the fitness surface for a long time need to be given some kind of "push" (e.g. mutation) to reach a new potentially more promising position on the surface. This feature helps GAs deal with fitness functions that are hard (and hence take long) to optimize, such as multi-modal functions (e.g. test functions *f3* and *f4* above).

Attached to each chromosome are two numbers; a mutation probability (P_m), and a new quantity, Life Time (or LT), which measures the number of generations passed since the chromosome was last modified (via crossover or mutation). Initially, P_m is equal to 1/l, where l is number of bits in the rest of the chromosome. In later generations, every chromosome that passes through (probabilistic) crossover and/or mutation is tested to see if it is identical to any of its parents. If it is, then its P_m is multiplied by its LT (and its LT is incremented by 1). If, on the other hand, this chromosome is altered (via crossover or/and mutation) then its P_m is reset to $1/l$ and its LT is reset to 0.

3.2 Reverse Traversal (RT), Phenotopic and Genotopic. Phenotopic Reverse Traversal deals with fitness surfaces that tend to drive the majority of the population towards local maxima and away from the global maximum (e.g. *f2*). RTP does this by getting a portion of the population to traverse the fitness surface against the gradient, i.e. towards minima rather than maxima. This also has the side effect of producing a more diverse population than simple fitness-proportional selection. In an RTP enhanced GA, 20% of the next generation is selected, via fitness proportional selection, but instead of selecting those individuals with the greatest fitness, RTP selects those with the lowest fitness.

Genotopic Reverse Traversal (RTG) deals with deceptive fitness surfaces (e.g. test function *f5* above). It does this by taking 20% of the individuals (after all selection and genetic operations are applied) and inverting their bits (turning 1's to 0's and 0's to 1's).This simple trick was the main factor behind the 100% reliability figure returned by the nGA for the fully deceptive function *f5*.

3.3 Non-Linear Fitness Amplification (NLA). This enhancement of the SGA is designed to deal with situations where the population converges to a rather flat neighborhood of a global optimum. In such cases, it is important that the selection mechanism becomes very sensitive to slight variations in the gradient of the fitness surface.

The way NLA works is straightforward: once the average fitness of the population exceeds 0.9, the fitness is scaled using equation (9); f' is the scaled fitness, f is the original un-scaled fitness and c is a constant (that we set to 100).

$$f' = 1 / (c (1 - f) + 1) \quad (9)$$

The nGA introduces the three main new features explained above, but also uses a fixed probability of crossover equal = 0.7 (~ De Jong [8] empirically determined value), and implements elitism at 10%. To determine the minimum size of the population, a pre-run large population of 1000 individuals is created and the fitness of each individual is computed. Hence, the standard deviation of fitness of the population is computed (call that $SD_{fitness}$) and used in equation (10) (below). The size of the initial population is set to LowBound; but the population is allowed to grow to as much double that value (as a result of STM). Constant k is set to 3; the probability of failure (a) is set to 0.05; and sensitivity (d) to 0.005- see [13] for more detailed information about equation (10).

$$LowBound = -2^{k-1} \;.\; \ln(a) \;.\; SD_{fitness} / d \quad (10)$$

In summary, the probability of mutation is variable and is determined by the mechanism outlined in STM. The probability of crossover is fixed at 0.7; and the size of the population is variable, but with lower and upper bounds.

As seen in Table 1, the new GA returned 100% reliability on all of the test functions. As to speed, reflected in the average number of evaluations to best fitness, the nGA is reasonably fast taking less than 146,000 fitness evaluations, on average, to achieve optimal convergence, which for an average population size of ~130 translates to 1023 generation. Finally, the amount of memory required to run the nGA is typical as the (average) maximum population size needed to reach optimal convergence never exceeded 178.

In figures 1a and 1b: blue stands for *f1*, red stands for *f2*, green stands for *f3*, black stands for *f4* and magenta for *f5*. The nGA was run 30 times per test function and the numbers used to plot the curves represent average values (over the 30 runs) of both fitness and diversity (entropy).

Figure 1a demonstrates the evolution of fitness. For four out of the five test functions, nGA's behavior is exemplary: it succeeds in converging by about 104 fitness evaluations; the only exception is function *f4*, which is the hardest multi-modal test function used. Indeed, the nGA performs better on the deceptive surface of function *f5* than on function *f4*, which is a testimony to the power of the anti-deceptive measures (Reverse Traversal of both colors) included in the nGA.

Figure 1b, on the other hand, demonstrates that the nGA maintains a high degree of diversity (entropy >= 10) throughout evolution - a positive feature of any GA.

4.0 Summary and Conclusions

In this paper, we present a brief (but thorough) review and classification of parameterless GAs. We define and use a number of statistical measures applicable to any parameterless GA; they are also platform-independent. Having them facilitates the process of comparing any number of GAs without having to repeat other people's work. They are also meaningful, in that they allow GA users to choose those GAs that are most reliable, fastest, or require the least amount of memory.

In addition, we propose a new parameterless GA (nGA), one that was born out of the problems encountered with existing pGAs. Our main goals in proposing the nGA is to a) build a more reliable pGA (which is proven by the results of Table 1), and to do so by b) adding a small number of easily realizable amendments to the simple GA.

It is our hope that given our success here, people would be more willing to adopt parameterless GAs as a common tool of optimization, rather than normal GAs, which require quite a bit of manual tuning by a domain expert, prior to application.

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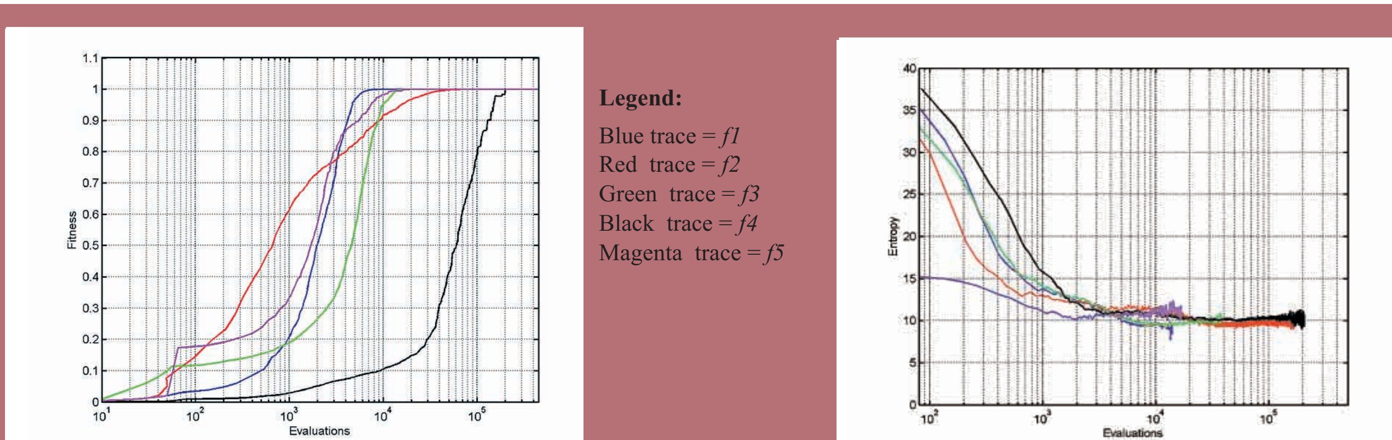

Figure 1: 1a) Fitness (left) and 1b) Entropy (right) for the New GA on Test Functions *f1* - *f5*

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DeCew Falls Hydroelectric Generating Station - Commemorative celebrations

IEEE recognizes the DeCew Falls Hydroelectric Generating Station as a Pioneering Project in distance transmission of electrical energy. The Power Generation Station, located in St. Catharines, Ontario, was the site of a Milestone Dedication Ceremony on May 2nd 2004. Members of the IEEE Hamilton Section, in co-operation with Ontario Power Generation, unveiled a commemorative plaque (see also page 13).

1. Ray Findlay of IEEE addresses the audience at the ceremonies.

3. Some of the dignatories present at the ceremonies. Seen are (left to right) Bill Kennedy, Janet Bradley, OPG Rep is Dave Heath (Plant Manager Niagara Systems - representative from Ontario Power Generation), Ray Findlay, Wally Read, Ron Potts and Honorable Jim Bradley (MPP Minister of Tourism and Recreation).

2. Members of the Hamilton Section with their banner and some of the pioneers who worked on the station commemorations. In the photo are (left to right) Ted Winch; Bob Barnett; Ray Findlay; Ed Shadeed; Janet Bradley; Scott Lowell; Blair MacCuish; Alan Jex and Ron Potts. Images by John Paytash (OPG).

Communications à fibres optiques : Limitations causées par la dispersion et les effets non-linéaires

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Abstract

Several phenomena occur during propagation of a signal in a fiber optic. We analyze here the effects of dispersion and nonlinear effects in a fiber optic system. We show how these effects affect the performance of optical communication systems. We do show in particular that under certain conditions, the dispersive and nonlinear effects are compensated between them and the signal is propagated then without distortion in the fibre. One speaks then about solitonic propagation.

Sommaire

Plusieurs phénomènes ont lieu lorsqu'un signal se propage dans une fibre optique : absorption, réflexion, etc. Nous analysons ici les effets des phénomènes de dispersion et de non-linéarité dans une fibre optique. Nous démontrons comment ces effets affectent la performance des systèmes de communications optiques. Nous montrons notamment que sous certaines conditions, les effets dispersifs et non-linéaires se compensent entre eux et le signal se propage alors sans distorsion dans la fibre. On parle alors de propagation solitonique.

1.0 Introduction

La fibre optique occupe de plus en plus de place dans les systèmes de communications optiques. En plus de son rôle de guidage, elle est à la base de la réalisation de plusieurs composants optiques comme les filtres, les réseaux de Bragg, les amplificateurs à fibre dopée à l'erbium et les coupleurs [3, 9].

La lumière entre la fibre par un bout et sort de l'autre bout tel que rentré. C'est ce que nous croyons et aussi observons à première vue. Malheureusement mais aussi heureusement, la situation n'est pas aussi simple que nous croyons. En effet, il se passe entre les deux bouts de la fibre des phénomènes aussi diverses que complexes. D'un côté, ces phénomènes compliquent énormément l'utilisation de la fibre mais d'un autre côté ils sont à l'origine de plusieurs applications intéressantes, telles que les réseaux de Bragg et leurs intérêts dans les télécommunications à haut débit. L'interprétation de ces phénomènes nécessite un arsenal mathématique très lourd. Nous invitons le lecteur dans cet article à découvrir la complexité de la chose sans pour autant se plonger dans les intégrales et les équations différentielles à plusieurs variables. La lumière se propage sous forme d'onde qui selon le milieu peut subir de l'absorption, réflexion, réfraction, diffraction, dispersion, non-linéarité, etc. Par exemple, c'est la réflexion de l'onde qui est à l'origine de l'intérêt des réseaux de Bragg (Figure 1). En effet, nous savons que la lumière blanche est composée de plusieurs composantes spectrales. Dans cette figure, nous voyons bien que quand la lumière traverse le milieu 2, une des composantes de cette dernière (disons la lumière rouge par exemple) est réfléchie vers l'entrée de la fibre. Ainsi de suite de sorte que chacune des composantes de la lumière est successivement réfléchie vers l'entrée et le réseau de Bragg sert alors de décomposition de la lumière. Ceci est particulièrement utile dans les systèmes DWDM où l'on doit réaliser des opérations de démultiplexage ou d'extraction de longueur d'onde.

L'étude de la propagation de la lumière dans les fibres optiques est donc d'une grande importance dans la conception, l'analyse et l'optimisation de la performance des systèmes de communications optiques. En effet, dans les systèmes où la modulation des signaux de données est faite directement à partir de l'intensité de la source lumineuse (ceci sera expliqué en utilisant des illustrations à la prochaine section), l'indice de réfraction du cœur de la fibre dépend de la longueur d'onde de la lumière qui la traverse de sorte que les diverses composantes d'un groupe de signaux (représentant en fait un ensemble de bits) vont 'voyager' à des vitesses différentes dans la fibre, créant ainsi un étalement temporel et un chevauchement de l'information, rendant le décodage de bits à l'arrivée inintelligible: c'est l'effet de dispersion chromatique ou dispersion en groupe de vitesse. Ce dernier limite alors la distance maximale à laquelle un signal peut être envoyé dans la fibre sans qu'il n'y ait de distorsion. À l'heure actuelle, c'est la dispersion de la fibre (et non l'atténuation) qui constitue le facteur limitant de la transmission de signaux à haut débit sur de longues distances. La section III sera consacrée à l'explication de cet aspect.

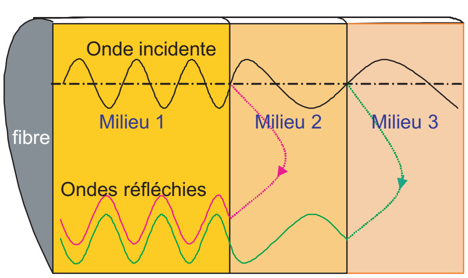

Figure 1: Ondes réfléchies dans un réseau de Bragg. Les ondes réfléchies peuvent interférer constructivement (cas de la figure) ou destructivement.

Dans le présent document, on se propose de faire un travail de vulgarisation sur les phénomènes de dispersion dans la fibre optique monomode et de présenter les diverses solutions utilisées de nos jours pour résoudre ce problème.

2.0 Modulation Optique

Depuis les travaux de Fresnel, nous savons que la lumière possède une nature ondulatoire. Avant d'envoyer le signal dans la fibre, on le module avec une autre onde dite porteuse. La modulation optique est jusqu'à présent une modulation d'amplitude.

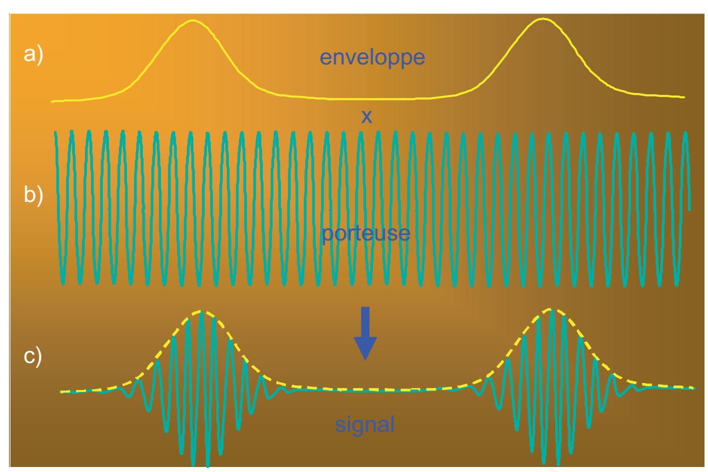

Figure 2: Modulation optique.

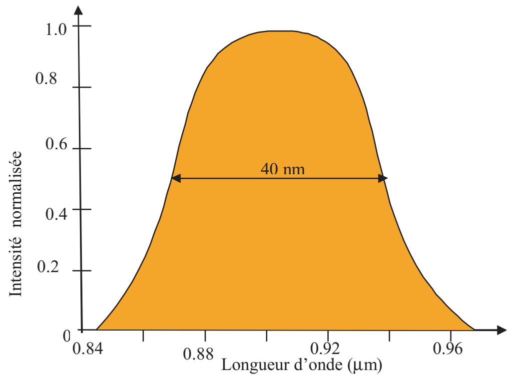

Figure 3: Spectre typique d'une LED.

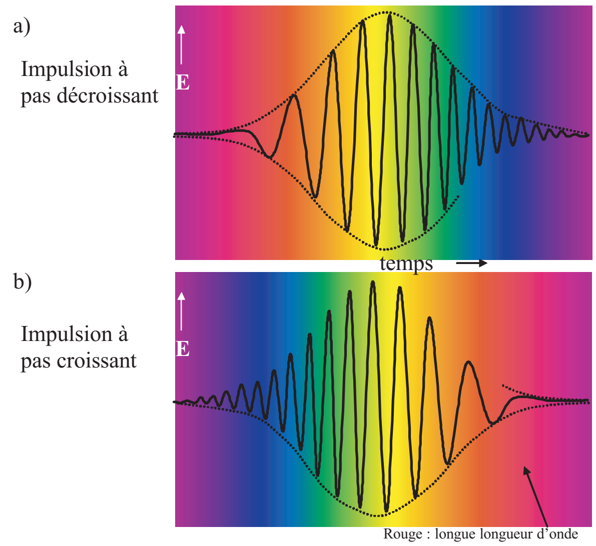

Figure 5: Impulsions à pas variables: a) pas décroissants; b) pas croissants.

La modulation optique consiste à multiplier le champ sinusoïdal (une seule harmonique - Figure 2b) par des impulsions (enveloppe - Figure 2a), pour obtenir le signal optique modulé (Figure 2c). Cette multiplication (modulation d'amplitude) crée des harmoniques de faibles mais aussi des hautes fréquences.

Les fréquences ne voyagent pas à la même vitesse: d'où le phénomène de dispersion dont nous allons plus en détail parler dans le paragraphe suivant.

Pour donc contourner ce phénomène de dispersion, il existe notamment deux solutions:

1. Choisir des formes d'impulsion particulières (des enveloppes particulières) qui se propageraient sans distorsion: les solitons,
2. Ne pas envoyer le signal sous une seule harmonique dans la fibre mais plutôt prévoir plusieurs harmoniques dans la même impulsion (avant propagation) avec des harmoniques de faibles fréquences qui doivent être initialement en avance dans le temps (Figure 5b) et des harmoniques de hautes fréquences qui sont initialement en retard dans le temps: c'est-à-dire des impulsions à pas décroissants.

En pratique pour réaliser ce genre d'impulsions, on fait traverser l'impulsion classique dans un milieu ayant un profil d'indice sous forme d'une structure longitudinale à pas variable (Figure 6).

3.0 Origine De La Dispersion Chromatique Ou Dispersion En Groupe De Vitesse Dans La Fibre Optique

Un milieu est dit dispersif lorsque l'indice de réfraction de ce milieu dépend de la fréquence (autrement dit de la longueur d'onde) de l'onde qui le traverse. Or, les sources de lasers utilisées dans le cadre de la communication WDM ne sont pas strictement monochromatiques; elles ont une largeur de spectre centrée autour d'une longueur centrale 0 (Figure 3) qui fait qu'une impulsion s'élargit lorsqu'elle se propage dans un milieu dispersif.

En effet, lorsqu'une onde se propage dans un milieu dispersif, les diverses composantes fréquentielles de l'onde se propagent à des vitesses différentes, créant un étalement temporel de l'onde à l'arrivée. On parle alors de dispersion en groupe de vitesse ou "Group Velocity Dispersion" (GVD) (Figure 4).

L'étalement temporel entre deux longueurs d'ondes est proportionnel à la distance de transmission, à la largeur spectrale de la source et au paramètre de dispersion du milieu. Plus la distance de transmission est élevée et la largeur spectrale de la source grande, plus l'impulsion s'élargit à l'arrivée.

Le paramètre de dispersion d'un milieu est proportionnel à la longueur d'onde et à l'accélération du changement de l'indice de réfraction lorsque la longueur d'onde varie dans ce milieu. S'il est négatif, le milieu est dit posséder une dispersion normale ou positive. Si un signal est transmis dans un milieu de dispersion normale, les composantes de hautes fréquences "voyagent" plus lentement que les composantes de basses fréquences et le signal devient "chirpé positivement" (Figure 5a) augmentant en fréquences avec le temps. Dans le cas contraire (Figure 5b) où le paramètre de dispersion est positif, le milieu possède une dispersion anormale et le signal devient "négativement chirpé" (i.e diminue de fréquences avec le temps). Si, enfin, ce paramètre est nul, le milieu est non-dispersif et toutes les composantes fréquentielles du signal voyagent à une même vitesse à travers ce milieu.

À un niveau microscopique, le retardement de la lumière, quand elle passe à travers un matériau peut être perçu comme un processus con-

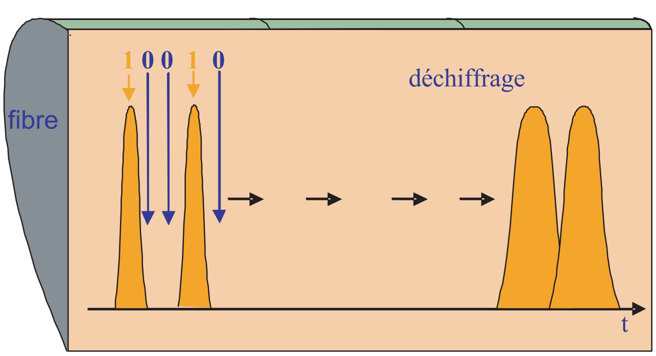

Figure 4: Élargissement temporel d'une impulsion dans une fibre dispersive.

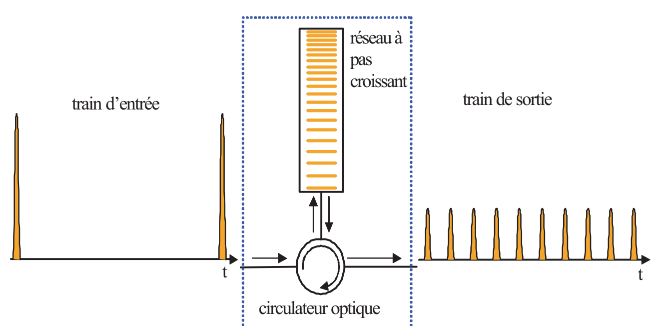

Figure 6: Réseau à pas linéairement variables utilisé pour augmenter la fréquence des impulsions en profitant de l'effet Talbot temporel.

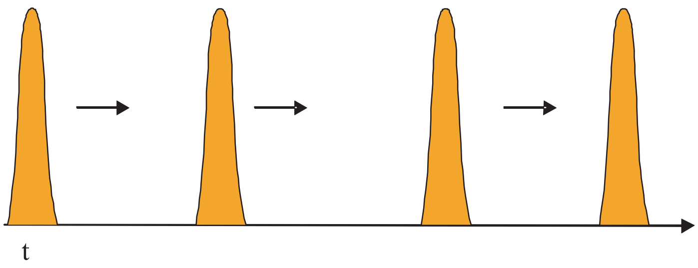

Figure 7: Propagation d'un soliton fondamental dans un milieu dispersif non-linéaire: le signal se propage sans distorsion sur toute la fibre.

tinu d'absorption et d'émission de photons par les atomes du matériau quand les deux types de particules sont en contact. Entre deux atomes voisins de matériau, le photon "voyage" à la célérité c, exactement comme dans le vide. Mais, quand les photons cognent les atomes, ils sont absorbés par ces derniers et aussitôt ré-émis, créant ainsi un délai au niveau de chaque atome, ce qui résulte à une réduction de la vitesse des photons; la vitesse d'absorption et de ré-émission du photon dépend évidemment de la longueur d'onde du photon incident (milieu dispersif).

Il existe d'autres types de dispersion dans la fibre, notamment la dispersion chromatique d'ordre élevé, la dispersion en mode polaire dont l'étude dépasse le cadre de cet article [3].

4.0 Propagation D'un Signal Dans Un Milieu Dispersif Non-Linéaire: Existence Possible Des Solitons

La puissance optique couplée dans les fibres monomodes se trouve confinée sur de très faibles surfaces du fait de la petite dimension de leur zone guidante (de 3 à 10 mm de diamètre suivant la longueur d'onde de coupure). Une intensité de l'ordre du MW/cm^2 est facilement obtenue en injectant 100 mW dans la fibre. Les champs électromagnétiques intenses qui en résultent sont susceptibles de modifier les propriétés de la silice, support de propagation, par exemple en déformant les nuages électroniques. Sous l'action du champ lumineux intense, l'indice de réfraction accuse une variation: C'est l'effet de Kerr optique. Un tel milieu est dit alors non-linéaire.

Lorsqu'un signal se propage dans un milieu non-linéaire, l'effet de Kerr induit deux phénomènes importants à savoir l'auto-modulation en phase (SPM: Self-Phase Modulation) et la modulation croisée de phase (XPM: Cross-Phase Modulation). Pour les autres phénomènes non-linéaires qui pourraient y avoir dans la fibre optique, à savoir la diffusion Raman, l'effet Brillouin ou l'oscillation paramétrique, nous invitons le lecteur à consulter la référence [3].

Comme on l'a dit plus haut, les sources de lasers utilisées dans le cadre de la communication WDM ne sont pas strictement monochromatiques; elles ont une largeur de spectre. La co-propagation de ces champs à diverses longueurs d'ondes induit un déphasage non-linéaire du champ

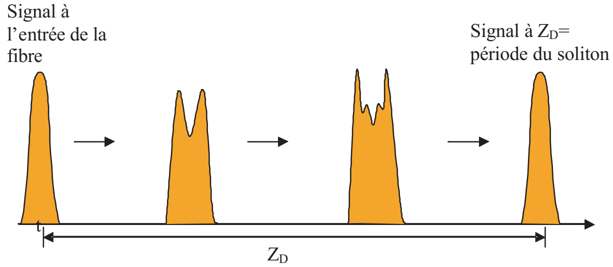

Figure 8: Propagation d'un soliton d'ordre supérieur dans une fibre optique: le signal est récupéré à toutes les distances multiples de la période ZD.

optique: c'est la modulation croisée de phase. La XPM est toujours accompagnée de la SPM et est due à la dépendance de l'indice de réfraction effectif d'une onde, non seulement de l'intensité de cette onde mais aussi de l'intensité des autres ondes en co-propagation. Ce déphasage augmente aussi avec la distance de transmission.

L'auto-modulation en phase, quant à elle, affecte une onde modulée en amplitude. Elle a pour effet d'introduire un déphasage non-linéaire dans le champ tout en gardant constant l'amplitude de ce dernier à travers la fibre. Il apparaît alors un retard de phase du sommet de l'impulsion par rapport à ses flancs car leurs vitesses de propagation sont différentes. Ce déphasage varie en fonction de l'intensité du champ et de la distance de propagation et implique un élargissement de fréquences au cours de la propagation dans la fibre. Ainsi, des fréquences inférieures à la fréquence initiale de l'impulsion sont générées sur le front montant de l'impulsion (aile Stokes), et des fréquences supérieures sur le front descendant (aile anti-Stokes).

Dans une fibre optique, les effets comme la dispersion en groupe de vitesse, l'auto-modulation de phase, de même que la modulation croisée de phase peuvent co-exister. Selon les paramètres du milieu et de l'onde qui s'y propage, nous avons quatre cas de figure:

- Aucun des effets dispersifs ou linéaires n'est signifiant; la fibre joue alors un rôle passif dans ce cas de figure et le signal se propage sans distorsion (surtout si l'atténuation est entre temps compensée par des fibres dopées à l'erbium par exemple)
- La GVD est prédominante et les effets non-linéaires négligés. C'est le cas de la plupart des communications terrestres. Le seul défi à relever dans ce cas est alors la compensation de la dispersion (voir plus loin)
- Les effets non-linéaires comme la XPM et la SPM sont prédominants et la dispersion négligeable. C'est le cas des communications océaniques où l'intensité du signal est assez élevée pour induire l'effet de Kerr, responsable de la SPM et de la XPM.
- Les effets non-linéaires et la dispersion en groupe de vitesse co-existent dans la fibre et peuvent interagir entre eux.

Dans le cas où la GVD et la SPM (ou XPM) coexistent dans la fibre, la SPM accroît le taux d'élargissement pour un régime de dispersion normale et fait décroître ce taux pour un régime de dispersion anormale. Il y a élargissement du spectre des impulsions qui vont subir la dispersion chromatique. Dans la région de dispersion normale, on a sur le front montant une diminution de la fréquence donc du temps de propagation. Le front montant est avancé et le front descendant est retardé: il y a élargissement temporel de l'impulsion. Par contre, dans la région de dispersion anormale, l'élargissement spectral provoque un rétrécissement temporel. Lorsque qu'une impulsion se propage dans une fibre optique, la dispersion chromatique implique une différence de vitesse de groupe entre les différentes composantes spectrales de l'impulsion et par conséquent un élargissement temporel de celle-ci.

- En régime de dispersion anormale, les hautes fréquences sont plus rapides que les basses fréquences. En opposition, l'auto-modulation de phase induite par effet Kerr optique se traduit par la génération de basses (hautes) fréquences sur le devant (derrière) de l'impulsion. Ainsi, sous certaines conditions, un équilibre exact peut s'instaurer et l'effet Kerr maintient alors en phase les composantes fréquentielles qui se seraient étalées par dispersion. L'impulsion qui en résulte, appelée soliton brillant fondamental, se propage de façon invariante (Figure 7). Elle correspond à une famille de solutions analytiques stationnaires de l'équation de Schrödinger non linéaire, mise en évidence pour la première fois par Zakharov et Shabat en 1972 [4]. Prédit pour les fibres optiques une année plus tard [5], le soliton temporel fut démontré expérimentalement en 1980 [6]. Le soliton brillant fondamental possède un profil en sécante hyperbolique et une phase plane.
- En régime de dispersion normale, les hautes fréquences sont cette fois plus lentes que les basses. Pour compenser l'effet d'étalement linéaire de l'impulsion dans la fibre, il faut inverser le signe de la variation temporelle de la loi d'auto-modulation de phase. Ainsi, l'équilibre peut être satisfait pour un profil de forme tangente hyperbolique, correspondant à un fond continu intense illimité présentant un creux d'énergie en son centre. Cette impulsion particulière, appelée soliton noir, possède deux fronts de phase plans de part et d'autre du creux, séparés par un saut abrupt de π, plaçant les flancs du soliton noir en opposition de phase. La première observation expérimentale des solitons noirs a eu lieu en 1987 [7]. En 1995, une ligne de transmission à longue distance basée sur les solitons noirs a été démontrée [8].

- Dans certaines conditions, le signal qui se propage dans la fibre peut présenter les propriétés d'un soliton d'ordre élevé périodique, c'est-à-dire que nous avons une réplique du signal à des distances multiples d'une distance particulière alors appelé alors période du soliton (Figure 8).

5.0 Effets De La Dispersion Et Des Non-Linéarités Sur La Performance Des Systèmes Optiques

5.1 Effets de la dispersion

En règle générale, pour un débit de transmission donné, l'étalement temporel doit être plus petit que la période de pulsation (qui n'est rien d'autre que l'inverse du débit) pour minimiser le chevauchement des bits. Ce qui aboutit à une limitation du produit Distance de transmission x Débit de transmission par la largeur spectrale de la source et le paramètre de dispersion du milieu. Pour une largeur spectrale de source donnée dans un milieu de paramètre de dispersion donné, ce produit est constant et inversement proportionnel à la largeur spectrale et au paramètre de dispersion. A titre indicatif, si l'on utilise comme source un laser multi-mode à semi-conducteurs (de largeur spectrale 2 nm) et pour un débit de l'ordre de 2.5 Gb/s et pour une propagation autour de la longueur d'onde de 1550 nm (où la constante de propagation est de l'ordre de -20 ps^2/km), la distance maximale sur laquelle on peut transmettre les signaux sans qu'il n'y ait altération est de 330 km environ tandis que cette même distance devient seulement 20 km pour un débit de 10 Gb/s.

5.2 Effets de la XPM et de la SPM

Lorsque l'on module l'information en amplitude avant de l'envoyer dans le medium de transmission et que la démodulation est faite de façon incohérente comme dans le cas des systèmes de communications à détection directe par exemple, le déphasage non-linéaire introduit par la XPM et la SPM n'a pas de grande conséquence. Mais quand la démodulation est faite de façon cohérente, un tel déphasage devient un facteur limitant la performance du système, surtout dans les systèmes multicanaux. Il limite la puissance maximale du signal à transmettre sur la fibre.

6.0 Quelques Solutions Aux Problèmes De Dispersion Et De Non-Linéarités Dans Les Fibres Optiques

6.1 Fibres à dispersion décalée

Le problème de la dispersion pourrait être résolue en envoyant le signal à la longueur d'onde de 1.28 microns (dispersion presque nulle de l'ordre de ±4 $ps.km^{-1}.nm^{-1}$ à cette longueur d'onde pour une fibre standard monomode G652), mais l'atténuation est plus importante qu'à 1.55 microns (de l'ordre de ±17 $ps.km^{-1}.nm^{-1}$) et deviendrait le facteur limitatif. De plus, il n'existe pas d'amplificateurs dans cette bande, ce qui constitue un handicap important. Par ailleurs, le coefficient de dispersion chromatique est composé de deux parties: la dispersion du matériau (due à la variation de l'indice de réfraction avec la fréquence de la lumière) et la dispersion du guidage (due à la variation de la constante de propagation en fonction de la fréquence): $D=D_m+D_g$. Or D_g dépend de la géométrie de la fibre. Dans la pratique, il est donc possible d'ajuster ce type de dispersion pour compenser la dispersion du matériau et ainsi obtenir des fibres optiques à dispersion décalée dans lesquelles le zéro de dispersion (environ ± 3 $ps.km^{-1}.nm^{-1}$) se trouve à une longueur d'onde de 1.55 microns. Cependant, les effets dispersifs d'ordres élevés persistent dans la fibre d'où on a recours aux fibres compensatrices de dispersion.

6.2 Réseaux à pas linéairement variables ou fibres à dispersion compensée

Une des solutions au problème de la dispersion est l'utilisation des réseaux de Bragg à pas linéairement variables ou fibres à dispersion compensée. Ces fibres compensent l'effet de "chirp" de façon négative ou positive (selon la normalité du milieu dispersif) et permettent ainsi une propagation sans distorsion dans la fibre.

6.3 Lasers à solitons

Une propriété intéressante des solitons est l'utilisation des fibres optiques dans le développement de lasers à solitons, i.e des lasers qui émettent des solitons qui auront la capacité d'être transmis sans distorsion. L'idée de base est d'utiliser la fibre optique comme retour dans le laser. L'impulsion ainsi émise est reformée par la fibre de sorte que lorsqu'elle revient au laser, elle est sous la forme d'un soliton fondamental ou d'ordre élevé qui peut être alors transmise sans distorsion dans la fibre de transmission.

7.0 Conclusion

- Par ce tour d'horizon, nous avons analysé la propagation d'un signal dans un milieu dispersif linéaire et non-linéaire, étudié la conséquence de la dispersion sur la performance des systèmes de communications optiques, et énuméré quelques techniques utilisées pour réduire la dispersion dans les fibres optiques. Il est à noter surtout que la technologie DWDM, malgré son degré de maturité, n'a pas encore atteint ses limites. De nouvelles techniques en cours de développement permettront de multiplier encore plus les capacités et les performances des systèmes optiques,
- La transmission soliton permettra le transport d'impulsions très étroites sur des milliers de kilomètres sans déformation, tout en conservant une bande passante très large,
- La modulation des impulsions, ou transmission duo-binaire, permettant la multiplication par deux ou trois fois du débit électronique, en utilisant des impulsions à 2 ou 3 niveaux binaires,
- L'amplification et le multiplexage dans la fenêtre 1300 nm (zone où la dispersion est nulle) permettront de mieux rentabiliser les fibres optiques conventionnelles G-652 qui connaissent des limites dans l'utilisation des systèmes DWDM à 1550 nm (zone où l'atténuation est faible mais la dispersion élevée).

8.0 Remerciements

Les auteurs aimeraient remercier le Conseil des Ressources en Sciences Naturelles en Génie du Canada pour sa contribution financière.

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Letters to the Editor

Subject: Electronic access to the IEEE Canadian Review / University of Regina Library

Dear Editor,

Our Library [University of Regina], has an electronic subscription to the IEEE ASPP journals package, and formerly subscribed for years to the paper version. I just had several past issues of IEEE Canadian Review sent over to me by one of our engineering faculty, for adding to the library's collection. It is not included in the ASPP package.

I checked and found that you began an electronic version with #42, and that we appear to be able to get access to the electronic pdf files.

Do you have any objection to our adding your journal to our catalogue holdings as an "e-journal" and putting in a hotlink to the issues on your website? Several of our professors are IEEE members, and Engineering has an active IEEE students club on campus. By putting it up in "e-form", there would be no problem with missing/lost issues, and students/faculty could access it from home or University labs through our proxy-server. Could also access it when they're off across the country on co-op semesters.

Please advise.

Ed Perry
Engineering/Kinesiology & Health Studies Librarian
Dr. John Archer Library
University of Regina
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Dear Ed,

We do not object to the university having an e-link to our site for access by your professors and students.

Just some clarifications: Our electronic data base now has issues going back to CR32, not just CR42. See:

http://ewh.ieee.org/reg/7/canrev/preissue.htm

By way of promoting this service further, I would like to make the same offer to other Universities.

Vijay K. Sood
Managing Editor

New Appointments of Associate Editors

IEEE Canadian Review is pleased to announce the appointment of two new Associate Editors:

Dr. Habib Hamam graduated from the Technical University of Munich (Germany) as an engineer in information processing in 1992. He earned his Ph.D degree in telecommunications from Université de Rennes I jointly with the France Telecom Graduate School of Brittany (ENSTB - France) in 1995. Since 2002, he is an Associate Professor in electrical engineering at Université de Moncton. His research interests are in optical telecommunications, diffraction, fibre components, optics of the eye, biomedical engineering and E-Learning. He is a registered professional engineer in New-Brunswick and a member of IEEE.

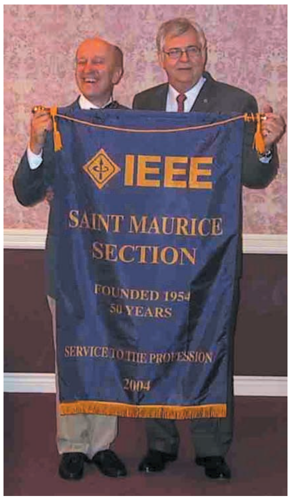
Dr. Alain Zarka received his engineering diploma from the IPSA (Paris) in 1993, and obtained a Masters equivalency from Laval University in 2000. He has over 13 years of experience in optical frequency standard and electrical metrology at the *Bureau International des Poids et Mesures* (France). He has published more than 15 papers and has 3 patents. In 2000, he immigrated to Québec where he co-founded Dicos Technologies (Sainte-Foy, QC) and SEA-Network (Québec, QC) which is built on an international network of experts dedicated to optimization and decision making tools like Learning Expert System. His interests are in modelization and optimization problems. Alain is multi-lingual and speaks French, English, German and Swedish. He is an IEEE member since 2000.

The contact information of the new Associate Editors is available on page 2 of this issue. For further details about the new appointees, please visit our website at **www.ieee.ca**. Readers may contact either Associate Editor for assistance regarding items for publishing in the IEEE Canadian Review.

Vijay K.Sood
Managing Editor
IEEE Canadian Review

IEEE Canada Volunteer Service Awards, 2004

The following members of IEEE Canada received awards at the Region 7 meeting in Niagara Falls during May 2004



Adam Skorek (left) and Bill Kennedy

Adam receiving the IEEE Banner to celebrate the 50th anniversary of the St. Maurice Section

Mike Janes (left) and Bill Kennedy

Mike Janes - receiving 3 RAB Friend-of-the-IEEE awards - one for Aliant, one for Memorial University and one for Yvonne Raymond (from Memorial University)

John Grefford (left) and Bill Kennedy

John Grefford receiving the RAB 2003 Student Branch Membership Growth Award on behalf of the University of Ottawa

Kash Husain (left) and Bill Kennedy

Kash Husain - receiving the RAB 2003 Membership Growth Award for the London Section

Luc Matteau (left) of the IEEE Canadian Foundation presents the certificates to Bill Kennedy

Section representatives accepting the **IEEE Canadian Foundation** student certificates for students in their sections.

Left to right (standing): Bob Alden (ICF), Luc Matteau (ICF), John Grefford (Ottawa), Adam Skorek (St. Maurice), Andrew Kostiuk (N. Saskatchewan), Michael Lawal (N. Canada) and Bill Kennedy (IEEE Canada).

(seated): Pelle Westlind (Toronto), Stephen O'Leary (S. Saskatchewan) Reza Soleyman (Montreal).

IEEE Canada

IEEE Canada Awards presented at the CCECE 2004 Banquet on May 2004 in Niagara Falls

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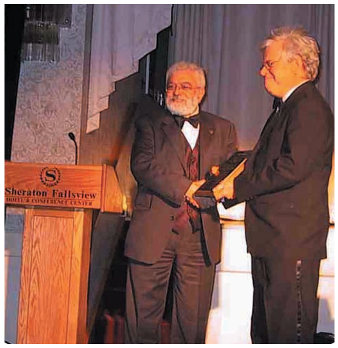

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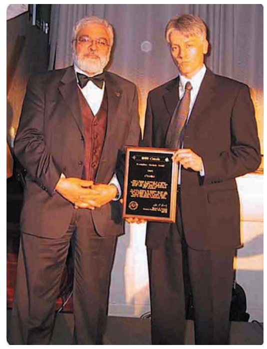

Volunteer Awards (left to right)

1. Isabelle Deslauriers received a certificate of appreciation from Bob Alden (right) for translation of the IEEE website.

2. Mo El-Hawary (left) presented a plaque to **Guy Olivier** for organization of CCECE 2003 in Montreal.

3. Mo El-Hawary (left) and **Ramiro Liscano** accepting the Section Award for Ottawa.

4

5

6

Three Council Awards

4. Ted Glass Western Canada Council - Dave Kemp (left) presented the plaque to **Rob Anderson**,

5. J.J.Archambault Eastern Canada Council - was presented to Xavier Maldague who was absent at the ceremonies.

6. M.B. Broughton Central Canada Council - Scott Lowell (left) presented the plaque to **Pelle Westlind**

10

10. Wallace S. Read Service Award - Wally Read (left) presented the plaque to **Witold Kinsner**

7

8

9

Outstanding Educator, Outstanding Engineer and Fessenden Awards (from left to right)

7. Outstanding Educator Award - Ray Findlay (left) presented the plaque to Hoang Le-Huy

8. Outstanding Engineer Award - Bill Kennedy (right) presented the plaque to Haran Karmaker

9. Fessenden Award - Bill Kennedy (right) presented the plaque to K.Wu

A.G.L. McNaughton Award 2004

The A.G.L. McNaughton Medal is IEEE Canada's highest honor. IEEE Canada remembers, through this medal, General McNaughton's contributions to the engineering profession in Canada. Recipients of the A.G.L. McNaughton Medal are outstanding Canadian engineers recognized for their important contributions to the engineering profession.

This year's recipient **Dr. Renato Bosisio** received the A.G.L. McNaughton Medal at the CCECE'2004 in Niagara Falls, ON, in May 2004 for "research and teaching of microwaves and innovation of six-port based digital receivers.". Shown in the photograph, Renato Bosisio receives his plaque from IEEE Canada president Bill Kennedy (right).

*****

*For further information on IEEE Canada Awards, please visit our website at **www.ieee.ca** and click on* awards & recognitions

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CCGEI 2005

"Eclairons nôtre future"

18e Conférence Canadienne de génie électrique et informatique

1 – 4 mai, 2005, Saskatoon Inn

Saskatoon, Saskatchewan, Canada

APPEL AUX COMMUNICATIONS

La conférence canadienne de génie électrique et informatique 2005 de l'IEEE offre un forum pour la présentation de travaux de recherche et de développement dans les domaines du génie électrique et du génie 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 limités à :

- Systèmes à base d'agents et sur Internet
- Communications et systèmes sans fil
- Traitement de signal et conception de filtres
- Électromagnétisme, optique et photonique
- Contrôle de procédé/Automation industrielle
- Robotique et mécatronique
- Réseaux et systèmes informatiques
- Réseaux neuronaux et logique floue
- Bases et exploration de données
- Électronique et systèmes de puissance
- Machines électriques et entraînements
- Circuits, Systèmes et ITGE
- Microélectronique et Optoélectronique
- Systèmes en temps réel et embarqués
- Architectures avancées d'ordinateurs
- Production de l'énergie et énergies renouvelables
- Informatique nomade
- Calcul haute performance
- Génie logiciel
- Systèmes intelligents
- Calcul évolutionniste
- Réalité virtuelle et vie artificielle
- Simulation et visualisation
- Interaction personne-machine
- Nanotechnologie et nanorobotique
- Antennes et EMC/EMI
- Micro-ondes et RF
- Bioinformatique
- Télédétection et applications
- Théorie du Contrôle et applications
- Ingénierie biomédicale
- Instrumentation et mesure
- Aérospatiale et Avionique

1.0 Soumission de communications régulières:

Veuillez soumettre par courrier électronique un résumé de 300 mots de votre communication au comité technique par la procédure décrite sur notre site http://ieee.ca/ccece05 avant le 10 decembre 2004. Choisissez le lien "Français" et suivez les instructions données sous "Appel de communications".

2.0 Proposition de tutoriaux, d'ateliers et de sessions sur invitation:

La proposition de sessions invitées, ateliers pré- et post-conférence et tutoriaux sera acceptée jusqu'au 17 décembre, 2004. Veuillez contacter le responsable des ateliers à l'adresse mentionnée ci-haut.

3.0 Compétition de soumission par étudiants

Veuillez soumettre votre article en suivant la procédure décrite ci-haut. S'il vous plaît, lisez les informations trouvées sur la page "Français", sous "Appel de communications" et "Fonds pour étudiants".

4.0 Dates Importantes:

Date limite pour la soumission des résumés d'articles:	**Vendredi, 10 décembre, 2004**
Date limite pour la soumission de sessions spéciales:	**Vendredi, 17 décembre, 2004**
Avis d'acceptation:	**Vendredi, 14 janvier, 2005**
Date limite pour l'inscription:	**Vendredi, 28 février, 2005**
Date limite pour la soumission finale des articles:	**Vendredi, 28 février, 2005**

5.0 Expositions industrielles:

Veuillez contacter le responsable des liaisons industrielles et des expositions afin d'obtenir des informations au sujet des présentations industrielles durant la conférence.

Si vous êtes intéressés par CCGEI 2004 et voudriez être ajouté à notre liste de distribution, veuillez contacter le secrétariat de la conférence à l'adresse inscrite à gauche. Notre site Internet sera mis à jour régulièrement.

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CCECE 2005

"Shining Light on Our Future"

18th Annual Canadian Conference on Electrical and Computer Engineering

May 1 - 4, 2005, Saskatoon Inn

Saskatoon, Saskatchewan, Canada

CALL FOR PAPERS

The 2004 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
- Agent-Based & Internet-Based Systems
- Bioinformatics
- Circuits, Systems & VLSI
- Computer Networks & System
- Database & Data Mining
- Electromagnetics, Optics & Photonics
- High-Performance Computing
- Instrumentation & Measurement
- Microelectronics & Optoelectronics
- Nanotechnology & Nanorobotics
- Power Electronics & Systems
- Process Control/Industrial Automation
- RF & Microwaves
- Signal Processing & Filter Design
- Visualization & Simulation
- Teledetection Remote Sensing & Applications
- Aerospace & Avionics
- Antenna & EMC/EMI
- Biomedical Engineering
- Communications & Wireless Systems
- Control Theory & Applications
- Electrical Machines & Drives
- Evolutionary Computation
- Human-Machine Interactions
- Intelligent Systems
- Mobile & Pervasive Computing
- Neural Networks & Fuzzy Logic
- Power Systems & Renewable Energy
- Real-Time Embedded Systems
- Robotics & Mechatronics
- Software Engineering
- Virtual Reality & Artificial Life

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/ccece04 before December 10, 2004. Click on "Call For Papers" and follow the instructions provided.

2.0 Workshop, Tutorial, and Invited Session Proposal Submission:

Proposals for invited sessions, pre- and post conference workshops and tutorials will be accepted before December 17, 2004. Please contact the Workshops Chair using the same web page as noted above in 1.0.

3.0 Student Paper Competition:

Please submit your paper using the on-line submission process using the same web page as noted above in 1.0. Please read the information provided in the "Call For Papers" and "Student Funding" pages of our web site.

4.0 Important Dates:

Paper abstracts must be received by:	**Friday, December 10, 2004**
Special Session proposals must be received by:	**Friday, December 17, 2004**
Notification of acceptance will be sent out by:	**Friday, January 14, 2005**
Registration must be received by:	**Friday, February 28, 2005**
Final papers must be received by:	**Friday, February 28, 2005**

5.0 Industrial Exhibits:

Please contact the Exhibits Chair at the Conference Secretariat for information about industrial exhibits at the conference.

If you are interested in CCECE 2004 and would like to be added to our contact list, please contact the Conference Secretariat at the address on the left. Check our Web site regularly for news and updates.

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