Nortel Institute for Telecommunications
of The University of Toronto

@NIT

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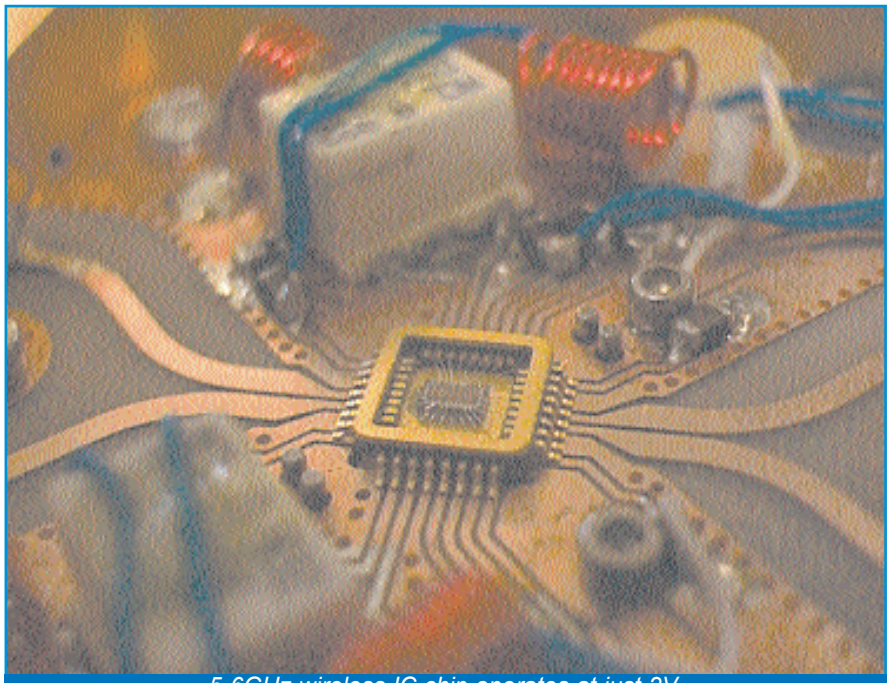

5-6GHz wireless IC chip operates at just 2V.

Revolutionary Wireless Receiver Chipset in Silicon

Present cellular telephone wireless receivers drain battery power far too quickly, and are still very expensive. Researcher James Maligeorgos, working with the University of Toronto's RF/MMIC research group led by NIT Research Thrust Leader Prof. John Long, has developed a low-voltage and low-power silicon microchip (40mW at 2V) utilizing miniaturized transformers. The IC chip implements a very sensitive, energy efficient 5-6GHz wireless receiver, or wireless "front-end".

This research is a breakthrough in the field of integration for wireless receiver circuits onto silicon integrated circuits. It demonstrates that many parts of the conventional cellular telephone can be pulled onto a single silicon chip that can be produced cheaply and in large volumes. This capability makes it possible to design lower cost and higher speed versions of such radio receivers, supporting the rapidly expanding field of wireless communications.

This research is a breakthrough in the field of integration for wireless receiver circuits onto silicon integrated circuits.

To achieve this result, computer-aided design tools, circuits, and techniques to realize on-chip inductors and transformers have been developed and demonstrated.

An inductor or a transformer winding can be fabricated on a microchip by interleaving interconnecting wires to reinforce the magnetic field produced by the flow of current through each wire. A computer-simulation package written by the group closely models the behaviour of interconnections, inductors, and transformers on a silicon integrated circuit. The package is also integrated with a commercial electronic circuit simulator, and this combination of software tools is then used to simulate and optimize microcircuit designs at radio frequencies. The accuracy of the inductor and transformer computer models has been verified through the use of three-dimensional computer simulations of the electromagnetic fields, and experimental measure-

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@NIT is published by the Nortel Institute for Telecommunications. We welcome your comments and suggestions.

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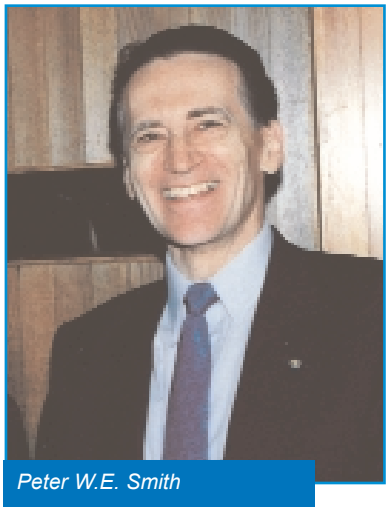
DIRECTOR'S MESSAGE



Peter W.E. Smith

This is an exciting time for the Nortel Institute as we develop plans for new research facilities and initiate new programs. We are building on the solid foundation provided commited support from Nortel Networks and the new funding from infrastructure programs of our Ontario and federal government partners.

The new Bahen Information Technology Centre will provide a wonderful home for our NIT Open Research Facility. Laboratories to support the four current research thrusts of the Institute (emerging technologies/device prototyping, network architecture and management, rf/satellite, and wireless) will be accessible to any University of Toronto researcher, subject to availability. The Facility will cover an area of 900 square metres and will include cleanrooms, network architecture test beds, baseband signal and microwave/RF, and millimiter-wave processing labs.

A new research initiative in plastic optoelectronics is being developed on several fronts. An application for federal infrastructure support has already been submitted, and discussions with Ontario government representatives are underway to attract their support. A France-Canada workshop on plastic optoelectronics (co-sponsored by the Nortel Institute) will take place in Paris later this year with high-level participants from government, industry, and universities.

The Bahen Information Technology Centre at the University of Toronto, future home of the NIT Open Research Facility, is currently under construction.

Recently, we have received a significant equipment donation from the Westaim Corp.-iFire Technology that not only reinforces our development of the plastic optoelectronics initiative in the area of displays, but also represents our first significant industrial partnership beyond our founding partner. We look forward to developing increasing research collaborations with iFire scientists in the months and years ahead.

A very successful workshop (co-sponsored by the Nortel Institute and the Fields Institute) was held February 1-4, 2000 entitled *Data Analysis for Commercial and Industrial Applications*. It was attended by over 100 international research, private sector, and student participants.

In 1999, through a call for proposals, we funded four Nortel Institute Associates' research projects. This year, in our second round of applications, the NIT Research Program Committee has selected another seven Associates (see p. 6).

We are also in the process of reviewing candidates for the Nortel Chair in Emerging Technologies. A number of excellent international candidates have submitted applications, and the selection process is underway.

In planning our activities we are guided by some general principles. We aim to:

1) focus on **LARGE-SCALE** and **INTERDISCIPLINARY** projects to take advantage of our "core capabilities",

2) look for **PARTNERS** to expand our resources and capabilities,

3) **COORDINATE** with the UofT undergraduate, graduate, and professional development programs, and

4) enhance **COMMUNICATIONS/ OUTREACH** to "showcase" NIT and to reach potential partners.

We hope you find this newsletter useful. You may also wish to check our website (www.nit.utoronto.ca) to keep up-to-date on current Nortel Institute events and issues. We welcome your input. Please feel free to contact me, a Thrust Leader, or a member of our administrative office with comments, ideas, and suggestions.

Who's who at NIT:

Director: Prof. Peter W.E. Smith

Advisory Council
Frank Dunn, CFO, Nortel Networks
Adel Sedra, Provost, University of Toronto
Claudine Simson, VP, Nortel Networks
Safwat Zaky, Chair, Electrical & Computer Engineering, University of Toronto

Research Thrust Leaders
Network Architecture and Management: Prof. Alberto Leon-Garcia
Emerging Technologies/Device Prototyping: Prof. Peter W.E. Smith & Prof. Ted Sargent
RF/Satellite: Prof. Keith Balmain
Wireless: Prof. John Long

Nortel Chairs
Network Architecture & Services: Prof. Alberto Leon-Garcia
Emerging Technologies: to be selected

Nortel Junior Chairs
Emerging Technologies: Prof. Ted Sargent
Software Engineering: Prof. Angelos Bilas
Communications Network: Prof. Jinwoo Choe

NIT Associates
Profs. Angelos Bilas, Jinwoo Choe, Al-Amin Dhirani, George Eleftheriades, Deepa Kundur, Eddie Law, Zheng-Hong Lu, Farid Najm, Kostas Plataniotis, Ted Sargent, Jianwen Zhu

Nortel On-site Manager: David MacLean

Program Manager: Helen Lasthiotakis

Secretary: Marjorie Boyle

Setting the Trend for a New Paradigm

Building on an outstanding record of achievement in collaborative research and education, in 1997 the University of Toronto and Nortel Networks created the Nortel Institute for Telecommunications (NIT) at the University. NIT has since blossomed after placing solid foundations to meet its goals of innovative research, education, and information exchange, and has succeeded in attracting additional industrial, academic, and government partners.

Before the Institute was formed, Nortel Networks and the University of Toronto had already developed a partnership spanning two decades. The partnership's many aspects included collaborative research projects, support for University students and faculty, continuing education of Nortel Networks employees, and the establishment of Industrial Research Chairs.

Based on the strength and breadth of these earlier interactions, in February 1997, Gedus Sakus, President of Nortel Networks Technology, and Robert Pritchard, President of the University, announced the founding of the Institute. The Institute's mission was to mount a substantial, comprehensive, and focused effort to drive the evolution of information technologies, while at the same time supporting the growth of Canadian industry. To heighten their impact, the Institute integrated a number of elements in the partnership by:

- establishing two endowed Chairs and three new junior tenure-stream positions;
- funding research, in support of ongoing collaborations;
- setting up a new Masters program in Telecommunications (MET) in 1998, and a summer Professional Program in Telecommunications. The MET class had 6 students in 1998, grew to 20 in 1999, and over 110 students have applied for the 25 spots in the 2000 program. It is a program unique in North America, where students learn about technical, regulatory, and new business paradigms of Telecom.
- creating endowment funds to support graduate and undergraduate students;
- donating equipment to establish two laboratories, one in Applied Physics and the other in Optoelectronics and Emerging Technology;
- forming an Advisory Council, co-chaired by the Provost of the University and a Vice-President of Nortel Networks, to provide long-term planning and leadership;
- placing a Nortel Networks Manager on-site to coordinate and enhance interactions.

Matching funds from the University and the Ontario Research and Development Challenge Fund (ORDCF) heightened the impact of Nortel Network's contributions. Subsequently, the Institute has applied for and received funding from the Canada Foundation for Innovation (CFI) and the Ontario Innovation Trust (OIT).

The benefits that flow from this partnership are many. For the University, it has provided resources for advanced telecommunications research and education, and the stimulation that comes from collaborating on research with a leading knowledge-based company. "This endeavour will firmly position the University of Toronto as a major centre for telecommunications studies. The Nortel Institute will bring together the best minds in the field from around the world, significantly enhancing Canada's profile as a leader in advanced technology," announced President Prichard when the Institute's was formed.

For Nortel Networks, the objective of the partnership has been to build within the company and the university a concentration of expertise in telecommunications technology which will lead to scientific achievement and commercial success, providing "windows" on technologies emerging through research at NIT. It gives the company access to the people and knowledge essential to maintaining of its leadership position in the telecommunications industry. In particular, Nortel Networks has been able to participate in world-class, pre-competitive research directed at the needs of the information technology sector. Its employees have also benefited from continuing education, allowing the company to remain competitive.

"This endeavour will firmly position the University of Toronto as a major centre for telecommunications studies."

The partnership between the Universityn of Toronto and Nortel Networks has developed over time into a model for building an effective collaboration. It encompasses many elements, and integrates them to achieve maximum results. Its positive impact will be felt throughout the information technology sector.

From left to right: A. Sedra (VP and Provost, University of Toronto), C. Simson (VP, Disruptive Technologies, Network and Business Solutions, Nortel Networks), A. Leon-Garcia (Nortel Chair of Network Architecture and Management, NIT), J. Xu (Founding Director, NIT, and former Nortel Chair of Emerging Technologies), D. MacLean (Nortel Networks On-Site Manager, NIT), S. Zaky (Chair, Dept. of Electrical and Computer Engineering), G. Sakus (Retired President, Nortel Technology)

Wendy M. Cecil-Cockwell (Chair Governing Council Secretariat of the University of Toronto) and Minister Jim Wilson sign ORDCF agreement (1999).

NIT FAST FACTS:

Established in 1997

Funding and Partners

University of Toronto
Nortel Networks
Ontario Research & Development Challenge Fund (ORDCF)
Canada Foundation for Innovation (CFI)
Ontario Innovation Trust (OIT)
Westaim Corp./ifire Technologies

Awards

The 1998 Synergy Award for University-Industry R&D Partnerships (NSERC and Conference Board of Canada)
Given in recognition of examples of university-industry collaboration that stand as a model of effective partnership. Nortel Networks and the University won the award for their long-standing collaboration in developing world-class research facilities and education programs.

Making Light of Polymers

Physically flexible light-emitting materials such as poly-phenylene-vinylene have received a great deal of attention over the past decade. Indeed, the promise of plastic electronics and polymer photonics is tremendous. Research in this field could lead to consumer products which can take virtually any shape, low-cost electronic paper fabricated using an ink-jet printing process, and intelligent distributed sensors which can process in parallel the information they acquire.

An example of a flexible plastic chip (Philips Corporation).

However, there is a vast chasm between the dream of photonic polymers and the present-day reality of low-emission efficiencies, poor reliability, and environmental sensitivity.

Now a research team, supported by the Nortel Institute and led by Prof. Ted Sargent, has made breakthroughs in understanding and designing a new class of materials for communication and information technology. The cross-disciplinary team led by Prof. Sargent consists of Dr. San Yu, Dr. Luda Bakoueva, and Erik Johnson, and involves collaborations with Prof. Alex Shik and Prof. Harry Ruda of UofT's Department of Metallurgy and Materials Science.

The research team has rejected the premise that the benefits of exploring the organic-materials domain can be achieved only inside an all-organic system. Instead, the team is simultaneously drawing on the very best qualities of organic and inorganic materials. The organic component gives flexibility, low cost, and spin-on processing. The inorganic constitutent is highly stable and can routinely exhibit near-unity quantum efficiency in converting energetic electrons into packets of photonic energy. The specially designed nanometre-sized semiconductor crystals considered in the Sargent group research permit quantum-confinement for discrete energy states and enhanced transport, linewidth narrowing, and memory effects.

The promise of plastic electronics and polymer photonics is tremendous.

Based on this new material, the team has elaborated a theory by which to describe the behaviour of charge carriers inside light-emitting devices. For the first time, they have predicted how electrons and holes flow and interact to create conditions efficient for production of photons. The team has reduced this complex three-dimensional, multi-variate problem to its physical essentials by first evaluating the field and transport structure of a single, spherical core-shell nanoparticle in isolation, and then building a composite model out of aggregates of such nanocrystals.

The research complements a number of other projects ongoing in the group. One research thrust involves creating intelligent photonic elements–aggregates of optical limiters which, when suitably interconnected, could ultimately lead to a fully optical packet switch–using ordered, nonlinear optical arrays. The Sargent group's discoveries in polymer-nanocrystal composites may provide the needed optical refractive index contrast and strong nonlinear effects required to make this new class of devices a reality.

Another area of research that may be opened up by these latest results involves the realization of optical networks that use many wavelengths of light to transmit information at very high speeds. The Sargent group recently reported breakthroughs in enhancing the efficiency with which the optical fibre multiple-access channel can be shared under a noncoherent code-division multiple access scheme. The technique involves creating two-dimensional time- and wavelength-spread codes which take full advantage of the broad low-loss bandwidth of optical fibre. Low-cost, integrable signal-processing componentry–most promisingly based on efficient light-producing and light-modifying polymers–will be needed in such systems.

The research team is also advancing knowledge of the inner operation of key components which will make up metropolitan-area optical networks. These semiconductor lasers are precisely engineered to

generate the purest of light to travel unperturbed down an optical fibre. In the heart of these lasers, known as the active region, high densities of photons and electrons interact to convert energy efficiently from one form to the other. Through innovative experiment and fundamental theoretical progress, the Sargent team is building a new understanding of these internal mechanisms. The group is paving the way for further advances in the perfection with which light can be created inside inorganic media.

The potential payoff of these research areas, when considered together, is tremendous. A new paradigm is being forged in the displaying, acquiring, and processing information using lightweight, low-cost materials. Real breakthroughs are being made toward the dream of efficient, robust, processible light-emitting materials–an emerging area of virtually limitless opportunity.

Prof. Ted Sargent
ted.sargent@utoronto.ca
NIT Associate & Nortel Junior Chair
in Emerging Technologies
NIT Thrust Leader,
Prototype Facility & New Materials

Many wavelengths of light dispersed inside a monochromator used to create two-dimensional time- and wavelength-spread codes which take full advantage of the broad low-loss bandwidth of optical fibre.

Revolutionary Wireless Receiver Chipset in Silicon

Continued from page 1

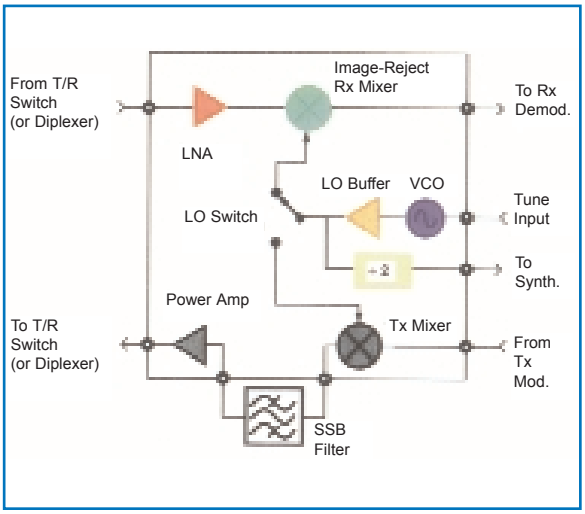
ments on actual devices and test structures.

The software design package has since been transferred to Nortel Networks and is currently being used to develop high-frequency analog and digital circuits in their production and experimental integrated circuit technologies.

A set of integrated circuits for radio communications was also developed using the computer models and software design system. The circuits were fabricated by Nortel Networks in a low-cost silicon technology very similar to that used to manufacture chips such as Intel's Pentium microprocessor.

Incorporating transformers into the front-end circuit design has allowed the high frequency portion of the radio receiver to operate at the same low power supply voltage as modern low power digital circuits, used in portable laptop computers. This result is a large improvement in "talk time" for a cellular telephone. Also, the possibility of integrating the both high- and low-frequency sections of the receiver together is an important step along the way to the "radio on a chip", where complex low-frequency digital computations are necessary to process the digital radio channels, as well as the high-frequency receiver section.

The results of this work have been published at a number of international conferences–most recently at ISSCC, which is the premier showcase for IC research and development–and have led to invited publications in the leading journals for microelectronic circuit research. In addition, Nortel Networks has applied for patents to cover its intellectual property rights to the radio receiver designs. Circuits developed during the course of this research have also been incorporated into products under development at Nortel Networks as well as other leading manufacturers of wireless communications products.



Prof. John Long
long@eecg.utoronto.ca
NIT Wireless Thrust Leader

New Nortel Institute Associates Announced

Prof. Angelos Bilas, Nortel Junior Chair of Software Engineering, Electrical and Computer Engineering

Cluster Computing: Server Infrastructure for Emerging Internet Applications and Services

Prof. Jinwoo Choe, Nortel Junior Chair of Communications Networks, Electrical and Computer Engineering

Developing an Architecture for Multi-service LANs incorporating High-speed Switching and Multi-access Technology

Prof. Al-Amin Dhirani, Chemistry, cross appointment with Physics

Electro-Optic Properties of Single Molecules

Prof. George Eleftheriades, Electrical and Computer Engineering

Micromachined/Mems Components and Subsystems for Broadband Wireless Communications

Eddie Law, Electrical and Computer Engineering

Design and Implementation of Photonic Switching Fabric System

Prof. Kostas Plataniotis, Electrical and Computer Engineering

Mobile Position Location in Third Generation Cellular Networks

Prof. Jianwen Zhu, Electrical and Computer Engineering

Optical Communications for Wireless and LAN Applications

In1999, NIT initiated a program to fund new faculty members as the Institute's Associates as part of its mandate to provide Canadian university-based global leadership in advanced information technology and telecommunications research. NIT Associates are chosen on the basis of proposals for innovative and significant research that fit in with the general mandate and scope of the Institute. New University of Toronto faculty may apply for seed operating funding (up to $50,000 over two years).

NIT Celebrates Processing Equipment Donation

The Nortel Institute recently celebrated a significant in-kind donation of processing facility equipment from The Westaim Corporation and iFire Technology Inc. The processing equipment will be placed within the NIT cleanroom devoted to Emerging Technologies/Device Prototyping.

The NIT cleanroom will be a part of the NIT Open Research Facility within the new Bahen Information Technology Centre under development at the University of Toronto. The Open Research Facility is a key and integral NIT component that will contain four strategically chosen core research laboratories: Emerging Technologies/Device Prototyping, Network Architecture and Management, RF/Satellite, and Wireless.

With an infrastructure designed to accommodate a wide range of users and a variety of processes and materials, the NIT Open Research Facility will fuse disciplines and facilitate the work of more than 100 researchers, visiting scientists, students, and industry professionals.

The Westaim Corporation is a publicly traded company specializing in launching high-potential technologies into the marketplace. A subsidiary of Westaim Corporatin, iFire Technology Inc. has developed a flat-panel display technology for a new generation of affordable hang-on-the-wall television sets. Its proprietary iFire^{tm} flat-panel displays are only a few millimetres thin, with bright, crisp, full-color images, unrestricted viewing angles and video-rate performance over an extended operating-temperature range.

Partnerships such as the one represented by Westaim Corporation and the NIT set the stage for ideal opportunities to focus research and development efforts by the private sector and university community.

Prof. Peter W.E. Smith (Director, NIT) presents Martin Kabat (Vice-President Finance and Administration, iFire Technology Inc.) a plaque in honour of the partnership.

Fields-NIT Workshop Success!

Over 100 international research, private sector, and student participants gathered together at the Fields Institute from February 1-4 for the workshop *Data Analysis for Commercial & Industrial Applications* organized by the Fields and the Nortel Institutes.

The aim of the workshop, sponsored by MITACS and Nortel Networks, was to bridge leading-edge mathematical techniques and to explore problems motivated by commercial and industrial needs.

Speakers presented both solutions and challenges to share mathematical results and ideas on data analysis across the mathematics, statistics, physics, biophysics, computer science, telecommunications, and engineering communities.

More info: Workshop program and abstracts can be found at www.fields.utoronto.ca/data_analysis/

UPCOMING EVENTS

Visit our web site at www.nit.utoronto.ca for details regarding NIT events:

New Technologies for Advanced Optical Networks

CITO/PRO/MMO Toronto Tech Talk
May 16, 8 a.m. to 4 p.m.
Sheridan Park Conference Centre
2275 Speakman Dr., Mississauga

Nortel Junior Chair Prof. Sargent and NIT Director Prof. Smith are presenting at this advanced technology research workshop. The workshop will focus on breakthroughs in optical devices that are radically transforming the world of communications. Leading world experts in innovating and engineering the optical networking components of today and tomorrow will set forth their latest results and debate their visions of the future.

Prof. Sargent will speak about "All-Optical Packet Switching using Photonic Crystals", and Prof. Smith about "Ultrafast Optical Switching and Time Division Demultiplexing".

Photonics: Making Light Work

Dr. Stewart Aitchison

NIT Distinguished Lecture & ECE Special Seminar
May 17, 10:00 a.m.
Sandford Fleming, Rm 1105
University of Toronto

Photonics is the term used to describe the use of photons instead of electrons. The increasing demand for communications bandwidth has resulted in many of the benefits of photonic technology finding direct applications.

This presentation will focus on two emerging themes: nonlinear optics and planar silica technology. The first part of the presentation will describe the application of III-V semiconductor technology for the observation of soliton-based effects in periodic structures. The well-developed semiconductor micro-fabrication technology available today has allowed a range of novel all-optical switching devices to be realised. The talk will review results on nonlinear waveguide arrays and nonlinear waveguide gratings. The second half of the talk will concentrate on the application of flame hydrolysis deposition for the production of integrated optical circuits and the development of hybrid integration techniques. Recent advances in the use of photosensitivity to directly write integrated circuits for optical communications and bio-sensing applications will be described.

Reconfigurable Multiple-Wavelength Optical Systems and Networks

Dr. Alan Willner

NIT Distinguished Lecture
IEEE LEOS Distinguished Lecture Program
May 29, 2:00 p.m.
Sandford Fleming, Rm 1105
University of Toronto

Three major thrusts will be discussed related to the exciting area of wavelength-division-multiplexed (WDM) communications, a technique involving the simultaneous transmission of several channels on different wavelengths down the same fiber. The first part of the presentation will provide an overview of the revolution in optical communications caused by WDM and optical amplifiers. The second section is aimed at dynamically compensating channel-degrading effects in reconfigurable systems. These time-dependent degrading effects occur since next-generation WDM systems will route signals through slowly-reconfigurable network paths, allowing several parameters to vary. Therefore, it is imperative to provide robust, dynamic schemes to compensate for issues such as unequal channel powers, EDFA transients, and chromatic and polarization-mode dispersion. The third thrust is aimed at enhancing the functionality of future packet-switched optical networks, in which each WDM packet can be actively routed through a network based on wavelength and packet information. Significant functions that can be enabled by high-speed optical switches include: contention resolution, header replacement, and synchronization.

This lecture will also be webcast live as RealVideo. Visit out web site, nit.utoronto.ca, for details.

Nortel Institute Professional Summer School 2000

The Nortel Institute for Telecommunications Professional Summer School will be offered at the University of Toronto again this year, scheduled for July 25 and 26. The theme of this year's program is disruptive technologies, and the threats (and opportunities) they pose to existing communications paradigms. Mark your calendars!

For further information, please visit www.nit.utoronto.ca or contact linda.espeut@utoronto.ca