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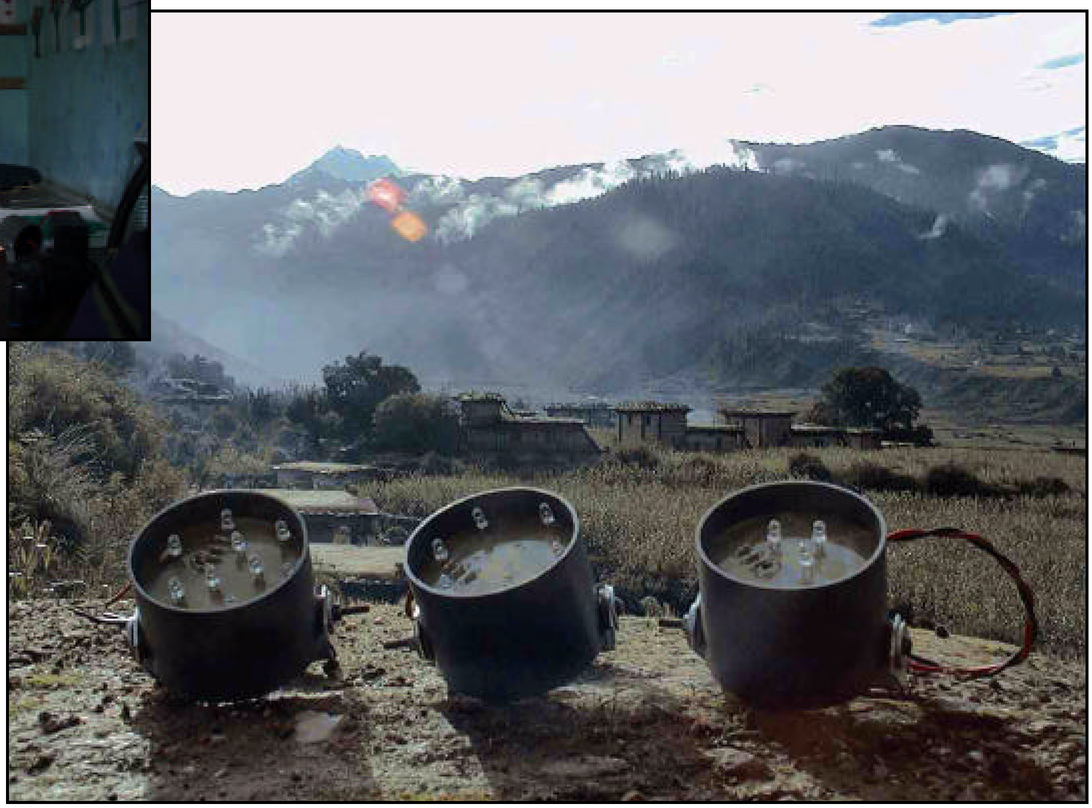

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(i) Canadian members of IEEE;
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(iii) The associated Canadian academic (i.e. universities, colleges, secondary schools), government and business communities.

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:

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Quelques mots du rédacteur en chef

Vijay K. Sood, Hydro-Québec

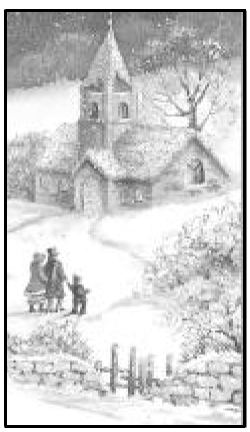
Il est temps de terminer une autre année réussie de publication du CR. Les vacances sont tout près et il est temps de réfléchir sur ce qui a bien fonctionné, et ce qui a moins bien fonctionné.

Ce qui a bien fonctionné : nous nous sommes organisés pour réaliser la mission technique du CR et faire les publications à temps et à l'intérieur du budget. Le contenu et la qualité des articles, des commentaires et des révisions etc. étaient encourageants. Les versions Web en anglais et en français sont maintenant disponibles, elles pourraient être encore meilleures mais malheureusement nous manquons de temps et de ressources.

Ce qui n'a pas bien fonctionné : le contenu français est toujours bas et pratiquement non existant. Les problèmes ne sont pas faciles à comprendre et d'autant plus difficiles à résoudre que nous travaillons avec des bénévoles ayant des contraintes de disponibilité ainsi que de sobres budgets.

Cette parution du CR est orientée vers deux thèmes : la robotique et la déréglementation des systèmes de puissance. J'espère que les articles publiés vont vous éclairer sur ces nouvelles réalités qui changent rapidement l'environnement de l'ingénierie.

Aussi, à cette époque de l'année, il est toujours important de rendre grâce pour notre chance de vivre dans un pays comme le Canada. Les expériences récentes d'une équipe de l'Université de Calgary dans le cadre du projet d'éclairage du Népal sont documentées dans un article publié à la page 14. Je vous encourage à lire cet article et à fournir du support à cette cause qui en vaut la peine. L'utilisation de lampes efficaces de haute technologie peut faire la différence pour fournir de l'éclairage à des enfants dans les écoles du Népal.



J'attends toujours avec impatience vos remarques et soumissions d'articles alors n'hésitez pas à me les envoyer. Même les critiques sont acceptées!

L'équipe du CR vous souhaite un heureux temps des Fêtes.

Cover picture / *Photo de couverture*

Nepal Light Project (NLP) (see also the article on page 14)

The cover picture shows the range of lamps (3, 6 & 9 WLED) that were available for the villages in Nepal this year. The background shows the village of Thalpi which is in the Jumla district, about one hour's flight NW from Kathmandu. It lies at an altitude of around 3,000m in the Himalaya mountains. Thalpi Village was chosen for White Light Emitting Diode (WLED) lamping because it already had an operational Pico Power Hydro Generator of 200 Watts. Each of the 28 homes received two WLED lamps.

Inset: Children using a 6WLED lamp for reading purposes in Child Haven.

Photos by Alex Zahnd.

A few words from the Managing Editor

It is time to close another successful year of publishing the CR. The Holidays are just round the corner and it is time to reflect on things that worked, and things that didn't.

Things that worked: We managed to meet the technical mission of the CR and publish the CR on-time and within budget. The content and quality of articles, views, reviews etc. were all up. The website versions in English and French are available at www.ieee.ca; these could be further improved, but I am lacking both time and resources to do better.

Things that haven't worked: The french content is still too low and virtually non-existent. The problems are not easy to understand, and then even more difficult to correct - given that we work with frugal budgets and volunteers with limited time and skills.

This issue of the CR has two themes: Robotics and Power System Deregulation. I hope that the articles will shed some light on these new realities of the fast changing landscape of the engineering playing field.

Also, at this time of the year, it is always important to note that we live in a rich country like Canada. The recent experiences of a team from the University of Calgary to assist in the Nepal Light Project are documented in the article on page 14. I encourage you to read this and, if you can, provide financial support to this worthwhile cause. The use of efficient high-tech lighting lamps can make a difference to improve the Quality of Life and provide reading lights to school children in Nepal.

I always look forward to your views and article submissions, so do continue to send them in; even your criticisms can be tolerated!

The CR team wishes you all a **Happy and Safe Holiday Season**.

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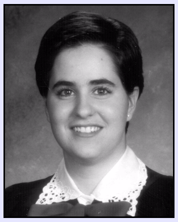
Newslog Editor



Rédactrice des Coupures de presse

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

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

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

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

JUN 14 ~ Hyperchip of Montreal announced a partnership with LINMOR Technologies, the leading developer of real-time performance management solutions, to develop performance management solutions for Hyperchip's highly scalable routers.

JUN 15 ~ Copernic.com de Québec et Alis Technologies de Montréal vont unir leurs forces pour intégrer les recherches sur Internet et la traduction en ligne. Les utilisateurs vont pouvoir obtenir une traduction quasi instantanée de n'importe quelle page web dans une des 14 paires de langues disponibles.

JUL 5 ~ 3M announced that its Optical Systems Division has purchased Vancouver-based Dynapro, a designer and manufacturer of world-class touch products. 3M purchased all of Dynapro's products including all touch products from touch screen components to touch computers, terminals and monitors; all intellectual property; trademarks; and the associated assets.

JUL 11~ SAMSys Technologies Inc. ("SAMSys") a solution provider for the automatic data tracking of industrial and retail products through the use of its proprietary intelligent, wireless technology, announced that it has entered into an arrangement with Philips Semiconductors, a world leader in smart card and smart label technology, which will see Philips Mifare, Hitag and I-Code Radio Frequency Identification (RFID) tag related products integrated within the SAMSys multi-protocol, multi-frequency RFID reader.

JUL 21 ~ Wolf Industries Inc. de Vancouver installera son système TravelPorts au Radisson Resort Parkway d'Orlando en Floride. Ce système d'information vidéo interactif sera installé sur le comptoir du service à la clientèle, dans le hall de l'hôtel. Wolf s'affaire actuellement à lancer un point de vente en réseau, ainsi que des systèmes interactifs de publicité vidéo et de billetterie électronique à Orlando et à Kissimmee, en Floride.

JUL 24 ~ Xplore Technologies Corp. of Toronto, a Rugged Pen/Touch Computing innovator, has signed a five-year purchase agreement with THOMSON-CSF TEXEN, a division of THOMSON-CSF. Under this long-term agreement THOMSON-CSF TEXEN will purchase and resell Xplore's family of rugged (Ram-line(TM)) and super rugged (GeneSys(R)) mobile computing systems to markets worldwide.

AUG 2 ~ Hydro-Québec and MICROTEC have signed an agreement for a partnership to establish a home automation business venture. The line of products offered, which comply with the CEBus (Consumer Electronic Bus) protocol, the recognized North American communications protocol for residential network management, will include communicating electronic thermostats and a home automation manager that can perform both security functions and heating, lighting and appliance management functions.

AUG 9 ~ PCS Innovations de Toronto devient un allié stratégique du Mobility Lab de Mobilocity, Avec le logiciel de plate-forme sans fil mobileMAGIC, Mobilocity et PCS Innovations travailleront ensemble pour fournir des solutions personnalisées de commerce mobile.

AUG 22 ~ Siemens AG Selects Intrinsyc of Vancouver as Partner to provide embedded networking solutions and services to Siemen's SIMATIC Human Machine Interface (HMI) panels. This engagement strengthens Intrinsyc's position as a recognized innovator in the Industrial Automation space.

AUG 30 ~ Compaq Canada Inc. will upgrade 100 Alpha processors at the University of Calgary which will greatly enhance its world-class computational and multimedia capabilities. Compaq Canada also donates $50,000 to the High Performance Computing Development Fund at the University.

SEP 18 ~ Semantix, fournisseur chef de file de technologies liées aux services linguistiques, a annoncé aujourd'hui qu'elle distribuera gratuitement « Le grand dictionnaire terminologique », qui renferme la banque de terminologie de l'Office de la langue française, sur le site Web à l'adresse www.granddictionnaire.com. Il renferme plus de 3 millions de termes français et anglais du vocabulaire industriel, scientifique et commercial se rapportant à près de 2 000 domaines spécialisés. Ce recueil contient autant d'information que 3 000 ouvrages de référence.

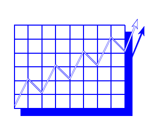
SEP 21 ~ VisualMED Clinical Systems Corp., Ericsson Canada Inc., Agilent Technologies Canada Inc., Locus Dialogue and the Montreal Heart Institute, have entered into a strategic alliance for the development of a wireless hospital registic solution. Hospital registic refers to the collective information technologies used for processing, communicating, updating and conserving clinical data.

SEPT 29 ~ i4i of Toronto has signed a contract for the largest ever deployment of XML authoring licenses. i4i's S4/TEXT will help the United States Patent and Trademark Office implement a new electronic system for filing patents.

OCT 4 ~ L'Unniversité Laval a sélectionné nStein Technologies, tous deux de Québec, pour le développement exclusif de la technologie Termplus. Cette entente permettra le développement d'engins de recherche puissants et la création de nombreuses applications de catégorisation multilingues et de gestion d'information.

OCT 11 ~ Unilabs, a European leader in medical analysis labs and Diagnos of Winnipeg, specialized in the area of artificial intelligence will partner to use a biological data set which could be used to automatically and contextually interpret data to make medical diagnosis.

NOV 6 ~ InfoSpace, provider of cross-platform merchant and consumer infrastructure services on wireless, broadband, and narrowband platforms, will acquire Locus Dialogue of Montreal, leader in multi-lingual natural language understanding and speaker verification technology.



Trends In The Productivity Of The Information Sector In Canada

by Dr. Hadj Benyahia
Université du Québec à Montréal, Montreal, QC

Abstract

This study shows that almost half of the national employment and production in Canada are due to its vast information sector. However, it also shows that, even if labour productivity in this sector has been superior to the national productivity, its annual growth rate has decreased during the 1980's and, for the period 1990-95, a recovery of this productivity growth has been observed in this sector. These two trends reveal, therefore, as in the USA, a productivity paradox of information technology in the 80's and the end of this paradox in the 90's.

Sommaire

Cette étude montre que près de la moitié de l'emploi national et de la production nationale au Canada sont dus à son vaste secteur de l'information. Par contre, l'étude montre que, même si la productivité du travail dans ce secteur a été supérieure à celle de la productivité nationale, le taux de croissance annuel de cette productivité a d'abord diminué dans les années 80 avant de se remettre à croître dans les années 90. Ces deux tendances révèlent donc, comme aux États-Unis, un paradoxe de la productivité des technologies de l'information dans les années 80 et la fin de ce paradoxe dans les années 90.

1.0 Issues

According to the Organization for Economic Co-operation and Development (OECD) [1], Canada is included in the group of the first ten countries having invested the most in information technology. The objective of this study is, therefore, to show whether this massive investment has been followed by significant productivity gains in the whole Canadian economy. This question is important if we consider that, during the last ten years, a large debate has been devoted to the examination and re-examination of the "productivity paradox" of information technology in the USA, Japan, France, Germany and England, in different studies, particularly those of Loveman [2], Dué [3], Brynjolfsson [4] and Dewan [5].

2.0 Research Methodology

This study concerns a large sector of the Canadian economy called the information sector. Indeed, this sector regroups not only computer and telecommunications industries (components, hardware and software) but also traditional information industries existing prior the electronic revolution of the early 1980's (e.g. telephone, radio, television, editing, financial services, education, public administration industries, etc.) and those industries which utilize products and services for the production of non-information sector goods and services (e.g. automobile and aeronautical industries). All these industries utilize information sector employees classified by OECD [6] in four major categories: information producers, information processors, information distributors and information infrastructure occupations.

Based on this international classification, the productivity of these employees is evaluated as follows:

1. Contribution of information sector employment (IE) to national employment (NE) = IE/NE
2. Contribution of information sector production (IP) to national production Gross Domestic Product (GDP) = IP/GDP

$$= \left[\sum_{i=1}^{n}(N_i{*}E_i) + (C/L)\sum_{i=1}^{n}(N_i{*}E_i)\right]/(GDP) \qquad (1)$$

Where n: number of information sector occupations,

N_i: number of employees in the i^{th} information sector occupation,

E_i: average labour income of the i^{th} information sector occupation,

C/L: ratio of capital income share (C) divided by labour income share (L) in GDP. According to Statistics Canada (catalogue 15204) [7], the value of this ratio was 0.54 in 1980; 0.55 in 1985; 0.46 in 1990 and 0.51 in 1995.

3. Productivity of information sector employees = IP/IE

3.0 Results Of The Research

Table 1 shows that the information sector is the largest employment sector in Canada with 43% of national employment coming from this sector during the period 1980-1995. However, in terms of trend, this relative share remained stable during this period and its employment growth rate has even declined a bit (-0.2%) in the recent years (1990-95). This paradox of the new economy based precisely on information activities could be explained by the dynamics of employment in this information sector where the creation of new jobs has been neutralized by the destruction of traditional jobs as observed in national census for the occupations shown in Table 2.

Table 3 reveals that the information sector has been the largest sector of economic activity in Canada since 1980, accounting for almost half

Table 1: Contribution of information sector employment to national employment in Canada

	1980	1985	1990	1995	1980-85	1985-90	1990-95
INFORMATION SECTOR							
- Employment	5,372,360	5,793,073	6,564,362	6,498,850			
- Annual growth (%)	-	-	-	-	1.5	2.5	-0.2
- % of total economy	43.7	44.3	44	43.3			
TOTAL ECONOMY							
- Employment	12,273,255	13,074,460	14,905,395	14,996,390			
- Annual growth (%)	-	-	-	-	1.3	2.6	0.13

Table 2: Professions in decline or experiencing growth

Professions in decline	Professions experiencing growth
- Supervisors, inspectors and controllers - Bookkeepers - Typists and word processing operators - Telephone operators - Telecommunication line and cable workers - Library clerks and archivists - Printing press operators.	- Senior management occupations - Professional occupations in business and finance - Professionals in natural science, engineering, mathematics and computer science - Teachers and professors - Writers, editors and public relations professionals - Graphic designers - Receptionists, switchboard operators and customer service clerks

(48%) of national production (GDP). This relative share is higher than that of employment (43%) because the average labour income in this sector (26.292 $ in 1995) is higher than that of the whole economy (20.763 $). However, the annual growth rate of production in this sector has strongly declined from 1990 (2.8%) to 1995 (1.0%) as a result of reduction in the number of information sector employees and the economic recession in the beginning of 1990's.

Table 4 shows, as expected, that productivity in the information sector has exceeded that of the total economy from 1980 to 1995. It then follows that the information sector contributes to the improvement of productivity gains. In this sector, the category with highest productivity is, as expected, that of information producers which regroups among others professional occupations in natural sciences, engineering and mathematics. It is followed by the category of information distributors represented essentially by teachers and specialists in communication. The third rank of productivity in this sector concerns the category of information processors which includes chiefly administrative, managerial and clerical occupations. Finally, the category with the lowest productivity is that of information support comprising mainly information machine operators.

- Table 4 reveals also an important observation in terms of productivity trends in the canadian information sector: During the 1980's, annual growth rate of this productivity has diminished from 1.1% in 1980-85 to 0.3% in 1985-90 and this decline in productivity growth is also seen in the whole economy (1.3% to -0.1%). This result confirms the productivity paradox observed also in the United States [3],
- In the first half of the 90's, we see a new trend with a recovery in the productivity growth, as observed also in United States by [4] and [5]. This new trend could be the end of the productivity paradox of information technology.

Table 3: Contribution of information sector production to national production in Canada

	1980	1985	1990	1995	1980-85	1985-90	1990-95
INFORMATION SECTOR							
- Total employment income (constant $million)	121,112	137,358	167,718	170,870			
- Average employment income (constant $)	22,543	23,711	25,550	26,292			
- % of national employment income	52.8	54.7	55.5	54.8			
- Production (constant $million)	168,513	212,905	244,869	258,014			
- Production as % of GDP	48.2	48.3	48.9	48.3			
- Annual growth (%) of production	-	-	-	-	2.6	2.8	1.0
TOTAL ECONOMY							
- Total employment income (constant $million)	229,232	250,689	306,019	311,378			
- Average employment income (constant $)	18,677	19,174	20,530	20,763			
- GDP (constant $million)	387,149	440,917	500,257	534,263			
- Annual growth (%) of GDP	-	-	-	-	2.6	2.5	1.3

Table 4: Evolution of productivity in the information sector and in the whole Canadian economy

	Productivity (constant $)				Annual growth (%)		
	1980	1985	1990	1995	1980-85	1985-90	1990-95
INFORMATION SECTOR	34,717	36,752	37,303	39,702	1.14	0.30	1.25
- Information producers	47,860	49,704	49,792	52,570	0.80	0.04	1.10
- Information processors	31,564	33,356	33,908	35,780	1.10	0.30	1.00
- Information distributors	38,342	39,626	41,377	43,287	0.60	0.80	0.90
- Information infrastructure occupations	27,087	29,739	27,577	28,646	1.80	-1.50	0.70
TOTAL ECONOMY	31,544	33,723	33,562	35,626	1.34	-0.1	1.2

4.0 References

[1]. OECD. "Information technology Outlook", Paris-France, 2000.

[2]. Loveman, G. "Cash drain, no gain". Computerworld, 25 (47), 1992, pp 69-72

[3]. Dué, R. "The productivity paradox revisited". Information System Management. Winter 1994. pp 74-76.

[4]. Brynjolfsson, E. "Beyond the productivity paradox". Communication of the ACM. August 1998. pp 49-55.

[5]. Dewan, S & Kraemer, K. "International dimensions of the productivity paradox". Communications of the A.C.M. August 1998. pp 56-62.

[6]. OECD(1989):"Trends In The Information Economy".Paris-France.

[7]. Statistics Canada (catalogue no 15204). "Measures globales de la productivité", Ottawa-Canada, 1998.

About the author

Hadj Benyahia is a Professor in the Computer Science Department of the University of Quebec at Montreal since 1983. He has a "Doctorat d'Etat" from the University of Paris.

He was formerly a project manager and consultant at Gamma Institute specializing in evaluation of new information technologies.

His present research fields are economics of computers, software engineering economics and office automation. He has published many books, reports and articles in these research areas.

The BEAM/WCRG Millennium Robot Games

Southern Alberta Institute of Technology, Calgary, Alberta. June 9-11, 2000

Terrance Malkinson and Craig Maynard

IEEE Canada

The BEAM/WCRG Millennium Robot Games held at the Southern Alberta Institute of Technology, Calgary, Alberta, June 9-11, 2000 represented the coming together of two world-class robot events. These were the International BEAM robotic games and the Western Canadian Robotic Games (WCRG). This three-day gathering brought together 80 competitors of all ages and skill levels who participated in more than 14 events with over 160 unique robots. The essential element of the games was creative thinking, i.e. thinking "outside the box" using ingenuity and craftsmanship to create an original robot that moves by itself and accomplishes the mission for which it was designed. Bizarre and strange ideas were encouraged.

The Western Canadian Robotic Games is one of the longest-running (10 years) annual robot events in N. America. The mandate of the WCRG is to encourage interest in science and technology using personal robotics as the channel. This annual competition allows robot designers of all ages and skill levels to demonstrate, showcase, and compete for prizes in a variety of competitions.

Today's workplace requires individuals who are creative, innovative, resourceful, competitive and self-motivated. Participation in an event such as this provides young and old the opportunity to develop and display these attributes as well as to have fun. A number of IEEE members from the Southern Alberta Section were involved in this gathering as mentors of students and as volunteers.

This year the 8th International BEAM Robot games were held concurrently with the WCRG. BEAM is an acronym for the Biology, Electronics, Aesthetics, and Mechanics style of robotics invented by Mark W. Tilden while at the University of Waterloo (Ontario, Canada). This is a philosophy building self-contained robotics that "live" for years and years, are built from recycled goods, and that begin as simple designs that evolve to become more complex over time.

A partial list of competitive events includes autonomous and remote Sumo, Atomic Hockey, Fire Extinguisher, Solaroller race, Aquarobotics, Legged Race, Micromouse, and Innovation Machines. Enthusiasm, innovation, and craftsmanship are the key to these competitions. It is not even necessary to complete in an event. Many participants simply brought their robots to the venue simply to "show-off" their device and engage in discussion with other enthusiasts.

In addition to the competition, lectures and workshops provided both the beginner and experienced robotic enthusiast with the opportunity to share ideas and advance their knowledge. Mark Tilden of the Los Alamos

National Laboratories presented a number of lectures on a diversity of subjects including the future of robotics and chaotic control for robotic systems. He emphasized the importance of designing these devices to be only as complex as they need to be to achieve their objective and not to be constrained by assumptions. Mark Hillier of HVW Technologies discussed tips for novices including important pitfalls to avoid. Jeff de Boer of the Alberta College of Art and Design led a fascinating discussion on interfacing robotics with our society and a futuristic vision of the design of robots. Other lectures and workshops discussed circuit design, an educator's course on robotics in the classroom, and building robots.

The Alberta Government through its ministry of science and innovation was one of many sponsors of this event. Alberta Innovation and Science is very supportive of providing an infrastructure supportive of creativity and innovation in the technologies.

A volunteer managed event such as this is an extremely valuable asset to our society. It provides us with the rewards of sharing our knowledge and experience with the future leaders of science and technology. Gatherings such as these provides opportunities for young people to meet together focusing upon a constructive activity of importance for developing interpersonal and technical skills that will serve them well in the future.

McMaster University Students Win Inaugural Design Competition

by *Mary-Louise G. Piner*
Computer, mpiner@computer.org

A team of five engineering students from McMaster University in Ontario, Canada, won $25,000 in prize and financial aid monies at the inaugural Computer Society International Design Competition (CSIDC) world finals in the Washington, D.C. area. McMaster led an international roster of prizewinners in the first year of a comprehensive computer engineering design competition that strives to advance excellence in undergraduate education and promises to provide an annual challenge to students worldwide.

The CSIDC judging panel, made up of computer engineering experts from academia and industry, selected McMaster's Heart Mate as the grand prize winner. Said Professor Edmund L. Gallizzi from Eckerd College, chair of the judging panel, “The ten finalist teams were all outstanding. It was obvious that a tremendous amount of work went into all the projects, but McMaster stood out to a majority on the panel as the best.”

Teams competing in the world finals demonstrated their devices on standard desktop computers, but most of the projects were conceived to include handheld devices, Java cards, or other portable components on the client side. Most presentations included descriptions and visual representations of the device as the team envisioned it.

In addition to planning and building the technical components for their devices, many teams considered aspects such as online security, potential pricing structures for consumers, and marketing slogans. All described the healthcare issue chosen, defended the need for such a device, and detailed the circumstances best suited to the use of their device instead of existing technologies.

“The first competition was a tremendous success,” observed CSIDC chair Bruce D. Shriver. “Several projects have great potential to evolve into real commercial products. Based on this initial success, the Computer Society will now proceed with plans for next year's competition and will double the number of teams competing to 100."

For full details on the CSIDC, including links to each team's presentations, team reports, and future information on how schools can enter next year's competition, visit http://computer.org/CSIDC.

Complete List Of Winners

The following teams placed within the top ten at the CSIDC world finals, held 25-27 June in the Washington, D.C. area. Prizes and financial aid funds are as follows:

1. McMaster University, Heart Mate: The Total Heart Care Unit, $15,000 (prize), $10,000 (financial aid)
2. National Taiwan University, Family Health Guard, $10,000 (prize), $8,000 (financial aid)
3. Poznan University of Technology, Health Care Information Appliance, $6,000 (prize), $6,000 (financial aid)
4. Slovak University of Technology, AMADIA-Asthma Monitoring and Allergy Data Information Appliance, $3,000 (prize)
5. University of Waterloo, Diabetes Internet Appliance, $2,000 (prize)

Teams who received honorable mention were each awarded $1,000 in prize money:

- Boston University, Health Pilot: Your Digital Health Assistant
- University of Hong Kong, Personal Medical Expert
- University of Illinois, Urbana-Champaign, eMbEDIC
- Moscow State University, Fatigue Diagnosis System
- Technical University of Plovdiv, Internet Application for Monitoring Infertility

McMaster's Heart Mate Winning Project

McMaster's Heart Mate winning project is a total heart care unit designed to be worn by patients who are at moderate to high risk of heart attack. Features of the unit include heart rate monitoring, communication capabilities between doctor and patient, emergency alert capabilities, and a global positioning system.

The students from McMaster conceived, designed, and demonstrated a prototype of the unit at the June CSIDC 2000 world finals. The team members split a combined $15,000 prize for the winning device. In addition, the school received $10,000 in financial aid funds to be dispersed for scholarships, student conference stipends, laboratory equipment, or other educational purposes as determined by the university.

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On the winning team were (see photo above, from left to right) Ajay Arora, Joshua Capogna, Rachita Kohli, Christopher Lambacher, and Wai-Yin Shum, who worked under faculty mentor Markad Kamath.

Computer Society International Design Competition (CSIDC)

Providing Students With A Real-world Problem

The challenge for this year's entrants was to create a working model of an information appliance that could improve public health. Only the teams with the top ten projects as judged by submitted reports were invited to compete in the live demonstrations of the world finals.

The 50 teams, selected at random, to compete in this year's event each received a high-performance embedded computer development system including a single-board computer, a monitor, dual USB ports, a parallel port, a serial port, and several levels of varying size and performance memory in its storage hierarchy. Software components given to all competing teams included four operating systems and three software development environments. The CSIDC technology sponsors donated all of the kit items, and limits were placed on the amount of money teams could spend on peripheral devices added to the CSIDC project kit items. Each team that completed a working prototype and submitted a project report is entitled to keep the project kit, valued at more than $7,000.

Control Considerations In A Deregulated Electric Utility Environment

by O. P. Malik,
The University of Calgary, Calgary, AB

Abstract

Major restructuring of the electric utility industry driven by economics and open competition is in progress in various parts of the world. Although it is well advanced in a number of countries, it is relatively new in North America. How the reliability of electricity supply in a deregulated environment may be affected is still unknown. Some control aspects to improve reliability are outlined.

Sommaire

Poussée par des raisons économiques et la compétition libre, la restructuration majeure de l'industrie électrique est en cours de réalisation dans plusieurs parties du monde. Bien que la restructuration soit bien avancée dans plusieurs pays, elle est relativement nouvelle en Amérique du Nord. Une inconnu demeure quant à la fiabilité de l'alimentation électrique dans un environnement déréglementé. Cet article présente quelques aspects du contrôle qui améliorent la fiabilité de l'alimentation électrique.

1.0 Introduction

Electricity supply industry is in the throes of significant change. Competition is the buzz word to-day accompanied with major changes that are taking place. For example, eighteen states with more than half of the total population of US have already committed to implement their version of customer choice. In Canada, the province of Alberta is the most advanced with a power pool already operating for the past few years and the province of Ontario well advanced to deregulating its electric utility business.

Although each jurisdiction has its own approach to privatization and de-regulation, it would be fair to say that at present only the generation is de-regulated and privatized. Except for a few large industrial customers, in general the individual customers at the distribution level still have no choice. Alberta is poised to deregulate distribution at the advent of the 21st century, i.e. Jan. 1, 2001. The third element, transmission grid, is mostly still regulated because of the overwhelming reliability concerns.

2.0 Traditional Structure

Due to political, territorial or geographical reasons, individual power systems evolved independently, but economic and technical reasons imposed the need for interconnections. As such they now constitute building blocks of interconnected power systems.

Although evolved primarily on the basis of need and good engineering practice, and not consciously designed using hierarchical system theory, vertically integrated utilities have developed into hierarchical systems. In a typical large interconnected power system, superpools, pools, areas, power stations, sub-stations and individual units can be identified as the individual levels of a typical hierarchical structure.

In such systems, policies are set at the executive level of the system management which may be called the self-organizing layer of control. This level involves a multi-disciplinary approach and is supremal to the other levels. A policy set at the executive level is translated into a set of goals and objectives to be achieved at the various structural levels of the power system. Achievement of these goals requires a well-defined strategy implemented in a set of controls corresponding to each structural layer of the power system.

In general, in interconnected power systems, generating units receive commands from area controllers which, in turn, may be controlled by pool computers (controllers) and so on. Controls are used to achieve collectively, as closely as possible, a predetermined performance from the integrated system. Thus, in parallel with the hierarchical structural levels of the power system, one can distinguish different control levels.

In the vertically integrated utilities a cohesive structure exists within one organization to oversee and perform all control functions. Of-course, there is enough interaction with other surrounding utilities to which the particular utility is interconnected. Adjectives such as, regulated, monopolistic, inefficient, started to be attached to this traditional structure. However, whatever the objectives, one overriding consideration in the operation of such utilities was the reliability of electricity supply to its customers.

Power systems are subject to a broad class of disturbances ranging from switching surges to changes in policies. Changes in policies can affect the interconnected system operation on a long term basis. Earlier the policies were set at the executive level of the system management, but now many of these policies are being set in response to economic and political trends.

3.0 Restructuring

The main incentive for restructuring is the introduction of competition through privatization and the economic benefits that competition between the resulting companies will bring. The major step in this process is the devolution of the vertically integrated utilities into three independent components, i.e. generation, transmission and distribution companies. This is resulting in the introduction of competition in generation, permitting open access to the transmission and distribution grid, and the introduction of retail competition.

Much attention is being devoted to the marketing aspects of the restructured electric supply industry. Words such as revolutionary, challenging, evolving, exciting, risky, etc. are being used to describe the electricity industry. Although the talk is of spot markets, forward contracts, direct sales agreements, power purchase agreements, contracts for differences, etc., very little attention is being paid to the effects such a change may have on the technical and operational aspects of electricity supply.

The objective of devolution is that the three major components comprising the devolved power system be individually owned and operated by:

- the generator, existing utility generator or an independent power producer,
- transmission facility owners, and
- distribution system companies.

The function of the generator and distributor is quite obvious, i.e. to bid respectively for the supply and purchase of electric energy through some kind of a Power Exchange. Contracts for the supply and purchase of energy are fulfilled with the help of a transmission facility owner who is responsible for the operation & maintenance of the transmission system.

In addition, now there will be a separate structure to administer the marketing aspects. It will generally consist of:

- a system administrator (under various names) to administrator the electrical energy market,
- system controller (scheduling coordinator) as the real-time manager of electrical energy network operation,

- a transmission administrator to ensure that all and sundry have open, non-discriminatory access to the grid. The transmission administrator also contracts the services of the transmission facility owner for the fulfillment of the energy supply purchase contracts.

As before, the ultimate aim is to ensure grid reliability. These various entities have to:

- schedule power flow over the grid,
- dispatch energy as per a pre-determined merit order,
- manage transmission congestion or any other constraints,
- manage market information flow to market participants,
- carry out financial settlements and account keeping,
- dispatch and manage support services.

Other marketing related functions include:

- contracts with transmission owners to provide services,
- tariff preparation,
- management of and payment for transmission losses, and operation related functions such as:
  - voltage and VAr dispatch,
  - establishment of standards for transmission system operation,
  - system security through network monitoring, and
  - directing system operation.

4.0 Management And Control Under Restructured Scenario

Under any scenario, whether the vertically integrated utilities interconnected through pools, or in the deregulated environment, power system still has to be managed properly. The primary functions of the power management system are the system dispatch functions and network security functions.

The dispatch functions include automatic generation control (AGC), generation schedule and dispatch with the desired merit order.

The network security functions include network topology processor, state estimation, security and stability validation, optimal power flow, dispatcher power flow and network security sensitivity calculations.

4.1 Automatic Generation Control

In some parts of the US, particularly California, power management is done through the existing area control centers. After some initial experimentation, the AGC functions are now being performed on a system wide basis and dispatch functions are sent to the generating units via Area Control Centers thereby utilizing a centralized generation control. This centralized AGC process is the interface with the scheduling applications by which process the supplementary energy bids and auxiliary services in support of the AGC function can also be calculated.

4.2 Voltage Control

In the deregulated environment power is traded through an open commodity market known as the pool, and the generators have no obligation to supply. At the same time they have to compete for business and have no assurance of market share. Thus the generators may come and go. From the system perspective this results in a continuously changing profile of power generation and reactive power support. This could adversely affect voltage at critical points within the system.

In the regulated industry, the utilities were obliged to maintain power system operation both in respect of meeting the load requirements and voltage profile. Any potential security problems could be identified well ahead of time and measures taken to obviate these problems. Automatically controlling the transmission network voltage is more effective than controlling the generator terminal voltage. Thus a utility could provide voltage support along transmission paths to improve synchronous stability.

Under the new structure, the system administrator does not control generation nor can it install reactive power equipment at appropriate locations so quickly. Such a situation will require ingenious solutions, e.g. relocatable VAr sources, etc.

4.3 Transmission Congestion

Transmission plays a key role in opening markets to competition. It provides the means to broaden and strengthen competitive generation markets. No amount of competition in generation will bring to the consumer the benefits of privatization unless a robust transmission system exists that can allow distant generators to enter the high priced market and add to the market power of local generating incumbents [2].

Transmission can function as a pipeline or as a bottleneck. The transmission operator, too, plays a vital role in maintaining grid reliability. Current operating practices are based on reliability criteria that were established in response to certain events in the 1960s. For example, one commonly accepted safety criterion requires that the system continue to run even if one major part such as a critical transmission line or the largest generator is lost. This may require re-examination or the operator may achieve reliability by adopting other strategies to run the network more effectively.

Transmission can function as a pipeline or as a bottleneck.

Unless something is done to reduce congestion or increase transmission capacity, there is always the possibility of more blackouts like the two Pacific Coast blackouts of 1996 [4] and the June 1998 price hikes. Transmission congestion management is becoming a major problem in system operation in the deregulated environment. Most solutions proposed in the literature to alleviate this problem seem to concentrate on rescheduling the power flow using some kind of economic incentives or economic penalty approaches. Those who believe that network congestion will be relieved through economics instead of command and control are either oblivious of or ignore the alternative that control can play a very important role in increasing the capacity of the transmission grid and reduce transmission congestion.

One key point will be to enable the system to operate closer to the limit. This requires system monitoring and development of appropriate controls. Power carrying capacity of individual transmission lines can be increased by installing FACTS devices, a family of electronic controllers. They offer the added advantage of improving overall system reliability by reacting almost instantaneously to disturbances. Using FACTS devices, system operator will be able to dispatch transmission capacity and facilitate open access.

5.0 Problems And Concerns

In an article entitled “Keeping the lights ON”, the authors state that “maintaining reliable grids in a deregulated power industry will get harder, as temptations to cut corners multiply” [3]. They further describe the paramount concerns within the industry as:

- “Market economics would define the optimal cost/benefit trade-off that determines how system reliability is maintained and provided.
- Voluntary cooperation between utilities and integrated planning would disappear.
- Voluntary compliance with reliability issues would be lacking to the detriment of the global network.
- Open access would lead to multiple transactions, system overloads and operational difficulties”.

5.1 Transmission Capacity

Technical problems arising from deregulation are chiefly related to transmission reliability in complex networks. Transmission capacity, already squeezed due to various factors, must now meet the new demands created by open access and deregulation. These demands consist of power flows for which transmission systems were not designed, arising from both open access and siting of new generation with little concern for transmission requirements [1].

Linked to this are the unit commitment and dispatch that are normally based on a computer model that minimizes production cost assuming that bids represent cost. The dispatch may be further modified on account of transmission constraints.

5.2 Coordination

One significant lesson that came out of the two major blackouts of July and August 1996 in the Pacific Northwest was the need, in the event of a disturbance, for a close coordination between the utilities, energy traders, generation operators and transmission operators. It is feared that such coordination may be limited under the competitive environment. Because of the lack of such coordination, controls for load shedding, etc. could not be implemented properly thereby resulting in the uncontrolled splitting of the entire interconnected system into four islands on August 10, 1996 and interruption of service to 7.5 million customers for periods ranging from several minutes to nearly six hours. Frequency in certain islands dropped to below 59.0 Hz for 20 minutes and below 60 Hz for over an hour. Such coordination is essential for the coordination of under frequency load shedding, load restoration, controlled islanding and establishment of criteria for multiple contingencies and relay failures.

5.3 Dispersed Generation

In the past utilities typically developed large central generating stations. Evolution of the grid under the restructured deregulated environment is resulting in the tying to the grid of a large number of independent generators. The pattern is not a totally uniform dispersion. Safety and reliability issues will go up as more of these come on line. There is also the problem of getting the power to go where and when it is required. Unscheduled power flows include loop flow on neighboring transmission systems and inadvertent interchange between neighboring systems. This will of-course require certain performance requirements from excitation and governor systems.

6.0 Concluding Remarks

Restructuring of electric utility industry in North America is still relatively new with limited experience to date. Generation only is deregulated initially. Since it is a common carrier of electric energy, a number of schemes for transmission system, like the distribution system, remaining in the regulated mode are being considered.

At present the major focus is to operate the system from an economic perspective and solve the various problems by economic disincentives or economic penalties. Very little attention has been paid to use control to remedy the problems encountered. Some recent incidents have demonstrated that there is a need to develop new ways to increase system reliability. Some actions aimed at increasing the reliability include:

- better communication and coordination among generators and the system controllers,
- creation of new markets which provide incentives to industrial customers for dropping loads.

Reliability issues in a competitive market can be mind boggling. Introduction of a competitive market is synonymous with buying and selling electricity and services. Reliability issues can be handled better by integrating the buying and selling with the physics of the network.

There is a scope for development of control techniques using new technologies to solve problems that may develop as deregulation spreads and electricity markets mature.

7.0 Acknowledgment

This is a condensed version of a plenary talk delivered at the IFAC Symposium on Power Plants and Power Systems Control, April 2000, Brussels, Belgium.

8.0 References

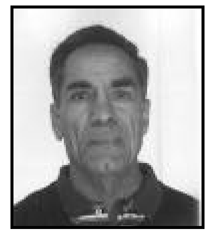
[1]. Baker, George C. (1999). "The wave of deregulation: operational and design challenges", IEEE Power Engineering Review, Vol. 19(11), pp. 15-16.

[2]. Hyman, Leonard S. (1999). "Transmission, Congestion, pricing, and incentives", IEEE Power Engineering Review, Vol. 19(8), pp. 4-10.

[3]. Mountford, John D. and Austria, Ricardo R. (1999). "Keeping the lights ON", IEEE Spectrum, Vol. 36(6), pp. 34-39.

[4]. Taylor, Carson W. (1999). "Improving grid behavior", IEEE Spectrum, Vol. 36(6), pp. 40-45.

About the Author



Om Malik, Professor Emeritus, University of Calgary, Alberta, has been involved in teaching and research in power system control and protection for the past 35 years. After graduating in electrical engineering in 1952 he worked for nine years in electrical utilities before going back to University to do first a Master's and then a Ph.D. degree which he obtained from Imperial College, University of London, London, England in 1965.

Professor Malik has done extensive research in the development and application of adaptive and artificial intelligence based techniques for real-time control and protection of machines and power systems. He is a Fellow of IEE and a Life Fellow of IEEE.

IEEE Third Millennium Awards

On the occasion of the start of the Third Millennium, IEEE presented 3000 special awards to its volunteers from all over the world. The following Canadian volunteer members were recognized at the IEEE Toronto Section Annual Meeting on November 4, 2000.

IEEE Toronto Section Millennium Medals.

- **Bruno N. di Stefano**, Nuptek Systems Ltd
- **Javan A. Erfanian,** Bell Mobility
- **W. H. Khella**
- **S. G. Zaky**, Chair, Edward S. Rogers Sr. Department of Electrical and Computer Engineering, University of Toronto,
- **N. Venetsanopoulos**, Edward S. Rogers Sr. Department of Electrical and Computer Engineering, University of Toronto
- **Alberto Leon-Garcia**, Edward S. Rogers Sr. Department of Electrical and Computer Engineering, University of Toronto.
- **Patrick G. Gulak**, Edward S. Rogers Sr. Department of Electrical and Computer Engineering, University of Toronto.
- **C.A.T. Salam**a, Edward S. Rogers Sr. Department of Electrical and Computer Engineering, University of Toronto.
- **A. Sedra**, Vice-President And Provost, University of Toronto
- **Peter W. E. Smith**, Director, Nortel Institute for Telecommunications, University of Toronto.
- **Gordon Slemon**, Edward S. Rogers Sr. Department of Electrical and Computer Engineering, University of Toronto.

Pelle Westlind, Toronto Section

PARELEC'2000

International Conference on Parallel Computing in Electrical Engineering, PARELEC'2000.

Sixty five scientists and engineers from nineteen countries around the world gathered in Trois-Rivières, Québec, at the end of August to participate in the *PARELEC'2000*.

As a part of the opening ceremonies, the Choir from the Technical University of Bialystok welcomed delegates with a special dedicated concert that opened with *Gaude Mater Polonia*.

Each day of conference began with a Plenary Session that focused on the current developments and future directions on high performance computations. The keynote address by Dr. Michael Rosenfield from IBM TJ Watson Research Center, USA was exceptionally exciting.

The technical part of PARELEC'2000 comprised of ten oral sessions covering parallel computing environments, methods and algorithms, heterogeneous computing, network computing, electromagnetics fields modeling, scheduling and optimization, VLSI implementation, electrothermal analysis and power systems investigations. In all, forty four stimulating papers were presented on these topics.

Three exhibitors were present for the first time at this conference which is only on its second edition.

The IEEE Computer Society Press is the publisher of the PARELEC'2000 Proceedings and will be responsible for promoting it to more than 100,000 IEEE Computer Society members worldwide and to university and technical libraries. All papers included in the PARELEC'2000 Proceedings and presented personally by authors will be specially reviewed and submitted to the IEEE Transactions on Parallel and Distributed Systems.

The welcome reception was held at the City Hall. The conference banquet was at the spectacular *Cité de l'énergie* where participants were treated to live classical music and legendary French-Canadian hospitality.

The two industrial tours to the Aluminerie de Bécancour Inc. and to the Gentilly2 Nuclear Power Station were very well appreciated by the participants.

Finally, the volunteers' efforts were recognized by diplomas presented to them at the conference banquet by Mr. Dominic Rivard, IEEE St.Maurice Section Chair and Prof. Adam Skorek, PARELEC'2000 Organizing Committee Chair.

PARELEC'2000, Organizing Committee

Remembering Frederick J. Heath

Pioneer in radar development

Frederick J. Heath, P. Eng. and IEEE life member, died on Tuesday, 28 Dec., 1999.

Mr. Heath received his bachelor's degree in electrical engineering from the University of Alberta, Edmonton, Canada. While a graduate student at MIT, Amherst, Mass, USA, Heath was one of three engineers chosen to work on the development of radar. He has been commended for his role in pioneering anti-air-craft radar during World War II.

Mr. Heath joined the National Research Council of Canada in1940, where he was engaged in the development of radar equipment. In 1945, he joined the Canadian General Electric Company, where he became involved in the design and manufacture of antennas and transmitters for AM and FM radio, television broadcasting, radar and sonar. In 1970, he joined Ontario-Hydro as a power line carrier engineer in the Protection and Control department. Mr. Heath also installed the first two television transmitters in Canada. He holds seven Canadian patents and has served on numerous national and international committees, as well as in professional and civic organizations.

After his retirement, Mr. Heath served on the IEEE Board of Directors and was IEEE Region 7 director from 1082-1983. He also served on the IEEE Educational Activities Board and Regional Activities Board. He was chairman for the IEEE Toronto Section in 1956 and for the IEEE Communications Society's conference board in 1981. Mr. Heath also served as chairman for various IEEE conferences and conventions.

He is survived by his son, Dr. Fred R.E. Heath. His wife, Jessie, is deceased.

IEEE Canada Foundation Travel Awards for undergraduate students

Participation in CCECE 2001, Toronto

Encouraging more participation from undergraduate students in IEEE Canada conference activities is very important. There are some concerns that our students do not get very excited about research and development, particularly during a booming economy. This inevitably results in a lack of highly qualified people in later years.

Encouraging undergraduates to become involved might stimulate their interest. The IEEE Canada Foundation has set aside $5,000 as a fund for proposed travel bursaries to attend the Canadian Conference on Electrical and Computer Engineering (CCECE) 2001, to be held in Toronto in May 2001 (see announcement in this issue on pages 30-31), and present a paper. The conditions are that the bursary is limited to a maximum of $1,000 and is based upon acceptance of the paper from an undergraduate (not graduate) IEEE Student member.

For further information, please contact Slawo Wesolkowski at:

s.wesolkowski@ieee.org

Thought for the Day

Judge your success by what you had to give up in order to get it.

GOLD Activities

IEEE USA 2000 Professional Development Conference,

Scottsdale, Arizona

September 1-4, 2000

Introduction

This year's Professional Development Conference was held in the beautiful Camelback Resort in Scottsdale, Arizona. The theme of the conference was "Success in the New Millennium". Surviving and thriving in today's work environment requires more than mastering technical skills. The engineering professional needs to master and use non-technical skills in order to succeed. There were approximately 50 presentations, which covered the following career related topics: careers development, skills development, management and leadership.

Sessions

I had the opportunity to attend various tutorials, workshops and panel discussions. Additionally I was able to see the exhibits by various associations, organizations and companies. Some of the presentations targeted the interests of engineers with 10 years or less of professional experience, i.e. the IEEE GOLD members. There were presentations that addressed the training and information needs of Section and Society professional activities. Registered attendees could have selected sessions from any of the tracks throughout the conference.

The "Assertive Communication for Engineers" presentation by Edna Grasz emphasized the importance of communicating well. While attending this presentation I learned about different styles of communication, how to handle different situations and to express ideas in ways that gain the attention, support, and respect of others.

I really enjoyed "Life Management Skills for Success" by Lory Fischler, head of Team Training Consultants. During her presentation she discussed six principles of personal management:

- **Productive People Don't Manage Time, They Manage Themselves.** This principle emphasizes the importance of how people view the world around them. People with goal-centered life can rise above any problem or condition.
- **Simplify, Don't Multiply.**
- **Control Tasks So They Don't Control You.**
- **Define Your Objectives.** This principle explains that if one chooses a direction and sets his/her mind on that direction, the path will become clearer.
- **Allocate Time Based on Priorities.** This principle states that the only way to realize the goal is by spending time daily or weekly on tasks that will get us closer to achieving it.
- **Find Something You Love to Do.** If the person truly loves the work he/she does, it makes it easier to dedicate time to it. All in all, it's important that we do something that excites us and something that sparks enthusiasm in us.

These six principles can help an individual become more successful and achieve his/her dreams. According to Lory Fischler, an individual generally tries to take control of external factors, instead of taking control where it really matters: in the way that he or she thinks.

Technical professionals study for many years to acquire knowledge to meet the demands of technical work. Typically, little time is spent developing people and management skills. The Professional Development Conference 2000 tried to emphasize the importance of developing those non-technical skills.

PDC is an excellent conference to attend for all engineers interested in improving their career related skills. It gives attendees an opportunity to attend presentations on variety of topics pertaining to their careers. Attending this conference I gathered a wealth of information that will help me in my career and professional development. To find out more information about the PDC go to the website:

http://www.ieeeusa.org/PRODEVCON

Ivana Vujosevic
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IEEE Senior Member Update - June 2000

Following is a listing of the newly elected Senior Members from the June 24, 2000 Admission & Advancement Panel meeting held in Vancouver, BC, Canada.

Region 7

Section Name	Member	Technical Affiliation
Montreal	Atanackovic, Djordje	
Montreal	Bilodeau, Hubert	Power Engineering

Light Up The World - Nepal Light Project and Everest

by *Dave Irvine-Halliday, University of Calgary, Alberta,*
Stewart Craine, Ledco, Kathmandu, Nepal
Muni Raj Upadhyaya, Pico Power Nepal, Kathmandu,
Gregor Irvine-Halliday, Pico Power International Corporation, Vancouver,

Abstract

This article describes the experiences of a scientific team from the University of Calgary which set out to provide a reliable, versatile, inexpensive, healthy and safe form of lighting for developing countries such as Nepal. This particular mission was referred to as Light Up The World (Nepal Light Project). The article demonstrates the utility of using White Light Emitting Diodes (WLED), running on batteries recharged through simple methods. The power for the WLED lamps was derived from various sources i.e. simple Pedal Generators, a Pico Hydro Generator and a Centralized Solar Panel system.

Sommaire

Cet article décrit les expériences d'une équipe scientifique de l'Université de Calgary qui s'est formée pour fournir un éclairage fiable, versatile, peu coûteux, robuste et sécuritaire pour des pays en voie de développement comme le Népal. Cette mission particulière était appelée "Allumer le Monde" (Projet d'éclairage du Népal). L'article démontre l'utilité des diodes électroluminescentes blanches (DELB), alimentées par des batteries rechargées par de simples méthodes. La puissance d'alimentation des lampes DELB était dérivée de plusieurs sources comme de simples génératrices à pédales, une génératrice hydraulique Pico et un système de panneaux solaires centralisé.

1.0 Introduction

The Light Up The World - Nepal Light Project was conceived, almost by accident, in the summer of 1997 when Dr. Dave Irvine-Halliday, having just completed a project at the Institute of Engineering, Tribhuvan University, Kathmandu, Nepal, decided to trek around the Annapurna Circuit.

During his trek, it rapidly became obvious that the majority of rural villages in Nepal lacked adequate lighting. This was especially of concern with regards to the village schools, which also often lacked a teacher. He concluded that there had to be some way to bring some form of lighting to the villagers. Upon returning to the University of Calgary, he plunged into what is referred to as “a wee personally funded project” which had little, if anything, to do with his 'real' research projects involving Fiber Optic Current Sensors and Gyroscopes, and Biophotonics. The rest is history as they say!

2.0 Design Considerations

One important point to note when designing a lighting system for rural villagers in the developing world is that they generally have very little income. For instance, a Nepali villager has an annual average income of a few hundred dollars. Therefore, any intended lighting system must be simple, reliable and economic. This is not the time to get all high-tech if the system reliability may be compromised and the chances of it being repaired in a reasonable time and at an affordable cost are slight. Another important point was that we were not trying to light up the entire home to a North American level of illumination, but only light up those areas of the home where it would be most useful.

3.0 Lighting Systems

The vast majority of rural homes in Nepal are presently lit by candles, kerosene wick lamps or resin soaked twigs, all of which are a fire hazard and a health problem due to the smoke produced. Furthermore, Nepali homes generally have no chimneys due to the belief that the creosote in the smoke from the cooking fires helps to protect the wooden ceilings from insect attack.

Existing technologies which have been employed for some time in Nepal are generally limited to the more affluent communities and particularly in locations with relative ease of access. Implementations typically incorporate some or all of the following components:

Light Source: Incandescent Bulb, Fluorescent Tube, or Compact Fluorescent Light

Power Generation: Fossil Fuel Based: Diesel/Petrol, Photovoltaic Panels, Pico and Micro - Hydro; or Peltric/Ghattas/Vietamese (low head) Wind Turbines (very few)

Transmission/Energy Storage: Direct AC Transmission, AC Transmission with Conversion to DC, Battery Storage, or Combined Transmission with Off-Peak Storage

4.0 The White Light Emitting Diode (WLED) [1]

There are basically two distinct parts to the home lighting challenge; the light source and the energy source. It quickly became evident that none of the existing light source technologies were the long-term solution since not only did the new light source have to provide sufficient light but it had to do so with a dramatically reduced power consumption or else the developing world would simply remain in the dark due to the lack of affordable and appropriate power generators. With a long background in photonics, Dr. Irvine-Halliday went to work in the lab experimenting with various color combinations of LED's trying to make an energy efficient and very reliable 'white' light of acceptable output power. He did not succeed!

Fate lent a hand with the timely development in 1997 of the world's first White Light Emitting Diode (WLED) by Nichia of Japan who were kind enough to send samples for evaluation to see if they were in fact suitable for the embryonic “Nepal Light Project” (NLP). The specifications for the WLED's suggested that they might just be the futuristic alternative light source that was being sought, so their arrival was awaited with some nervousness. The WLED test day in the photonics lab will never be forgotten. On switching on that single WLED in the pitch dark, Dr. Irvine-Halliday said to his technician, John Shelley, “Good God John, a child could read by the light of a single diode!” It was a defining moment!

Table 1 illustrates a subjective comparison between a 25 W incandescent bulb and a 12-cluster WLED lamp and clearly demonstrates the advantages of the WLED lamp.

Numerous WLED configurations are possible when making lamps and many square, rectangular, triangular and circular forms were tested. At this time, the chosen design for Nepal is the concentric circular that allows either a 3, 6 or 9 WLED configuration using the same printed circuit (PC) board (see cover photo also). Since a room in a typical Nepali rural house can be lighted to an acceptable level with either 6 or 9 WLED lamps then it is perfectly feasible to light up a home with a power consumption of approximately 1 W!

Table 1: Comparison Between an Incandescent Bulb and a WLED Lamp

Lamp Type	Input Voltage	Input Power	Cost (C$)	Relative Heat Output	Ruggedness	MTBF (Hrs)	Luminous Efficacy	Improvement Potential
Incandescent	110 V AC	25 W	1	Very high	Very low	1,000	10-20 lm/W	Very low
12 WLED	12 V DC	1 W	20	Extremely low	Extremely high	100,000	15-20 lm/W	Extremely high

To date a number of other companies have joined Nichia in producing WLED's such as: Hewlett Packard-Phillips; Panasonic; Sumitoma; Toyoda Gosei (Toyota); GE-Osram and Fujitsu.

5.0 The Generator

It is very important to realize that with the advent of the WLED that the 'rules' of the game have changed forever! No longer is it necessary to think in terms of kilowatts for developing country village lighting but “Pico Power” suddenly becomes the norm. It is feasible to light up an entire village with 100 Watts!

Once various configurations of WLED lamps had been constructed and tested in and out of the lab and found to satisfy all the requirements for our NLP, the search was on for a “Pico Power Generator”. After much analysis of the conventional power sources i.e. Solar, Hydro and Wind, it was concluded that none of them fitted the personally funded budget at that time, and therefore another solution would be needed, at least for the short term. After experimenting with various forms of human-powered treadle, pedal, push and pull systems it was determined that by far the most appropriate approach was the Pedal Generator (PG) for the following reasons. It was low tech; it could operate 24 hrs/day if required; it was economic and safe; it could charge multiple batteries simultaneously; it was rugged and reliable; it was easily maintained & repaired; it could be manufactured in the developing world; it was multi-functional and it could be easily transported to the remote villages.

6.0 Field Testing 1999

In the summer of 1999, different types of WLED house lamps and torches (flashlights), plus two PGs were taken to various villages in East and West Nepal to test them in the real environment (Figure 1). The following places were visited:

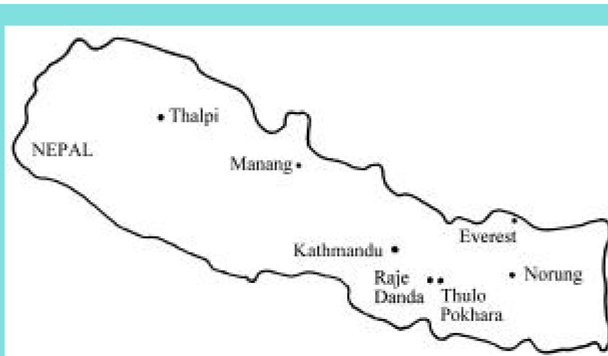

Figure 1: Location of the villages in Nepal

Majhigaun (Fisherman's Village) - installed Nepal's very first WLED household light.

Feedback: the householder wished to have more light so we doubled the number of WLED's.

Manthali (District of Ramechap) - demonstrated the PG WLED home lighting system and torches to a gathering of 150 villagers.

Feedback: the District Chief advised the audience to spend less on weddings and more on their children's futures by investing in Solar Home and PGSs. He also said that they could sell 2000 of our WLED torches straight away if we could supply them.

Khimti (District of Ramechap) - demonstrated the WLED torches in the hydroelectric Project tunnels and penstocks (1 km deep in the mountain).

Feedback: the engineers working on the Khimti Hydro Project would very much like to be able to buy our WLED torches and they provided us with some very insightful comments regarding the design features.

Chandrawati - first full-scale field demonstration in Nepal of the entire Pedal Generator WLED Home Lighting System.

Feedback: the guest house owner used the PGS in his dining room for the entire evening and was delighted with the results and lack of smoke and fumes. The villagers would also like to buy the WLED torches.

Annapurna Base Camp (ABC) - demonstrated the WLED Home Lighting System at numerous villages and teahouses all the way to ABC at 4,130 meters).

Feedback: there was a great deal of interest in using the WLED lamps for the kitchen, dinning room and sleeping quarters since they are energy efficient, non-polluting and safe. The WLED torches were used extensively and approved with great enthusiasm - so much so that it was difficult to get them back at times!

Sherpa - one of our WLED torches, complete with spare batteries and a recharging system was given to a Sherpa to field-test.

Figure 2: Dave I-H showing the Pedal Generator and WLED lamps to the great Nepali mountaineer, Babu Chiri Sherpa, who has summited Everest eleven times and all without oxygen. He would like to use the WLED lamps in a school he is building. Photo by DI-H.

Feedback: after one year it was still working perfectly and he had nothing but praise for its powerful and beautiful white light and the many weeks he could go between recharges. As it had been accidentally dropped many times he was very impressed by its ruggedness and dependability.

Overall the feedback from the villagers was thoughtful, comprehensive and very positive. What was a little 'surprising' was the strong desire of the villagers to get hold of our WLED torches since a 3WLED torch gives at least as much light as a typical incandescent bulb torch. Our data shows that a three D cell WLED torch has at least seven times the battery life of it's incandescent bulb cousin! It is interesting to note that even if non rechargeable D cells are used then there will be seven times less old batteries thrown away (because they are) which is environmentally beneficial. Of even greater significance however is the fact that if rechargeable D cells are used then they will last approximately 200 times as long as the non-rechargeables, saving much money for the user.

With this information we returned to Canada more than ever determined to return to Nepal in 2000 with complete WLED home lighting systems for a number of villages [2].

7.0 Project Planning: 1999-2000

In collaboration with Mike Rojik, Director of the Nepal School Projects (NSP) [3], a Canadian-Nepali NGO, several villages were selected for a trial of the innovative new WLED system developed at the University of Calgary. Extensive lab and field-testing of the WLED lamps and PGs proved that they were a viable and possible alternative for the villages, located south east of the capital Kathmandu (Figure 3).

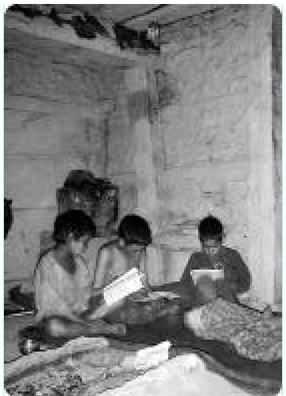

Figure 3: Three older children studying with the light of their 6WLED lamp in Thalpi. The light is seen fixed on the ceiling at the top of the photo. Photo by A. Zahnd.

The villages were chosen on the basis of need and their remoteness and that none were deemed likely to be electrified via the national grid in the foreseeable future. After field surveys and consultation with the respective Village Development Committees (VDC), two villages were accepted: Thulo Pokhara and Raje Danda which are two days hard trek southeast of Kathmandu.

8.0 Oops Everest 2000!

Just to complicate the situation even more, an invitation to be a member of the "AGF (American General Funds) Everest 2000" expedition could not go a begging. As Everest base camp (5,364m) communication engineer and education expert for the web based interactive education program for Canadian school children there was much to do. We did however find time to erect and test our Pico Power Wind Generator and the PG. Of great joy to the team cooks from many expeditions was the little grind stone that was part of the PG since they were always looking for ways to get their knives sharpened. Our Pico Wind Generator did in fact charge our sealed lead acid batteries but we required a fair bit more wind velocity than usual due to the very much reduced air density at these altitudes. The University of Calgary engineering students ("Team Pico") [4] who designed the system did a terrific job and so much so that we brought it back to Calgary for more testing and upgrading and fully expect to take it back to Nepal in 2001 - for use at much lower altitudes! The technical trials and tribulations of a month and a half at Everest Base Camp (EBC) were made so much easier to bear due to the assistance of my son, Gregor, and wife, Jenny. Gregor's reputation for being able to fix anything be it the team radios, computers or video equipment was such that he was referred in emails to the Canadian Broadcasting Corporation (CBC) as "Amazing Gregor" and he fully deserved the title.

Though not equipped for it, and thanks to the assistance of Noel, the technician for the successful British team, I was able to build a 5WLED headlamp which our climber, Tim Rippel, took to 8,500m before he had to turn back due to hypothermia. Though it should have been brighter it got much praise from Tim and other climbers for the quality of its light. It was the very first WLED lamp on Everest and given different circumstances (that's another story) it would have summited!

A nearly catastrophic tent fire due to a faulty connection on a butane lamp proved to us forever the value of WLED lighting in a tent.

The Everest expedition was the best and the worst of times but we were glad to have had the opportunity to play our part in its eventual success and we learned a great deal about human egos! Always however at the back of our minds was the thought that we could hardly wait to get on with our real work - the Nepal Light Project.

9.0 System Design Modification and Appropriate Technology

Preliminary site inspection of the two villages in June 2000 revealed limited local potential for a possible Pico Hydro development. At the time neither village's water delivery system offered sufficiently reliable flow for Peltric sets. Additional concerns were raised in regard to maintenance and seasonal flux (May-Aug. comprise the Nepalese monsoon).

Wind generation was judged inappropriate due to inadequate local data and cost. After due consideration, including the remoteness of the villages and technical abilities of local artisans, the PGS was confirmed as the most appropriate power source for the villages of Thulo Pokhara and Raje Danda (Figure 4).

Figure 4: Early morning battery charging in Raje Danda. Photo by DI-H.

Late into our scheduling period Fate again seemed to influence our plans with the discovery that there was an experimental 200 Watt Pico Hydro Generator (PHG) operating in the village of Thalpi in the remote northwest Jumla district. On investigation it was also discovered that it powered only three homes fitted with incandescent bulbs. An offer was made to the village elders, and accepted, that we wire the entire village of 28 homes with 220 V AC, convert it to 12 V DC and then equip each home with two WLED lamps.

10.0 PG and PH System Implementation

On the basis of the research carried out in Canada and in Nepal, a PGS coupled with widely available 12 V batteries was designed and subsequently manufactured in Kathmandu by local technicians. The form of electrical generator for this phase of the NLP was chosen such that it would be affordable, simple, safe, dependable, multi-functional and independent of sun, wind and rain.

Each village dwelling was provided with a single 6WLED lamp including a wall/roof fitting, a 12 V sealed lead acid battery, and adequate wiring. Six to eight households share each PG with one householder being responsible for its well-being. Data from testing confirms that approximately 30 minutes or less of slow pedaling is sufficient to meet the daily lighting needs of each home which is roughly between four and five hours per night. Each PGS recharges four SLA's simultaneously and this number could be easily and safely increased.

The generator consists of a locally manufactured flywheel, low RPM DC motor/generator, voltage regulator, digital multimeter, and poly-fibre belt. Each generator was also equipped with an attachable rotating grinding stone, much appreciated for sharpening tools. Also provided was a small chuck, used for holding small carving tools or whatever else the imaginative villagers could think of. The Thalpi PHG system implementation was relatively straightforward in that

Table 2: Description of NLP Year 2000 Projects

Location	Thulo Pokhara	Raje Danda	Manang	Thalpi	Bhaktapur	Norung
Power source	PGS	PGS	Ghatta Generator	Pico Hydro (200W)	220 AC	Centralized Solar
# of Homes	23 (+Gompa & School)	31	15	28	12 lamps total	45
LED's/ Lamp	6 (homes) 9 (others)	6	9	9 + 6	Varies (3 to 9)	9
NGO	NLP-Nepal School Projects	NLP-Nepal School Projects	NLP- N. Eagle	NLP-KCST Jumla: A.Zahnd & S.Craine	NLP-Child Haven Int. (Canada)	NLP - A. & F. Harckham (Canada)

Figure 5: The proud custodians of the Thulo Pokhara Pedal Generators about to take them home. Photo by DI-H.

the power source already existed and was reasonably well regulated so all that was required was a dependable 220 V AC to 12 V DC converter [5]. The villagers dug all the trenches, laid all the plastic pipes to protect the electrical wiring between the generator and the village and wired their own homes.

Table 2 illustrates typical village home lighting assemblies and Table 3 the total projects that the NLP was involved in for 2000.

Table 3: Typical WLED Home Lamp Assemblies & Power Requirements

Fixture	Type	Application	Power
Flexible Table Lamps	3 WLED	Reading	0.22 W
Fixed type, box shaped	2 WLED	Torch	0.15 W
Ceiling Light	6 WLED	Main Room	0.43 W
Ceiling Light	9 WLED	Main Room	0.65 W

11.0 Discussion

With respect to sustainable development and long-term viability, there is reason to believe that the NLP-initiated projects have set the trend to follow. The above data does not begin to demonstrate the substantial savings that accrue from the durability/longevity of WLED lighting. Initial transport and installation costs comprise 99 % of the predicted costs for WLED's, whereas owners of less capital-intensive forms must endure the cost of continual replacement, on an unpredictable basis with costs varying according to market fluctuations. One would have to make a concerted effort to damage a WLED and evaluations made by high altitude climbers on Everest, Sherpa guides and field-testing all indicate that the WLED torch can withstand damage that would destroy conventional halogen/incandescent bulbs installed in the same assembly. Fixed interior lighting would not likely be subjected to such conditions.

The relatively high initial capital cost for WLED's will drop precipitously through the next five years, principally through competition and increased output achieved by economies of scale. It is likewise predicted that WLED output power per dollar will increase accordingly.

Tables 4 and 5 illustrate approximate costs for typical lamps and batteries for a sample village of 100 homes.

12.0 Ongoing Research and Development

To reach a greater number of households, schools and workplaces (Figure 6) the NLP has founded and funded a company (Pico Power Nepal) in Kathmandu for the development, production, and marketing of WLED technology and its concomitant power generation systems. The advantages of domestic Nepalese production include reduced costs, local employment and training, incorporation of local market knowledge, and reduced vulnerability to currency fluctuation or regional instability. In keeping with our philosophy regarding gender equality the CEO of PPN is a 21-year old woman! In Nepal, WLED technology is emerging as an important component of rural electrification: no other technology can provide light for as many people for the same power input. A notable advantage to the adoption of WLED lighting for torches and homes is environmental since the significantly increased battery life reduces waste including toxic heavy metals found in single-use and rechargeable batteries, a serious problem in developing countries like Nepal where disposal facilities are primitive or non-existent.

A team of fourth year mechanical and electrical engineering students at the University of Calgary are currently designing a new low-flow, high head Pico Hydro Generator and it will be field tested in Nepal in 2001.

Table 4: Approximate calculations for different lighting-only plant (Costs in Nepali Rupees, NRs)

Lights	Cost per lamp	Cost of lamps for all households	Total capital cost for all households	Power cost per lamp	Battery cost per lamp	Total capital cost per lamp
Bulbs	60	17,850	1,120,350	3675	-	3,735
AC Compact Fluorescent	1040	312,000	721,500	1365	-	2,405
DC Fluorescent	603	180,900	946,543	945	1607	3,155
DC WLED's	1750	525,000	610,071	105	179	2,034

$1.00 Canadian = 46 Nepali Rupees (NRs)

Table 5: Approximate Calculations for Different Battery Costs in Nepali Rupees

Type of Lights	# of households	# of lamps per household	Power required per household	Cost of power for all households (NRs)	Battery Cost per household (NRs)
Bulbs	100	3	105 W	1,102,500	-
AC Compact Fluorescent	100	3	39 W	409,500	-
DC Fluorescent	100	3	27 W	283,500	4,821
DC WLED's	100	3	3 W	31,500	536

Figure 6: Dave and the lama of Thulo Pokhara in the Gompha. (We do not have his name unfortunately). The PGS is seen near the right hand bottom of the photo and the lamps are in the top left hand corner.

Photo by Gregor Irvine-Halliday.

Such generators will allow power production at sites previously considered unsuitable for hydro development. PPN designed and manufactured the entire WLED lighting system for the Norung project. PPN is also pursuing research into commercially viable spin-off technology to fund rural development and numerous designs have been developed for both Nepali and international markets.

13.0 Conclusion

The year 2000 has been exciting for the Light Up The World (LUTW) - NLP with Thulo Pokhara and Raje Danda being the first two communities to be permanently lit by WLED lighting, and the Thalpi PHG powered system was the icing on the cake. Foundational projects have successfully gone ahead with the collaboration of Nepalese and international Non Government Organizations (NGOs), and feedback has thus far been very positive. Additional villages are being selected for illumination and there is no shortage of requests - only a shortage of funding!

The complete cost to light a Nepali home by PG is approximately $100 Canadian and this can be most definitely reduced significantly.

The future expansion of activities in Nepal is certain, while NGO's and businesses from India, Bangladesh, Africa, South America and other developing regions have expressed their desire to introduce WLED technology to their nations. LUTW is attempting to address this interest while continuing its pioneering efforts in Nepal.

If any incentive to continue this work were required (which it isn't) one only has to remember the words of a villager who visited Thulo Pokhara days after it was lamped: “A foreigner has come and made Thulo Pokhara heaven.”

It is a fundamental obligation for us in the so called developed world to assist those in the developing world to raise their standard and quality of life, by their own efforts and in the manner which they chose - it is also our privilege.

14.0 Acknowledgments

Sincere thanks go to: Alex Zahnd and Ghanashyam Ranjitkar for their timely advice and unselfish assistance in lamping Jumla; the Nichia Corporation for their extremely generous donation of 2000 WLEDs for the NLP; the Nepal School Projects; the UofC ECE technicians John Shelley, Frank Hickli and Rob Thomson; the University of Calgary for the NLP research grant and the citizens of Calgary for their very generous donations to the LUTW Fund. Also very much appreciated were Jenny Irvine-Halliday's nimble fingers in helping to build the Thulo Pokhara and Raje Danda WLED lamps and of course the banks for allowing us to overdraw all of the Irvine-Halliday's credit cards.

15.0 References

[1]. Nichia Corporation: www.nichia.co.jp

[2]. “Pico Power Lighting for Nepal - A Field Study”, Dave Irvine-Halliday, August 1999

[3]. Nepal School Projects: www.nepal-school-projects.org

[4]. “Nepal Light Project - 4th Year Engg. Design Report”, University of Calgary, March 2000

[5]. Notes, Advice and Technical Assistance from Alex Zahnd, Stewart Craine and Muni Raj Upadhyaya, Kathmandu, June-July 2000

[6]. “Demand Side Management for Rural Nepal”, Dave Irvine-Halliday and Stewart Craine, Boiling Point U.K., Fall 2000

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He emigrated to Canada in 1970 and joined BNR in Ottawa. After 5 years, he moved to Edmonton and worked for AGT for 4 years, and then moved to Calgary University where he has been for the past 18 years. His research topics are in Fiber Optic Sensors and Communications, and Biophotonics. His present research projects include: the networking of fiber optic electrical current sensors; the use of the fiber optic gyroscope in the precision drilling of horizontal oil and gas wells; the optical properties of biological tissue with regard to the measurement of strain and the healing process, and the "Light Up The World -Nepal Light Project".

Dave has been a mountaineer and trail runner for nearly four decades - "You can never have too many mountains". Halliday@enel.ucalgary.ca

Stewart Craine graduated from Wollongong University in 1998 with first class honours in civil engineering, as well as a second degree in applied mathematics.

He has been in Nepal for 15 months as a rural electrification engineer, focusing on micro hydro installations. This work is with the Australian Volunteers International program. The focus of his work is to reduce the cost of rural lighting for villages in Nepal and other developing countries. This work focuses on the use of energy efficient lighting such as white LEDs, compact fluorescent lamps (CFLs) and battery charging.

Stewart also enjoys running around big mountains, taking photographs, eating at cheap restaurants and sampling the Nepali wines. stewart@wlink.com.np

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His technical experience covers the following: since 1972 as Proprietor: 'Radio & Electronic Works' 1975; Design Engineer for Solar Photovoltaic system manufacturer 'Wisdom Light Group (P) Ltd.' 1995-1997; Production Manager for Solar Photovoltaic system manufacturer 'Wisdom Light Group (P) Ltd.' 1997-1999; Technical Supervisor & Executive partner in 'Pico Power Nepal (P) Ltd.' 2000 to date. Since 1989, he is also the Assistant Administrator for the 'Institute of Engineering, Pulchowk Campus'. muniraj@wlink.com.np

Gregor Irvine-Halliday, earned his double degree BA in Development Studies & French in 1996 from the University of Calgary.

During his undergraduate term he spent 8 months working in West Africa and Quebec as part of a development exchange. Since 1996, he has worked in education and development in Quebec, Alberta, N. China and most recently in Nepal as part of the LUTW-NLP.

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Mechatronics at the University of Guelph

by John S. Zelek, Otman Basir and Bob Dony,
University of Guelph, ON

Abstract

Today's engineering systems require multi-disciplinary design teams. In addition, the computer tends to now be an integral component of these complex systems. Our Engineering Systems & Computing (ES&C) program's objective is to provide the necessary background for the analysis and design of such systems. We have recently introduced options for our ES&C seniors, where one of the options is Mechatronics. In the Winter 2000 semester, our introduction to mechatronics course was successfully offered for the first time to our third year students. This course serves as the introductory course in our Mechatronics option which also includes courses in robotics, manufacturing and advanced mechatronics.

Sommaire

Les systèmes d'ingénierie d'aujourd'hui exigent des équipes multidisciplinaires pour la conception, l'entretien et le service. En outre, l'ordinateur est un composant intégral de ces systèmes complexes. Notre programme (ES&C) de systèmes et de calcul d'ingénierie étudie des systèmes où l'ordinateur est un composant intégral. Nous avons récemment présenté des options à nos étudiants seniors dans notre programme d'ES&C où l'une d'elle est la mécatronique. Nous avons offert pour la première fois notre introduction au cours de mechatronics aux étudiants de troisième année. Le cours a été développé afin d'équilibrer la théorie et la pratique en laboratoire, les étudiants devant concevoir et construire un robot jouant au soccer. Cette formation a été donnée avec succès et tous les groupes ont développé un robot fonctionnel.

1.0 Introduction

Today's engineering graduates require a diverse set of skills, multi-disciplinary in nature, in order to solve the complex problems that employers and society demand. These multi-disciplinary skills typically cross over the traditional engineering disciplines such as electrical, mechanical and chemical. In addition, computers have become ubiquitous in today's society and have also become a standard engineering discipline at many Canadian engineering schools. The School of Engineering at the University of Guelph is unique with respect to the programs offered (Biological, Environmental, Engineering Systems & Computing, Water Resources) not neatly fitting into what some would consider the classical engineering disciplines. Actually, each program bridges more than one of the traditional areas. The ES&C (Engineering Systems & Computing) program is a relatively new program that was introduced in the early 1990s. It covers material that is typically covered in electrical, systems, computer and some mechanical engineering programs. One way of describing the ES&C program is “a study of systems where the computer is an integral component”. It would be useful to our students if they achieved some specialization before completing their undergraduate engineering studies and therefore three options into the ES&C program were introduced: Biomedical systems, Embedded systems and Mechatronic systems. The students specialize in their third and fourth year by choosing one of these options. In practice, this requires the students taking four courses associated with the particular chosen option. The other engineering programs at Guelph are also introducing specialization options. The nurturing of cross-program dialogue is encouraged by some options actually being shared by programs. For example, the ES&C Biomedical option coincides with the Biomedical option in the Biological engineering program.

2.0 Engineering Systems & Computing Program

The Systems engineer requires to know how to identify and define a problem in addition to being a problem solver. Sometimes it is more difficult to define the problem, but this is a crucial step before a solution can be attempted. Even though students are always eager to engage in solving a problem, the design mentors continually stress the importance of initially having a well defined problem in order to explore design solutions. A well-defined problem statement also serves as a measuring stick to evaluate the final design against. The Systems engineer is concerned with the entire system and not just the components that comprise the system. An analogous profession would be an architect who oversees a large building project. Like an architect, ES&C graduates need to be well versed in an array of disciplines so that they can communicate with specialists in other engineering disciplines.

Our ES&C graduates obtain a diverse background in computer systems for the purpose of application into an assorted number of systems including industrial, biomedical, business enterprises and mechatronic to name a few. The ES&C educational program is an accredited professional engineering program. Fundamental courses in the areas of physics, math, chemistry, modeling, simulation, analysis, control and optimization form the core in the first couple of years of study. Given the importance of computing to the program, the students take an extensive list of related hardware and software computer courses. This forms the common base for ES&C students before they specialize in one of the options. In each year there is a design course that all Guelph Engineering students are required to take and successfully complete before proceeding into the next year of study. As part of the design sequence and other courses, the students develop their skills in communications, management and team dynamics. They also learn how to address ethical, legal and social issues. The design problems increase in the level of complexity and responsibility in appropriate years. The design sequence culminates in a fourth year project that is quite intensive.

Currently, there are seven faculty members in the ES&C program and that number should reach nine by 2001. All faculty members try to expose our students to the research they are engaged in; for example: biomedical systems, autonomous robotics, embedded systems, food and animal technology, Geographic Information Systems, parallel computing, software reliability, real-time systems, computer vision as well as document processing. Engineering is, by its very nature, an applied field and the integral role of the computer in a system is sometimes uniquely defined by the application (e.g., process control, biomedical systems, instrumentation systems, communication networks, computer systems, manufacturing systems, or environmental systems).

3.0 Mechatronics

Mechatronics is an interdisciplinary field of engineering and also a design methodology. The field of mechatronics has been described as an intersection of the engineering areas of control systems, electronic systems, mechanical systems as well as computers. Control theory contributes feedback design and stability analysis. The controller is part of a loop for continuous operation in a particular environment resulting in a need for real-time interfacing for analyzing analog, digital and frequency signals. Mechanical engineering donates design, manufacturing and system dynamics. The study of mechanical systems also involves kinematic and dynamic analysis. Computer science/engineering supplies data acquisition methods and algorithms. Information systems tools are necessary for modeling and simulation, automatic control as well as optimization. Modeling and simulating a system before construction is important in order to reduce costs and anticipate potential problems in the implementation phase. Electronic aspects include the actuators and sensors which help interface the system to the outside world. Electrical areas of study include DC and AC circuit analysis, power as well as semiconductor device analysis. Sensors can be as simple as sonar, touch, thermistor or as complicated as vision. Actuators can include stepper motors, DC and AC motors, servo, hydraulic, pneumatic and possibly other unconventional types. In general, the mechatronics design process is typically iterative, and this is exemplified by multi-disciplinary trade-offs.

There are many systems in the existing world that require a synergy of these expertise areas including systems in automotive, aerospace, medical, materials processing, manufacturing and the consumer products application sectors. Some examples of mechatronic systems include aircraft flight control and navigation systems, automobile electronic fuel injection and anti-brake systems, automated manufacturing equipment (e.g., robots, numerically controlled machinery), as well as smart kitchen and home appliances (e.g. bread machines, washers, dryers, toys). The field of robotics can be considered to be a subfield of mechatronics. The typical components of a robotic system include the actuator, communicator, control computer, end effector, manipulator, power supply as well as sensors (see Figure 1). An excellent example of a common mechatronic system is the photocopy machine. Analog circuits are used to control the lamp, heater and power. Digital circuits control the digital displays and indicator lights. Buttons and switches are used for the user interface. Optical sensors and micro-switches are used to detect the presence or absence of paper as well as the correct positioning of the paper. Encoders also track the motor rotation for the various drums that guide the paper through the machine. The actuators include the servo and stepper motors that load and transport the paper, turn the drum and index the sorter. All of these complex interactions are transparent to the eventual user of the system; typically, a mechatronic design goal for any mechatronic systems.

The life cycle for mechatronic design requires addressing: (1) delivery parameters such as time, cost and medium; (2) reliability issues such as failure rates, materials and tolerances; (3) maintainability, which necessitates modular design; (4) serviceability protocols and methods such as on-board diagnostics, prognostics and again modular design; (5) upgradeability; and (6) disposability processes including recycling and disposal of hazardous materials. A computer-aided prototyping environment should provide the tools necessary for modeling, simulation, project management, design, analysis (as well as synthesis), real-time interface, code generator and embedded processor interface. The key to success for any mechatronic system is to strike a balance between: (i) modeling, analysis, control design, computer simulation of dynamic systems; and (ii) experimental validation of models, analysis and understanding key issues of hardware implementation.

4.0 Our Mechatronics Option

The mechatronics focus in our ES&C program is geared to systems which are the synergistic integration of mechanical, electrical and electronic components that are connected by a control architecture typically embedded in a computer. Our students are exposed in their first two years to the primary disciplines that are necessary as a prerequisite for mechatronics design: mechanics, electronics, control, signal processing and computer science. Senior students are exposed to some intelligent control and artificial intelligence principals but the intent is to leave these areas primarily for graduate study.

As mentioned earlier, each of the options, including Mechatronics, is introduced to the students in their third year of study and entails the student taking four designated courses associated with the option area in their third and fourth years. Currently the Mechatronics option consists of an introductory course that has been offered once, an introductory robotics course which is to be offered for the first time in the winter of 2001, an advanced mechatronics course and an automated manufacturing course. The robotics course will focus on the components of a robotic arm, forward and inverse kinematics, internal and external sensors as well as aspects of programming. The automated manufacturing course will introduce the students to the various facets of the manufacturing enterprise. The plan is to have the advanced mechatronics course focus on complex intelligent electro-mechanical design. Our new robotics lab houses 5 A-255 arms (manufactured by CRS Robotics Corporation in Burlington, ON) which will be used for the introductory robotics course and possibly the manufacturing course. The robotics lab also contains a ping pong table which is used for small scale robot competitions in the introductory mechatronics course. This lab is part of a new addition which became operational in September 2000. The introductory to mechatronics course lab sessions are chiefly conducted in a new electronics lab where the students construct small scale soccer playing robots. The robotics lab is utilized towards the end of the term for robot testing and competition. We are currently investigating funding and space options for a new Computer Integrated Manufacturing facility for the manufacturing course.

It is interesting to note that Mechatronic programs at other engineering schools in N. America are typically situated in Mechanical engineering programs. The textbooks available for Mechatronics fit this mold making it difficult to find an appropriate textbook if a Mechatronics option does not fit into the Mechanical niche. Since our ES&C program is a closer relative to a Systems or Computer engineering program than a Mechanical engineering program, our students have a unique background when entering into our Mechatronics option. This necessitated that our Mechatronics curriculum be different than the standard Mechanical engineering one. The emphasis of an introductory Mechanical engineering offering in Mechatronics is placed on electronics and the computer aspects. In contrast, our students are well grounded in these areas, and therefore more emphasis is placed on the kinematics and dynamics analysis as well as the integration aspects.

5.0 Our << Introduction to Mechatronics >> course

Our "Introduction to Mechatronics" course is offered to third year students in the winter semester. It was offered for the first time in the 2000. At that time, 40 students took the course, with about 25 of them being in third year and the rest being fourth year students. Our introduction course tries to strike a balance between the theoretical (reviewing material covered previously at a deeper level) and the practical.

The objectives of our introductory course are that students who successfully complete this course will be able to do the following: (1) choose electronic, software and/or mechanical components for an intelligent electro-software-mechanical system based on cost, performance, ability to manufacture, complexity, reliability, predictability and scalability; (2) model, analyze, design control, execute computer simulations of dynamic systems, identify architectural features of mechatronic systems - components and interfaces - and justify selections made for each component: mechanical, electrical, computer hardware or software; (3) apply mechatronic design principles to robotic (arm and mobile) systems; (4) troubleshoot and debug complex mechatronic systems and specify the tools necessary to initiate and conduct this effort; and (5) construct and debug experimental prototypes of mechatronic systems using analytically validated models. The lecture material covered in the course includes (1) a review of systems

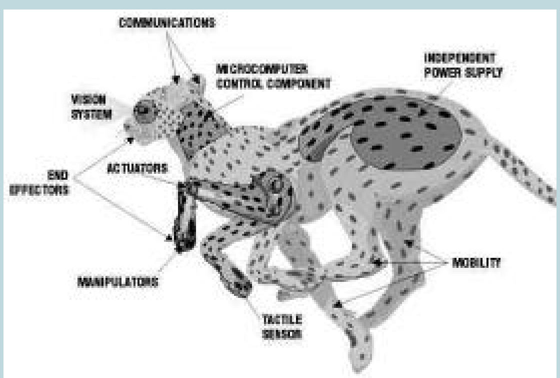

Figure 1: Illustrated are the components of a typical robotic system - which is a type of mechatronics system.

engineering (e.g. modeling, simulation and optimization), (2) an introduction to the theory behind sensors and transducers, (3) the theory behind actuating devices, (4) a review of kinematics, (5) control theory principles, and (6) advanced topics if time permits. The books by Shetty and Kolk [2] and Stadler [3] were chosen as text books. Since the text by Shetty and Kolk [2] did not have adequate assignments and challenges for the students, we plan on using the Stadler text in future years. Four handwritten analytical assignments and three laboratory assignments were assigned. The goal of the laboratory assignments is to properly prepare the students for accomplishing the goal of the project. The analytical assignments were individual efforts while the project and laboratory assignments were done in groups of four.

Mechatronic design requires hands-on exercises in order to instill the necessary concepts; thus, the project and laboratory components. Each laboratory assignment required a physical working demonstration by the students to the teaching assistant (TA) and a submitted report. The three laboratory exercises explored (1) sensing, (2) actuation and (3) control and communications. The laboratory assignments were used to guide the students in activities that were necessary pre-requisites for completing their project: to design a soccer-playing robot (Figure 2). The robot had to meet the specifications as defined by the RoboCup [5] organization, in particular the Small-Size League rules. The students were encouraged to use our machine shop to design and build their robot bases. In addition, the following equipment was provided to the students: a computer workstation, a Handyboard, 4 servo motors, rubber wheels and hubs, a sonar transducer, a RF transmitter and receiver, cabling, headers and shrink tubing, infrared reflective photo sensors, two switches, thermistor, and a hall effect sensor. The equipment was used to construct the robot and conduct the laboratory exercises. The Handyboard [4] is a 68HC11-based microcontroller board with only 32K of static RAM, and is designed for experimental mobile robotics work. It was originally designed at MIT for this purpose. Interactive C was used as the language for developing software for the Handyboard. The host development computer was a Pentium machine running Linux. Linux is an open operating system which made it ideal for tasks like programming the serial interface code for RF communications between the robot and a PC. The first laboratory assignment required the students to use the Handyboard to receive distance and angle readings from 4 infrared sensors (2 types) as well as a sonar sensor. For the second lab assignment, the students had to modify servo motors to function as DC motors. Subsequently, they had to construct and control a differential steering mechanism. The third lab required the students to demonstrate wireless communications between the robot and a PC, trajectory planning and obstacle avoidance.

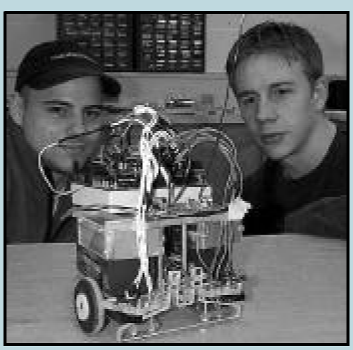

Figure 2: Students Victor Haramina (left), Brian Johnson (right) are shown with their soccer playing robot. Ron Tezuka was also part of the group. This group was one of two groups which designed a kicking device. This group used a solenoid for the kicking device which required a larger battery back.

6.0 Discussion

Given that it was the first time the introductory mechatronics course was run, I think that the course could be considered a success. It is a continual challenge to strongly parallel the analytical aspects (lectures and assignments) with the laboratory and project. The students were excited by the project and spent a considerable amount of time working on the labs and project. This can be verified by all of the groups (10 in all) coming up with a working prototype, mind you, some were definitely far superior to others. As with other courses that involve group work, there is always the problem that some members of the group do more than their share of the work. For future course offerings, it is recommended that the groups consist of only 2 or 3 students at most. Typically, the students spent a lot of time debugging their labs and projects. We were quite fortunate to have a competent technician who proved to be the student's ally in these times of tribulation. Originally, we had acquired a ping pong table to be used for robocup soccer matches. However, the first time offering did not result in any mini World Cup matches but we hope to integrate such competitions in the last two weeks of the term in the future. The experience of building a soccer playing robot provided the opportunity for the students to actually learn and appreciate the concepts that are necessary for an introductory mechatronics course.

The role of the introductory course was to introduce our students to the Mechatronics option. The aspects of group work and a heavy laboratory component will definitely re-occur in the other courses within our Mechatronics option: robotics, manufacturing and advanced mechatronics. As of September 2000, we are very excited by having access to a new robotics laboratory which be used for both the robotics and introductory mechatronics courses in addition to a new electronics laboratory which will also be used for the introductory mechatronics course. Both introductory mechatronics and robotics courses will serve as pre-requisites for the other courses in the option. In January 2001, both introductory courses will be offered, with the robotics course being offered for the first time. We hope to introduce the other two advanced courses within the year.

Readers are invited to look at our web site for the introductory course [1] and provide feedback from industry and other educators about the course and the entire option. As new courses are introduced, course materials will be placed on-line at our School of Engineering web site.

7.0 References

[1]. http://www.eos.uoguelph.ca/webfiles/zelek/http://www.eos.uoguelph.ca/webfiles/zelek/05-340/05-340-syllabi.html, "ENGG3400 course web page"

[2]. Devda Sheety, Richard A. Kolk, "Mechatronic System Design", PWS Publishing, 1997.

[3]. Wolfram Stadler, "Analytical Robotics and Mechatronics", McGraw-Hill, 1995.

[4]. http://el.www.media.mit.edu/groups/el/projects/handy-board/index.html, "Handyboard Home Web Page"

[5]. http://www.robocup.org, RoboCup Official Site.

8.0 Acknowledgments

The authors thank technician Mr. Sean Smith for his invaluable assistance to the students during the first offering of the introductory mechatronics course, the students for being the guinea pigs for testing out this new course, and the School of Engineering at the University of Guelph for providing the opportunity to offer this new course.

About The Authors

John Zelek, Otman Basir and Bob Dony are professors in the ES&C (Engineering Systems and Computing) program at the School of Engineering at the University of Guelph. They were instrumental in getting the ES&C options off the ground. Dr. Zelek took a lead role in the Mechatronics option while Dr. Basir directed the Embedded option and Dr. Dony has molded the Biomedical option. Dr. Zelek's research interests include autonomous robot navigation and dynamic artificial visual perception. Dr. Basir's research interests span sensor fusion and gesture recognition. Dr. Dony's research interests involve medical imaging and image compression.

Quality of Service (QoS) in the New Public Network Architecture

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Abstract

This article provides an overview of Quality of Service in the new public network architecture that is committed to replace the traditional IP network to include multimedia services. Focus is on the different mechanisms and models available and the important aspect of end-to-end implementation of quality of service in the new public network domain. Quality of Service based on different service levels is considered in every side of the network - the user, the backbone network access, and the IP core network.

Sommaire

Cet article présente un survol de la qualité du service dans la nouvelle architecture de réseau qui est dédiée à remplacer le réseau IP traditionnel afin d'inclure les services multimédias. L'attention est portée sur les différents mécanismes et modèles disponibles et l'aspect important de l'implantation complète de la qualité du service dans le nouveau domaine des réseaux publics. La qualité du service basée sur des niveaux différents de service est considérée de tous les angles-l'utilisateur, l'accès à la structure du réseau et le réseau IP central.

1.0 Introduction

In recent years, the most active area in networking is - data, voice, and video integration. Business users are beginning to combine real-time applications such as voice and video, which have a limited tolerance for network latency, with non-real time data traffic. With Voice over IP (VoIP) technology - defined as the ability to make telephone calls (real-time voice) over IP-based data networks with a suitable QoS and a much superior cost benefit - systems can provide simultaneous voice and Internet access over the same connection, or integrate existing phone connections with the Internet through VoIP Gateways.

1.1 What is Quality of Service (QoS)?

QoS refers to the capability of a network to provide better service to selected network traffic over various technologies including Ethernet and 802.1 networks, Wireless networks, IP-routed networks, Asynchronous Transfer Mode (ATM), and Frame Relay (FR) that may use any or all of these underlying technologies. It can also be interpreted as method to provide preferential treatment to some arbitrary amount of network traffic, as opposed to all traffic being treated as "best effort".

1.2 Factors affecting Quality of Service

Following factors can profoundly impact the quality of service:

a) Delay: Echo and talker overlap are the problems that result from high end-to-end delay in a voice network. Round trip delay should be less than 50 ms to avoid echo. Since VoIP has longer delays, such systems must address the need for echo control and implement some means of echo cancellation. The ITU recommendation G.168 defines the performance requirements that are currently required for echo cancellers. Talker overlap (problem of one caller stepping on the other talker's speech) becomes significant if the one-way delay becomes greater than 250 ms. Delay can be attributed to - accumulation delay, processing delay and network delay. The choice of a fast CODEC like the G.729 CS-ACELP takes care of the accumulation and processing. Network delay describes the average length of time a packet traverses in a network. The network delay is handled by a good network design that minimizes the number of hops encountered and by the advent of faster switching devices like Layer 3 switches, tag switching system like MPLS (Multi Protocol Label Switching) systems and ATM switches.

b) Jitter (Delay Variability): This is the variation in the inter-packet arrival time (leading to gaps, known as jitter, between packets) as introduced by the variable transmission delay over the network. Removing jitter requires collecting packets in buffers and holding them long enough to allow the slowest packets to arrive in time to be played in correct sequence. Jitter buffers cause additional delay, which is used to remove the packet delay variation as each packet transits the network.

c) Packet Loss and Out of Order Packets: IP networks do not guarantee delivery of packets, much less in order. Packets will be dropped under peak loads and during periods of congestion. Approaches used to compensate for packet loss include interpolation of speech by re-playing the last packet, and sending of redundant information. Out of order packets are treated as lost and replayed by their predecessors. When the late packet finally arrives, it is discarded.

d) Bandwidth available: Maximal data transfer rate that can be sustained between two end points affects service quality. Techniques used to minimize congestion loss in the network may reduce the available bandwidth for an application. With current advancements in transmission media technologies, plentiful capacity is a reasonable assumption for a controlled, localized environment, such as a corporate LAN, but it is currently unrealistic across a global network such as the Internet.

2.0 Different Service Levels

Service levels refer to the actual QoS capabilities, meaning the ability of a network to deliver service needed by a specific network application from end-to-end. This can also include edge-to-edge, as in the case of a network that connects other networks rather than hosts or end systems, (the typical service provider network, for example), with some level of control over bandwidth, jitter, delay, and loss, provided by the network.

Essentially, QoS can provide three levels of strictness from end-to-end or edge-to-edge: best effort, differentiated, and guaranteed.

2.1 Best-Effort Service

Also known as lack of QoS, best-effort service is basic connectivity with no priorities or guarantees. It provides basic queuing during congestion with first-in, first-out (FIFO) packet delivery on the link. Examples of this type of traffic include a wide range of networked applications such as low-priority e-mail and general file transfers.

2.2 Differentiated Service

Also called "qualitative QoS / Soft QoS", differentiated services treats some traffic better than the rest (faster handling, more bandwidth on average, lower loss rate on average), however, there is no hard and fast guarantee. With proper engineering, differentiated service can provide expedited handling appropriate for a wide class of applications, including lower delay for mission-critical interactive applications, packet voice applications, and so on. Typically, differentiated service is associated with a course level of packet classification, which means that traffic gets grouped or aggregated into a small number of classes, with each class receiving a particular QoS in the network.

2.3 Guaranteed Service

Also called “quantitative QoS / Hard QoS”, guaranteed service is an absolute reservation of network resources, typically bandwidth, which implies reservation of buffer space along with the appropriate queuing disciplines, and so on, to ensure that specific traffic gets a specific service level. This type of service is for delay-sensitive traffic, such as voice and video. The Guaranteed Service level is intended for applications requiring a fixed delay.

3.0 QoS mechanisms

Several mechanisms have been proposed to support real-time and multimedia traffic at different layers of networking.

3.1 Data Link layer

At this layer (Layer 2) media access control needs to be modified to provide service differentiation so that QoS guarantees can be supported. Asynchronous Transfer Mode (ATM) is associated with wide area network (WAN) and in the local area network (LAN), Frame Relay (FR) in the WAN and IEEE 802 style in the LAN media.

ATM: Constant Bit Rate (CBR) and Variable Bit Rate (VBR) are best suited for telephony and voice applications, and for multimedia applications such as video. Available Bit Rate (ABR) and Unspecified Bit Rate (UBR) are designed for best-effort delay-insensitive traffic such as file transfers and e-mail.

FR: attempts to provide a simple mechanism for arbitration of network over subscription. Committed Information Rate (CIR) confirms to the commitment on the part of the network to provide network delivery.

IEEE 802.1: 802.1p specification provides a method to allow preferential queuing and access to media resources by traffic class, on the basis of a “priority” value signaled in the frame. This value will provide across the sub-network a consistent method for Ethernet, token ring, or other MAC-layer media types. The priority field is defined as a 3-bit value, resulting in a range of values between 0 and 7, with 0 assigned as the lowest priority and 7 indicating the highest priority. Packets may then be queued based on their relative priority values.

3.2 Network layer

At this layer (Layer 3) too real-time services should be distinguished from non real-time services.

IP precedence utilizes the three precedence bits in the IPv4 header's Type of Service (ToS) field to specify class of service for each packet. These bits may be assigned by an application or a user, or by destination and source subnet, and so on. Typically this functionality is deployed as close to the edge of the network as possible, so that each subsequent network element can provide service based on the determined policy.

Packet marking: The ingress router must mark the packets as they enter the network with appropriate values so that interior routers can handle packets differentially. The marking of the IPv4 packets use the ToS octet.

Packet classification: Routers must check all received packets to determine if the packets should receive differential treatment. The traffic can be policed and shaped to the network in order to maximize the probability that the traffic will meet the service required and receive the desired quality of service.

Packet queuing: In interior routers, packets must be handled differently. The routers may employ multiple queues along with some scheduling disciplines such that delay-sensitive traffic will be serviced sooner.

- **FIFO queuing:** In a traditional IP router, first-come first-serve is the scheduling policy used. This is a fair algorithm and same delay is imposed on all queued packets. It is necessary to alter this fairness and introduce mechanisms such that preferential treatment may be given to differentiated classes of traffic.
- **Priority queuing:** There is a queue for each distinct priority levels and queues are serviced in order of priority. Highest priority traffic receives minimal delay but lower priority queues may be prevented from being serviced leading to their starvation. This simple priority mechanism must be used with some other mechanism to police traffic into the queues.
- **Weighted Round-Robin:** Queues are serviced round-robin in proportion to a weight assigned for each queue. The assigned weight is normalized by dividing it by the average packet size for each queue. Normally, at least one packet is transmitted from each non-empty queue in every round.
- **Deficit Weighted Round-Robin:** Each non-empty queue has a deficit counter that begins at zero. The scheduler reads the packet at the head of each non-empty queue and tries to serve one quantum of data. A packet is served if the counter is zero and if it is less than or equal to the quantum size. If the packet cannot be served, then the value of the quantum is added to the deficit counter for that queue.
- **Weighted Fair queuing:** It schedules interactive traffic to the front of the queue to reduce response time, and it fairly shares the remaining bandwidth among high-bandwidth flows. It ensures that queues do not starve for bandwidth, and that traffic gets predictable service.

Figure 1 shows this classification and queuing of packets to provide differential treatment.

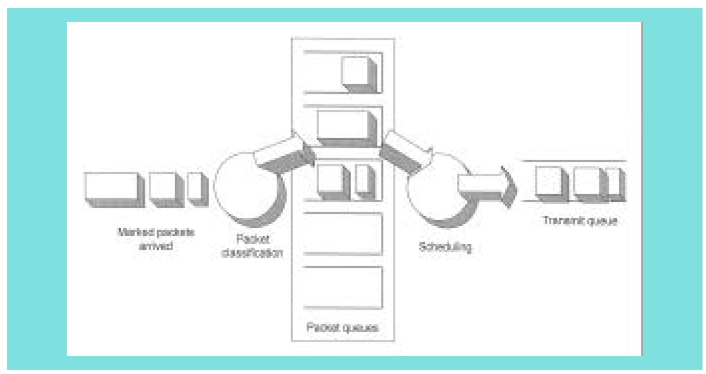

Figure 1: Packet classification and queuing

3.3 Transport and Application Layer

Packets may be marked and classified by transport layer and application layer. Routers could use port numbers, however, they will have to locate the transport-level header that might be behind the optional IP header. By adding application-specific information to packet payloads, the routers need to know the many application-level protocols.

The transport and application levels must however provide new functionality to support real-time applications. The real-time transport protocol (RTP) is the standard for real-time data transmission on an IP-based network. RTP provides no QoS capability but implements specific framing for real-time media, such as sequence numbers and time stamps, to the user datagram protocol (UDP).

4.0 DiffServ and IntServ Models

The main architectures and techniques defined for IP QoS are:

- The Integrated Services: IntServ
- The Differentiated Services: DiffServ

4.1 IntServ Model

The Integrated Services architecture for the Internet was proposed in RFC 1633 to support real-time traffic as well as “best-effort” traffic. It is founded on reservations-based traffic engineering, where resources for traffic are explicitly identified and reserved. Network nodes classify incoming packets and use reservations to provide differentiated services. It performs resource reservation using a dynamic signaling protocol and employs admission control, packet classification, and intelligent scheduling to achieve desired QoS. This model is relatively complex and has difficulties in scaling to large backbones. This architecture is based on the Resource Reservation Protocol (RSVP).

RSVP is an IETF Internet Standard (RFC 2205) protocol for allowing an application to dynamically reserve network bandwidth. It enables applications to request a specific QoS for a data flow. Hosts and routers use RSVP to deliver QoS requests to the routers along the path, and to maintain router and host state to provide the requested service, usually bandwidth and latency. Bandwidth reservation is based on mean data rate, the largest amount of data the router will keep in its queue, and the minimum QoS required.

The specific standards and definitions for services developed by the Integrated Services (IntServ) working group in the IETF fall under Guaranteed QoS. Technologies that can provide guaranteed service for portions of the end-to-end connection include:

- IP-WFQ combined with RSVP signaling or guaranteeing bandwidth on a single link,
- Ethernet- Subnet Bandwidth Manager (SBM) (when used with a compliant switch),
- ATM-Variable Bit Rate (VBR) and Constant Bit Rate (CBR), and
- FR- Committed Information Rate (CIR).

4.2 DiffServ Model

The DiffServ working group in the IETF is working on specific standards and definitions for services that fall under Differentiated QoS. It is looking at a more scalable model and more likely to be easier to implement than IntServ/RSVP model for identifying flows. It is based on traffic aggregation rather than individual per-application instance flows. The DiffServ model largely focuses on the use of the ToS field in IPv4 header or the IPv6 Traffic Class octet as a QoS mechanism. These bits are used to mark a packet to receive a particular forwarding treatment, or per-hop behavior, at each network node. Classification, marking and policing are done at the network edges and only packet handling requirements need to be provided in the core of the network.

Technologies that can provide differentiated service for portions of the end-to-end connection include:

- IP-WRED, WFQ, combined with IP Precedence signaling or prioritizing traffic on a single link
- ATM-Unspecified Bit Rate (UBR) and Available Bit Rate (ABR), especially if no Minimum Cell Rate (MCR) can be specified in the implementation
- Frame prioritization in campus switches in conjunction with 802.1p signaling.

5.0 End-to-End Implementation

In order to provide end-to-end QoS in the new public network architecture, it requires that every element in the network path - router, switch, firewall, host, client, etc. - deliver its part of QoS (Figure 2). The Service Providers should therefore ensure that QoS elements are available throughout in the Intranet/Internet, or some other mechanisms such as reserving the bandwidth are available to support QoS in the network.

On the host side, an access device may receive voice packets and/or data packets that are differentiated based on the ports on which they are received. For packets arriving at the voice port, its related service priority is provided in the Layer 2 and/or Layer 3 header by the access device. For packets arriving at the data port, best effort service is provided if not specified in its Layer2/Layer3 header. In case of same port used for both voice and data packets, differentiation is based on Layer 2 header (IEEE 802.1p), and/or Layer 3 header (IP ToS) fields. Prioritization field is added to the Ethernet packets by most of the recent terminal equipments providing voice traffic, to differentiate voice from data on the same port.

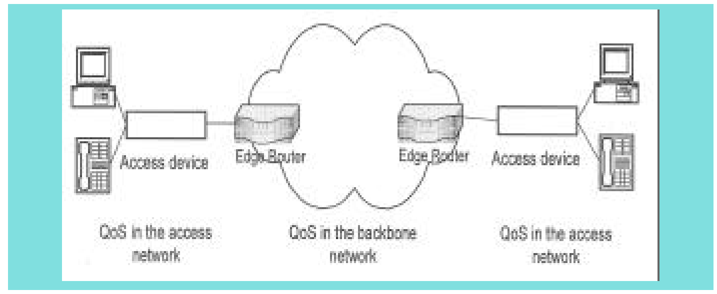

Figure 2: End-to-end QoS

Router switches that can forward packets and apply traffic conditioning at wire speeds are essential to provide QoS delivery in the IP backbone network. The presence of legacy routers will potentially limit service offerings and the QoS level will default to the capability of the lowest performing router. Routers should therefore be quality aware and be able to classify delay-sensitive traffic from non real-time traffic. They must be configured to handle packets based on their IP precedence level, or similar semantics expressed by the bit values defined in the IP packet header. Any priority scheme that was used at Layer 2 should be mapped to a particular IP precedence value.

It has been observed that higher-layer protocols, such as TCP/IP, provide the end-to-end transportation service in most cases. Although it is possible to create QoS services in the lower layer of other protocol stacks (for example, ATM), such services may cover only part of the end-to-end data path. It is therefore not sufficient to have a lossless ATM subnetwork from the end-to-end performance point of view. In addition to a large ATM cell header overhead, the disadvantage of using ATM networks would be to still use routers at the boundary of the network, and to maintain two sets of configurations: one for routers and the other for ATM switches. One of the possible solutions would then be to confine legacy routers to the best-effort traffic only and the QoS-sensitive traffic to send over the ATM network (Figure 3).

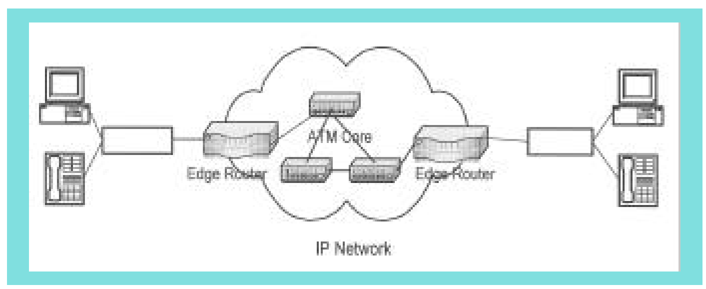

Figure 3: Delay-sensitive traffic channeled to ATM core

Another solution would be the use of Multi Protocol Label Switching (MPLS) with Differentiated Services (DS) whereby which router networks can also provide QoS and Traffic Engineering. The Service Provider must have a Service Level Agreement (SLA) with the customers specifying the service levels supported. The access network marks the DS fields of individual packets to indicate the desired service and the edge routers classify, police and possible shape the incoming packets based on the SLAs using the First-in First-out queuing, Weighted-Fair queuing, Priority queuing or other queuing mechanisms. To support interactive traffic, the router should also be able to support fragmentation of large datagrams and interleaving of delay-sensitive packets with the resulting smaller packets.

MPLS is a forwarding technique that offers simpler mechanisms for packet-oriented traffic engineering allowing Service Providers to deliver new services that are not readily supported by conventional IP routing techniques. It provides a solution that describes the integration of Layer 2 switching and Layer 3 routing with a decreased complexity of mapping between the two distinct architectures. It therefore allows networks to be built using an overlay model in which a Layer 3 IP runs over and is independent of an underlying Layer 2 switched topology. MPLS can be used together with Differentiated Services to provide QoS. In such a architecture, a Label Switched Path (LSP) is first configured that is followed by all packets between each ingress-egress pair. The core routers process the packet based on its labels and class of service field. With such schemes, MPLS effect is confined within the service providers that use MPLS. Its effect is transparent to other Service Providers. Figure 4 shows the position of MPLS in the new public network.

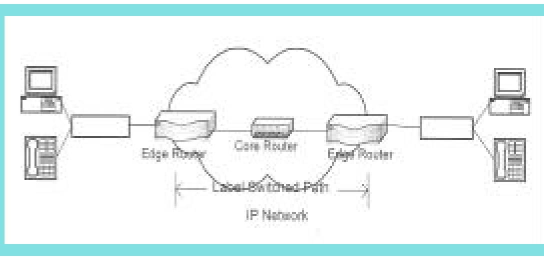

Figure 4: MPLS based Service Provider Network

6.0 Conclusions

With Internet usage doubling each year, more and more companies have started to develop products for Internet Telephony and other real-time applications. But the basic problem still remains of providing QoS to such applications in the global Internet. This paper presents the different QoS mechanisms available that can support customer's different service level agreements. This paper also proposes architecture to implement end-to-end QoS. Both access network and IP network should recognize and treat packets belonging to real-time traffic with priority. This involves marking such packets, classifying the packets based on the markings so that they are given differential treatment, and allowing the scheduling mechanisms to transmit the packets in a timely manner.

7.0 References

[1]. M. Carlson et al., "An Architecture for Differentiated Services," RFC 2475, Dec 1998; http://www.ietf.org/rfc/rfc2475.txt

[2]. R. Braden, ed., L. Zhang et al., "Resource Reservation Protocol (RSVP) - Version 1 Functional Specification," RFC 2205, Sept 1997; http://www.ietf.org/rfc/rfc2205.txt

[3]. J.Wroclawski, "The Use of RSVP with IETF Integrated Services," RFC 2210, Sept 1997; http://www.ietf.org/rfc/rfc2210.txt

[4]. H.Schulzrinne et al., "RTP: A Transport Protocol for Real-Time Applications," RFC 1889, Jan 1996; http://www.ietf.org/rfc/rfc1889.txt

[5]. D.Awduche et al, "Requirements for Traffic Engineering Over MPLS," RFC 2702, Sept. 1999; http://www.cis.ohio-state.edu/htbin/rfc/rfc2702.html

About the author

Anjali Agarwal received her Ph.D. from Concordia University, Montreal in 1996. She is an Assistant Professor at Concordia University since June 1999.

Prior to that she worked as a Protocol Design Engineer and a Software Engineer in industry, where she was involved in providing specifications and design issues for TCP/IP and VoIP support, and in the software development life cycle of real time embedded software. Her current research interests are in various aspects of real-time and multimedia communication over Internet and over the access network. Most recently, she has been working on IP telephony for Broadband Wireless Access networks.

Letters to the Editor / *Lettres envoyées au rédacteur*

Summer issue of the Review

Nice issue as usual. Since Queen's Physics lives in Stirling Hall, opened by John B Stirling, I do have to "twit" you mildly about the spelling on page 13!

Dr. Howard J Wintle,

Thanks for Canadian Review

Congratulations and many thanks for the Summer 2000 issue of the Review. Enjoyed all articles cover to cover, and been informed too.

Gordon Chen LS

My complements to you.

The IEEE-USA Editorial Board was very impressed with our Canadian Review publication. Their primary comment was "Why cannot they produce a publication as good as ours"!!!!

Terry Malkinson, U of Calgary

IEEE Vancouver Section Millennium Awards - Addendum

Missing from the list of winners of the IEEE Millennium Awards for the Vancouver Section was **Roger K. Nelson** (see CR35, page 29).

Nick Keenan, IEEE Vancouver Section

Surfing the net

An architect, an artist and an engineer were discussing whether it was better to spend time with the wife or a mistress. The architect said he enjoyed time with his wife, building a solid foundation for an enduring relationship. The artist said he enjoyed time with his mistress, because of the passion and mystery he found there. The engineer said, "I like both." "Both?" Engineer: "Yeah. If you have a wife and a mistress, they will each assume you are spending time with the other woman, and you can then surf the net."

Bob McLoud, Markham, ON

Fully Digital Real-Time Simulation

With regards to the article "Fully Digital Real-Time Simulation" appearing in Issue No. 34 of the IEEE Canadian Review, we congratulate TransÉnergie Technologies and École de technolgie supérieure (ÉTS) on their accomplishment. We discovered in 1994, while implementing our first "big" system, that achieving real time for large scale power system simulations is no small task.

As it may not be known to the authors of the above mentioned article, we wanted to provide some information about our most recent large scale simulator which is about to be shipped to the Korean Electric Power Corporation (KEPCO). The RTDS® Simulator purchased by KEPCO has successfully represented a power system including 160 buses, 41 generators, 131 single and twin (counted as one line) circuit lines, 78 transformers, and more than 60 dynamic load models. Continuous, real time operation was achieved for the system with a simulation timestep of 50 microseconds. Since only 60% of the available processors were used in the simulation, it is expected that a power system with as many as 250 or more buses could be represented by KEPCO's simulator. The Simulator and its application by KEPCO were described in a paper titled "Overview of the Development and Installation of KEPCO Enhanced Power System Simulator" presented at ICDS '99, an IEEE sponsored conference on real time digital simulators.

For any information, you can contact us by phone at (204) 989-9700 or by email at rtds@rtds.com.

Paul A. Forsyth,
RTDS Technologies, Winnipeg, MB

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Du 13 au 16 mai 2001 L'Hôtel Delta Chelsea
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Appel de conférence

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

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1.0 Soumissions des communications régulières :

Veuillez soumettre un résumé de 300 mots de votre communication au président du programme technique à l'attention du secrétaire du congrès indiqué à gauche. Les soumissions par télécopieur ou par la poste sont acceptées, mais la transmission par courrier électronique est préférée. Votre soumission doit inclure trois mots clés et le nom d'une personne contact avec son adresse de courrier électronique, son adresse postale et ses numéros de télécopieur et de téléphone.

2.0 Soumissions des propositions pour tutoriaux et sessions sur invitation :

Les propositions pour les ateliers, les tutoriaux et les sessions sur invitations seront acceptées jusqu'au 19 janvier 2001. Veuillez contacter le président du comité des tutoriaux et sessions spéciales à l'adresse de secrétariat du congrès (montrée à gauche) pour les instructions détaillées.

3.0 Compétition de communication d'étudiant :

Pour avoir droit à la compétition de communication d'étudiant, le premier auteur doit être un étudiant. Le résumé de communication soumis doit être clairement marqué «Compétition de communication étudiant ». Une lettre officielle indiquant le statut d'étudiant doit être incluse avec la soumission de la communication finale. Les résultats du concours seront basés sur l'analyse du papier au complet. Les versions complètes des communications des étudiants gagnants seront publiées au journal canadien du génie électrique et informatique, sujet à l'acceptation éditoriale finale par le journal.

4.0 Dates importantes :

Résumés des communications reçues :	avant vendredi le 1er décembre 2000
Propositions pour les sessions spéciales reçues :	avant vendredi le 19 janvier 2001
Avis d'acceptation envoyés :	avant vendredi le 19 janvier 2001
Textes finaux complets reçus :	avant vendredi le 2 mars 2001

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Veuillez contacter le président des expositions au secrétariat du congrès pour les informations sur les expositions industrielles au congrès.

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Please submit a 300-word abstract of your paper to the Technical Program Chair at the Conference Secretariat address on the left. E-mail submissions are preferred, but fax and mailed paper submissions will also be accepted. Your submission should include three keywords and the name of a contact person with e-mail and postal addresses, as well as a fax and phone number.

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Proposals for invited sessions, pre- and post conference workshops and tutorials will be accepted before January 19, 2001. Please contact the Tutorials and Special Sessions Chair at the Conference Secretariat address shown on the left for detailed instructions.

3.0 Student Paper Competition:

To be eligible for the Student Paper Competition, the first author of a paper must be a student. The submitted paper summary must be clearly marked "Student Paper Competition". A formal letter stating the participation in the Student Paper Competition with proof of student status must be included with the final paper submission. The competition results will be based on reviews of the full paper. Extended versions of the winning student papers will be published in the Canadian Journal of Electrical and Computer Engineering subject to the final editorial acceptance by the Journal.

4.0 Important Dates:

Paper abstracts must be received by:	Friday December 1, 2000
Special Session proposals must be received by:	Friday, January 19, 2001
Notification of acceptance will be sent out by:	Friday, January 19, 2001
Final papers must be received by:	Friday, March 2, 2001

5.0 Industrial Exhibits:

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

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