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IEEE Canadian Review General Information

The ***IEEE Canadian Review*** is published 3 times/year as follows: Winter (to appear in April); Spring/Summer (to appear in August); Fall (to appear in December). Its principal objective is to project an image of the Canadian electrical, electronics, communications and computer engineering professions and their associated academic and business communities to:

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

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

1- National Affairs	4- Education	7- Computers
2- International Affairs	5- Power	8 - Electronics
3- Industry	6- Communications	

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Quelques mots du rédacteur en chef

Vijay K. Sood, Hydro-Québec

La version en ligne de la revue canadienne de l'IEEE est en voie de devenir riche en contenu grâce aux efforts de nombreux bénévoles. Notre demande pour des traducteurs anglais-francais s'est avéré être un grand succès et je remercie tous ceux qui ont contribué et ont respecté leur engagement.

Ce numéro renferme des articles et des nouvelles fort intéressants. Le premier article est une revue des architectures de systèmes ordinés fiables pour des applications temps réels. Un autre article (voir la photo sur la page frontispice) traite du vélo électrique. Ce projet a gagné un prix à la compétition pour étudiants de l'IEEE Canada (voir page 26). J'espère afficher d'autres articles sur cette compétition dans de prochains numéros. La qualité de ces projets était très impressionnante. Mes félicitations à tous les participants.

Les lettres envoyées au rédacteur en chef montrent clairement le sentiment des membres sur les versions en ligne et papier de la revue canadienne. Je vais assurer le maintien de ces deux versions aussi longtemps que possible. Continuez à exprimer vos points de vue et recommandations et n'hésitez pas à envoyer vos articles.

Publier la revue canadienne de l'IEEE est une merveilleuse, mais parfois périlleuse, aventure puisque je dois échanger avec plusieurs personnes, pour la plupart très occupées, qui donnent bénévolement de leur temps et offrent gratuitement leur expertise. Ça fait maintenant huit ans (deux ans comme adjoint et six ans comme rédacteur en chef) que je m'implique à la rédaction de la revue canadienne. Même si ça m'a demandé et demande encore beaucoup d'efforts, c'est toujours aussi plaisant.

Finalement, l'hiver est fini. Il était temps!

Contest: Caption to photo in Canadian Review CR42

STOP!
Electrons Crossing Ahead

Sent in by:
A. Mikolajewski, Toronto, ON

Cover picture / *Photo de couverture*

Cover picture shows an e-bike controller and mechanical system. developed at the University of Toronto. The article on the e-bike is presented on page 16 in this issue of the Canadian Review, and was the recipient of the Hackbusch Award (page 28) for the IEEE Canada Student Paper Competition.

A few words from the Managing Editor

The online version of the Canadian Review (CR) is becoming quite respectable with the efforts of many volunteers. Our request for English-French translators of articles was a resounding success and I thank all those who volunteered and delivered on their commitments.

This issue has an interesting mix of articles and news items. The first article is a survey of architectures for dependable computing systems for critical real-time applications. Another article (see cover page photo) deals with an electrical bike. This project was a prize winner at the IEEE Canada Students Competition (see page 26). I hope to feature other articles from this competition in future issues. The kind and depth of these student projects was very impressive indeed. My congratulations to all the entrants.

The Letters to the Editor in this issue show very clearly the sentiments of the membership with regards to the online and hardcopy versions of the CR. I will continue to maintain both versions as long as possible. Please keep your viewpoints, articles and recommendations coming in.

Publishing a journal like the Canadian Review is not without its perils, since I must deal with many, often busy individuals who are volunteering their time and talents. I have now been doing this for the past eight (two as Associate and six as Managing Editor) years! Although it has been a lot of hard work, it has been a lot of fun too.

Finally, this winter is over. And boy, am I glad!

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Newslog Editor

Rédactrice 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

GUELPH, ON, Nov. 1, 2002. The University of Guelph will take part in a nationwide supercomputer test on Nov. 4, 2002. The test will link thousands of computers, from 18 universities, together across Canada to solve a computational chemistry question in one day. Such test will be the first step in building the Canadian Internet worked Scientific Computer (CISS), which is a virtual supercomputer. The CISS will be used for instance to predict weather trends inter alia.

TORONTO, ON, le 18 nov., 2002. Le Queen's University Anesthesiology Informatics Laboratory (QUAIL) et Avaya Inc ont annoncé avoir conclu une entente afin de livrer de l'information en temps réel au chevet des patients au moyen d'un réseau sans-fil. Le cryptage sera notamment intégré au fonction à la solution. Cette information sera destinée aux professionnels de la santé et comprendra notamment des données médicales, les résultats des laboratoires, des images et sera consultable au moyen d'un portatif. Elle sera transmise en utilisant la norme IEEE 802.11b et sera encryptée par VPN.

MONTREAL, QC, Mar. 17 2003. Visuaide is launching a new product adapted for the blinds and visually impaired. It will enable them to determine a position, create a route, receive information on navigating to a destination, etc. It will be possible to share data with other users. The product is operating with a GPS on a PocketPC running WinCE.

MONTREAL, QC, le 3 mar. 2003. La première puce OFDM (Multiplexage par répartition orthogonale de la fréquence) est mise sur le marché par Wavesat Wireless. La technologie OFDM permet d'améliorer substantiellement la fiabilité et la portée des communications sans-fil haute vitesse. La technologie est compatible avec la norme IEEE 802.16a.

MONTREAL, QC, Feb. 11 2003. A new product has been released by Forensic Technology Inc. The product automates the process for capturing and storing digital images of a firearm's serial number and test-fired cartridge case marks during the manufacturing process. This product will help the police to identify a crime gun, tracing its history. It will therefore enable "ballistic fingerprinting".

MONTREAL, QC, Dec. 10. 2002. D-BOX Technology will show their product Odyssee (TM) XL motion lift simulator in conjunction with JVC in January 2003 at the International Consumer Electronics Show in Las Vegas.

NEW YORK, NY, Feb. 4, 2003. Consilient Technologies, Research In Motion and the New York City Fire Department (FDNY) announced that FDNY has deployed RIM's Blackberry (TM) wireless platform and consilient's MX software in order to enable an access to its email server. Security of communications will be achieved at least using Triple-DES encryption.

SCHAUMBURG, IL, Le 27 jan. 2003. Un contrat d'une valeur de 35M$ a été signé entre le Gouvernement du Québec et Motorola pour la livraison d'un système de télécommunication. Le système desservira 10000 radios bidirectionnelles mobiles et portatives. Il permettra une communication entre les différents ministères et les organismes de sécurité publique. Il sera adapté pour répondre aux situations d'urgence.

WATERLOO, ON, Jan. 14, 2003. Research in Motion has announced that a reexamination of five patents assigned to NTP Inc in view of uncited prior art will be performed at the USPTO (U.S. Patent and Trademark Office). The claims of the five patents are part of an ongoing litigation between Research in Motion and NTP Inc. where Research in Motion is alleged of patent infringement.

OTTAWA, ON, Dec. 5, 2002. The Canadian Radio-Television and Telecommunication Commission (CRTC) calls for the views of Canadians with respect to pay phones services.

LONDON, ON, Nov. 28, 2002. Bell Canada donated $300,000 to support telesurgery and telementoring at London Health Sciences Centre. The telementoring will enable surgeons at a remote location to mentor a local surgeon.

WATERLOO, ON, Nov. 5, 2002. Research In Motion (RIM) is announcing the signature of an agreement setting out terms of a licensing of some patent to Handspring Inc. Research In Motion will dismiss its pending litigation against Handspring Inc.

MONTREAL, QC, Jun. 17, 2002. Raymark Inc. has won this year a Retail Application Developer award from Microsoft for its wireless point-of-sale solution. It uses a PDA and enables retail management.

TORONTO, ON, Dec. 12, 2002. CAE announced to have conclude contracts for approximately for 50M$ with the U.S. Air Force, three flag carriers and seven other airlines.

OTTAWA, ON, Nov. 21, 2002. Xwave announced to have delivered an Air Navigation Monitoring and Control System (AMCS) to Nav Canada. Nav Canada. Nav Canada is the Canadian civil air-navigation service provider.

TORONTO, ON, Feb. 6, 2003. Bioscrypt Inc has announced that American Express has implemented the use of their fingerprint readers at their headquarter in New York City. Bioscrypt develops various biometric-related products.

Director's Report

Dear Canadian Members of IEEE:

My tenure as Region 7 Director and President of IEEE Canada for 2002-2003 has not only been rewarding, but has also provided me with an excellent opportunity to learn first hand of the achievements and dedication of our superb volunteers throughout this wonderful country of ours. Volunteering makes all members of the one fantastic family called IEEE. I sure feel that IEEE is our family, which contributed to our growth and well-being.

As Regional Director, I have undertaken to meet with as many of our sections as possible to learn of their concerns and to promote IEEE to the general public. I am pleased to report that I have visited the eleven of our nineteen sections during the past fifteen months. The list includes:

- Ottawa Section.
- Toronto Section, at their Annual General Meeting.
- Northern Saskatchewan Section.
- Southern Saskatchewan Section.
- South Alberta Section.
- Kitchner-Waterloo Section.
- London Section.
- Newfoundland and Labrador Section.
- Montreal Section.
- Quebec Section.
- Canadian Atlantic Section at their Annual General Meeting.

In the Fall of 2002, I was privileged to help the Hamilton Section celebrate their 50th Anniversary, and I indeed look forward to help the Toronto Section celebrate their Centennial in October. I was accompanied on many of these visits by my partner-in-life, Dr. Ferial El-Hawary, who as always added a touch of class to these visits. I intend to visit the remaining eight sections in the very near future.

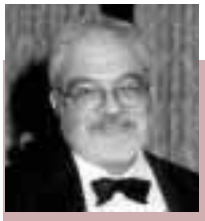
I have attended the ExCom Meeting of the IEEE Reliability Society ExCom as well as the Geosciences and Remote Sensing Conference as R7 Director when they both met in Ottawa. I also attended four Council Meetings of the Engineering Institute of Canada representing IEEE Canada.

The activities in the Region during 2002 culminated by holding a Regional Committee Meeting in conjunction with Section Congress 2002 in Washington, D.C. The meeting included a Caucus and subsequently, the Region 7 Committee met in formal session.

Two issues are currently of concern to IEEE Canada. The first relates to the extent and depth of service in French to our membership in Canada, and the second deals with many folks really being unappreciative of the apparently recent trend towards replacing print issues (hard copy) assuming that everyone will sit at a computer terminal for the major portion of their remaining life. The March Issue of the Institute carried quite a noticeable number of letters to the editor. I note that your leadership is responding to your concerns and that the electronic and print versions are being produced as complementary to each other.

The Region is continuing to provide resource support to our Student Branches and their conducting of SPACs, provide for the rejuvenation of existing Student Branches, and assist in the rejuvenation and establishment of Chapters and Affinity Groups. I wanted to take this opportunity to single out the contributions of some of our stellar volunteers. Dr. R. T. H. (Bob) Alden has done a superb job in revamping and streamlining our IEEE Canada's WEB site. Mr. Ron Potts, and Dr. Wally Read, with the help of Bob Alden, and Dave Kemp have undertaken to build a network of Life-Member groups throughout this country. I salute all of them for their contributions.

I wish you all well, and look forward to meeting many of you at the Canadian Electrical and Computer Engineering Conference in Montreal early in May.



Mo El-Hawary

IEEE Region 7 - Director/Président,
Halifax, NS
March/mars 18, 2003
email: elhawary@dal.ca

Rapport du Président

Chers membres canadiens de l'IEEE:

L'exercice de mes fonctions en tant que directeur de la Région 7 et président de l'IEEE Canada pour 2002-2003 a non seulement été enrichissant, mais il m'a également fourni une excellente occasion de voir par moi-même les accomplissements et le dévoeument de nos excellents volontaires partout dans notre merveilleux pays. Le volontariat fait de tous les membres d'une famille fantastique appelée l'IEEE. J'ai en effet le sentiment que l'IEEE est notre famille, ce qui a contribué à notre croissance et notre bien-être.

En tant que Directeur régional, je me suis engagé à rencontrer autant de nos sections que possible afin de connaître leurs soucis et de promouvoir l'IEEE au grand public. Je suis heureux de vous rapporter que j'ai visité onze de nos dix-neuf sections lors des derniers quinze mois. La liste inclut:

- Section d'Ottawa.
- Section de Toronto, lors de son assemblée générale annuelle.
- Section du nord de la Saskatchewan.
- Section du sud de la Saskatchewan.
- Section du sud de l'Alberta.
- Section de Kitchner-Waterloo.
- Section de London.
- Section de Terre-Neuve et du Labrador.
- Section de Montréal.
- Section du Québec.
- Section atlantique canadienne, lors de son AGM.

À l'automne 2002, j'ai eu le privilège d'aider la section de Hamilton à célébrer son 50ième anniversaire, et j'anticipe avec intérêt l'occasion d'aider la section de Toronto à célébrer son centennal en octobre. J'ai été accompagné lors de plusieurs de ces visites par ma conjointe, Dr. Ferial El-Hawary, qui a toujours su ajouter une touche de classe à ces visites. J'ai l'intention de visiter les huit sections restantes à très court terme.

J'ai assisté à la réunion d'ExCom de la "Reliability Society" de l'IEEE ainsi que la conférence de "Geosciences and Remote Sensing" en tant que Directeur R7 lorsqu'elles se sont toutes deux réunies à Ottawa. J'ai également assisté à quatre sessions du "Engineering Institute of Canada" en tant que représentant de l'IEEE Canada.

Les activités dans la Région au cours de 2002 ont culminé par la tenue d'une réunion régionale du Comité conjointement avec le congrès 2002 de section à Washington D.C. La réunion a inclus un Caucus et par la suite le Comité de la Région 7 s'est réuni en session formelle.

Deux points préoccupent présentement l'IEEE Canada. Le premier concerne l'étendu et la profondeur du service en français fourni à nos membres au Canada, et le deuxième concerne le nombre important de personnes n'appréciant pas la tendance apparemment récente de remplacer la copie imprimée en assumant que tous et chacun passerons la majeure partie de leur vie future assis devant un terminal d'ordinateur. La parution de mars de l'Institute comprenait un nombre remarquable de lettres au rédacteur. Je note que vos dirigeants réagissent à vos soucis et que les versions électroniques et imprimées sont produites de façons complémentaires.

La Région continue de fournir un support en ressources à nos branches étudiantes et à leur mise en oeuvre de "SPACs", pourvoit au rajeunissement des branches étudiantes existantes, et à aider au rajeunissement et à l'établissement de Chapitres et groupes d'affinité. J'ai voulu saisir cette occasion afin de souligner les contributions de certains de nos volontaires exceptionnels. Le Dr. R. T. H. (Bob) Alden a fait un travail superbe en améliorant et rationalisant notre site WEB de l'IEEE Canada. M. Ron Potts, et Dr. Wally Read, avec l'aide de Bob Alden, et Dave Kemp se sont engagés à établir un réseau de groupes de Membres à vie au travers de tout le pays. Je les salue tous pour leurs contributions.

Je vous transmet mes meilleurs voeux, et j'anticipe avec intérêt l'occasion de rencontrer bon nombre d'entre vous lors de la conférence canadienne du génie électrique et informatique ayant lieu à Montréal en mai.

Traduit par: C. Robillard, ing., McCarthy Tétrault, Montreal, QC

5 November, 2002

Dear Dr. Sood,

Please accept my thanks for the article on the Bahen Centre for Information Technology that included in the IEEE Canadian Review.

As a long standing member of IEEE and as a Fellow of IEEE, I have long been an avid reader of your publication. I would like to express my appreciation to you for making your readers aware of the fact that we now have an outstanding new facility for teaching and learning electrical and computer engineering.

Anastasios N. Venetsanopoulos

Dean - ECE, University of Toronto,

Toronto, ON

16 December 2002

Dear Sir,

You ask for comments regarding publication of the Review on the Internet and not as hard copy.

I am sure that some people would much rather have it this way, but I hardly use the Internet at all and I avoid e-mail as much as possible. So if you went this way, I might very well not bother to read it at all. This is the very first time I have visited your web site, and it may indeed be the last. I may be in the minority, but, you asked for it!

Dr. Sidney V. Soanes

Toronto, ON Life Member (Senior) IEEE

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19 December 2002

Sir,

The IEEE Institute is reducing its paper mailings to four times a year in favour of a monthly electronic format. It now appears that the IEEE Canadian Review is considering reducing or eliminating its paper format in favour of an electronic format. Since I do not have internet access at home and have little time to read electronic publications on my work internet connection, I will probably cease to read these publications when they stop being mailed to me. Most of my reading is done by carrying the publications with me and reading when I get a chance. When a publication shows up in the mail, I will look at it. I will not likely bother to check a web site, and to print all of these things myself will use a lot of (my employer's) paper. I have no argument with providing electronic versions. This is great for archiving information. I do prefer to see the paper mailings continue. I pay over $200 Canadian a year for IEEE membership and the only thing I get for that is the Canadian Review, the Institute and Spectrum. If the first two are no longer mailed to me in paper form, Spectrum magazine will be the only thing left.

When that goes solely electronic, my membership will no longer have value and I will then drop it. My main message is that by emphasizing totally electronic distribution, you are reducing your services to the point that my membership has less and less value.

David M. LeBlanc, P. Eng.

Fredericton, NB

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15 January 2003

Dear Dr. Sood,

I am responding to your Managing Editor's request for comments on the on-line version of the Review (No. 42). The many contributors whom you mention are to be congratulated, along with yourself, for a most impressive effort in creating the web-site. The Review itself is an excellent compilation of news and articles which are of interest to Canadian electrical engineers.

If the expense can be tolerated, continuation of the hard-copy is convenient for reading on the metro or in the waiting rooms of doctors and dentists.

With best wishes for 2003 and continued success of the Review,

Ed Neville

Montreal, QC

Dear Sir,

My name is Carlos Fernando Rodríguez. I am an Electrical Engineering Student in Bogotá (Colombia). I am an IEEE student member. I am developing my dissertation or thesis, which is "Feasibility Study of Converting one Circuit of San Carlos – Sabanalarga AC line to DC line".

I would like to obtain a copy of "Using DC to increase capacity of AC transmission circuits" by Woodford D.A and Young A.H., IEEE Canadian Review, March 1989 pp15-18. I appreciate if you can send me any information about it.

Carlos F. Rodríguez S.

Bogota, Columbia

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10 March 2003

Dear Sir,

I'm a Peruvian IEEE Member that has recently moved to Toronto, Canada. I've already changed my Contact Information and received the March issue of the IEEE Spectrum in my new address. I'd like to know if I'll also receive the hardcopy version of the IEEE Canadian Review. In the meantime I'd like to be subscribed to the on-line version.

Pedro Cotillo

Toronto, ON

Editor's comments:

The letters received are all important to us. I thank you all personally for taking the time to respond.

To Dean Venetsanopoulos: I must say it is quite a pleasure and an honor for us to know that you are an avid reader the IEEE Canadian Review. I hope that you will appreciate that the present issue of the CR carries a number of article from your department. Please continue to let us have your comments.

To Dr Soanes, Mr. LeBlanc and Mr. Neville: The issue of going electronic and online with the CR is not going to go away anytime soon, if at all. The Internet is going to be a power to deal with and to accept it for what it is - a cheap and efficient media - and embracing it is the logical way to move ahead. However, your points about the hardcopy being desired by the membership is being heard. I am personally in favor of having both versions complementing each other. Using the speed/ease of access, archiving and referral benefits of the Internet are a foregone conclusion. However, providing a condensed, visually-appealing hardcopy version for the ease of reading at ones leisure (even at the dentist's office!) is something I will continue to fight for.

Mr. LeBlanc's point of the **"value of membership"** hits the nail right on the head. The CR will continue to be the unique magazine for Canadian electrical, computer and telecoms engineers/technologists etc. for news, views and reviews. However, being a volunteer-based effort, we can only go so far. My team is very much encouraged to hear from you. Please do keep your comments coming in.

Finally, all I can say is that the **CR is read,** far beyond Canada; the submissions I receive from all over the world indicate that. Unfortunately, I cannot accept these submissions since I must give first preference to Canadian issues and perspectives. The CR is a benefit/service to our members. And what is more, our members want to maintain this magazine. I do thank you for your input.

STIQUITO for beginners - An Introduction to Robotics

Written by

James M. Conrad & Jonathan W. Mills

Published by

Angela Burgess, CS Press

ISBN 0-8186-7514-4

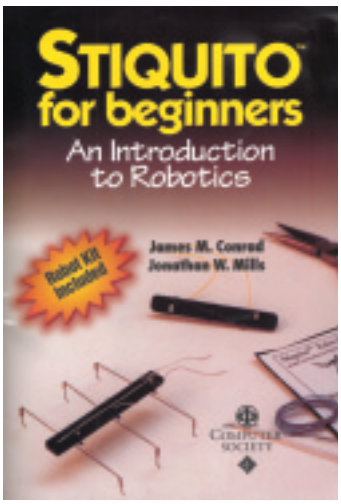
Book Reviewed by

Mark C. Dias,
Automation - Robotics Technologist, Toronto, ON

The world of robotics is a fascinating place, filled with moving parts and microchips. Robots have jumped out of the pages of science fiction into the real world. Robotic technology has become a vital part of modern manufacturing and a challenging hobby for many Robot Builders. Building robots can be very difficult because it involves much planning. Due to the cost, size, shape and complicity of robotic components it is easy to see why robotics is usually left to the experts. These barriers can discourage many hobbyists from making their own creations.

But thanks to a material named Nitinol, even beginners can create small, inexpensive, lightweight, walking robots. Nitinol has the properties of contracting when heated, and returning to its original size when cooled. This material has the ability to give robots true muscle-like propulsion which did not exist until recently.

STIQUITO for beginners: An Introduction to Robotics gives a step-by-step guide to building a working insect-like robot and it even comes with all the parts you need. This book provides a beginner with plenty of knowledge about robots and the engineering properties behind how they work. This book has even been used by some high schools to introduce students to the world of electricity and electronics.



The first of nine chapters gives a brief history of robotics and the invention of Stiquito. This chapter also describes how Stiquito works, the skills needed to build a Stiquito robot and even how this guide came to be.

In Chapter 2, Engineering Skills and the Design Process are discussed. This chapter describes what an Engineer does, how they go about designing things and solving problems.

In Chapter 3, The basics of electricity and electronics are discussed and some simple experiments are given to show how electricity and electronic components work.

In Chapter 4, The basics of Nitinol, how it works and how it is used to make Stiquito walk are covered. This chapter also provides simple experiments to show Nitinol in action.

In Chapter 5, The building of Stiquito, there are step-by-step instructions on how to assemble the (robot kit included in the book) main body of Stiquito. Some of these assembly steps are tricky if you have never stripped small gauge wire before. Be sure to practice before attempting to build this robot.

In Chapter 6, The Manual controller is the final step to make Stiquito walk. This chapter gives step-by-step instructions on assembling a simple tethered controller for Stiquito.

In Chapter 7, The PC-Based controller (requires additional hardware not included with book) allows you to use your PC to control the robot's actuators and experiment with various gaits.

In Chapter 8, A simple electronic circuit is described to make Stiquito walk autonomously. Again, this requires additional hardware not included with the book.

The final chapter then describes the future of walking robots and gives some ideas on how you can use the robot you just built.

To summarize, this book is a great guide for anyone interested in building robots or for teaching an introductory course on electricity and electronics. The information is well organized and provides good illustrations and schematics for assembly and experimentation.

****

The CR Editor acknowledges the support of Mr. Aida Krneta (email: akrneta@wiley.com), J.Wiley and Sons Publishers for her support of this Book Review.

IEEE Canada On-Line

If you've you misplaced an earlier issue of the Canadian Review, then you can always download previous issues in PDF. For back issues, IEEE member services, news and much more, go to:

www.ieee.ca

A Survey Of Generic Architectures For Dependable Systems

by *Yang Liu and Purnendu Sinha*
Concordia University, Montréal, QC

Abstract

Dependability and availability of computing systems for critical real-time applications have been major concerns in development of different fault-tolerant architectures. With ever growing need to provide for reliable and timely services in varied applications, generic architectures for dependable systems are being developed that can adapt with ease to very diverse requirements of such applications. The main stream of building generic architectures for dependable real-time systems consists of the GUARDS architecture, the AQuA architecture, the FRIENDS architecture, and the Chameleon architecture. Their common goals are to achieve transparency, generality and adaptability. This survey paper compares the architectures in terms of their fault models, fault detection mechanisms and fault treatment schemes. A qualitative comparison between these architectures is summarized after evaluating them based on cohesion and coupling principle.

Sommaire

La sûreté de fonctionnement ainsi que la disponibilité de systèmes informatiques pour des applications critiques en temps réel ont été des soucis majeurs dans le développement de différentes architectures tolérant les fautes. Avec un besoin sans cesse grandissant de fournir des services fiables et à temps, dans diverses applications, des architectures génériques pour des systèmes sûrs de fonctionnement sont développées pour s'adapter avec facilité aux exigences fort variées de telles applications. Le courant principal dans la construction d'architectures génériques de systèmes sûrs de fonctionnement en temps réel est composé des architectures GUARDS, AQuA, FRIENDS et Chameleon. Leur but commun est l'atteinte de la transparence, de la généralité ainsi que la faculté d'adaptation. Le présent article donne une vue d'ensemble de ces différentes architectures et les compare en termes de leurs modèles de fautes ainsi que de leurs mécanismes et procédés pour détecter et traiter respectivement ces dernières. Une comparaison qualitative de ces architectures est présentée après les avoir évaluées selon les principes de couplage et de cohésion.

1.0 Introduction

Providing fault tolerance to distributed applications is a challenging and important goal. Towards this objective, in the past several years, fault-tolerant architectures, such as SIFT, FTMP, FTPP, MAFT, ERICA, Delta-4 [5,6] among others have been designed and implemented. The initial efforts in building software-implemented fault tolerance were put in integrating fault tolerance mechanisms into the operating system. These systems are limited in terms of accessibility and customization, and tend to only offer a static level of fault tolerance that remains fixed throughout the lifetime of the system. A better approach is to implement basic fault tolerance mechanisms in a library on top of the operating system. However, in this case, since the library functions are coupled with application source code, the mechanisms are still not independent.

Currently, efforts are being made to build generic architectures for fault-tolerant distributed systems. The FRIENDS [2], the AQuA [1], the GUARDS [4], and the Chameleon [3] represent the main streams of this effort. The common goals of these architectures are:

- **Transparency:** the fault tolerance mechanisms should be transparent to application programmer.
- **Generality:** a wide range of applications with different fault tolerance requirements can use the architecture.
- **Adaptability:** the architecture should be able to adapt to changing requirement both spatially and temporally.

The paper is structured as follows: Section 2 outlines the comparison criteria based on fault model, fault detection mechanisms, fault treatment strategies, and cohesion and coupling principles. Sections 3 to 6 summarize GUARDS, AQuA, FRIENDS, and Chameleon architectures respectively. In Section 7, we evaluate the above four architectures based on the criteria defined in Section 2.

2.0 Comparison Criteria

To evaluate the generic architectures, two system design and evaluation concepts are needed: cohesion within each module and coupling with the other modules:

- **Cohesion** is a qualitative indication of the degree to which a module focuses on just one thing, whereas,
- **Coupling** is a measure of the relative interdependence among modules,

Ideally, in a generic architecture, the cohesion within each module should be as high as possible and the coupling between modules should be as less as possible,

More concretely, the listed architectures will be evaluated on the basis of how they answer the following questions within these three subdomains:

1. **Fault-model:** What is the fault model of the architecture? Specifically, what are the faults handled in the architecture? Are crash faults, value faults, time faults and their combinations considered or just a subset of them are considered? The guiding principle is that the lesser the assumptions about faults that can occur, the better would be the architecture. Moreover, how many fault classifications are there in the architecture? Are the faults simply classified as crash faults, value faults, and time faults or the faults classified based on different basis such as location, duration, and criticality? More classifications mean that the architecture is capable of differentiating the faults in detail, thereby achieving high efficiency for fault tolerance.

2. **Fault-detection:** How are faults detected? Specifically, are the faults detected by operating system services or by system independent modules? Are there different modules for different faults? How long does it take for an error to be detected? How are different fault detection techniques organized? The principle is that a generic architecture should incorporate all available fault detection mechanisms into the architecture in a highly cohesive way. In addition, if new fault detection mechanism were invented, it should be easily adopted by the architecture.

3. **Fault-treatment:** How are detected faults treated? Specifically, How are faults masked? How are faulty components handled/eliminated? How are different fault treatment mechanisms organized? The basic idea is that a generic architecture should incorporate all available fault treatment mechanisms in a highly cohesive way and open to new technologies that might be invented in the future.

We emphasize that we focus only on the design of fault-tolerant mechanisms built into these systems for our comparative studies.

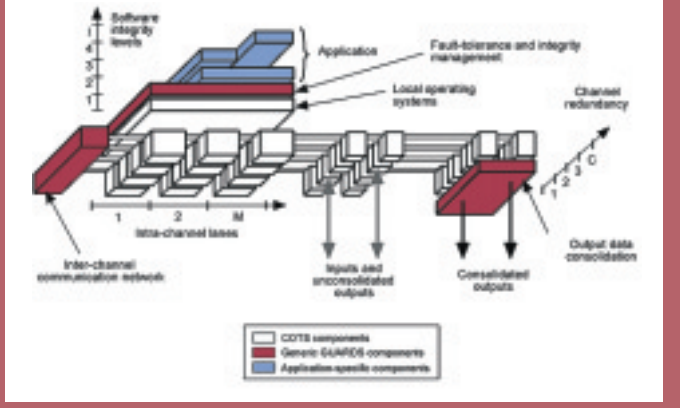


Figure 1: The Overall GUARDS architecture [4]

3.0 GUARDS

GUARDS (Generic Upgradable Architectures for Real-Time Dependable Systems) architecture provides a comprehensive framework from which specific instances can be derived to meet the dependability requirements of various application domains.

3.1 The Overview of the GUARDS Architecture

As Figure 1 shows, GUARDS uses a limited number of specific, but generic, hardware and software components to implement an architecture that can be configured into a wide variety of instances along three architectural dimensions - redundant channels, redundant lanes and integrity.

Channels provide the ultimate line of defense within a single instance for physical faults that affect a single channel. Multiple processors or lanes can be used to improve the capabilities for fault diagnosis within a channel, e.g., by comparison of computation replicated on several nodes. The integrity dimension aims to provide containment regions with respect to software design faults.

3.2 Fault model of GUARDS Architecture

The GUARDS architecture is capable of handling crash faults, value faults and time faults. Furthermore, the architecture considers both physical faults and design faults. Physical faults are assumed to occur independently on different components. The architecture differentiates channel-correlated faults, lane correlated faults, and globally correlated faults as well. However, most of the time, the faults in GUARDS architecture are classified as either temporary or permanent, because this classification is more pertinent to the efforts of masking faults in real time systems where temporal redundancy is not available.

3.3 Fault Detection and Diagnosis in GUARDS Architecture

Fault detections are done in two levels in the GUARDS architecture: intra-channel level and inter-channel level. First, each channel has local mechanisms to detect crash faults, value faults, and time faults that are from different sources such as nucleus, hardware, system, and application. In addition to the ability to locate faults, each channel is capable of diagnosing the fault as permanent or temporary by running a self-test algorithm. The self-test is carried out on a channel after it has been isolated from the pool. Secondly, the inter-channel fault detection depends on the number of operational channels in the system. As long as there are at least three operational channels, any errors due to a single faulty channel are detected by majority voting. In the case when two operational channels are available, a two-out-of-two vote is considered and single channel errors are detected. Any configuration with more than three channels is capable of tolerating arbitrary faults except a Byzantine fault leading to failure of the clock synchronization mechanism.

The efficiency of fault detection and diagnosis depends on the level of redundancy of the channels and the lanes. Moreover, the detections are achieved by the deliberate cooperation of channels and lanes. The components are tightly coupled together to provide efficient fault detection.

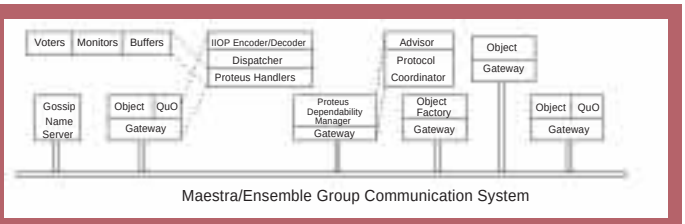


Figure 2: The Overall AQuA Architecture [1]

3.4 Fault treatment in GUARDS Architecture

Detected errors trigger fault diagnosis to determine which channel is faulty. The faulty channel is then isolated from the operational channels to execute a self-test aimed at determining whether the fault is permanent or temporary. If the fault is judged to be permanent, an explicit repair action must be carried out whereas in the case of a temporary fault, certain fault treatment strategies may authorize automatic re-integration of the faulty component. Furthermore, Correlated faults at integrity level 1 should be confined to that level by the integrity policy (IP) enforcement mechanisms.

Essentially, the faults, if any, will be first contained within the channel dimension; if the efforts fail, attempts are made to contain the faults within the lane dimension; finally the integrity dimension tries to prevent the software faults from propagating.

4.0 AQuA Architecture

The AQuA architecture, which stands for Quality of Service for Availability, allows distributed applications to request and obtain a desired level of availability by configuring the system in response to outside requests and changes in system resources due to faults.

4.1 The Overview of the AQuA Architecture

Figure 2 shows the different components of the AquA architecture in one particular configuration. In the AQuA Architecture, the application uses “Quality Objects (QuO)” to specify dependability requirement. The AQuA framework employs the QuO runtime to handle these requests, and the Proteus dependability manager to configure the system in response to faults and availability requests. In addition, a CORBA interface is provided to application objects using the AQuA gateway. The AQuA architecture is heavily dependent on the Ensemble protocol stacks to provide group communications services.

4.2 Fault Model in AQuA architecture

The AQuA architecture handles object faults of three types: crash failures, value faults and time faults, but imposes the following assumptions:

- All faults occur in nodes not in links,
- Value faults occur within objects themselves, not in the links,
- Value faults occur only in the application and/or QuO runtime, thus not in AQuA gateway.

The assumption about no value faults in links holds only when the conventional coding/correction techniques (such as hamming code) are available. If the conventional coding/correction techniques do not exist in the underlying infrastructure, then the consequence of this assumption is that either some faults that cannot be tolerated or they will be tolerated in a very inefficient way.

4.3 Fault Detection in AQuA architecture

The crash failures are detected by Ensemble. Among the elements composing the object, only the gateway process is an Ensemble process. However, since the crash of the application process or the QuO runtime process leads directly to the crash of the gateway process, Ensemble can detect the crash of any element of an object. The failure of any replica will cause a view change of the group composition. This view change is communicated to the Proteus manager through the Proteus Communication Service (PCS) group. The comparison between the old structure of the group and the new composition allows the dependability manager to detect the crash failure.

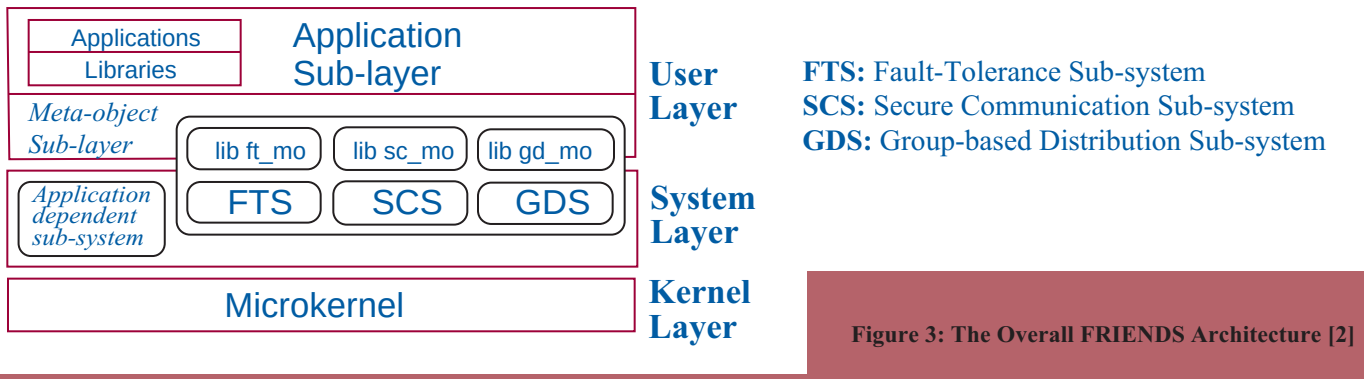


Figure 3: The Overall FRIENDS Architecture [2]

The voter that is implemented in the gateway part of the leader object detects value faults. Although each object has a voter implemented, only the voter present in the leader of the replication group is active. When an object on the client side sends out a request it sends it to the leader of its replication group. Then the voter of the leader votes on the requests. If some requests differ from the majority, a single or multiple value fault has occurred. In this case, the leader gateway process of the replication group joins the PCS group to notify the Proteus manager about the value fault. Equivalently, on the server side, after a request has been processed by the different replicas of the replication group, all replicas send back their reply to the leader of the server replication group. The voter of the leader then votes on the different replies. A value fault has occurred if one or more replies differ from the majority. The leader gateway process then joins the PCS group to complain about the value fault. Proteus thus detects a value fault by the communication of the complaint when the leader joins the PCS group.

Time errors are detected by monitors that record information regarding various times and omissions. Where and how the timers operate depends on the type of faults that are being tolerated. A monitor is implemented in the gateway part of each object. When tolerance to time faults is required, all monitors of the object members of replication groups activated time faults are communicated to the Proteus manager using the PCS group structure described earlier.

The separation of detection mechanisms of crash faults and detection mechanisms of value faults and time faults makes the fault detection of AQuA less cohesive. Furthermore, voters and monitors are not independent components themselves; they are parts of the AQuA gateway whose main function is however to interface between Ensemble and application level components. Such coupling of error detection mechanisms and interfaces makes the cohesion within AQuA gateway less efficient.

4.4 Fault Treatment in AQuA architecture

The Proteus manager advisor, using fault information communicated from the gateways, makes decisions regarding fault treatment. After a decision is reached, the object factories and gateways make the configuration change, under control of the protocol coordinator.

For crash failures, since the number of replicas may need to be maintained, a new object may be started either on the same host or on another host. The advisor decides when and where the new object is to be started. The new object joins the replication group and the state of the leader is transferred to the new replica.

For value and time faults, the fault treatment consists of two phases. First, the source of the fault is determined, based on information provided to the advisor. Using complaints from the various object monitors and voters, the advisor decides whether to kill suspected replicas, or start new replicas, and where to start the new replicas. Second, the replicas for which a value or a time fault has been detected may be killed and new replicas started, if mandated by the advisor, in order to maintain the global number of replicas. The newly created objects then join the replication groups from which objects have been killed, and the leaders of these replication groups transfer their state to the new objects.

As the decision on how to treat faults and the action of fault treatment are done by the advisor and the coordinator, respectively, the separation of decision-making and action makes both advisor and coordinator more cohesive as well as less coupling with the other modules. This is advantageous in a sense that further modification of the advisor and the coordinator is transparent to other components.

5.0 FRIENDS

The FRIENDS architecture, which stands for Flexible and Reusable Implementation Environment for your Next Dependable System, achieves fault tolerance by providing a library of meta-objects that can be recursive to add new properties to distributed applications in an object-oriented manner.

5.1 The Overview of the FRIENDS Architecture

The FRIENDS consists of three layers and a protocol:

4. The kernel layer which can be either a Unix kernel or a microkernel, like Chorus,
5. The system layer composed of several dedicated sub-systems,
6. The user layer dedicated to the implementation of applications and mechanisms as meta-objects, and
7. A customizable meta-object protocol (MOP) that defines how the application objects and meta-objects interact.

A simplified static view of the overall system architecture is given in Figure 3.

5.2 Fault Model and Detection in FRIENDS Architecture

The FRIENDS architecture currently deals with only physical crash faults and assumes that application objects have a deterministic behavior. Concurrency and other sources of non-determinism have not been considered yet. The fault-tolerance mechanism for other types of faults (e.g., software faults) can be added to an application by connecting the appropriate meta-objects to the application objects. Note that meta-objects behavior depends on information provided by the application objects, thus differing from mechanisms used for handling physical faults.

The FRIENDS architecture mainly employs watchdog timer, fail silent network attachment controllers and double memory boards to implement its fault detection mechanisms. Fault detection mechanisms are provided in the library of fault tolerance meta-object classes (libft_mo). In turn, the libft_mo builds these mechanisms on top of the basic service provided in fault tolerance subsystem. New meta-objects for different fault detection mechanisms can easily be added into the library in a cohesive manner.

5.3 Fault Treatment in FRIENDS Architecture

Basically, three fault tolerance mechanisms are implemented in the form of meta-object classes: a mechanism based on stable storage, a primary-backup replication protocol and a leader-follower replication protocol. Specifically, the stable storage is achieved by two meta-objects: STABLE_STORAGE and DOMAIN. During the object method execution, an error can be detected by the error detection system service

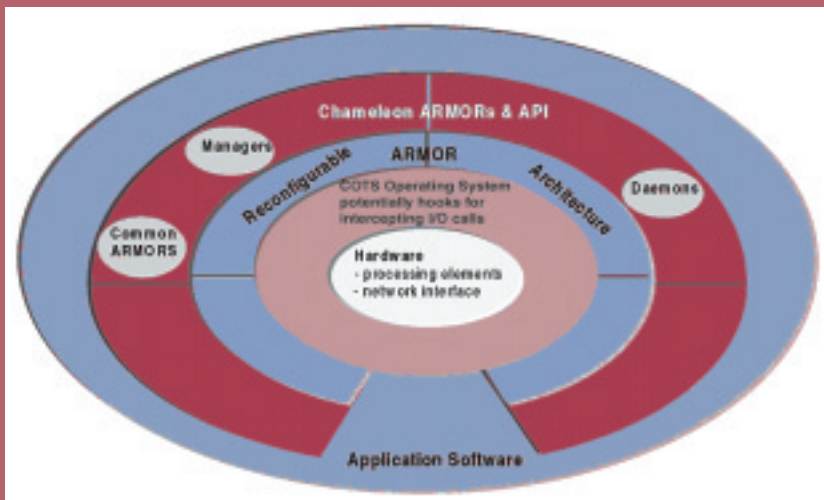


Figure 4: The Overall Chameleon Architecture [3]

either before the new state is saved to stable storage or in between the time it is backed up and the time the server sends the reply to the client. In both cases the error is signaled to the client meta-objects, and the STABLE_STORAGE will identify the recovery point and the DOMAIN will invoke its method to maintain stable storage.

The primary-backup replication mechanism is implemented in two meta-objects: PBR_CMO and PBR_SM. In this strategy, all replicas of a server belong to the same atomic multicast group and, thus, receive the same input messages in the same order. Among the replicas, only the primary handles the client requests and checkpoints its new state at the end of every method executed to the backups. Any primary errors will be detected by backups, which then choose a new primary among them. This new primary restores the last checkpointed state and, if necessary, executes the current request before returning the reply to the client.

The leader-follower replication mechanism is achieved by two meta-objects: LFR_CMO and LFR_SMO. In this mechanism, all replicas process input messages, but only the leader sends output messages. All replicas of a server belong to the same atomic multicast group and receive the same messages in the same order. The leader first executes the request and then notifies it to the other replicas that in turn execute the request. Only the leader returns the reply to the client.

6.0 Chameleon

The Chameleon architecture provides a powerful framework through which fault tolerance execution strategies may be constructed and reused to provide dependability to substantially off-the-shelf applications.

6.1 The Overview of the Chameleon Architecture

Chameleon provides the runtime environment for reliability through the use of ARMORs that stand for Adaptive, Reconfigurable, and Mobile Objects for Reliability. ARMORs are components that control all operations in the Chameleon environment and can be classified into three categories: Managers, Daemons, and Common ARMORs.

There are three kinds of managers in the Chameleon architecture: Fault Tolerance Manager (FTM), Surrogate Manager (SM), and Backup Fault Tolerance Manager (Backup FTM). There are six kinds of common ARMORS in Chameleon environment: Heartbeat ARMOR, Execution ARMOR, Checkpoint ARMOR, Voter ARMOR, Initialization ARMOR and Fanout ARMOR. Daemons are entities resident on every participating node.

6.2 Fault Model in Chameleon Architecture

Chameleon makes no assumptions about faults that may occur in the system. This makes it applicable to wider range of applications. Furthermore, Chameleon differentiates the faults that might occur in application, its own components and underlying network components. This differentiation makes it more efficient to locate the faults and subsequently to recover from them.

6.3 Fault Detection in Chameleon Architecture

The detection mechanisms are implemented in Heartbeat ARMOR, Execution ARMOR, Voter ARMOR, Backup FTM and the Daemon. The Heartbeat ARMOR is responsible for detecting crash faults that occur in nodes, links, and daemons. If necessary, Heartbeat ARMORs can collect information sufficient to determine the health of the node being monitored.

The Execution ARMOR is responsible for detecting abnormal terminations (crash failures) and live-locks in applications by overseeing application executions. The erroneous computations (value faults) of applications are detected by voter ARMORs. The value faults and time faults in applications originated in underlying hardware or operating system can also be detected by execution ARMORs and voter ARMORs in the same manner.

The Backup FTMs are able to detect the crash faults in FTMs and the crash faults in Daemons on FTMs' nodes. Daemons are capable of detecting crash faults in common ARMORs by monitoring all the ARMORs installed by them.

Having different fault-tolerant mechanism modules inherited from the same parent class ARMOR, the Chameleon architecture achieves high cohesion and low coupling harmoniously.

6.4 Fault Treatment in Chameleon Architecture

Heartbeat ARMOR detects a crash failure in a node, link or daemon, and then it notifies the FTM, which in turn removes the node from the list of registered nodes and restarts any affected ARMORs it manages on a new node. After that, the FTM notifies its immediate managers of the crashed node; these managers restart any of their ARMORs and recursively notify all subordinate managers.

When an erroneous computation (value fault) is detected, the voter ARMOR has two choices: if the application is in dual mode, the voter ARMOR will restart the application and notify the user; if the application is in TMR mode, the voter ARMOR will mask the error and optionally notify the user.

When a crash failure occurs in common ARMORs, the corresponding Daemon will notify the crashed ARMOR's manager. The manager will try to reinstall the ARMOR on the same node, on a different node or on a different platform depending on the situation. The manager may also try to employ another ARMOR with similar functionalities. When a common ARMOR is found alive but unresponsive, the corresponding daemon will kill the ARMOR and then notify the ARMOR's manager; and the manager will reinstall the ARMOR accordingly.

When a crash fault is detected in a daemon, the querying Heartbeat ARMOR notifies the daemon's manager. The daemon's manager will treat a daemon failure as if the entire node has crashed and recovers as for the node failure.

A crash fault in FTM and a crash fault in FTM Daemon are treated in the same way. The corresponding backup FTM promotes itself to become the FTM and notifies all ARMORS that it manages directly of the change. All subordinate managers recursively notify the ARMORs managed by them respectively. Finally, new FTM promotes a new backup FTM from one of the surrogate managers.

As different managers and ARMORS handle different faults, fault treatment mechanisms are organized in such a way that high cohesion and low coupling are achieved without sacrificing each other.

7.0 Discussion

The GUARDS is a real-time-oriented architecture, which is naturally determined by its three major applications that are from railway, nuclear propulsion, and space domain. Consequently, GUARDS aims at containing and masking various faults because time redundancy is assumed unavailable, and more emphasis are given to fault diagnosis and fault

Table 1: A Comparison of Fault Tolerance Mechanisms of Different Architectures

	FRIENDS	AQuA	CHAMELEON	GUARDS
Fault Models	Physical crash failures	• Crash failure • Value and time faults • Fault-free links • No value faults in AquA gateway	• No specific assumptions • Differentiates faults occurring at different locations	Based on: • Location • Duration • Interdependence
Fault Detection Mechanisms	Organized into the library of meta-object classes	• Crash failures detected by Ensemble • Value and time faults detected by voters and monitors, respectively	Implemented in different ARMOR, Backup FTM, and Daemon	Achieved by the deliberate cooperation of redundant channels and lanes
Fault Treatment Mechanisms	Implements separate detection and handling mechanisms as meta-object classes	• Supports both active and passive replication • Differentiates between decision making and fault handling actions	Different managers and ARMORs handle different faults	Focuses on fault containments and fault masking

containment instead of fault recovery. These aspects make GUARDS more suitable for highly critical systems.

The AQuA architecture is unique in that it supports runtime reconfiguration of the system; whereas other architectures only support reconfiguration at compile time. As a result AQuA is able to offer changing Quality of Service (QoS) at runtime. AQuA is heavily dependent on the Ensemble system that is based on group communication methodology. Consequently there is no central control point in AQuA at all, which makes the decision making in AQuA inefficient. Currently, AQuA is still programming language dependent, which is due to his dependence on the Maestro system that is based on C++ language.

The FRIENDS architecture's fault tolerance ability is still very limited due to its weak fault model. However, FRIENDS holds a different philosophy on how to separate fault tolerance mechanisms from application programmers. While other architectures try to make the fault tolerance mechanisms totally transparent to application programmers, FRIENDS tries to distinguish fault tolerant programmers from application programmers; and the fault tolerant programmers' task is to customize meta-object classes and meta-object protocols that should be highly reusable. By this approach, the FRIENDS architecture will be open to any new technologies in the field and also more extensible. Another strength of FRIENDS is that it is fully object-oriented. FRIENDS supports C++ application only.

The Chameleon is a centralized architecture. The fault tolerance manager is able to oversee the whole system. The hierarchical arrangement of managers makes the system more efficient. Chameleon is object-oriented as well, providing the same level of extensibility as the FRIENDS architecture. It has a much better fault coverage than the AQuA and FRIENDS architectures, at the same time, it is not dedicated to critical real-time applications only. It suits a wider range of applications with different dependability requirements. Chameleon makes no assumption about programming language.

Table 1 shows the comparison of the four architectures in fault models, fault detection mechanisms and fault treatment mechanisms. We emphasize that this comparison in no way undermines other effective and efficient mechanisms being supported by each of these individual architectures.

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9.0 Acronyms

ERICA: Error-Resistant Interactively Consistent Architecture

FTMP: Fault Tolerance Multiprocessor

FTPP: Fault Tolerance Parallel Processor

MAFT: Multi-computer Architecture for Fault Tolerance

SIFT: Software Implemented Fault Tolerance

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Neural Engineering: Unraveling The Complexities Of Neural Systems

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University of Waterloo, Waterloo, ON

Abstract

The incredible and often subtle complexity of neural systems may seem like an engineer's nightmare. But, when we examine such systems carefully, they can turn out to be an engineer's dream - a way to learn about robust, complex systems. Using techniques from information theory, control theory, and signals and systems analysis, it is possible to formulate a framework for constructing large-scale, biologically plausible simulations of neural systems. Such simulations help us learn both about how the underlying neural systems work, and about good solutions to the problems faced by such systems.

Sommaire

L'incroyable, souvent subtile complexité des systèmes neuronaux semble être le cauchemar de l'ingénieur. Mais quand on examine ces systèmes soigneusement, ils peuvent devenir le rêve de l'ingénieur - un moyen pour étudier des systèmes robustes et complexes. En utilisant des techniques de la théorie de l'information, théorie du contrôle, et l'analyse des signaux et systèmes, il est possible de formuler un cadre pour construire de grandes et biologiquement plausibles simulations de systèmes neuronaux. Ces simulations nous aident à apprendre comment fonctionnent les systèmes neuronaux sous-jacent et comment obtenir de bonnes solutions aux complexes problèmes faisant face à ces systèmes.

1.0 An engineering approach to neuroscience

Recently, several leaders in neuroscientific research have made independent calls for the development of a theoretical framework that can help unify the field [1]. Such a framework, it is hoped, can provide structure to the chaotic landscape of experimental and theoretical results in contemporary neuroscience. Essentially, these neuroscientists have come to the realization that neuroscience is 'data rich, but theory poor.' That is, generating results regarding neural systems, their components, and their behaviour has become routine. But, there is no established method for integrating such results into a consistent, informative theory of neural systems. As a result, it is difficult to make predictions regarding such systems, and to determine what the most needed experiments on a neural system are.

There are reasons to think that engineering is not going to help provide such a unifying framework. This is because engineers typically deal with systems composed of identical, well-characterized, sparsely interconnected, and often digital parts. None of these constraints apply to neural systems. Neurons are wildly diverse in size (10^{-4}-5 m), transmission speed (2-400 km/h), response curves (orders of magnitude gain for the same stimuli), connectivity (500-200,000 inputs), and temporal dynamics (5-100 ms for synapses alone). But, of course, engineers do not have to focus on digital, identical component systems.

In this article, I briefly describe the results of work that I have been doing with Charles H. Anderson from Washington University School of Medicine. We attempt to show how the complexities of neural systems can be systemmatically understood using quantitative tools standard in engineering. A more comprehensive discussion can be found in our recent book *Neural engineering: Computation, representation, and dynamics in neurobiological systems* [2].

2.0 Three principles of neural engineering

Our research has built on the important contributions of a number of others to understanding neural coding and dynamics [3-6]. Our contribution has been to synthesize these results, extend them to characterize neural computation, and incorporate them into a neurally-relevant version of control theory. The resulting framework is effectively summarized by the following three principles:

1. Neural representations are defined by the combination of nonlinear encoding (exemplified by neuron tuning curves, and neural spiking) and weighted linear decoding (over populations of neurons and over time).

2. Transformations of neural representations are functions of the variables represented by neural populations. Transformations are determined using an alternately weighted linear decoding.

3. Neural dynamics are characterized by considering neural representations as control theoretic state variables. Thus, the dynamics of neurobiological systems can be analyzed using control theory.

In addition to these main principles, we take the following addendum to be important for analyzing neural systems:

- Neural systems are subject to significant amounts of noise. Therefore, any analysis of such systems must account for the effects of noise.

I do not discuss the addendum in detail here, but it is important to note how central it is for properly characterizing real-world, biological systems. Let us consider each of the main principles in more detail.

2.1 Principle 1 - Representation

There are two obvious nonlinearities in neural systems. The first is the neural action potential. This is a rapid, stereotypical depolarization of the neuron that results when the current in the cell body goes over some threshold. These neural 'spikes' effectively convert an analog voltage inside the cell body into a series of delta-function like responses (creating a 'spike train') that are then sent down the axon to subsequent cells. Despite this highly nonlinear temporal encoding, it has been shown that about 95% of the information carried by the action potentials can be recovered using an optimal linear filter (i.e., a first-order Weiner filter) [6].

The second nonlinearity in neural systems is evident in the neuron response function. This function describes the increase in spike rate as a function of input voltage to the cell body. While these functions are generally monotonically increasing, they go to zero abruptly (mathematically a singularity) and saturate. It would be very difficult to encode a stimulus with one such response function. However, neurons generally work in concert to encode any given stimulus. That is, different neurons are sensitive to over-lapping but non-identical parts of the stimulus space. As a result, different neurons provide different, though partially redundant information regarding a stimulus (i.e., the neurons form an overcomplete encoding of the stimulus space). As a result, we can show that the optimal linear population filter provides a good decoding, whose error decreases at a rate of 1/(Number of Neurons), even under noise.

As is well-known from information theory, to properly define a code we must specify both an encoding and decoding. Given the above characterizations of neural responses, we can define such a code over both time and populations of neurons. Mathematically, we can express the following 'population-temporal' code:

$$\sum_n \delta_i(t-t_n) = G_i[\tilde{\varphi}_i \cdot \mathbf{x}(t)] \qquad \text{Encoding} \quad (1)$$

$$\hat{\mathbf{x}}(t) = \sum_{in} \delta_i(t-t_n) * \varphi_i^{\mathbf{x}}(t) \qquad \text{Decoding} \quad (2)$$

where $\sum_n \delta_i(t-t_n)$ is the spike train resulting from $G_i[\cdot]$ which defines the (spiking) neuron response function, $\tilde{\varphi}_i$ are encoders (or 'preferred' stimulus) vectors observable in neurons, and $\varphi_i^{\mathbf{x}}(t)$ are the product of the linear population decoders and the temporal filter, giving a combined 'population-temporal filter.'

2.2 Principle 2 - Transformation

In order to make these neural representations useful, we need to be able to define transformations of these representations (i.e. functions of the encoded variables). In fact, this turns out to be rather straightforward: rather than finding the optimal representational decoders (i.e., those that extract the original variable from the information encoded by the neural spikes), we can find optimal transformational decoders to extract some function of the encoded variable from those spikes:

$$\hat{f}(\mathbf{x}) = \sum_{in} \delta_i(t-t_n) * \varphi_i^{f(\mathbf{x})}(t) \qquad (3)$$

These decoders, $\varphi_i^{f(\mathbf{x})}(t)$, tell us how to implement computations using biologically plausible networks. Notably, both linear and nonlinear functions of the encoded variable can be computed in this manner. In fact, we can use this approach to determine precisely what set of functions can be computed with this linear decoding given a particular population of neurons (i.e. neurons with a particular distribution of nonlinear tuning curves). This can be extremely useful for limiting the set of possible functions a given neural population can compute.

2.3 Principle 3 - Dynamics

Traditional approaches to artificial intelligence, including work on artificial neural networks, have often been criticized for ignoring the importance of temporal constraints for determining successful behaviour. In the biological world, not performing certain behaviours (i.e., computing certain functions) fast enough can mean the difference between life and death. As a result, many contemporary approaches to modeling cognitive systems have elevated dynamics to be of as much importance as representation and computation when trying to understand neural systems.

Adopting this philosophy, we have integrated our characterization of representation and transformation with modern control theory. Control theory is the engineer's tool for describing the dynamics of physical systems and is thus a natural choice for describing neural dynamics. Our central suggestion, which makes the marriage between standard control theory and our description of neural systems possible, is that the variables represented by a neural population are control theoretic state variables.

However, we must do some work to show how this can occur. Standard control theory takes the basic transfer function to be integration. However, neural systems do not perform integration easily, but have their own intrinsic dynamics. Fortunately, we can show that the dynamics of the post-synaptic current (PSC) which results in the dendrite of a neuron that receives a spike is likely to dominate the dynamics of the cellular response as a whole. As a result, it is reasonable to characterize the dynamics of neural populations based on synaptic dynamics. Assuming a simple but plausible model for synaptic dynamics, we can effect a 'translation' between traditional control theory and a 'neural' control theory[1].

For example, in the linear case, the dynamics of a standard control structure are written as:

$$\dot{\mathbf{x}}(t) = \mathbf{A}\mathbf{x}(t) + \mathbf{B}\mathbf{u}(t) \qquad (4)$$

where $\mathbf{x}(t)$ is the vector of state variables, $\mathbf{u}(t)$ is an input or control signal, and $\mathbf{A}$ and $\mathbf{B}$ determine the dynamics. In the neural case, assuming our simple PSC model, we can find two neural dynamics matrices:

$$\mathbf{A}' = \tau\mathbf{A} + \mathbf{I}$$
$$\mathbf{B}' = \tau\mathbf{B} \qquad (5)$$

Importantly, using these new matrices results in the same dynamics in a neural system $\mathbf{A}$ and $\mathbf{B}$ did in the standard control system. This means that all of the tools of control theory, including known control structures, stability analyses, and so on, can be brought to bear on understanding neural systems.

To complete the synthesis, we can now embed this description of the

1: Specifically, we assume $h(t) = \frac{1}{\tau} e^{-t/\tau}$ where τ is the synaptic time constant. More accurate models of PSC generation can be used, but this one makes the analysis more tractable.

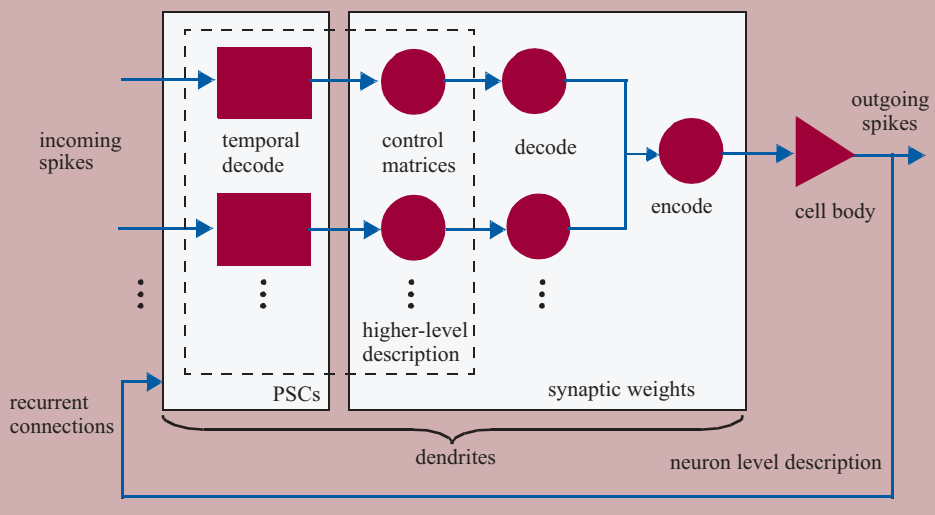

Figure 1: A generic neural subsystem. The labels provide a qualitative description of the function of each of the interior elements (defined in equations (1)-(4)). See text for further discussion.

dynamics of a neural representation directly into our characterization of neural encoding in equation (1). This results in the following general, quantitative description of neural spiking:

$$\sum_n \delta_i(t - t_n) = G_i\left[\tilde{\varphi}_i \cdot h_i(t) * \left[\mathbf{A}'\mathbf{x}(t) + \mathbf{B}'\mathbf{u}(t)\right]\right] \quad (6)$$

where $h_i(t)$ is our PSC model. The functions needed to implement such a neurally embedded control system can, of course, be implemented using principle 2.

2.4 Synthesis - A generic neural subsystem

These three principles quite clearly come together in equation (6). The result can be expressed as defining the 'generic neural subsystem' shown in Figure 1.

In this figure, the interior dotted line indicates the higher-level description of the overall neural dynamics. Separating out these elements can be practically useful because it allows for a computationally cheap means of characterizing the system's behaviour. The exterior dotted line bounds elements usually referred to in a description of neural function: i.e., spikes impact dendrites that give rise to PSCs weighted by a synaptic weight whose effects at the cell body result in the generation of outgoing spikes. The grey boxes indicate the elements that we can now quantify given these principles. Most importantly, we can determine the synaptic connection weights that need to connect this population to its predecessors in order to exhibit the desired high-level behaviour. This alleviates the need for (though does not exclude the possibility of) including learning in constructing neurally plausible simulations.

3.0 Discussion

Taken together, these three principles can serve to direct the construction of large-scale, biologically plausible simulations. This is no more evident than in the numerous simulations we have constructed. Here is a brief description of three:

1. Vestibular system (sensory): This is a large-scale, spiking neuron model that solves a nonlinear control problem: namely, estimating inertial acceleration given linear acceleration (from the otolith organs) and angular velocity (from the semi-circular canals). The model maps well to known vestibular nucleus physiology, and provides predictions regarding the distribution of receptors and tuning curves in the relevant neural populations.

2. Working memory (cognitive): This recurrent spiking model accounts for two phenomena previously observed but that remained unexplained by simulations (parametric variation and multiple target representation in working memory). It simulates parts of the lateral intraparietal cortex, involved in remembering the location of external targets.

3. Lamprey swimming (motor): This spiking model demonstrates the synthesis of top-down and bottom-up data in a model. The result is a novel model that guarantees certain high-level behavior (e.g. swimming stability over a range of frequencies), unlike past models.

In addition, these principles help to unify several central concepts in neuroscience - going some way to systematizing neuroscientific results. For instance, principle 1 unifies population and temporal representation in neural systems via the definition of a population-temporal decoder. As well, principles 1 and 2 taken together provide a unified characterization of representation and transformation (or computation) as optimal linear decoding. Considering all three principles together, we can see how this approach can be used to unify top-down and bottom-up evidence on a single neural system. High-level hypotheses, which inform the control theoretic description of the overall system is integrated with the evidence regarding individual neurons, such as tuning curves and response properties.

As well, the principles are general. While I have here characterized the principles in terms of vector representation, there are equivalent characterizations for scalar and function representations, and their combinations (e.g., vector fields). As well, the characterization generalizes over modeling assumptions made regarding individual neuron behavior (i.e., how neural spikes are generated), transformations (i.e., linear and nonlinear), and dynamics (i.e., time invariant, time varying, linear, nonlinear, or stochastic control).

4.0 Conclusion

While we hope that these principles can provide some needed structure to the many results being generated by neuroscientists, we are careful to remind others (and ourselves) that this is, at best, a 'first guess.' However, because there are not a lot of other theories of this kind on offer, and because a first guess paves the way for better guesses, we think that this framework can play a valuable role in the development of neuroscience. We have greatly benefitted from adopting this view because of the new and important issues and insights it has generated regarding the organization of neural systems. Many of the seeming complexities of neural behaviour (e.g., the heterogeneity of neural responses) become expected once we understand these behaviours as a certain kind of neural representation. Of course, many such questions remain unanswered, but we, and others, have found this framework useful for determining which questions are most worth asking.

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A Smart Motor Controller for E-bike Applications

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Abstract

A smart motor controller for electric bicycle (e-bike) applications is described. The e-bike is a hybrid electric vehicle than can be powered by the cyclist and/or an electric motor. The controller is the first to provide automatic clutch control, which allows the cyclist to coast without the drag from the motor. The controller also supports regenerative braking and includes numerous safety features.

Sommaire

Une commande intelligente de moteur pour bicyclettes électriques e-vélo est expliquée. Le e-velo est un véhicule électrique hybride qui peut être propulsé par le cycliste et/ou le moteur électrique. La commande automatique de transmission de ce e-velo est la première en son genre et permet au cycliste de rouler sans le fardeau du couple du moteur. Le système de commande permet aussi d'avoir un freinage par régénération et renferme plusieurs dispositifs de sécurité.

1.0 Introduction

Hybrid vehicles are rising in popularity due to high fuel prices and growing environmental awareness. The electric bicycle (e-bike) is rapidly emerging as a new form of simple and cost-effective transportation for smog-infested urban areas. The e-bike is a hybrid light electric vehicle (HLEV) that can be powered both by pedals and/or an electric motor. Adapted from the standard bicycle, the additional components of an e-bike include a battery, a motor and an electronic controller. The primary role of the controller is to provide smooth power flow to the motor. There are currently a number of companies specializing in e-bikes such as Currie Technologies, EV Global Motors, and ZapWorld. It has been estimated that in China alone, approximately 300 companies sold over 1 million electric bikes in 2002 [1].

The efficiency of the e-bike is unquestionably superior to the automobile; a simple calculation shows that a typical e-bike requires 50 times less energy per kilometer than a standard car. In addition, as solar panel technology becomes more affordable, the net amount of energy required to power an e-bike can be reduced. For example, roof mounted solar panels could be used to charge spare batteries during the workday. Table 1 gives a perspective on current e-bike technology [2].

In the past, the majority of e-bikes were built by hobbyists, resulting in low-efficiency designs. However, with advances in power electronics and microelectronics, vast improvements have recently appeared on the market. These include the use of high efficiency motors, such as Brushless DC (BLDC) [3], regenerative braking and fault monitoring. A BLDC motor is conceptually similar to a traditional permanent magnet DC motor except that operates without brushes and a mechanical commutator [4]. The stator's magnetic field must be rotated electronically, which increases the motor drive complexity. However, when compared to DC motors, BLDC motors have higher efficiency, superior heat dissipation, increased power density and lower maintenance [5]. Regenerative braking refers to the use of the motor as a generator to capture kinetic energy from the bicycle during braking. The energy is redirected to the battery, increasing battery life and system efficiency.

This paper describes the design and implementation of a high performance BLDC motor drive controller and a test-bench for an e-bike. Our design demonstrates the first e-bike controller that incorporates all of the following features:

- BLDC motor control,
- Voltage, current, temperature and speed protection,
- Adaptive dead-time control in three-phase power-stage,
- Soft-start,
- Automatic clutch control for coasting and regenerative braking.

In addition to the hardware-based controller, the design includes both a mechanical setup to simulate realistic riding conditions and a software interface to allow comprehensive testing through a PC.

Table 1: Commercially Available E-Bike Technology

Characteristics	Min	Max	Units
Battery Voltage	12	36	V
Distance on One Charge	20	80	km
Motor Power	150	500	W
Price	300	2000	USD
Weight	25	40	kg
Recharge Time	4	10	Hours
Battery Capacity	10	30	Ah
Type of Drive	Friction/Belt/Chain/Hub		
Motor Type	AC Induction / Brushless DC / Switched Reluctance / DC Brush		

2.0 Design And Implementation

2.1 Overview

The complete e-bike system includes the controller hardware, as well as a mechanical test-bench. The controller hardware incorporates mixed-

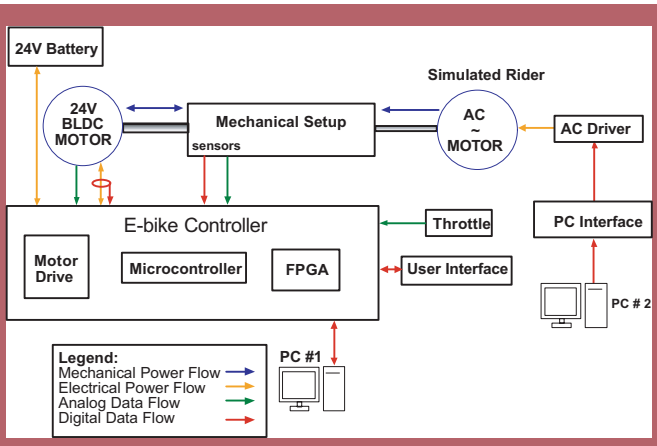

Figure 1: Controller and testbench system.

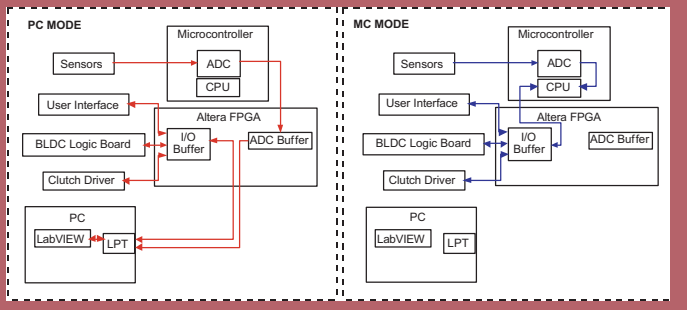

Figure 2: Data flow under PC and MC (microcontroller) mode.

signal circuits, sensors and a user interface for the e-bike cyclist. The mechanical setup, which includes a simulated rider interface, provides a versatile platform on which to test our controller. Figure 1 shows a representation of the e-bike controller and test-bench system.

For testing purposes our controller runs in 2 modes: PC mode and MC (microcontroller) mode. In PC mode the PC handles the controller duties while the microcontroller performs sensor data acquisition and transfers data between its various peripheral devices. This mode is used for testing the general functionality of our system and is essential for determining the effectiveness of the control algorithm. MC mode is the final form of the controller. In this mode the microcontroller acts autonomously to gather data from the sensors and implement the control algorithm. Figure 2 shows data flow under the two operation modes.

The major components of the e-bike system are listed below. Details are provided for several crucial components.

- Mechanical setup
- Rider simulation
- Three-phase BLDC motor drive
- FPGA design
- Speed, temperature and voltage sensor
- User interface
- Throttle filter
- Microcontroller and control algorithm

2.2 Mechanical Setup

A representative diagram of the mechanical setup is shown in Fig. 3. The flywheel simulates the inertia of the bicycle and a computer-controlled AC induction motor is used to simulate the power contribution of the cyclist. An electromagnetic clutch is used to isolate the BLDC motor from the drive-train for reduced friction during coasting.

The BLDC motor uses a three-phase synchronous buck topology that allows bi-directional current flow. The power switches are discrete HEXFETs from International Rectifier. SenseFETs are used as low-side switches to provide current-feedback. The pulse-width-modulated (PWM) gate drive incorporates adaptive dead-time control. This minimizes the dead-time while avoiding large punch-through currents. The three-phase gate drive signal is generated from a single phase PWM by a dedicated decoder as shown in Figure 4. The phases are synchronized using hall-sensor inputs from the BLDC motor.

2.3 Microcontroller and Control Algorithm

In order to model the typical demands of an e-bike, several drive-cycles were obtained in downtown Toronto using a traditional bicycle equipped with sensors and a portable data acquisition system. A drive-cycle is

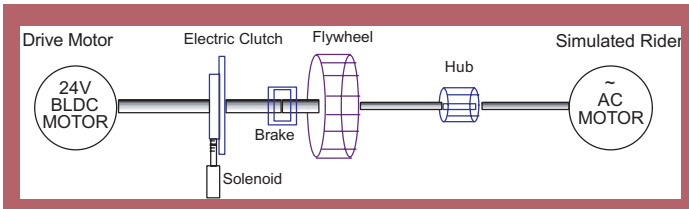

Figure 3: Mechanical setup.

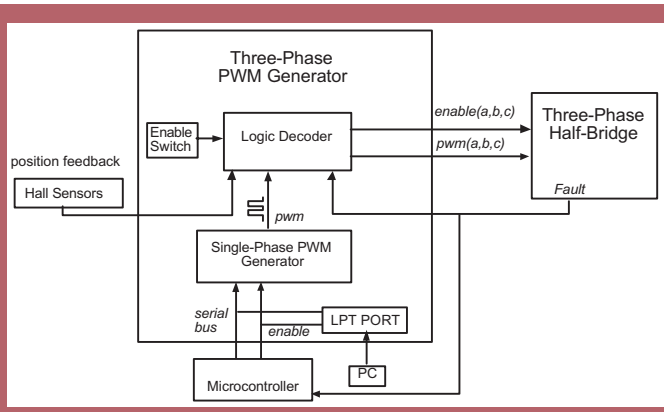

Figure 4: Three-phase PWM generation.

defined as a chart giving the instantaneous speed of a vehicle versus time for a particular terrain. Figure 5 shows an experimental drive-cycle.

The control algorithm was developed in PC mode and then implemented in MC mode using a 68HC11 microcontroller. Using data from experimental drive-cycles the following drive stages were encoded in the drive algorithm:

- Regular driving
- Coasting
- Braking
- Low speed operation
- Motorless operation

During regular driving, the clutch is engaged and the throttle input controls the motor. During the coasting stage, our design allows the rider to coast just as one would on a traditional bicycle by disengaging the clutch. A free-wheel cannot be used as in other e-bike controllers [2] since it does not allow regenerative braking. Our design increases the length of coasting and thus saves valuable energy by disengaging the clutch. The user enters coast-mode by pressing the "clutch request" button, located on the user interface. When this button is pressed, the controller disengages the clutch and waits for the user to fully release the throttle. When the user resumes pressing the throttle, the controller ramps up the motor until the motor speed equals the bike speed and then engages the clutch. The speed control is then transferred back to the user. The rider can signal a braking event by lightly pressing on the brake levers. This signals the CPU to efficiently manage regenerative braking. At this point the CPU must disable the throttle; the PWM signal supplied to the motor is ramped down exponentially to maintain negative motor torque. When the brake is released, the user regains speed control. It should be noted that the e-bike user can also brake manually by fully pressing the levers.

Under all conditions, the PWM signal is disabled if the e-bike speed

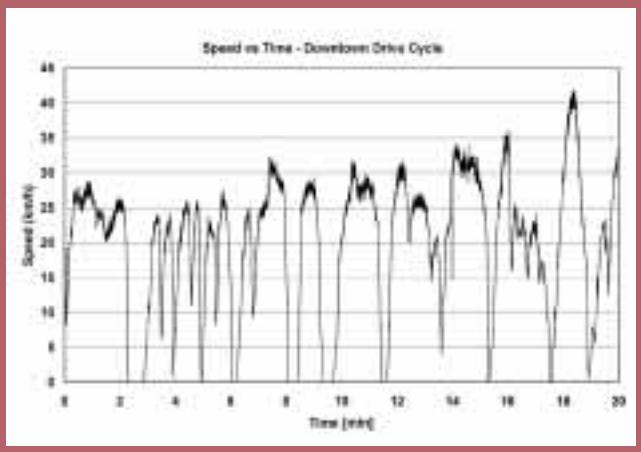

Figure 5: Experimental drive-cycle.

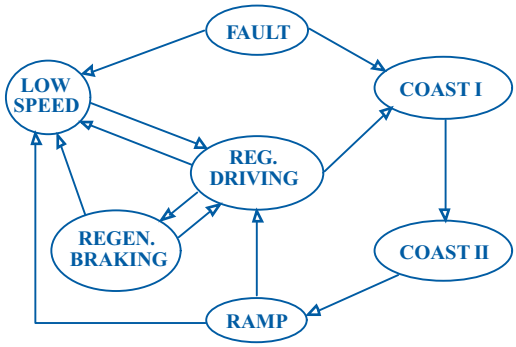

Figure 6: State diagram for control algorithm.

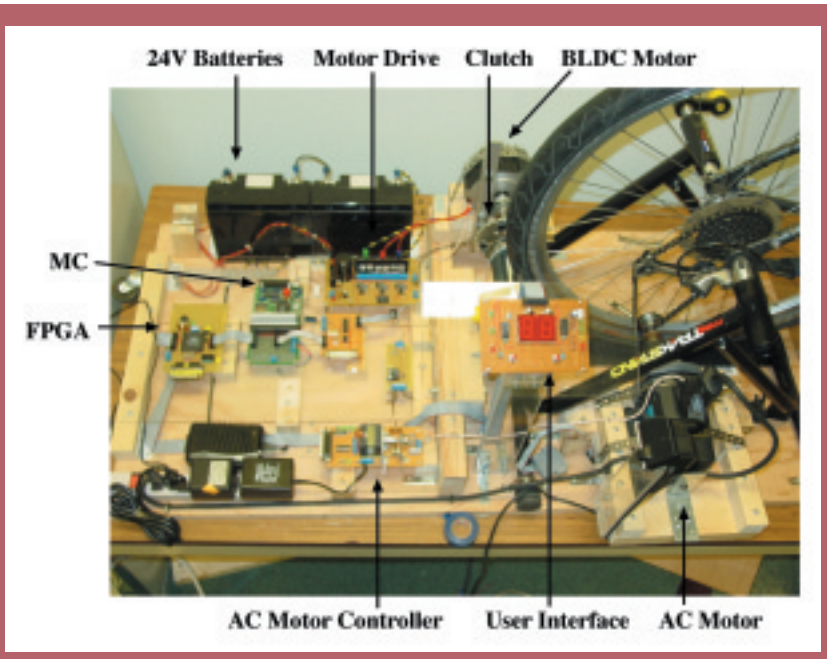

Figure 7: E-bike System.

falls below 5 km/h to prevent damage caused by high currents during low-speed operation. This also protects the motor if the wheel is jammed. A simplified state diagram for the controller algorithm is shown in Figure 6.

3.0 Results

Figure 7 shows the final e-bike controller and mechanical system. Tests have confirmed proper operation of the security features and the controller algorithm. This was demonstrated by programming the AC motor to simulate the behaviour of a cyclist while the e-bike controller carried out the algorithm described in the previous section. Figure 8 shows the GUI used in PC mode and Figure 9 shows the commutation of the motor phases. Final specifications are listed in Table 2.

4.0 Conclusion

An e-bike controller for a BLDC motor has been designed and implemented using low-cost off-the-shelf components. The design includes a versatile mechanical test-bench with a computer-controlled AC induction motor used to simulate the power contribution of the cyclist. The controller is the first to provide automatic clutch control, which allows the cyclist to coast without the drag from the motor. The controller also recharges the battery through regenerative braking for increased efficiency. Having completed the hardware development phase, current efforts are directed toward further algorithm development and system integration. A new research team is currently working on integrating the entire controller onto a single printed circuit board (PCB). Possible future algorithm improvements include adaptive control and battery management based on the terrain and cyclist habits.

Figure 8: PC-mode graphical user interface (GUI).

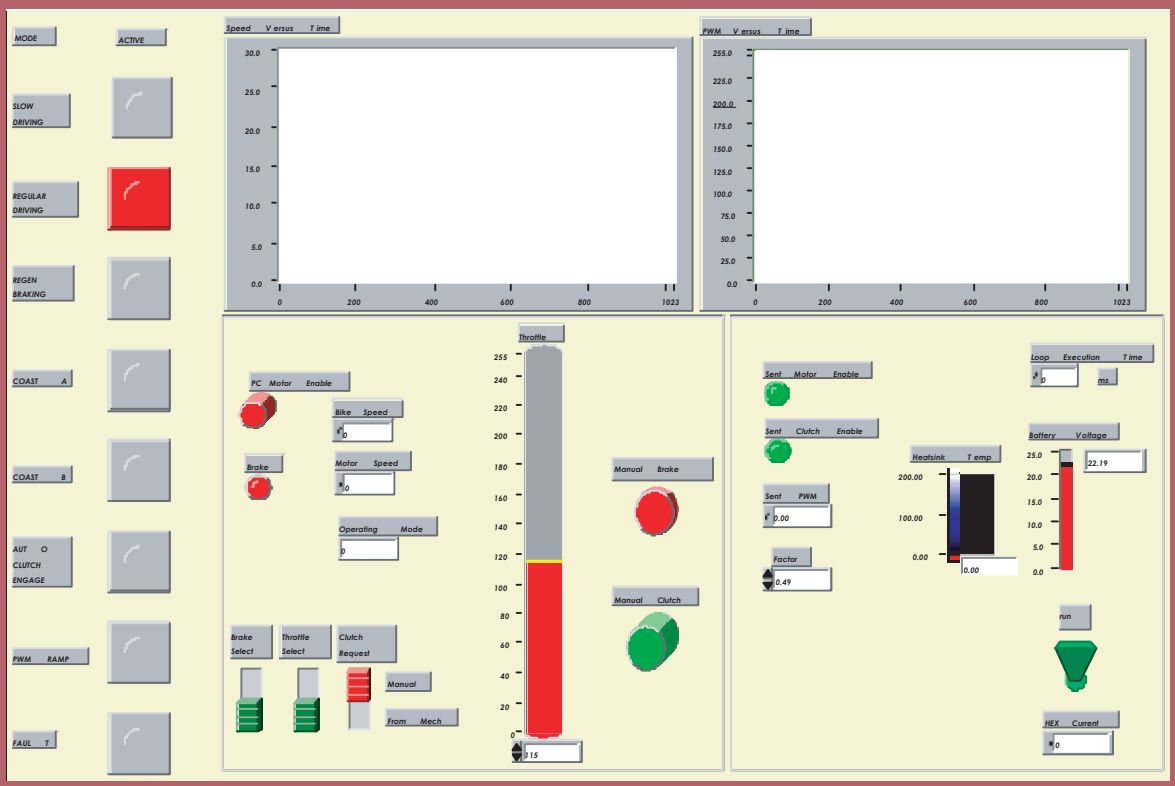

Table 2: Specifications

Module	Relevant Features	Specifications	Value	Units
Motor Drive	Adaptive non-overlap gate drives 3-Phase MOSFETs High-side charge pumps 3-Phase current feedback Temperature feedback Under/Over-voltage lockout Current limiting	Nominal battery voltage	24	V
		Electronic current limit	15	A
		Peak power	360	W
		Electronic heatsink temperature limit	120	C
		PWM switching frequency	25	kHz
		Minimum operating voltage	10	V
Buck Regulator		Output voltage	5	V
		Efficiency	77	%
		Rated current	1	A
		Switching frequency	56	KHz
BLDC Logic Board	Digital PWM LPT (PC) Interface	PWM generator clock frequency	17.4	MHz
		PWM resolution	8	Bits
Micro-controller	Multi-channel ADC Programmable interrupts Serial interface	Clock frequency	2	MHz
		ADC channels	8	
		ADC resolution	8	Bits

5.0 Acknowledgment

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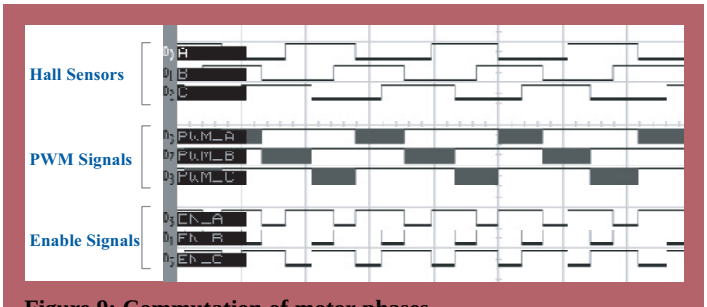

Figure 9: Commutation of motor phases

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Olivier Trescases was born in Paris, France. He received his B.A.Sc. degree in Electrical Engineering from the University of Toronto in 2002, where he is currently pursuing a M.A.Sc. His primary research interests include low-voltage DC/DC converters for microprocessor loads, hybrid vehicle motor controllers and audio amplifiers. He currently holds a Natural Sciences and Research Council Post-Graduate Scholarship. He was awarded the 2002 Gordon Slemon award for his E-bike motor controller prototype. In 2003 he received the IEEE Vehicular Technology Grant and the IEEE Hackbusch Student Paper Award.

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Wai Tung Ng received his B.A.Sc., M.A.Sc. and Ph.D. degrees in Electrical Engineering from the University of Toronto, in 1983, 1985 and 1990, respectively. In 1990 he joined the Semiconductor Process and Development Center of Texas Instruments, Dallas TX to work on LDMOS power transistors for automotive applications. His academic career started in 1992 when he joined the Department of Electrical and Electronic Engineering, University of Hong Kong, where his focus was on device models and circuit design. In 1993, Dr. Ng joined the University of Toronto, and was promoted to Associate Professor in 1998. His current work covers a wide spectrum, ranging from advanced MOS and RF BJT devices, analog circuits, smart power integrated circuits and fabrication processes.

Nanotechnology for the Optical Network

1.0 Introduction

Fiber-optic communications systems (Figure 1), which transmit vast quantities of information over a thin strand of glass, advanced telecommunications dramatically from the 1970's to the present time.

The enabling technologies and architectures of the decade to come have the potential to revolutionize the optical network. Instead of maximizing one parameter - speed - future optical communications systems will need to be simultaneously sensitive and responsive to the competing needs of many users. Optical switches will route information-bearing beams of light from different points of origin into the many different fibers, amplifiers, and nodes of the network. We call these proposed networks agile optical networks - their dynamism is achieved within the optical domain, rather than through electronic switches and routers.

A smart and sophisticated strategy is needed to bring order and reliability to this potentially chaotic environment. Nanotechnology may, through new functions, offer one important path.

For the past ten years, the number of bits of information which can be communicated over a fiber-optic link per unit time - its transmission capacity - has grown at an astonishing rate.

Nanotechnology adds new dimensions and directions to the progress of networking using light. It uses engineering to harness physics and chemistry to enable not just higher speeds, but new capabilities. This nanoscale science could exploit the ways in which matter organizes into regular shapes and structures to integrate many such functions onto a single chip. The diverse functional possibilities of engineering on the nanoscale may help to deliver a new agility to the optical network.

2.0 Physics into novel function

2.1 Linking electrons and photons

Nanotechnology has the capacity to probe the structure and composition of atoms, molecules, and materials. Scientists are now investigating the function of matter and its constituents.

The prospective power of functional imaging in nanotechnology is brought out by a comparison with a breakthrough area in medical research. Functional magnetic resonance imaging (fMRI) allows researchers to follow and localize subtle internal metabolic changes as they occur in response to external stimuli. Structure-function relationships may be traced out and the workings of the brain progressively uncovered.

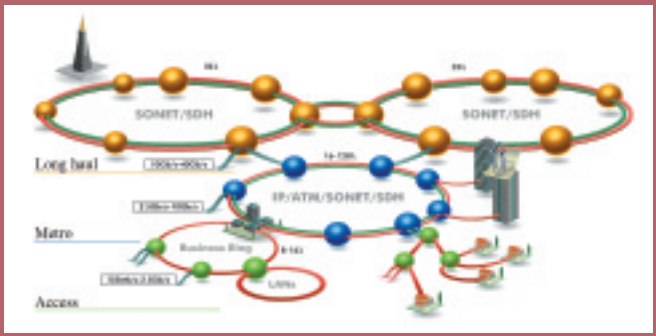

Figure 1: An image of the evolution of the optical network. The reach of the network is extending its reach from long-distance communications toward metropolitan- and local-area networks. Increased dynamism is needed in connecting disparate points in the network as network usage changes in time.

by Prof. Edward (Ted) H. Sargent
Nortel Networks—Canada Research Chair in Emerging Technologies, University of Toronto, ON

Abstract

Instead of maximizing information rate alone, future optical communications will need to be simultaneously sensitive and responsive to the competing needs of many users. Optical switches will route beams of light from different points of origin into the many different fibers, amplifiers, and nodes of the network. A smart and sophisticated strategy is needed to bring order and reliability to this potentially chaotic environment. Nanotechnology may, through new functions, offer the path to harmony. It may add new dimensions and directions to the progress of networking using light. It harnesses new and fundamental physics, chemistry, and engineering to enable not just higher speeds, but new capabilities. This nanoscale science could exploit the ways in which matter organizes into regular shapes and structures to integrate many such functions onto a single chip. The diverse functional possibilities of engineering on the nanoscale may deliver a new agility to the optical network.

I summarize the results of our recent investigations of function-property relationships in multi-quantum well semiconductor lasers as explored through novel electronic scanning probe microscopy techniques. I present our picture of photonic heterostructures, combinations of photonic crystals designed to act upon optical signals in the temporal, spectral, and intensity domains. I finish with a perspective on the potential of nanotechnology in the agile optical network.

Sommaire

En plus de maximiser le débit de transmission de l'information, les communications optiques devront aussi à l'avenir être conscientes de la présence d'une multitude d'utilisateurs concurrents et réagir à leurs besoins. Des commutateurs optiques conduiront des faisceaux lumineux partant de différents endroits à travers les nombreuses fibres, amplificateurs et noeuds du réseau. Une stratégie adroite et sophistiquée est requise pour mettre en ordre cet environnement potentiellement chaotique et pour assurer sa fiabilité.

Les nanotechnologies peuvent, par les nouvelles fonctions qu'elles permettent, apporter au réseau une nouvelle harmonie. Elles ajouteront de nouvelles dimensions et directions à l'évolution de la gestion de réseau par la lumière. Elles exploitent de nouveaux principes fondamentaux en physique, en chimie et en ingénierie pour permettre non seulement des vitesses plus élevées, mais aussi de nouvelles aptitudes. Cette science à l'échelle du nanomètre peut exploiter la façon dont la matière s'organise en formes et en structures régulières pour intégrer plusieurs de ces fonctions sur une seule puce. La fonctionalité diverse possible à l'échelle du nanomètre pourra donner au réseau optique une agilité sans égale.

Je résumerai les résultats de nos récentes études sur les rapports fonction-propriété dans les lasers à semi-conducteurs avec puits multiquantiques, obtenus grace à de nouvelles techniques de microscopie à sonde électronique de balayage (electronic scanning probe microscopy). Je présenterai notre vision d'hétérostructures photoniques, combinaisons de cristaux photoniques conçues pour agir sur les signaux optiques dans les domaines temporel, spectral et d'intensité. Je terminerai en offrant notre perspective sur le potentiel des nanotechnologies dans les réseaux optiques agiles.

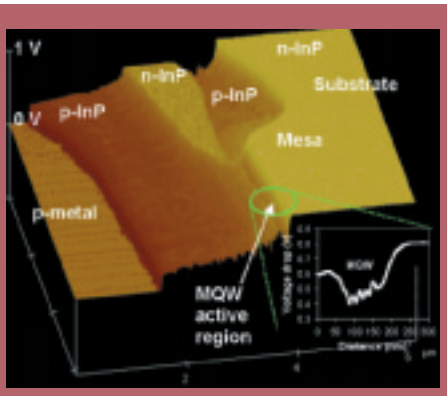

Figure 2: Electrical potential image of a laser while it is producing light. The profile shows the forces which electrons experience in traversing the laser active region

Our research group has recently used a nano-sized probe to study the potential and flow of electrons in a laser emitting an intense beam of light. We have observed - with nanometer resolution - the detailed flow of electrons to and from the laser's active region, and have witnessed how healthy lasers successfully concentrate electron flow into the active region, while electrons bypass the region in unhealthy lasers (Figure 2). Our team uncovered blockages to electron flow and has traced their origins to the early stages of laser crystal growth.

The work illuminates the inner workings of lasers whose performance is critical in building better networks. Fiber-optic communications systems, connecting buildings within a metropolitan area, demand lasers which convert electrons efficiently and rapidly into photons. With the aid of functional imaging of lasers, we can now diagnose and treat impediments to the efficient production of light.

Researchers are turning physics into novel function on many other fronts as well. One research thrust involves the controlled merging of electronic and photonic materials. Materials that control the quantum behavior of electrons must confine these particles to a few nanometers. Quantum dots, or boxes, do just this, since they have dimensions in the dozens of atoms.

In order to control the flow of photons, light must be confined to sizes more on the scale of a micrometer, or one millionth of a meter. Photonic crystals, tiny lattice-like structures that may be able to manipulate light waves just as semiconductors manipulate electrical current, are the prototype for such optical control.

Through a combination of new theory and experiments, our group recently combined engineering on both the electron and photon length scales. Collaborating with the University of Toronto's Dr. Eugenia Kumacheva and her research group, we have grown nanometer-sized quantum dots on the surfaces of micron-sized polymer spheres, and have induced the spheres to organize into regular arrays. Recent developments predict that these structures can enable functions urgently needed in the optical network - in particular, switches which automatically limit the power on an optical signal to a safe level, and which can restore and recalibrate optical pulses that have traveled over different distances. A dynamic optical network urgently requires components which can stabilize the network and groom the optical signals which it conveys.

3.0 Chemistry for integration:

3.1 Planting the seeds to orchestrate growth

The agile optical network needs not only new and complex functions. It needs to combine the monitoring and control of many disparate optical signals onto a convenient platform. Optical integration, wherein many different devices and their associated functions are conveniently combined on a planar substrate, could do for agile optical networks what the electronic integrated circuit did for computing: it could create the foundations of a technology which grows in performance and decreases in cost.

Photonic crystals could be a platform technology for optics just as crystals of silicon are at the foundation of electronic integrated circuits. The crystals allow scientists to control the flow of light. While researchers have been successful in creating a stable photonic crystal, they need to be able to control its placement, order, and configuration on the surface of materials.

Our group recently showed that we could specify how photonic crystals grow on a glass or silicon substrate, determining the pattern of crystal growth or its absence (Figure 3). We also discovered that the shape and size of the openings in their templates governed the properties of the crystals - whether they organized themselves according to square or hexagonal symmetries. These symmetries determine which wavelengths of light will be trapped and which ones will flow inside photonic crystals. Controlling this flow is the basis for developing a successful photonic circuit.

4.0 Science-Technology Convergence:

4.1 Chemistry and Physics for Information Technology and Medicine

Nanotechnology can do much more than enable a dynamic optical network. It creates an abundance of connections between biological and physical sciences and engineering. Living organisms are a triumph of the genesis of complex macroscopic structure and function out of nano-sized genetic material. Optical networks engineers have much to learn from the genius of the biological world in creating robust complex function out of nanoscopic building blocks. At the same time, they have much to give: with healthcare costs and expectations rising rapidly, integrated advances in information and medical technology offer a solution to enhancing quality of life in a world with finite resources. Nanotechnology may play an important enabling role - from the bottom up.

5.0 Further Reading

[1]. Reprints of the research papers discussed herein: http://light.utoronto.ca/reprints

[2]. U.S. National Nanotechnology Initiative http://nano.gov/nsetrpts.htm

[3]. Nanotechnology: National Consultation on the Nanotechnology Industry in Canada - within Canada's Innovation Strategy http://www.innovationstrategy.gc.ca/cmb/innovation.nsf/SectorReports/Nanotechnology

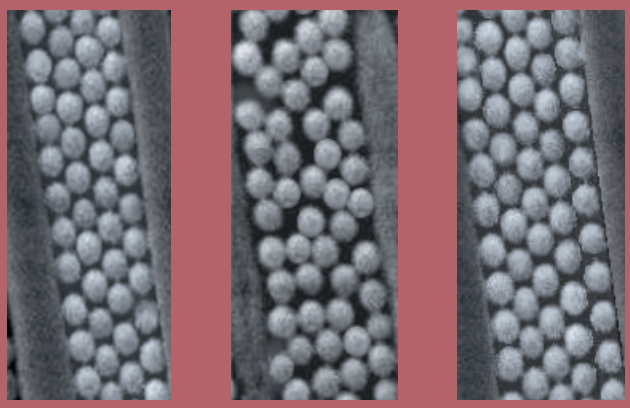

Figure 3: Bottom-up self-organized spheres whose placement and order are programmed by top-down templating.

About the author

Ted Sargent holds the Nortel Networks - Canada Research Chair in Emerging Technologies at the University of Toronto. In 2002, the Canadian Institute for Advanced Research named Prof. Sargent one of the nation's top twenty researchers under age forty across the natural sciences, engineering, and the social sciences. In 2002, he won the IEEE Canada Outstanding Engineer Award for "for ground breaking research in applying new phenomena and materials from nanotechnology towards transforming fibre-optic communications systems into agile optical networks."

L'Institut canadien des ingénieurs ? Un organisme essentiel pour l'avenir du génie au Canada

par Guy C. Gosselin,
EIC, Ottawa, ON

1.0 Histoire et mandat

L'Institut canadien des ingénieurs (ICI), qui fut jadis la plus importante association dans le domaine du génie au Canada, continue de jouer un rôle important dans la vie d'une profession regroupant diverses disciplines.

Fondée à Montréal, en 1887, en vertu d'une charte royale, la "Canadian Society of Civil Engineers" avait pour objectif de diffuser les renseignements et les expériences techniques. Vingt-cinq années plus tard, elle comptait 3,000 membres et regroupait des disciplines comme le génie mécanique, le génie électrique et le génie minier. Afin de mieux refléter ce caractère multidisciplinaire, le Parlement amendait, en avril 1918, la charte de la Société, qui devenait L'institut canadien des ingénieurs (ICI).

L'ICI a poursuivi sa croissance. Au début des années soixante, elle comptait plus de 22 000 membres, à travers tout le pays. Comme c'est le cas dans beaucoup de gros organismes, l'organisation de services pour une aussi vaste gamme de membres représentait un énorme défi. On a donc accordé une importance plus grande aux divisions techniques de l'ICI en en faisant des "sociétés", qui finirent par obtenir un statut de société autonome. De nos jours, l'ICI est devenu une fédération regroupant ces sociétés.

Chronologiquement, la première de ces sociétés fut la Société canadienne de génie mécanique **(SCGM)**, constituée en 1970. Elle fut suivie par la Société canadienne de génie civil **(SCGC)** et la Société canadienne de géotechnique **(SCG)**, en 1972, et la Société canadienne de génie électrique **(SCGE)** en 1973, devenue **IEEE Canada** à la suite d'une fusion avec la région no 7 de la IEEE. D'autres membres de l'ICI se sont intégrés au Groupe des membres généralistes, qui s'est depuis transformé en Société canadienne de gestion en ingénierie.

De nouvelles sociétés se sont également jointes à cette fédération qu'est l'ICI, dont : la Société canadienne de génie chimique **(SCGCh)**, en 1998, la Société nucléaire canadienne **(SNC)**, en 2001, et, encore plus récemment, la section maritime canadienne de la Société de technologie marine **(STM)** et l'Organisation des membres à vie **(OMV)**. Le nombre total de membres au sein des neuf sociétés membres dépasse 20,000, et l'ICI est toujours prêt à accueillir d'autres sociétés reliées à la profession d'ingénieur.

2.0 Les services de l'ICI

Le mandat fondamental de l'ICI est de rendre service aux sociétés membres en offrant des services communs qui enrichissent la valeur de l'appartenance de chaque membre à ces sociétés. L'ICI encourage l'épanouissement de toutes les professions reliées au génie en faisant la promotion de normes de qualité en matière de formation permanente et d'activités de perfectionnement.

Voici un aperçu des services offerts par l'ICI, et qui sont autant d'avantages additionnels que vous offre votre qualité de membre de l'ICI. Pour obtenir plus de renseignements, consultez le site web de l'ICI, à l'adresse suivante (www.eic-ici.ca).

Un authentique forum permettant aux sociétés membres de partager leurs renseignements et leurs expériences. Un conseil d'administration formé des présidents de chaque société membre, et un petit exécutif, dirigent l'ICI. Les réunions du c.a. et les ateliers permettent aux sociétés de mettre en commun leurs meilleures pratiques et de discuter des préoccupations de la profession.

Un forum virtuel est offert aux membres par le truchement du site web de l'ICI. Il offre le nouveau **"Centre d'affaires des ingénieurs"**, qui permet de consulter les occasions d'affaires, diverses activités, diverses offres, les emplois disponibles, les communiqués de presse, les demandes à Dun & Bradstreet et les réponses fournis par diverses personnes-ressources.

L'assurance pour les administrateurs est achetée pour l'ensemble des sociétés membres, ce qui réduit les frais d'assurance pour chaque société.

La représentation des sociétés membres lors des réunions avec d'autres organismes nationaux de la profession, comme le Conseil canadien des ingénieurs **(CCI)**, l'Académie canadienne du génie **(ACG)**, l'Association des ingénieurs-conseils du Canada **(AICC)**, le Partenariat en faveur des sciences et de la technologie et les Ingénieurs pour le secours en cas de catastrophe **(RedR-Canada)**.

Des normes reconnues en matière de formation permanente et de perfectionnement ont été adaptées par l'ICI pour correspondre aux besoins de la profession au Canada, et des ententes sont maintenues avec des **Fournisseurs de qualité** qui décernent des unités de formation permanente **(UFP)** de l'ICI aux personnes qui participent à leurs programmes.

Un registre des UFP est tenu par l'ICI, où les ingénieurs peuvent consigner leurs expériences en matière de perfectionnement et de formation permanente. Il suffit de signifier à un fournisseur reconnu par l'ICI que vous désirez faire enregistrer vos UFP auprès de l'ICI, et les inscriptions au registre seront effectuées. Vous pourrez ainsi compter sur un dossier facilement utilisable attestant de toutes vos activités en matière de formation permanente, et le tout est garanti par un organisme tiers jouissant d'une grande crédibilité.

Un registre des activités de perfectionnement fait également partie du site web de l'ICI, où les ingénieurs peuvent consigner leurs Heures de perfectionnement (HP). Nombre d'organismes de régie des professions reconnaissent les HP comme étant une mesure valable des activités de perfectionnement pour lesquelles il n'y a pas d'UFP. L'usage du registre est gratuit et confidentiel (protégé par un mot de passe) ; vous pouvez ainsi garder votre propre dossier à jour, et imprimer votre propre dossier à partir de votre propre ordinateur.

Le programme des **Prix, distinctions honorifiques et "fellows"** de l'ICI représente le programme de récompense le plus prestigieux pour toutes les sociétés membres. À tous les ans, 20 membres des sociétés reçoivent le titre de "fellow", et jusqu'à six prestigieuses médailles sont attribuées à l'occasion d'un banquet très couru.

Le comité des **Affaires historiques et des archives** rend service à l'ensemble de la profession au Canada en recueillant des renseignements, en publiant des communications, et en faisant reconnaître, par le public, les grands ingénieurs canadiens, et en voyant à ce que des plaques commémoratives soient installées sur les lieux historiques du génie au Canada. Le président du comité des affaires historiques de la **SCGC** fait partie de ce comité de l'ICI.

3.0 En guise de conclusion…

L'ICI a connu beaucoup de changements au cours des 116 années de son histoire, mais elle a toujours eu une constante : son dévouement total pour l'avancement de la profession. Aujourd'hui, cette mission s'articule autour des activités suivantes :

- La promotion de la coopération entre ses sociétés membres, de façon à assurer des normes de qualité supérieure ainsi qu'un registre national pour la formation permanente et le perfectionnement.
- Aider à améliorer l'image de la profession
- Souligner l'excellence du génie canadien par ses prix et ses récompenses
- Sensibiliser le public à l'importance de l'histoire du génie canadien

The Engineering Institute of Canada? Its continued relevance to the future of engineering in Canada

by Guy C. Gosselin,
EIC, Ottawa, ON

1.0 History and Mandate

Once the largest engineering association in Canada, the Engineering Institute of Canada (EIC) still plays an important role in the affairs of a diverse Canadian engineering community.

Founded by Royal Charter in Montreal in 1887 as the Canadian Society of Civil Engineers, its objective was the dissemination of technical information and experience. Twenty-five years later, membership had grown to 3000 and embraced other disciplines such as mechanical, electrical, and mining. To better reflect this multi-disciplinary nature, the Society's Charter was amended by Parliament in April 1918, to The Engineering Institute of Canada.

The EIC continued to grow and, by the early 1960s, membership exceeded 22,000 throughout Canada. Like many big organizations, the provision of services to a diverse membership became a challenging task. More profile was given to the EIC technical divisions by renaming them 'societies' and these eventually gained autonomy through incorporation. The EIC now represents a federation of these societies.

Chronologically, the first among these was the Canadian Society for Mechanical Engineering **(CSME)**, incorporated in 1970, followed by the Canadian Society for Civil Engineering **(CSCE)** and the Canadian Geotechnical Society **(CGS)** in 1972 and the Canadian Society for Electrical Engineering **(CSEE)** in 1973, now known as **IEEE Canada** through a merger with Region 7 of IEEE. Other EIC members joined a General Members' Group, later re-formed as the Canadian Society for Engineering Management **(CSEM)**.

New societies have since joined the EIC federation ? the Canadian Society for Chemical Engineering **(CSChE)** in 1998, the Canadian Nuclear Society **(CNS)** in 2001, and more recently, the Canadian Maritime Section of the Marine Technology Society **(MTS)** and the Life Member's Organization **(LMO)**. Total membership within the nine member societies exceeds 20,000 and the Institute remains open to the inclusion of additional engineering-related societies.

2.0 EIC Services

The fundamental mandate of the EIC is to serve its member societies by providing shared services that enhance the value of individual membership in those societies. The EIC fosters the development of all engineering professions by promoting quality standards for continuing education and professional development activities.

Here is a glimpse of EIC's services that come as additional benefits through your CSCE membership. Please visit EIC's website for further details **(www.eic-ici.ca)**.

A real forum is provided for the exchange of experience and information between member societies. A Council comprised of presidents of each member society and a small executive governs the Institute. Meetings of this Council and workshops provide opportunities for societies to share best practices and discuss issues facing the profession.

A virtual forum is provided through EIC's website. It hosts a new **"Engineers Business Centre"**, used for posting and reviewing opportunities, events, offers, jobs, news releases, queries to Dun & Bradstreet and questions answered by resource persons.

Director's Insurance is purchased as a group for all member societies, significantly decreasing the cost to each society.

Representation of member societies at meetings with other national engineering bodies such as the Canadian Council of Professional Engineers **(CCPE)**, the Canadian Academy of Engineering **(CAE)**, the Association of Consulting Engineers of Canada **(ACEC)**, the Partnership Group on Science and Engineering **(PAGSE)** and Registered Engineers for Disaster Relief **(RedR)** Canada.

Recognized standards for the delivery of continuing education and training have been adapted by the EIC to meet Canadian engineering needs and agreements are maintained with **Quality Providers** that award the EIC Continuing Education Unit **(EIC CEU^{TM})** to participants in their programs.

A CEU Registry is maintained by the EIC, which engineering practitioners can use to record their high quality professional development experiences. Simply signify to the EIC-recognized training provider that you want your CEU award recorded with EIC, and the Registry will be updated accordingly. The advantage to you is the ability to maintain a readily retrievable, safe and complete record of your recognized continuing education activities with a credible third-party organization.

A Professional Development Registry is also maintained on EIC's website so engineering practitioners can record their Professional Development Hours (PDH). Many licensing bodies recognize the PDH as a valid measure of professional development activity that cannot be awarded CEUs. You can use the Registry freely and in confidence (password-protected) to keep your own record of professional development activities, and you can print your records from your computer.

The **Honours, Awards and Fellowships Program** of the EIC represents the highest of the recognition programs of its member societies. Each year, 20 society members are recognized as Fellows and up to six prestigious medals are awarded at a well-attended banquet.

The **History and Archives Committee** serves the Canadian engineering community by collecting information, publishing papers, lobbying for public recognition of great Canadian engineers and ensuring that historical plaques are installed at sites appropriate to the engineering history of Canada. The CSCE History Committee Chair sits on this EIC Committee.

3.0 Conclusion

The EIC has gone through many changes over its 116-year history, but one aspect has remained constant: its dedication to the advancement of the engineering profession. Today, its mission is focussed on:

- Promoting cooperation between its member societies to ensure high quality standards and a national registry for continuing education and professional development.
- Assisting in promoting the good image of the profession
- Recognizing Canadian engineering excellence through EIC Honours and Awards
- Promoting the awareness of Canadian engineering history

About the author

Guy Gosselin, P.Eng, MBA, is Manager of Industry Liaison and Outreach at the Institute for Research in Construction, National Research Council Canada. He has enjoyed a varied career at the NRC over the last 22 years covering fire research and investigations, technical and business development related to the National Building and Fire Codes, and the evaluation of innovative construction products.

Mr. Gosselin is a Past-President of the Society of Fire Protection Engineers' Ottawa Chapter and a former Treasurer of both the Engineering Institute of Canada and the Canadian Society for Civil Engineering. Mr. Gosselin is currently serving as President of the Engineering Institute of Canada. He is also Vice-Chair of RedR Canada, a non-profit organization training engineers for disaster relief work.

Reflections on Managing Technology in the New Economy:

The 2002 IEEE International Engineering Management Conference.

by Terrance Malkinson
IEEE Canada, Calgary, AB

The 2002 IEEE International Engineering Management Society Conference Managing Technology for the New Economy was held August 18-20, 2002 at St. Johns College of the University of Cambridge, United Kingdom. The University of Cambridge originated in the year 1318, and attracts students of excellence globally to its thirty-one self-governing colleges. Research is of importance and since the beginning of the twentieth century more than eighty university members have won Nobel prizes.

St. John's College proved to be a venue of excellence for the conference. Most conference delegates were accommodated in the college residence adjoined to the modern Fisher Building Conference Center. This facilitated discussion and networking among participants. Submissions from some 35 countries were received, resulting in a program of over 164 presentations. These presentations offered stimulating insights into emerging approaches for managing technology, organizations, and individuals, in order to achieve success and growth in today's turbulent business environment.

1.0 Plenary Addresses by Distinguished Industrialists

A series of plenary addresses by distinguished industrialists who shared their wisdom and experiences in managing organizations in the New Economy was a highlight. The conference opened with a plenary address "nurturing innovation" by Dr. Lewis Terman, President IBM Academy of Technology. The IBM Corporation has a distinguished record of innovation leading the world for the last nine years in issued U.S. patents. Dr. Terman discussed the IBM programs that stimulate, recognize, and reward the creativity of its employees. Important to success is support from the highest level of management. The afternoon's plenary address "creating value for science - The New Alchemy" by Sir John Chisholm, Chief Executive Qinetik Group discussed the challenge of creating value from science and how the Qinetik model works as one large science provider. Starting the second day of the conference Sir Robin Saxby, Executive Chairman ARM Holdings discussed how the creation of a new business model for the exploitation of ARM chip architecture technology now licensed to 90 semiconductors partners globally. ARM technology is at the heart of 80% of the world's mobile phones and is used in many consumer products. This was followed in the afternoon by Mr. Chris Earnshaw, Chief Technology Officer British Telecommunications. Discussing new approaches adapted by BT to stimulate innovation and exploit creativity. This was enabled by building partnerships with an extended network of commercial and academic organizations as well as by developing new ways to acquire, retain, and reward its employees. Dr. Hans Thambain who was IEEE Engineering Manager of the Year in 2001 presented the final Plenary Address. Dr. Thamhain shared with conference delegates his view of the best practices of team leadership and his recommendations of tools and techniques for effective teamwork in technology-based work environments.

2.0 General Sessions

In the general sessions 164 presentations were delivered all of which stimulated lively discussion and provided valuable learning experience to conference participants. A host of topics were covered including: Aligning Business and Technology Strategies; Organisational Learning; Knowledge Management; Managing, Sustaining, and Financing Innovation; Managing Complex Systems; Management of R & D; E-Business Strategies and Processes; Managing ICT and Software Technology; Effective Engineering Management; Technology Transfer/ Technology Acquisition; and Decision Support Systems. Distinguished academics, business people, and students all contributed and shared insights of value to the professional development of all.

3.0 Common Themes Emerging from the Conference

One of several common themes emerging from the speakers is that an organization's failure is seldom attributable to the employee but rather is a result of management failure. Another is the importance of having engineering and technical expertise in management. Inquisitiveness is a necessary personal characteristic necessary for career success. You should not fear failure or be punished for taking reasonable risks many of which may fail. Employees are motivated by external recognition of their work, people who are properly motivated do whatever is necessary to get the job done in the finest possible way. It is important that employees that they find their work interesting and challenging and that management treats them with respect. Employees should be committed to success and actively seek ways of removing barriers to success. This will result in a satisfied work force that will produce quality products and services ensuring competitive success in today's competitive work environment.

4.0 Networking and Conversation

In addition to the technical sessions a full social program was organized keeping delegates busy in the evenings and giving them the opportunity to network and converse under relaxing conditions. An example of this was the farewell reception hosted in the Fitzwilliam Museum. This museum is distinguished for its architecture, its fine collection of Egyptian, Greek, and Roman antiquities and paintings by Titian, Rembrandt, and Gainsborough.

5.0 Importance of Professional Conferences

In an earlier article (IEEE Society Conferences and Their Value to Your Career. Today's Engineer April, 2002) I discussed the importance of participation in conferences. In today's economy the development of an information network is critical to career success. Conference attendance provides you with the opportunity to meet and discuss with others who are role models, who can provide career advice, and who may act as mentors and references as you advance in your career. Conferences provide you with the opportunity to get to know your peers, competitors and leaders as individuals in a relaxed and friendly atmosphere. This is one of the best ways of finding out where the job opportunities are, what skills are in demand, and what the future may hold so that you can be proactive in your career management. The most successful people are those who have a mind prepared by making the effort to become knowledgeable and therefore gaining insights into the future - they are forward thinking.

Copies of the conference proceedings are available from the IEEE Services Center Catalogue # 02CH37329. Next years conference will be held in Albany, New York, November 1-3, 2003.

Terrance Malkinson is a proposal manager/documentation specialist; a Senator of the University of Calgary; Today's Engineer's international correspondent; and editor of IEEE Engineering Management Society Newsletter. Opinions expressed are those of the author.

Wireless OFDM Systems - How to make them work?

Edited by

Marc Engels, IMEC, Belgium

Published by

Kluwer Academic Publishers

ISBN 1-4020-7116-7

Book Reviewed by

Zongsen Wu, Shaowen Song and Tianying Ji
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The basic idea of multicarrier modulation was introduced and patented in the mid 60's by R.W.Chang: the available bandwidth W is divided into a number Nc of subbands, commonly called subcarriers or subchannels, each of width .f=W/Nc . Data symbols are transmitted in parallel by modulating the Nc carriers. To assure a high spectral efficiency, the subchannel waveforms must have overlapping transmit spectra. They need to be orthogonal for enabling simple separation of these overlapping subchannels at the receiver. Multicarrier modulations that fulfill these conditions are called Orthogonal Frequency Division Multiplex (OFDM) system.

Although the principle of OFDM communication has been around for several decades, it was only in the last decade that it started to be used in commercial systems. The most important wireless applications that make use of OFDM are Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB), wireless local area networks (WLAN), and more recently wireless local loop (WLL). Although the theory of OFDM is well understood, implementation aspects of OFDM system are seldom discussed. This book fills this gap and gives a comprehensive overview of the implementation of OFDM systems. The book capitalizes on the large experience of the authors with the implementation of OFDM base WLAN system.

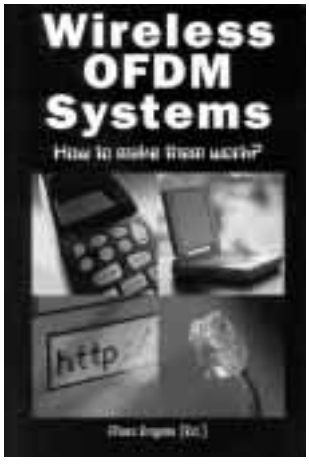
This book consists of eight chapters. The first chapter is an introductory which reviews the extraordinary success of the Internet and the digital mobile communication. This chapter also briefly introduces wireless OFDM systems: DAB, DVB and WLAN.

In Chapter 2, the indoor wireless environment is discussed. Knowledge of the propagation property is essential for several aspects of the receiver design. The first task in any wireless system design is to establish an accurate channel model.

Next, the book reviews the OFDM in chapter 3 and provides a system model tha serves as a reference in the remainder of the book. Besides an overview of well-known theory, the chapter contains also some new materials on introduction of Doppler effect in this system model.

The fourth chapter introduces the WLAN standards. Most materials in this chapter deal with physical and medium access control layers of the HIPERLAN/2. However, a comparison with the IEEE 802.11a and Japanese HiSANa standards is also included.

The next two chapters are devoted to baseband implementation challenges. In chapter 5 several channel estimation algorithms are presented. The book shows that large performance differences exist between the estimation methods. In chapter 6, various synchronization problems and solutions for OFDM modems are examined.



An OFDM transceiver does not only consist of a bandband circuit but also needs a radio that translates the signal to and from its carrier frequency. Several effects of this radio part have a considerable influence on the performance of the OFDM system. These effects are analyzed in detail in Chapter 7.

Finally, chapter 8 puts everything together and shows some practical implementation of OFDM systems involving wireless OFDM transceivers. The authors concluded with the question that how far we are away from the optimum? Two examples, automatic gain control and power-efficient transmission, are presented at the end of the book.

In summary, this book focuses well on OFDM. It covers most of the related topics within 200 pages. For those who study or work on broadband communication in a wireless multipath environment, this book is a useful and easy-to-read reference monogram. We would like to see some improvement on the quality of the graphics in future editions.

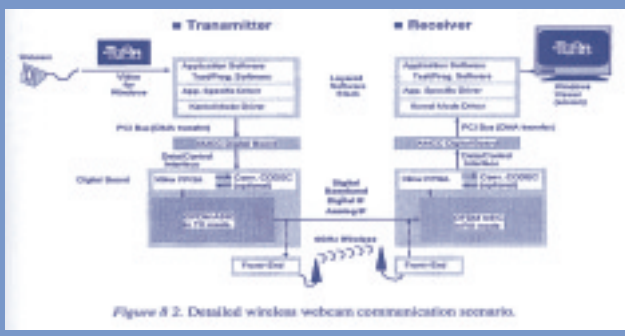


Figure 8 2. Detailed wireless webcam communication scenario.

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The CR Editor acknowledges the support of Mr. Alex Greene (email: Alex.Greene@wkap.com), Kluwer Academic Publishers for his support of this Book Review.

Obituary

Dr. Do Xuan-Dai, 1945-2003, passed away at home March 6, 2003 at the age of 58. He leaves his wife Mrs Marielle Haché, a son Daniel, his mother and numerous relatives and friends. Dr. Do was coordinator of the IEEE Ecole Polytechnique Student Branch. He taught Electrical Networks to many generations of engineers and researchers.

En Memoriam

Dr. Do Xuan-Dai, 1945-2003, est décédé à son domicile le 6 mars 2003 à l'âge de 58 ans. Outre sa conjointe Mme Marielle Haché, il laisse dans le deuil son fils unique Daniel, sa mère ainsi que de nombreux parents et amis. Dr. Do était le coordonateur de la branche étudiante IEEE de l'Ecole Polytechnique. Il a enseigné à plusieurs générations d'ingénieurs et de chercheurs en réseaux électriques.

2003 IEEE Herman Halperin Electric Transmission And Distribution Award

Sponsored by Herman and Edna Halperin

Awarded to:

P. SARMA MARUVADA (F'IEEE) - Consultant, Quebec, Canada

"For contributions to the understanding and characterization of electromagnetic fields and corona phenomena associated with high voltage AC/DC overhead transmission lines."

IEEE Canada News

2002 IEEE Canada Student Paper Competition

The winners of the 2002 IEEE Canada Student Paper Competition are announced. For each of the three Councils in IEEE Canada (Western, Central and Eastern), there are three awards. The first one is the IEEE Life Member Award that is granted to the best overall paper, which consists of a prize of $400 per team. When this award is granted, two other awards are granted amongst the remaining papers, with the Hackbusch Award going to the best paper by University student(s) and the Palin Award to the best paper by College student(s). These two awards consist of a $250 prize per team. In addition to the cash prizes, the winners receive a congratulatory letter and certificate. The titles of the winning papers as well as the name(s) of their author(s) are also published on the IEEE Student Paper Contest Hall of Fame web site. For further information, contact:

Dominic Rivard, P. Eng.

Region 7 (IEEE Canada) Regional Student Activities Coordinator

E-Mail: d.rivard@ieee.org

2002 IEEE Canada Student Paper Competition Awards

Western Canada Council:	*Central Canada Council:*	*Eastern Canada Council:*
Life Member Award (best overall paper)		
Experimental Verification of Microwave Detection of Breast Cancer Jeff Sill University of Victoria, Victoria, BC	**Self-Erecting Inverted Pendulum: Swing up and Stabilization Control** Stephen McGilvray Lakehead University, Thunder Bay, ON	**Wavelength-Switchable, Dual-Wavelength Erbium-Doped Mode-Locked Fiber Laser** Dominik Pudo and KahnLi Lim McGill University, Montreal, QC
Hackbusch Award (best paper by university student(s))		
Electronic Third Brake Light Controller and LED Brake Light Heather Clancy, Dawn Friesen, Greg Sawatzky and Jason Zabolotney University of Saskatchewan, Saskatoon, SK	**Smart Motor Controller for an E-bike** Olivier Trescases University of Toronto, Toronto, ON	**Wireless Gambling Prevention System (WGPS)** Taimoor Majeed and Shashank Bommaganti Dalhousie University, Halifax, NS
Palin Award (best paper by college student(s))		
Automated Wire Dispenser Tim Stampe and Colin Mantay Red River College, Winnipeg, MB	No award	No award

IEEE Canada

Guidelines for submitting an article to the IEEE Canadian Review

Contact any one of the Associate Editors (address information is available on page 2 of this journal). A short abstract should be sent in and will be reviewed before approvals are given for a full paper submission.

Follow these broad-based guidelines for paper preparation:

- Papers (in English or French) must be on topical subjects of interest to the vast majority of our members across Canada,
- Papers selected for the CR are not the type that would normally be submitted to a Conference or Transactions/Journal type of publication. Any mathematical material must be kept to a minimum,
- Papers are normally about 4 pages long (about 2000 words), but articles can be as short as 1 page or as long as 6 pages,
- Submit text in ascii (or WORD) format, as well as a typeset version in PDF format,
- Graphics and images can be in either Grayscale or Colour: Graphics should be scanned at 300 dpi at minimum of 8 bit and submitted electronically in either jpeg, gif or tiff formats.
- A short Abstract (about 200 words) in English and French (we can provide assistance in translation) is required,
- A short biographical note (about 150 words) about the author(s) is also required, together with a passport size photo,
- For samples of previously published articles, see our website at **www.ieee.org/reg/7**, and follow the links to the *IEEE Canadian Review*,
- Items are normally submitted on-line directly to the Editor,
- We particularly encourage articles from small businesses on topics in electrical, electronic, computer or telecommunications related industries etc.
- We encourage academic institutions to present their new programs so that the community is aware of recent program changes,
- Newsworthy items such as senior appointments in academia and industry are also welcome.

For further information, contact Vijay Sood, Managing Editor, at:

v.sood@ieee.org

Phone: 450-652-8089

IEEE Toronto Is Almost 100 Years Old

by Bruno Di Stefano
IEEE Canada, Toronto, ON

The IEEE Toronto Section was formed on September 30, 1903 as a section of the American Institute of Electrical Engineers (AIEE). It was the first such section formed outside the United States. This was 18 years after Thomas Edison and Alexander Graham Bell formed the AIEE, 6 years after the formation of the Canadian Society of Civil (non-military) Engineers - to become the Engineering Institute of Canada (EIC) in 1912, and 9 years before the formation of the Institute of Radio Engineers (IRE). The Canadian Section of the IRE was formed in Toronto in 1925. The AIEE and IRE merged in 1963 to create IEEE, and IEEE Canada was created in 1994 with ties to both IEEE and EIC. Before 1912, the formation of IRE, local entities were creatures of the AIEE. The www page at http://www.ieee.ca/history/sections/first20.htm records the first 20 sections formed under the AIEE banner. Toronto was the first and only section to be formed outside the United States in this period. Vancouver was the second - in 1911.

Since those early beginnings, the Section has grown and prospered together with our great city of Toronto as electrical engineers have developed and managed electricity to provide the power for its industry and communication for its citizens. The Toronto Section executive committee, chaired by Bob Hanna, is developing plans for celebrating this unique event. Members can keep informed about these plans by looking at http://ewh.ieee.org/r7/toronto/centennial.htm, just on click away from http://www.tor.ieee.ca (that is http://ewh.ieee.org/r7/toronto/).

The first planned event was a lecture on "On the Origins of DSP", by Prof. Andreas Antoniou, University of Victoria, BC, on April 14, 2003. Details about this lecture are available at http://ewh.ieee.org/r7/toronto/events/dlsantoniou.pdf.

The second event is scheduled for Sunday July 13, 2003 during the IEEE Power Engineering Society annual general meeting that will take place in Toronto on July 13-17, 2003 (http://www.ieee.org/pesgmtoronto2003). The PES conference committee will be recognizing the Toronto section for its centennial celebration during the welcoming reception.

The third planned event is the "2003 IEEE Toronto Centennial Workshop on Wireless Communications - CWWC2003", to be held on October 3-5, 2003, at the University of Toronto, Toronto. You can find details about this workshop at http://ewh.ieee.org/r7/toronto/cwwc03/index.html. The Workshop Co-Chairs are Prof. D. Hatzinakos (dimitris@comm.utoronto.ca) and Prof. K.N. Plataniotis (k.n.plataniotis@ieee.org), who is also Section Vice-Chair.

The Section executive is working on a new logo for the section to reflect its achievements over the past 100 years.

The section will plan and deliver other activities.

Bruno Di Stefano (b.distefano@ieee.org) is collecting information about the history of the Section. With the help of Cathie Lowell (admin@ieee.ca) Bruno has built a list of all Section Chairs since the formation of the Section. You can find this list at http://www.ieee.ca/history/sections/ch_tor.htm. Bob Alden (r.alden@ieee.org) has kindly organized this material for the www. If you are one of the past Section chairs or you are in contact with a past Section chair, please, send e-mail to Bruno Di Stefano. Similarly, if you have been a past member of the Section executive, please, contact Bruno and pass on whatever information you may have. This Toronto Section History Page is meant to be a growing web presence, beyond the Centennial celebration.

It is reasonable to say that the Centennial of the IEEE Toronto Section is also the Centennial of IEEE Canada. This is probably the reason why the official name of the IEEE Toronto Section in many documents is shown as "IEEE Canada - Toronto Section". Another interpretation of this name is that, prior to the merger of AIEE and IRE, in 1963, the AIEE section was known as the "AIEE Toronto Section" and the IRE section was known as the "IRE Canada Section". Bob Alden (r.alden@ieee.org) is the source of this second interpretation and is the source of all of the above historical information. He maintains a web page about the history of IEEE Canada. You can find it at http://www.ieee.ca/history. Indeed, part of this article is a result of a cut-and-paste from Bob's web pages.

Please, visit this web page and all related pages and see if you can contribute any information. If you have information that could be posted on this web site, please contact Bob Alden.

Acronyms used for Society Names

AIEE	American Institute of Electrical Engineers
CSECE	Canadian Society for Electrical & Computer Engineering
CSEE	Canadian Society for Electrical Engineering
EIC	Engineering Institute of Canada
IEEE	Institute of Electrical and Electronics Engineers
IRE	Institute of Radio Engineers

Milestones

1884	AIEE formed in Philadelphia by 25 electrical experts including Thomas Edison and Alexander Graham Bell.
1887	Canadian Society of Civil (non-military) Engineers (CSCE) formed
1903	AIEE Toronto Section formed on September 30 at the Engineers Club in Toronto
1912	IRE formed by merging the Society of Wireless Telegraph Engineers (initiated in Boston in 1907) and the Wireless Institute (initiated in New York in 1909)
1912	CSCE becomes the Engineering Institute of Canada (EIC)
1921	AIEE Canada District (No. 10) formed on August 1
1925	IRE Canadian Section formed at Canadian General Electric in Toronto in October
1944	Ralph Hackbush becomes first Canadian to be IRE Vice-President
1957	John Henderson becomes first Canadian to be IRE President
1963	IEEE Region 7 created out of AIEE Canada District and IRE Canadian Section during the merger of AIEE and IRE
1972	Bob Tanner becomes first Canadian to be IEEE President
1976	CSEE formed
1990	CSEE renamed as CSECE
1994	IEEE Region 7 and CSECE merge to form IEEE Canada

Each year, IEEE names a few selected members to its Honors roll list for their outstanding contributions. This year's list of Canadian members and their citations are given below:

Fellows 2003

Dr. Wojtek Jan Bock University of Quebec in Hull Hull, QC For contributions to fiber optic sensing devices and systems.	**Dr. Victor C.M. Leung** The University of British Columbia Vancouver, BC For contributions to the design of protocols and management strategies for wireless and mobile communication networks.
Prof. Nick Cercone University of Waterloo Waterloo, ON For contributions to knowledge discovery and data mining.	**Prof. Wooil Matthew Moon** The University of Manitoba Winnipeg, MB For contributions to theoretical geodynamics for earth system observation.
Dr. Mohamed Jamal Deen Mc Master University Hamilton, ON For contributions to modeling, noise, and parameter extraction in silicon transistors and high speed photodetectors.	**Prof. Farid N. Najm** University of Toronto Toronto, ON For contributions to estimation modeling of power dissipation in integrated circuits.
Dr. William Duncan Greason The University of Western Ontario London, ON For contributions to the fundamental principles of electrostatic discharge and its effect on electronic devices and systems.	**Prof. Boon-Tech Ooi** McGill University Montreal, QC For contributions to high power converters.
Prof. Mohammad Reza Iravani University of Toronto Toronto, ON For contributions to power engineering education and the modeling, design, and control of power electronic converters for power system applications.	**Dr. Basantkumar John Oommen** Carleton University Ottawa, ON For contributions to automata learning and syntactic pattern recognition.
Dr. Graham Arnold Jullien University of Calgary Calgary, AB For contributions to the application of number theoretic techniques in signal processing.	**Mr. Clayton Hedley Reid** Rockwell Automation Cambridge, ON For contributions to medium voltage motor control technology.

EIC Awards

ENGINEERING INSTITUTE OF CANADA
L'INSTITUT CANADIEN DES INGÉNIEURS

Honours, Awards & Fellowships - Médailles, Distinctions et Fellowships

Presented at the EIC Awards Banquet on Saturday 1 March, 2003
Présenté lors du Banquet de l'ICI le samedi 1 mars, 2003

FELLOWSHIPS

The following memebers of IEEE Canada received the EIC Fellowships:

Dr. Yahia M. M. Antar, Kingston, ON

Dr. Antar is a Canada Research Chair in Applied Electromagnetics and Microwave Engineering with the Royal Military College of Canada, where he teaches applied electromagnetics for wireless and satellite, radio wave propagation and electromagnetic modeling of complex structures.

Dr. Eric Dubois, Ottawa, ON

Dr. Dubois est professeur et vice-président du département de génie électrique à l'Université de Ottawa. Ses principales réalisations chevauchent plusieurs secteurs en matière de traitement des signaux, dont le traitement de l'image et de la vidéo.

Dr. Paul Fortier, Québec, QC

Dr. Fortier est professeur et directeur du département de génie électrique et d'informatique à l'Université Laval. Il a également créé le "profil télécommunications" à l'intention des élèves, dans le cadre de l'entrée de l'Université Laval au sein de l'International Institute of Telecommunications.

Dr. Samuel Pierre, Montréal, QC

Dr. Pierre est professeur au département de génie informatique de l'Ecole Polytechnique de Montréal où il a fondé et dirige le Laboratoire de Recherche en Réseautique et Informatique Mobile (LARIM). Il est titulaire de la "chaire de recherche industrielle CRSNG/Ericsson en systèmes réseautiques mobiles de prochaines générations".

Dr. Frederick N. Trofimenkoff, Calgary, AB

Dr. Trofimenkoff is currently Professor Emeritus of Electrical and Computer Engineering at the University of Calgary. He has carried out pioneering research in the area of semiconductor physics, and in high temperature instrumentation and electromagnetic wave propagation for geophysical prospecting.

Workshop Co-Chairs

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dimitris@comm.utoronto.ca

K.N. Plataniotis
University of Toronto
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IEEE Toronto Chair

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Visit our Web Site:

www.tor.ieee.ca/cwwc03/

IEEE Toronto Section
serving members and the commununity since 1903

CWWC 2003

The 2003 IEEE Toronto Centennial Workshop on Wireless Communications

October 3-5, 2003

University of Toronto, Toronto, Ontario, Canada

CALL FOR PAPERS

This special event, The 2003 IEEE Toronto Centennial Workshop on Wireless Communications to beheld at the University of Toronto, on October 3-5, 2003, is bringing together pioneers as well as participants from around the world to celebrate the Centennial of the IEEE Toronto Section. The University of Toronto is conveniently located in downtown Toronto in walking distance from a plethora of hotels, restaurants and recreation facilities. It is an internationally acclaimed institution with strong activity in the areas of Wireless Communications and Signal Processing and with exceptional meeting and classroom facilities. Toronto is a large, modern, cosmopolitan city, easily accessible, home to many high-tech centres and companies and a hub of IT activity. Technical presentations , exhibits, and cultural activities will be planned as part of the Workshop. The Technical Program will consist of Plenary and Interactive Lectures, which are devoted to the following subjects:

- Adaptive communication receivers
- Coding and modulation
- Equalization and multiuser detection
- MIMO systems
- Smart Antennas
- CDMA
- Mobility and location management
- Next Generation Wireless Systems
- Wireless Ad-hoc networks
- Signal Processing for communications
- Wireless networking
- Wireless multimedia
- Software radio
- Wireless IP and home networks

Prospective authors should submit electronically a six page camera ready paper in standard IEEE two-column format (PDF or Postscript files only) to the Conference Secretariat at the address below. The paper should include affiliations, addresses, and keywords identifying one of the above topics. Details about the workshop and the submission process are available at the workshop www site.

Important Dates:

Electronic submission of camera ready papers by: ... June 15, 2003

Notification of acceptance: ... ... July 15, 2003

Address For Paper Submissions And General Correspondence:

CWWC 2003 Conference Secretariat
Multimedia Communications Lab
University of Toronto
Bahen Centre for Information Technology
Room 4140, 40 St George Street
Toronto, ON, M5S 3G4
CANADA

Tel: 416-978-1613, 416-949-5605
Fax: 416-978-4425
Email: cwwc03@comm.utoronto.ca
URL: http://www.tor.ieee.ca/cwwc03/

University of Toronto

Faculty of Applied Science and Engineering
The Edward S. Rogers Sr. Department of Electrical & Computer Engineering

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Site web:
http://ieee.ca/ccece04

IEEE Canada

CCGEI 2004

L'Innovation, Force Directrice en Technologie

17th Conférence Canadienne de Génie Électrique et Informatique

2-5 mai, 2004 Hôtel Sheraton Fallsview

Niagara Falls, Ontario, Canada

APPEL AUX COMMUNICATIONS

La conférence canadienne de génie électrique et informatique 2004 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/ccece04 avant le 21 novembre 21 2003. 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 19 décembre, 2003. 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, 21 novembre, 2003**
Date limite pour la soumission de sessions spéciales:	**Vendredi, 19 décembre, 2003**
Avis d'acceptation:	**Vendredi, 9 janvier, 2004**
Date limite pour la pré-inscription:	**Vendredi, 27 février, 2004**
Date limite pour la soumission finale des articles:	**Vendredi, 27 février, 2004**

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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IEEE Canada

CCECE 2004

Technology Driving Innovation

17th Annual Canadian Conference on Electrical and Computer Engineering

May 2-5, 2004 Sheraton Fallsview Hotel

Niagara Falls, Ontario, 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 November 21, 2003. 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 19, 2003. 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, November 21, 2003**
Special Session proposals must be received by:	**Friday, December 19, 2003**
Notification of acceptance will be sent out by:	**Friday, January 9, 2004**
Pre-Registration	**Friday, February 27, 2004**
Final papers must be received by:	**Friday, February 27, 2004**

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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