Network of excellence (NoE)
Information & Communication Technologies (ICT)

Pan-European Photonics Task Force: Integrating Europe’s Expertise on Photonic Subsystems
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European Higher-Education Handbook

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## WP participants

ICCS/NTUA, UPC, Institut TELECOM, ACREO, AIT, CHALMERS, SSSUP, UKA, TNI, IT, DTU, UPVLC, POLITO, HHI, UESSEX, IMEC, TU/e

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Executive Summary

The dissemination of optical communications and photonic technology through higher education degrees is one of the key targets of the Spreading of Excellence EURO-FOS work-package (WP2). The creation of a handbook summarizing the available postgraduate degrees aims at serving as a guide to students who wish to pursue a higher education degree at the latest technologies of optical networks and photonic technology. This document is a first approach. For its preparation information provided by all EURO-FOS beneficiaries has been compiled. The document will continue to increase with up-to-date information aiming to cover at the end of EURO-FOS project all major organizations across Europe.

The document is entitled “Higher Education Handbook” and lists Europe’s M.Sc/PhD courses covering the area of photonic systems/networks and optical telecommunications. It outlines basic information about the institutions and provides details about the offered postgraduate courses, research activities of the respective research groups and contact details. The handbook information is also enriched with institutions outside the EURO-FOS network. Gathering of this information has been enabled by direct contacts of the EURO-FOS beneficiaries with their colleagues outside the consortium. Moreover, a call of advertisement of the handbook has been located since February 2010 (M22) on the EURO-FOS website for any European institution that may want to contribute to the dissemination of optical communications and photonic technology higher education degrees. The handbook content will be updated frequently with any new contribution.

The purpose of the handbook is to provide to the public and any interested party up-to-date information about higher education on photonics studies and drive future candidates to start postgraduate degree in Europe’s state of the art relevant courses. The distribution of the handbook to the public will be accomplished in the beginning through the website of the EURO-FOS Project. Later on the handbook will be accessible and downloadable from the public website of the members of EURO-FOS consortium as well. Finally, EURO-FOS project intends to distribute the final version of the handbook through mailing lists to various targeted offices and foundations that provide consulting and guidance to future graduate candidates.
Academic Research on Photonic Systems in Europe
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Introduction

Welcome to the first issue of our EURO-FOS handbook. This booklet describes Europe's academic research groups and available laboratory infrastructures that perform research on photonic systems applicable to telecommunications. We hope that you will find the information useful for familiarizing yourself with what Europe has to offer in terms of academic research on photonic systems and subsystems.

The Editors

About EURO–FOS

Project EURO–FOS [Pan–European Photonics Task Force: Integrating Europe’s Expertise on Photonic Subsystem] is a Network of Excellence project, co–funded by the European Commission through the 7th Framework Programme, Information & Communication Technologies (ICT). The project targets the creation of a powerful Pan–European cluster of research groups specializing in the research and development of photonic subsystems and systems applicable to telecommunications.
Research domain: Photonic Systems

The term "photonic system" refers to the functional integration of diverse photonic components for creating more complex and larger photonic systems used in different parts of an optical fiber network. The research area of photonic systems is the interface between device-level physics and network-level research.

Depending on the functionality required and the specific technology used, photonic systems are designed and developed for high capacity backbone networks, Metro networks or cost-effective access networks, such as Passive Optical Networks.

Groups performing research on photonic systems have expertise in the design and development of such systems by taking into account each individual component and creating new functionalities by combining these components into a larger system.

Within a photonic systems laboratory, one would find a large variety of photonic components, used as building blocks for developing large photonic systems. In addition, 19" racks and large equipment are also a viable part of such labs for generating the necessary light signals and also performing the necessary measurements for validating the functionality of photonic systems and testing their performance under different conditions.
BELGIUM

IMEC – Ghent University
INTEC–design laboratory, Department of Information Technology

Imec is an independent microelectronics research centre, founded by the Belgian Flemish Government in 1984. The Department of Information Technology (INTEC) of Ghent University acts as a division of IMEC since 1984. The INTEC–design research is situated in the field of high-speed, high-frequency (opto-) electronic circuits and systems, and its applications on chip and board level. INTEC–design developed the physical-layer opto-electronics for Passive Optical Access Networks (PONs) such as APON/BPON (since 1990), SuperPON (since 1995), GPON (since 2001) and 10G next generation GPON (since 2006). INTEC–design is headed by Prof. Jan Vandewege, and comprises 3 professors, 1 postdoc, 1 technician and 13 postgraduate students working towards their PhD degree.

The educational activities of INTEC–design are focused on the teaching and hands–on training in high–speed and high–frequency electronic circuits and systems in the frame of the Master of Electrical Engineering. Ghent University and the Vrije Universiteit Brussel (VUB) also offer a joint Master of Science in Photonics and Ghent University also coordinates an Erasmus Mundus Master of Science program in Photonics.

The INTEC–design lab is active in high speed optoelectronics and high frequency electronics since the early eighties. INTEC–design developed EURO–FOS Project | 2010 the physical-layer opto–electronics for Passive Optical Access Networks (PONs) such as

APON/BPON, GPON and 10G next generation GPON. Various high speed prototypes such as burst–mode (BM) laser drivers, BM receivers, BM clock–and–data–recovery chips, lab and field demonstrators were successfully developed in the ACTS projects PLANET and PELICAN, in the FP6 IST projects GIANT and PIEMAN, and in the FP7 ICT projects MARISE and EURO–FOS. Ongoing research targets APD–based BM receivers for optimum sensitivity at 10G and 40G in the frame of MARISE and for symmetric 10G PONs complying with the ongoing next generation PON standardization.

Contacts and Websites

Postgraduate Admissions – PhD Program:
http://www.firw.ugent.be/

Research group contact details:
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http://www.intec.ugent.be/design/
Université de Mons – Faculté Polytechnique (UMONS/FPMs)
Service d’Electromagnétisme et de Télécommunications (SET)

Université de Mons (UMONS) is a brand new educational entity namely enclosing Faculté Polytechnique de Mon (FPMs), the oldest Engineering school in Belgium. FPMs is a member of the TIME Network (Top Industrial Managers for Europe), which gathers the most prestigious Engineering schools in Europe. UMONS/FPMs delivers engineering degrees in Computer and Management Science, Electrical Engineering, Mechanical Engineering, Chemical and Materials Engineering, Architectural Engineering, and Mining Engineering. SET (Service d’Electromagnétisme et de Télécommunications) is part of the Information Technology (IT) Research Center of UMONS/FPMs, a R&D Excellence group working on signal and information processing technologies, software development, hardware design, and telecommunication networks. IT activities are connected with those of two independent spin-off research centers: MULTITEL and CETIC. SET group is part of several European Networks of Excellence in the field of optical communications (e–Photon/One, BONE). SET is a teaching and research group of 20 members headed by Prof. Patrice Mégret.

UMONS/FPMs organizes a Master of Science in Electrical Engineering. Within this program, the professional focus ‘Telecommunications and Multimedia’ proposes a whole formation in optical communications. UMONS/FPMs also offers, in collaboration with the MULTITEL Research Center, the Special Program TELEMEDIA in Telecommunications and Multimedia. It specifically targets students already having a Master degree in Electrical Engineering or Computer Science, and willing to obtain a Belgian Master degree specialized in Telecommunications and Multimedia in one year. TELEMEDIA graduates have a privileged access to PhD programs (specific grants available) and to industrial positions in Belgium. All courses are taught in English. The TELEMEDIA program proposes a complete formation in optical communications.

The work carried out in optics within the SET group is focused on the following thematics: 1. Polarisation in optical fibers and in FBGs – 2. Non linear effects in fibers and fiber lasers – 3. Design of FBGs and metrology in the frame of optical sensors (biomedical applications, vibrations, gaz detection, ...) – 4. Optical metrology for telecom applications (OTDR & OFDR techniques applied to the monitoring of point-to-point and PON optical networks, high bit rate measurements, ...) – 5. Measurements and design of hybrid fiber/copper systems.

The main experimental infrastructure of the SET group is its fully equipped laboratory with, in particular, a clean room for the writing of FBG (femtosecond laser) and 10 Gbit/s facilities.

Contacts and Websites
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DENMARK

Technical University of Denmark
DTU Fotonik, Department of Photonics Engineering

High-Speed Optical Communications.
Over the years we have developed considerable expertise on the generation, detection, transmission and signal processing of ultra-high bit rate serial data using optical time division multiplexing. We have demonstrated systems operating at record bit rates of 640 Gbit/s and 1.28 Tbit/s per wavelength channel and are always working at pushing this limit even further. We are also active in the field of optical modulation formats, especially multilevel and phase modulation. Furthermore, we are working on a wide range of optical signal processing functionalities, including switching, regeneration, wavelength conversion, clock recovery, etc at bit rates ranging from 40 Gbit/s to 1.28 Tbit/s. We are also involved in a new research activity on the design of photonic avionic networks.

Metro-Access & Short Range Systems
Our activities are driven by the challenges facing the global telecommunication network of the future to cope with the increasing demand for instant, reliable, any time, anywhere and affordable delivery of broadband services directly to the end-user. We pursue research in topics division multiplexing–passive optical networks (WDM–PON), converged signal generation, detection and transport of wireless or wireline signals all the way long from the metro to the indoor (in–home) environment spanning transparent interfacing between the metropolitan and access area network segments, high–capacity wavelength

At DTU Fotonik, we offer teaching activities in the field of optical communications and host related courses at various levels. We take pride in welcoming motivated PhD, bachelor, and master students in our group and offer a wide range of projects (special courses, 3-week courses, bachelor and master projects) that are closely related to our research activities. We are small, international groups that enjoy working at the cutting edge of optical communication technology. We strive to maintain excellence in research and education and believe this can be done in a respectful and friendly working atmosphere.

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http://www.fotonik.dtu.dk/English/Research/ResearchActivities/Highspeed_research.aspx
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idtm@fotonik.dtu.dk
http://www.fotonik.dtu.dk/English/Research/CommunicationTechnology/Metro–Access.aspx
Educator coordinator: Knud J. Larsen
knjl@fotonik.dtu.dk
http://www.fotonik.dtu.dk/English/Education.aspx
FRANCE

Institut Telecom

Telecom–ParisTech is one of the most prestigious “écoles d’ingénieurs”. Its field of study is centred on communication engineering in a very broad sense (From telecom systems to economics of the telecom business line including computer science and signal and image processing.

Telecom Paristech provides courses on Optical Communications and optoelectronics, which can be coupled with other topics such as Radio–frequency engineering, Digital communications or network engineering leading to a nice multi disciplinary curriculum.

The optical communication research group (http://www.comelec.enst.fr/recherche/gto.en) regularly proposes student internships and PhDs. Its research activity is related to optical devices and systems for communication.

Other Engineering Institutes

Similar master courses in the field of optical systems can be found in the other school of Institut Telecom:

Telecom Bretagne
(http://www.telecom-bretagne.eu/)

Telecom Sud–Paris
(http://www.it-sudparis.eu/fr_accueil.html).

The “Institut d’Optique Graduate School” (http://www.institutoptique.fr/) concentrates teaching and research activities on optical engineering with no special emphasis on telecom applications. Both located in Brittany, ENSAAT, ENIB.

EURO–FOS Project | 2010
GERMANY

**Fraunhofer–Gesellschaft**

**Fraunhofer Institute for Telecommunications, Heinrich–Hertz Institute**

The Fraunhofer Institute for Telecommunications, Heinrich–Hertz-Institut (HHI) belongs to the Fraunhofer-Gesellschaft, an autonomous non-profit R&D organization, currently maintaining 59 different R&D institutes throughout Germany. HHI has 230 employees and about 60 student research assistants. The core competencies are in the areas of photonic networks and components (nearly 50% of the staff), mobile broadband systems, and electronic imaging technology for multimedia. Along with this expertise, a full range of design, technology, measurement, and experimental capabilities exists for photonic networks, systems and devices. HHI is a valued partner in national and international cooperative R&D projects, where most of the work is carried out in close partnership with industry and universities.

Research and development (R&D) activities of the department ‘Photonic Networks and Systems’ aim to advance optical networking technologies that are needed to realise the physical layer of the future Broadband Internet. The primary goal of the department is to obtain a better utilization of the fiber–optic infrastructure as well as to increase the performance of optical networks by means of novel system concepts and transmission schemes. The groups are primarily interested in designing high speed and high capacity ultra long haul optical transmission systems. Current work covers upgrade studies of submarine systems and terrestrial core and metro systems for bitrates up to 100 Gbit/s per wavelength.

Further research topics of these groups are coherent detection in combination with electronic distortion equalization and digital phase estimation as well as transmitter sided electronic pre-distortion.

Other areas of expertise include the design of high speed local area and campus networks as well as fibre–to–the–home systems.

The photonic networks and systems department has 40Gbit/s re-circulating DWDM loop testbeds, 2.5Gbit/s CWDM testbed and a 2.5Tbit/s OTDM testbed.

**Contact details**

Dr. Ronald Freund (freund@hhi.de)

http://www.hhi.fraunhofer.de
Karlsruhe Institute of Technology

The Karlsruhe Institute of Technology (KIT) is a higher education and research organisation with about 8000 employees, 18,500 students, and a total annual budget of about 700 million Euros. The KIT was established on 01/10/2009 as merger of Universität Karlsruhe (founded in 1825), one of Germany’s leading research universities, and Forschungszentrum Karlsruhe (founded in 1956), one of the largest research centres in the Helmholtz Association. Higher education, research, and innovation are the three pillars of KIT’s activities. The KIT is devoted to top research and excellent academic education as well as exchange of know-how, and sustainable innovation culture. KIT’s research profile is characterised by a strong focus on energy technology, nanotechnology and materials research, elementary particle, information and communication technologies, optics and photonics.

The Institute for Photonics and Quantum Electrodynamics (IPQ) is working in the field of optical communications. It is an acclaimed contributor to research in this field, regularly contributing to the largest relevant conferences such as OFC and ECOC with regular and postdeadline papers. The Institute is headed by Prof. J. Leuthold and maintains activities and labs for the design, fabrication and system-level testing of the latest high-speed photonic devices and systems.

Current activities are in the fields of high-speed optical telecommunication research in the 10, 40 and 160 Gb/s range, non-linear optical communication research and photonic crystal and nano-photonics device research. The institute maintains software and equipment for state-of-the-art optical chip and network design, as well as CAD programs, in-house fabrication and packaging of optical devices.

In addition, measurement setups for telecommunications system level testing up to 160 Gbit/s are available. The heads of the IPQ have a strong background in the telecommunications industry, a track record of successful international collaborations and a reputation for research in communications science.

The Masters program “Electrical Engineering and Information Technology” at the Universität Karlsruhe forms the foundation for a science-oriented pathway. It, in harmony with the goals of the research university, presents the intrinsic career-qualifying degree. Therefore, the efforts of the Department of Electrical Engineering and Information Technology are largely concentrated upon the Masters program and its fields of concentration, in addition to the basic fundamentals taught in the Bachelors program. The Karlsruhe School of Optics & Photonics was established in 2006. KSOP is the first graduate school at the Karlsruhe Institute of Technology (KIT). The KSOP envisions a novel combined masters program (funded by the KIT) and a Ph.D. program (funded by the Excellence Initiative). They cover the research areas of KSOP: Photonic Materials & Devices, Advanced Spectroscopy, Biomedical Photonics and Optical Systems.

Contacts and Websites
Prof. Juerg Leuthold
Prof. Wolfgang Freude
http://www.etit.uni-karlsruhe.de/english/index.php
Universität Stuttgart (UST)
Institute of Communication Networks and Computer Engineering

Introduction
The Institute of Communication Networks and Computer Engineering at the University of Stuttgart (UST–IKR) is part of the department of Computer Science, Electrical Engineering and Information Technology.

Prof. Andreas Kirstädter, together with about 20 scientific staff members, performs research and teaches in the field of mobile, automotive, context-aware, high-speed, and photonic networks.

In the field of high-speed and photonic networks, a group of eight colleagues focuses on traffic engineering, dimensioning, and resilience in multi layer networks, on performance and realization aspects of optical burst and packet switching architectures, as well as on traffic measurement, characterization, and modeling as well as network virtualization.

Teaching/Educational Activities
The University of Stuttgart offers an international interdisciplinary post graduate master program on Information Technology (INFOTECH).

INFOTECH aims at the interdisciplinary education and training of fundamental methods and scientific skills for development and research in information technology in the following areas: electronic and photonic components, computer and communication systems architectures, hardware and software design methodologies, communication networks, multimedia, vehicular, traffic and process control systems.


Research Activities
The institute has a long tradition in network architectures, protocols, digital systems design and modeling. This broad spectrum – from complete communication networks all the way down to logic elements on chip level – allows to comprehensively evaluate all aspects of communication networks ranging from QoS performance to security, and realization complexity.

UST–IKR has always been actively involved in international project frameworks such as ACTS, RACE, IST, and COST with IST NOBEL1/2, STRONGEST and the COST actions 266 and 291 as well as E-photon/ONe, E-photon/ONe+ and BONE. In addition to the international activities, the group has been working in several projects within the national funded research frameworks 100GET, eiBone, MultiTeraNet and TransiNet.

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GREECE

Athens Information Technology (AIT)
Networks and Optical Communications (NOC) group

Athens Information Technology (AIT) is an internationally-renowned education and research center in the fields of information technology, telecommunications, and innovation management, and was founded in 2002 by the INTRACOM group of companies. The Networks and Optical Communications (NOC) group of AIT is actively involved in optical transport solutions and network design in optical access, metro and core segments. NOC is headed by Prof. Ioannis Tomkos with 7 senior researchers and 3 postgraduate students working towards their PhD degree.

AIT in agreement with Carnegie Mellon University (CMU) operates a joint Carnegie Mellon-AIT Master of Science in Information Networking (MSIN) Program. This program is based on the curriculum of the current MSIN program offered by CMU including a full module in optical networks.

AIT also offers a Master of Science in Information and Telecommunications Technologies (MSITT) with a full module in optical communication and a PhD program with Aalborg University in Denmark covering the above areas.

AIT organizes professional educational programs to provide participants with the key technical and managerial issues for the use of telecommunications and information systems infrastructure by organizations.

The work carried out within the AIT’s NOC group is focused on novel architectures for circuit-, burst- and packet- switching, optical system and subsystem design, signalling and routing protocols, network resilience, service aware network design and traffic engineering, advanced transmissions and switching techniques, and techno-economic studies. The main experimental infrastructure of AIT’s NOC group is its fully equipped transmission test bed able to support both 10 Gbit/s and 40 Gbit/s facilities within a recirculating loop that is configured to emulate the concatenation of optical components, subsystems and systems as well as long transmission distances.

Contact and Webpages

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http://www.ait.gr/ait_web_site/research_HSN.jsp
National Technical University of Athens (NTUA)
Photonics Communications Research Laboratory (PCRL)

The National Technical University of Athens (NTUA) has contributed unceasingly since its foundation in 1836 to the scientific, technological and economic development of the country. The Photonics Communications Research Laboratory (PCRL) was founded in September 1995 by Hercules Avramopoulos as a research facility of the School of Electrical and Computer Engineering (ECE) of NTUA. Its charter has been to pursue all optical techniques and to apply them to telecom and datacom environments with purpose to render them commercially attractive and exploitable. The research group is led by Professor Hercules Avramopoulos and consists of young motivated researchers with unique skills in the design and development of photonic subsystems through the functional integration of photonic components.

The School of ECE of NTUA offers a variety of graduate study programs that result in a graduate specialization degree after a period of at least one full year of study. The participants have the possibility to continue with doctoral studies in the various laboratories of the School including PCRL. The specific programs offer a number of courses that are closely related to architectures, systems and subsystems for lightwave communication networks, optical–logic, nonlinear optics, optoelectronic integration and novel material systems for photonic applications.

PCRL research activities focus on the design and development of novel optical network sub-systems (high-capacity optical routers, switching elements, all-optical regenerators), the development of advanced optical–logic subsystems using either fiber- or semiconductor-based optical gates, the investigation of novel concepts for single- and multi-wavelength optical sources, and the design of node architectures that exploit optical signal processing techniques to perform all necessary network functionalities for receiving, regenerating, switching and routing packet traffic without requiring O/E/O conversions and high-speed electronics. PCRL is a fully equipped laboratory with a range of high-speed test and measurement systems and a large number of passive and active photonic devices. It has worldwide links and collaborations with academia and industry and its activities are supported by industrial grants, as well as national and EU-funded research programs.

Contacts and Websites
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Aristotle University of Thessaloniki (AUTH)

Department of Informatics
Photonic Systems and Networks (PhosNET) Research Group

The Aristotle University of Thessaloniki has been established in 1925 and is the largest University in the region of Balkans. Today the main campus extends over an area of 429 metric acres in the heart of the city and the number of enrolled students is about 67,000 in 41 departments that cover the full range of scientific disciplines. Its Department of Informatics, founded in 1992, is actively involved in research on computer architectures, communications and networks through its Computer Architecture and Communications Laboratory (CACLab). CACLab’s Photons Systems and Networks (PhosNET) Research Group specializes in optical communications and photonics, pursuing research and development activities on system-level optical switching and routing systems, photonic integrated circuits, optical access and optical wireless networks. PhosNET employs 2 faculty members, 3 senior research associates and 3 PhD students.

Dpt. of Informatics offers currently a MSc program on Networks, Communications and Systems Architecture as part of its postgraduate MSc course program. This program offers a series of courses on topics in Networks and Communications including three full modules in optical networks: Optoelectronic technology systems, Optical Computing and Advanced Topics in Optical Communications.

The Dpt. of Informatics offers also a PhD program covering the above areas.

PhosNET focuses on novel systems and architectures for packet- and burst-switched networks, on optical system, subsystem and integrated circuit design for optical switching, buffering and signal processing applications, on optical interconnects, silicon photonics, plasmonics, Radio–over–Fiber networks and biophotonics. PhosNET is a fully equipped laboratory with a range of test and measurement systems and a large number of passive and active photonic devices, including a 10Gb/s BERT, 40GHz oscilloscopes, optical spectrum analyzers, microwave signal generators, EDFAs, a 8–channel laser source, semiconductor optical amplifiers, Mach–Zehnder interferometric switches and a Material Testing System.

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University of Peloponnese (UoP)
Department of Telecommunications Science and Technology – Optical Networking Group (ONG)

According to its founding Presidential Decree 138/17–5–2002 (Official Government Journal, no.113/2002), “the Department of Telecommunications Science and Technology of the University of Peloponnese has a mission to promote the science and technology of voice and data communication systems and their applications, as well as to train scientists according to the needs of research, industry and education”.

The Optical Networking Group (ONG) is part of the Department of Telecommunication Science and Technology. Its primary objective is to provide integrated solutions for the telecommunications network infrastructure and to promote the research and development in optical systems and networks. ONG is inspired and motivated by the concepts and needs of Information and Communications Technologies (ICT). The role of a fast, robust and reliable network to support a plethora of broadband services anytime, anywhere, at the lowest cost, is indispensable. ONG’s scope is to develop a Center of Excellence for designing, experimenting, testing and generating novel solutions that meet the requirements of modern telecommunication systems. The research interests of ONG are related to the development of the necessary concepts and the technology needed for deploying photonic networks. The group has gained significant experience in physical layer design and simulation of components, systems and networks as well as on Level 1 to Level 3 integration and experimental testing of photonic sub-systems.

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Advanced Telecommunication Systems and Networks. This program is among the few MScs in this area that are offered in Greece (established by the Official Government Journal, no.1661/2008) and comprises many different modules, one of which is on optical networks. The Department also operates a PhD program.

- The ONG research focuses on the following topics:
- Architectures supporting and reinforcing highly dynamic networking
- Switch Architectures for various dynamic networks
- Cross-layer routing algorithms for QoS and context-aware networking
- Infrastructures for ultra high capacity/dynamic networks
- Control plane architectures targeting dynamic resource allocation
- Broadband access networks
IRELAND

Tyndall National Institute, University College Cork
Photonic Systems Group

The Tyndall National Institute (Tyndall) was created in 2004 at the initiative of the Department of Enterprise Trade and Employment and University College Cork (UCC) to bring together complementary activities in photonics, electronics and networking research at the National Microelectronics Research Centre (NMRC), several UCC academic departments and Cork Institute of Technology (CIT). The strengths of the institute at the present time lie in the area of photonics, electronics, materials and nanotechnologies and their applications for life sciences, communications, power electronics and other industries. Research programmes range from theoretical modelling and design to novel material, nanotechnology, device processing and fabrication, packaging and integration; and novel systems incorporating these new devices.

The Photonic Systems Group (PSG) is part of the Tyndall National Institute, and is affiliated with the Department of Physics at University College Cork. The group was created in 2003 with Science Foundation Ireland support to investigate advanced photonic systems, and enjoys lab facilities which are amongst the best in Europe. PSG is headed by Prof. David Cotter with 5 senior researchers, 9 postdoctoral researchers and 14 PhD students.

University College Cork offers a Master of Science in Photonics with a full module in optical communication and PhD programs in Photonics and Optoelectronics. Tyndall National Institute and University College Cork run educational programs to provide students with relevant courses in Photonics, Device theory and design, and theoretical modeling, as well as commercially oriented courses covering IP and business management.

MSc course link:
http://www.physics.ucc.ie/mscphonotics/MscWeb/courses.html

PSG has research programs in a range of topics, including: optical and quantum communications, optical and optoelectronic device physics and their systems applications, nonlinear optics for optical signal processing, and biosensing. The optical communications work covers Access, Metro and long-haul network research, with test-bed facilities at 10Gb/s and 40Gb/s, and access to a 124km installed British Telecom link for field trials

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The RINCE Institute, Dublin City University

Radio and Optical Communications (ROC) Group

The RINCE Institute is a national centre for excellence focused on innovations in targeted engineering technologies. It is located within the Faculty of Engineering and Computing at Dublin City University in Ireland. The institute was established in 1999 through competitive funding obtained from the Program for Research in Third Level Institutes (PRTLI). The Radio and Optical Communications (ROC) Group is one of the main research groups within RINCE and its focus is on the design, simulation and demonstration of new technologies for future broadband photonic communication system. ROC is headed by Prof. Liam Barry and the group has 2 faculty members, 6 senior research fellows and 10 postgraduate students working towards their PhD degree.

Dublin City University offers a taught Masters of Engineering Program in Telecommunications Engineering and a taught Masters of Engineering Program in Electronic Systems. Both of these programs require the students to complete 8 taught modules in addition to a research project, and both programs offer a module on optical communication system design and a module on photonic devices. In addition the Electronic Systems Program offers a major in Photonics and Nanoelectronics on completion of relevant modules.

Dublin City University also offers a Master of Engineering by research and PhD degrees in the general areas of Optical Communications and Photonic Systems.

The work carried out within the ROC group within the RINCE Institute is focused on the design, simulation and demonstration of new technologies for future broadband photonic communication system. The main areas of research in the group involve; Optical Packet Switching Using Tunable Lasers, Radio-over-Fiber Systems, All-Optical Signal Processing, and Advanced Modulation Formats for Optical Systems. The main experimental infrastructure of the Radio and Optical Communications group is its fully equipped transmission test bed able to support both 10 Gbit/s and 40 Gbit/s facilities that is configured to determine the performance of optical components and subsystems for possible implementation in access, metro, and core networks. The group also has significant expertise and relevant equipment to undertake detailed characterization of novel photonic and opto-electronic devices that could be employed for future optical subsystem design

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ITALY

Politecnico di Torino
Optical Communication Group, Dipartimento di Elettronica, School of Information Engineering

Politecnico di Torino is a major Italian technical university founded in 1859, host of a distinguished Telecommunication group with several highly cited researchers of the field. In this environment, Prof. Sergio Benedetto constituted in 1989 the Optical Communication Group (OPTCOM, www.optcom.polito.it).

The OPTCOM group is now headed by Prof. Pierluigi Poggiolini, and it counts 6 staff members active in all fields of optical communication systems, with areas of expertise including long-haul high capacity transmission systems, access networks based on plastic optic fibers and free space optic links.

OPTCOM has participated in several research programs funded by both Italian agencies and the European Commission, developing a long tradition of close cooperation with several international universities and industrial partners.

OPTCOM researchers have a long experience in developing models and algorithms for the simulation of fiber propagation: they have participated in the development of OptSim, now a successful commercial optical communication systems simulator.

During last years, the OPTCOM group has built a sound experimental background, as well. It now shares with other groups a multi-disciplinary lab facility (PhotonLab, www.photonlab.it), which is equipped with state-of-the-art test and measurement instruments and components, enabling OPTCOM to carry on WDM system experiments with bit-rates up-to 100 Gbps per channel and beyond. A key feature of PhotonLab is the access to several hundred kilometers of installed fiber in the metro environment of the city of Torino.

In the context of the School of Engineering Information Technologies www.infotech.polito.it, OPTCOM staff members teach several Bachelor and Master level courses and coordinate a Specializing Master in Optical Communications and Photonic Technologies didattica.polito.it/offerta., where all aspects of photonics components, systems and networks are covered. OPTCOM group members also coordinate the activity of PhD students working towards their degree in “Electronics and Communications Engineering”.

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Scuola Superiore Sant’Anna (SSSUP)
Centre of Excellence for Information, Communication and Perception Engineering (CEIICP)

The Centre was created in 2001, to respond to a higher scientific and technical demand regarding the next generation of communication services, and the various platforms for future high-speed internet services, with specific attention to photonics applied to telecommunications. Current research activities include communication networks based on photonic technologies, information technology and telematics, real-time and embedded systems, virtual environments and perceptual robotics. CEIICP is headed by Prof. Giancarlo Prati, and it currently has 10 professors, 56 researchers and about 70 PhD students. The Centre, together with the hosted Photonic Networks National Laboratory of CNIT (National Inter-University Consortium for Telecommunications), has given rise to an Integrated Research Centre for Photonic Networks and Technologies (IRCPhoNeT) working in close synergy with the co-located Ericsson Research Branch Italy.

Laboratory facilities include, among the other equipments, a service-oriented multilayer network platform, a 640 Gb/s OTDM systems testbed, a 100 Gb/s coherent optical system, optical pulse sources up to 40 Gb/s, testbeds for systems and optical components characterization, optical recirculating loops, and optical sampling oscilloscopes.

CEIICP synergically coordinates top-level educational courses within national and international programs in the area of photonic systems and optical telecommunications, strongly connected to the research activities of the laboratories. These courses include an International Master on Communication Networks Engineering (IMCNE), an Erasmus Mundus Master on Photonic NETworks Engineering (MAPNET, in collaboration with Technische Universität Berlin, Aston University, and Osaka University), a double degree graduate program Master of Science in Information and Communication Technology (ICT, in collaboration with the University of Trento), a Master of Science in Computer Science and Networking, (MCSN, in collaboration with the University of Pisa). CEIICP also offers a Ph.D. program in Telecommunications, especially referring to networks and photonic technologies.

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Roma Tre is the youngest university of Italy’s capital. Founded in 1992, it is the home of 44,000 students distributed over 8 faculties ranging from the Arts and Economics to Science and Engineering. Research is grouped in 29 Departments, with the Optical Communication group being part of the Department of Applied Electronics.

The Optical Communication group is engaged in research into devices and subsystems for access networks, optical packet and label switching, and optical cryptography. The group is headed by Prof. Gabriella Cincotti and is composed of PhDs and Postdoctoral researchers.

University Roma Tre offers a Master of Science in Information and Communication Technologies. Among the courses offered is a full module on Photonics (fibres, optical waveguides, lasers, receivers, modulators, passive devices) and a full module on Optical Communications (modulation formats, network protocols, routing, monitoring, security). Roma Tre also offers a PhD Level Course in Electronic, Biomedical, Electromagnetic and Telecommunication Engineering.

The research of the Optical Communications group focuses on subsystems, devices, and protocols for access networks and routing systems.

The Optical Communication group’s expertise is focused on the design, numerical simulation, and characterization of optical devices, as well as of high speed optical networks and switching systems. The laboratory is equipped with simulation tools to investigate integrated optical and sub-wavelength scale devices, many of which tools were developed in house.

Contacts and Webpages

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POLAND

Poznan University of Technology (PUT)

Faculty of Electronics and Telecommunications

Poznan University of Technology (PUT), founded in 1919, is ranked as one of top Polish technical universities. The Faculty of Electronics and Telecommunications is responsible for education of BSc, MSc and PhD, and involved in research in ICT. Chair of Telecommunication Systems and Optoelectronics is concerned with both theory and practice in the domains of synchronization techniques, fiber optics, signal processing procedures, design and programming of computer measuring systems, applications of microprocessors, cryoelectronics and nanostructures. Chair of Communication and Computer Networks is involved in research concerning the most recent networking technologies. Particular interests focus on traffic theory, broadband networks, Internet and billing systems. The courses in optoelectronics are offered within the MSc curriculum in English, in Information and Communication Technologies

Optical Networks and Optical Internet

The course covers such problems and optical network architectures, routing and wavelength assignment problems and algorithms, networks elements (OADMs, ROADMs, OXCs), optical packet and circuit switching, node architectures and control, network protection and restoration.

Optical Fiber Communication Systems

The course is designed to provide students with theoretical and practical knowledge and understanding of optical communication systems. It aims at preparing students to design, operate and maintain optical fiber systems.

Optotelecommunications

The course aim is to make the students familiar with properties of elements and modules of optical communication.

Photonics

Course aims at presenting the increasing knowledge of modern photonics, operation of optical devices used in optical communications and optical signal processing.

The research group lead by Prof. Kabacinski focuses on photonic switching networks: space-division, photonic switching networks, different architectures of expandable photonic switching networks and switching networks of mixed architectures composed of tree-structured elements made of directional couplers. The research group works also on switch fabric control and control algorithms for photonic unicast and multicast switching networks with and without crosstalk constrain and its implementation in FPGA structures. The main experimental equipments are Xilinx Spartan 3A and Spartan 3E boards, Virtex-5 LXT ML555 FPGA Development Kit, Virtex-5 LXT FPGA Gigabit Ethernet Development Kit and integrated optical switch controlled either manually or by TTL signals.

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PORTUGAL

Universidade de Aveiro
Department of Electronics, Telecommunication and Informatics Engineering, Universidade de Aveiro (DETI, UA)

Instituto de Telecomunicações (IT)

The Instituto de Telecomunicações (IT) is a private, not-for-profit organization, of public interest, a partnership of five institutions with experience and traditions in research and development in the field of Telecommunications: Instituto Superior Técnico (IST); Universidade de Aveiro (UA); Faculdade de Ciências e Tecnologia da Universidade de Coimbra (FCTUC); Portugal Telecom Inovação, S.A. (PTIn); Nokia–Siemens, S.A. IT mission is to create and disseminate scientific knowledge in the field of telecommunications. IT is actively involved in fundamental and applied research in telecommunications both at national and international level.

IT is committed to foster higher education and training, by hosting and tutoring graduate and postgraduate students. The involvement of IT will be carried out by the Optical Communications Group. It has a large experience in Optical Fibre Technologies and High-Speed Networking. The specific areas of research in Optical Communications are: optical access and transport networks, all-optical transparent WDM networking and routing, electrical and optical impairment monitoring and compensation, advanced modulation formats. IT has successfully managed and participated or is participating in several national and international projects. At Universidade de Aveiro, two courses in optical communications area are offered to under-graduated students in DETI, as part of the MsC on Electronics and Telecommunications Engineering, and covering the basics of optical communications and networking.

Another course is given through the Professional Master in Information Networking (MSIN) course (collaboration between Universidade de Aveiro and Carnegie Mellon University).

Contacts and Webpages

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The University of Algarve is a young higher education public institution located in the southern part of Portugal. The number of students is around 10,000 students of which 1,500 were enrolled in postgraduate programs. The University's four core research areas are: science and technology, management and economy, earth and marine sciences, social sciences and health. Recently, the University's R&D performance (Publications per capita) was ranked among Portugal's top universities.

The Center of Electronics Optoelectronics and Telecommunications (CEOT) is a multidisciplinary research center of the Algarve University evaluated and funded by the Portuguese Science Foundation, acting mainly within the information and communications technology; specifically in optical communications networks, and organic electronic subfield. The optical communications network research group is composed by five PhD staff members.

CEOT in collaboration with the Department of Electronics and Informatics of the Algarve University supports the Master Degree in Electronics and Telecommunications (Mestrado Integrado em Electrónica e Telecomunicações). This program includes seven optional courses corresponding to 35 ECTS (European Credit Transfer System) that can be chosen in the area of optical communication networks.

CEOT coordinates the Doctoral Programme in Electronics and Telecommunications Engineering.

The program has four scientific specializations areas and a duration of 3 years corresponding to 180 ECTS. The Telecommunications specialization area is focused on networks and optical communications. In the first year the students are required to attend courses corresponding to 12 ECTS of the specialization area, 18 ECTS on the Research Seminar and to work on their work plan (30 ECTS). The courses of the Telecommunications area are chosen from: optical communication systems, optical networks, optoelectronics devices and systems and network modelling and performance evaluation and high speed integrated circuits. The final two years are entirely dedicated to the thesis.

The research on optical communication networks covers two fundamental aspects of broadband networks: a) how to provide radio/fiber broadband access networks; b) how to implement efficient and reliable IP over optical networks. The main goals are the development of strategies able to make the progression to a single Next Generation Network based on Internet Protocols (IP) networks and optical transport networks (IP over optical networks) and the demonstration of novel cost effective wireless access networks combining optical networking concepts and radio over fiber techniques.

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SPAIN

The Nanophotonics Technology Center

NTC is a research center at the Universidad Politécnica de Valencia (UPVLC), Spain. The center includes its own team of 45 researchers. Its mission is to establish leadership in Europe in the micro/nanofabrication of silicon structures for the development of nanotechnologies. NTC is located in a new building for the exclusive use of the center inside the UPVLC scientific park. The building measures 3500 square meters with space for 100 professionals including a 500 square meter cleanroom with silicon facilities. The aim of the NTC and the UPVLC scientific park is to encourage regional development by transferring university research results to industry. The NTC offers an extraordinary technological potential and is dedicated to business development. Research strategy at NTC ranges from the development of technology using diverse materials to the implementation of the most advanced functionalities in multiple applications. Currently the research activities at NTC are focused in four different topics: optical networks and systems; photonic materials and devices; micro and nanofabrication; and photovoltaics.

As a research centre within a public university, NTC continuously offers positions associated to the MSc. and Ph.D. academic programs of the Telecommunication Engineering Technical School:

- Ms.C. program in Communication Systems, Networks and Technologies involves the following topics and objectives: design and implementation of devices and sub-systems for communication systems, generation, propagation and detection of electromagnetic signals, signal processing for information and communication applications design, implementation and performance evaluation of communication networks real time distributed systems, architectures and protocols for multimedia communications development of the Information Society. The program has a lecturing charge of 120 ECTS and is mainly oriented to the following university degrees: telecommunication or electronic engineering, physics and computer sciences. The Ms. C. degree will be obtained after the public defense of a Ms. C. Thesis.

- Ph. D. in Telecommunication Engineering program is divided in an academic and a research periods. The first one has a lecturing charge of 60 ETCS credits, which may be related to the

The MSc. program, mainly involving the following topics and objectives: communication theory, optical communications, photonics and optical signal processing, advanced electromagnetism, microwaves and electromagnetic compatibility spatial communication wireless and mobile communications digital signal processing. The research period will be aimed to the development of a Ph. D. Thesis under the supervision of a university academic staff member. The Ph.D. degree will be obtained after the public defense of the Ph. D. Thesis.
More information regarding the Ms.C. and Ph.D programs at UPVLC, pre-enrolment requirements, registration, legal regulation and others may be found at [http://www.upv.es/estudios/posgrado-master-doctorado/index-en.html](http://www.upv.es/estudios/posgrado-master-doctorado/index-en.html).

Updated information regarding the offer for Ms. C. and Ph. D. opportunities as well as funding scholarships at NTC may be checked at the internet address:


The NTC spin-off company DAS-Photonics also regularly offers job positions and scholarships that may be checked at the internet address:


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[http://www.ntc.upv.es](http://www.ntc.upv.es)
The Optical Communications Group (GCO) is part of the Signal Theory and Communications Department (TSC). The key research areas involve Optical Fiber Technologies for Access and Transmission, High Speed Networking and Raman Spectroscopy. The group experience is related to optical wavelength domain transport and access networks (WDM, HDWDM, SCM), broadband fibre transmission, sources and receivers, all-optical amplification, optical heterodyne detection, wavelength stabilization and monitoring, transparent WDM network architectures and management, optical linear and non-linear distortions, polarization/PMD treatment and network quality monitoring.

GCO laboratories are fully equipped with broadband instrumentation for WDM and high bit rate optoelectronic system design and characterization, as well as long haul fibre link measurements and IP-ATM-SDH-WDM networking.

The group is also integrated in the Advanced Broadband Communications Centre (CCABA). UPC supports this research centre and its laboratory was partially funded by the Spanish Education Ministry (CICYT) and by Research Commission of the Catalan Government (CIRIT) under several grants.

In the EC IV Framework Programme, UPC participated in the Spanish National Host through the network platform of the CCABA. Currently this centre integrates researchers from several Departments which have interests on complementary communications research fields: Integrated Broadband Communications research group, the Optical Communications research group, and the Radio and Mobile Communications research group.

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Technical University of Cartagena (UPCT)

Telematics Engineering Group (GIT) group

The Technical University of Cartagena (UPCT) is the youngest of the four Technical Universities in Spain. It was founded in 1998. The Telematics Engineering Group (GIT, Grupo de Ingeniería Telemática) carries out research and teaching activities in the Telecommunications Engineering Faculty. The group is composed of more than 20 full-time researchers and 10 PhD students. It is involved in national and European projects in different aspects of networking, summing more than 1M € in 2009.

GIT is involved in the BsC and MsC Telecommunications Engineering degrees, belonging to the national educational system in Spain. The MsC program includes a full module focused on optical and photonic communications. GIT also takes part in the PhD program in Information Technologies, which includes advanced material in optical networking.

The work carried out within the UPCT’s GIT group is focused on network architectures for optical circuit-, burst- and packet- switching networks, with emphasis on network planning and optimization, and the performance evaluation of switching architectures, also from a techno-economic perspective.

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SWEDEN

Chalmers Technical University of Technology
Photonics Laboratory, Department of Microtechnology and Nanoscience

The Photonics Laboratory at Chalmers, with about 25 members, is conducting research in the areas of Fiber optical communication and Optoelectronics. It participates in several major research programs funded by Swedish funding agencies and the European Commission. With a majority of its research projects being applied, it also has a long tradition of working closely with industrial partners. To its disposal it has well-equipped laboratories for measurements on fiber optical transmission links and systems, for characterizing optoelectronic and optical components, and for analyzing the optical properties of various materials. For fabrication of optoelectronics and optical components the clean room facility at MC2 is used, a state-of-the-art facility for micro and nanofabrication in semiconductors and other materials. Several Master level courses are taught, which together provide a thorough survey of the photonics area, including important industrial applications. These courses can be taken separately or as a part of the Master Program in Wireless and Photonics Engineering, which we coordinate together with the Microwave Electronics Laboratory.

The Photonics Laboratory conducts application oriented, theoretical and experimental research in the areas of optoelectronics and optical communication, with most efforts directed towards new device and system technologies for communication and measurements.

Fiber optics
The research in fiber optics currently addresses three main areas: Optical communication using advanced modulation techniques, optical waveform analysis using optical sampling, and fiber optic parametric amplifiers. This research includes experimentally investigating different aspects of using DPSK, DQPSK, and D8PSK modulation formats at 10 Gbaud or 40 Gbaud, FOPAs with 40 dB of gain across 81 nm in a double–pumped design, and experimental verification of sub–3–dB noise figure, a feature unique to FOPAs.

Optoelectronics
The research in optoelectronics deals exclusively with various types of semiconductor based light emitters and associated material issues. This includes development and fabrication of vertical cavity surface emitting lasers (VCSELs), optically pumped semiconductor disk lasers and two color lasers for THz generation. The group has also been collaborating with the Chinese Academy of Sciences on metamorphic materials for high performance telecommunication lasers.

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Acreo
Transmission and Networking Laboratory (Netlab)

The focus of the Acreo Netlab, with its 30 members, is in the area of high-speed long-haul transmission, optical signal processing, control plane and management plane for next generation networks, as well as techno-economic studies for access networks.

Acreo investigates both fundamental physical phenomena and practical system applications. We have a complete transmission test set-up for high-speed transmission experiments, characterization of optical amplifiers, as well as simulation tools for modeling of DWDM systems.

Acreo’s scientists have long experience from leading research laboratories and companies in Sweden and abroad. Our broad expertise in optical systems is internationally acknowledged.

We also assist companies with design, simulation, laboratory and field tests of DWDM systems, EDFA, SOA and Raman amplifiers as well as high level system integration.

Some of the topics we are actively working on is 100 Gb/s, 160 Gb/s and Tb/s transmission, coherent communications and multilevel modulation formats, analysis of non-linear effects: XPM, SPM, FWM, development of linear and non-linear compensating schemes based on DSP.

Our expertise in numerical modeling of optical fiber transmission with emphasis on WDM, high bit-rates and ultra long-haul is based on key knowledge of component physics and mathematical and numerical techniques related to WDM transmission (BER) models.

EURO-FOS Project | 2010

Field trials of operating systems in real working conditions and numerous laboratory experiments effectively complement our theoretical capabilities.

Acreo Netlab regularly hosts international researchers (PhD students, post-doctoral scientists, as well as professors) from the leading research institutions across Europe and beyond. We also define and supervise several MSc and PhD thesis projects each year, in collaboration with Stockholm’s Royal Technical Institute (KTH), as well as other European Universities.

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The research activities are guided by our vision of the globe-spanning “optical ether”: we want to create the infrastructure for a widely-ranging communication environment in which users can communicate with virtually unlimited bandwidth, without congestion, fully reliably, wherever they are and whichever services they need. The creation of this vision requires ultra-broadband ultra-long-reach transmission links, fully-transparent ultra-fast routing of signal streams, ultra-flexible high bandwidth links to the end user supporting also mobility, and last but not least the intelligent functionalities with which the network autonomously can map the user’s location and service requirements on the network resources. Our research programme hence is structured in four tracks:

1. High capacity links
2. Telecommunication nodes
3. User access networks
4. Network management and control

We have leading roles in international programmes (e.g., in EC’s FP7 ICT projects) and in national research programmes.

Our research activities are executed in the COBRA Research Institute. The mission of COBRA is to excel in acquisition, transfer and application of knowledge in communication technology by doing high-quality research topics combined with offering a prestigious post-academic educational program for PhDs and Post Docs. More information can be found at

http://w3.ele.tue.nl/en/cobra/home

Information of our two-year master’s study of Broadband Telecommunication Technologies can be found in

http://w3.ele.tue.nl/nl/onderwijs/masteropleiding/master_of_broadband_telecommunication_technologies/

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University of Essex
High–Performance Networking Group, School of Computer Science and Electronic Engineering.

The School of Computer Science and Electronic Engineering was inaugurated on 1st August 2007. It was created by merging two long–established departments: The Department of Computer Science and the Department of Electronic Systems Engineering. This is in recognition of the ever increasing synergy and overlap between the two disciplines.

The Department of Electronic Systems Engineering was founded in 1966 as the Department of Electrical Engineering Sciences and throughout its 40–year history has been one of the leading electronics and telecommunications departments in the country.

The Department's MSc Masters course in Telecommunications was the first one in the world to cover the complete telecommunication system, including both switching and transmission.

The Department of Computer Science was also founded in 1966, and is one of the most well established departments in the UK.

The High Performance Networks Group (HPNG) at the Department of Electronic Systems Engineering specializes in the application of advanced technologies to future communication network infrastructures together with the study of control, node architectures, and technologies best suited for future requirements. The group consists of the following labs and experimental facilities:

Photonic Network Lab, Networked Media Lab, Future Internet Experimental Facility

HPNG is committed to a high standard by extensively publishing in selected highly–ranked journals and conferences and contributing to standardisation activities. The Group has a very strong collaborative profile and interacts with researchers and users in the UK, EU, US, Japan and China; many of these links were established due to the support offered by EPSRC platform grants.

University of Essex offers a MSc Telecommunication and Information Systems with focus on a hybrid mix of optical, wired and wireless networks.

http://www.essex.ac.uk/csee/pg_taught/telecommunicationinfosystems/index.aspx

HPNG research activities in the area of optical communication and systems include:

• Optical Transport Networks
• Optical packet, burst and circuit switched networks
• High speed (i.e. 160 G) optical systems and networks
• Multi–granular optical subsystems and systems
• Network planning and design

Contacts and Websites
http://hpn.essex.ac.uk/index.php?mn=hm

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