

Foundation for Research and Technology - Hellas (FORTH)
Institute of Computer Science (ICS)



**Building a competitive
Greece**

MINISTRY OF DEVELOPMENT

GENERAL SECRETARIAT
FOR RESEARCH AND TECHNOLOGY



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Research and Technology for the Information Society



Prof. Constantine Stephanidis
Director of FORTH-ICS

The Institute of Computer Science (ICS) is one the seven institutes of the Foundation for Research and Technology - Hellas (FORTH), a major national research centre partly funded by the General Secretariat for Research and Technology of the Hellenic Ministry of Development. The mission of FORTH-ICS is to perform high quality basic and applied research, to promote education and training, and to contribute to the development of the Information Society, at a regional, national, and European level. Since its establishment in 1983, FORTH-ICS has had a long history and recognised tradition in conducting basic and applied research, and playing a leading role, in Greece and internationally, in the field of Information and Communication Technologies.

FORTH-ICS

- ***has achieved excellence by establishing a balance among its various activities***, and in particular: (i) basic and applied research, (ii) development of large scale applications exploiting the results of research, (iii) development of products and services, (iv) cooperation with other research institutions and the private sector, (v) participation in national and European research and development projects, as well as in collaborative projects with industry.
- ***is highly competitive at an international level***, and many of its activities are carried out in the context of European collaborative research and development projects, which emphasise the development of Information Society Technologies and infrastructures in a number of domains of national importance and regional interest.
- ***is a protagonist in the sector of Information and Communication Technologies in Greece***. Its activities cover important research and development topics in the framework of the emerging Information Society.
- ***contributes to the economic, social and technological development of the Region of Crete*** through international collaborative activities and, in particular, through its participation in programmes addressing the South-East Mediterranean area. In this effort, FORTH-ICS collaborates closely with local authorities and organisations.
- ***places special emphasis on education and training***, by providing a significant number of scholarships to undergraduate and postgraduate students and by training numerous professionals in cutting-edge Information and Communication Technologies.

FORTH-ICS



LABORATORIES, PROGRAMMES & DEPARTMENTS

FORTH-ICS comprises laboratories, each of which conducts basic and applied research in thematic areas in the field of Information and Communication Technologies. The Laboratories of FORTH-ICS are staffed with specialised scientific and technical personnel and possess state-of-the-art equipment. Activities cover important research and development areas, taking into consideration new perspectives, emerging fields of research and technological challenges worldwide.

Besides its laboratories, FORTH-ICS has established horizontal interdisciplinary Research and Development Programmes in the domains of Ambient Intelligence and Information Security. These Programmes constitute connecting threads for the activities of the individual laboratories and provide opportunities for defining interesting new problems. In the context of its Ambient Intelligence Programme, FORTH-ICS is creating a large-scale, state-of-the-art Ambient Intelligence Facility, unique of its kind, which will act as a research nexus for studying and developing, under a human-centred perspective, related technologies, and for assessing their impact on the individual, as well as on the society as a whole.

Additionally, FORTH-ICS has four departments which are focused on providing specialised services.

<http://www.ics.forth.gr/>

REGIONAL AND INDUSTRIAL OUTREACH

A successful example of a spin-off is FORTHnet, a pioneer company in the internet and telecommunications sector in Greece, which was founded in 1995 and has been listed on the Athens Stock Exchange since 2000. Another recently founded spin-off of FORTH-ICS is Nanochronous Logic, Inc., targeted to the commercialisation of research results in the domain of asynchronous nanotechnologies. The company will have its Corporate, Sales and Marketing departments in San Jose, California, and its Research, Development and Engineering departments in Heraklion, Crete.

FORTH-ICS has played a major role in the development of the Science and Technology Park of Crete (STEP-C) and is now establishing a new dynamic framework for technology transfer and collaborative activities with companies based at STEP-C, by providing consultancy, support and training services, and the maintenance of computer networks.

Given its substantial technological know-how, FORTH-ICS is often requested to assist with the study and preparation of operational plans for the Region of Crete and the Regional System of Health of Crete. FORTH-ICS has played a key role in the RITTS (Regional Innovation and Technology Transfer Strategies) - Region of Crete Project, funded by the European Commission, which concerned the technological development of the island of Crete, and promoted innovation and technology transfer between the academic and research institutions and the local industry. FORTH-ICS is also the registry for the country-code top-level domain [.gr] since 1989.

INTERNATIONAL PRESENCE

FORTH-ICS is internationally recognised and has received several citations in scientific journals. FORTH-ICS researchers have received international recognition for their work in the form of prestigious awards and prizes. Moreover, they have been invited as keynote speakers to major international conferences, have organised major international events, participated in editorial boards of international journals and conference programme committees, and been elected or appointed to various senior advisory boards and committees. The scientific achievements of FORTH-ICS have been the subject of extensive reports in the mass media. Additionally, senior politicians at European and national level (President of the EC, Commissioners, Prime Minister, Ministers, General Secretaries) and scientists around the world have made verbal and written references to the world-class excellence of the scientific work conducted by the Institute.

FORTH-ICS is a member of ERCIM, the European Research Consortium for Informatics and Mathematics. Members of FORTH-ICS participate and, in many cases, play a leading role in various ERCIM activities and Working Groups, as well as research roadmap projects, funded by the European Commission, in scientific areas of strategic importance for Europe. FORTH-ICS also hosts the W3C (World Wide Web Consortium) Office in Greece. W3C is an international consortium aiming at defining guidelines, software and tools for the future development of the World Wide Web.

Contents

Laboratories

- Biomedical Informatics Laboratory (**BMI**) 4
- Computer Architecture and VLSI Systems Laboratory (**CARV**) 10
- Computational Vision and Robotics Laboratory (**CVRL**) 16
- Distributed Computing Systems Laboratory (**DCS**) 22
- Human-Computer Interaction Laboratory (**HCI**) 26
 - Centre for Universal Access and Assistive Technologies (**CUA&AT**) 28
- Information Systems Laboratory (**ISL**) 32
 - Centre for Cultural Informatics (**CCI**) 37
- Telecommunications and Networks Laboratory (**TNL**) 38

Programmes

- Ambient Intelligence Programme (**AMI**) 42
- Information Security Programme (**INFOSEC**) 44

Other Departments

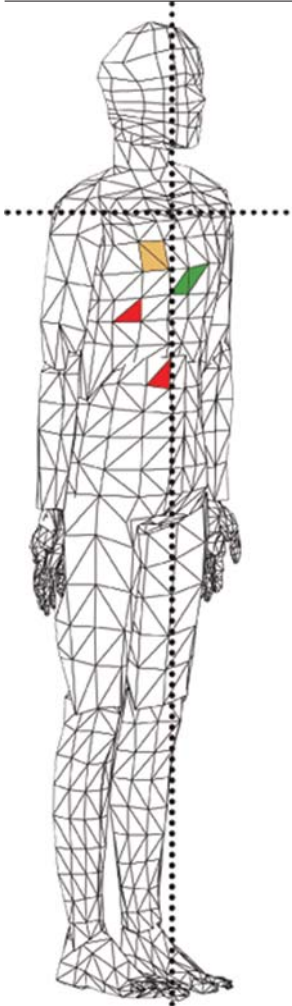
- Department of Education and Training (**DET**) 46
- Department of Systems and Networks Administration (**DSNA**) 46
- Registry of **.gr** Domain Names Department 47
- **W3C** Greek Office 48

International Links:

- ERCIM 48

Biomedical Informatics

USING TECHNOLOGY TO IMPROVE HEALTH



The Biomedical Informatics Laboratory (BMI) at FORTH-ICS has been at the forefront of biomedical informatics research, development and education since 1985. BMI is actively involved in:

- *the production of knowledge, novel computational methods and tools to support the Virtual Physiological Human (VPH) initiative*
- *individualised healthcare*
- *ambient intelligence eHealth environments*
- *the development and transfer of technology and knowledge to clinical settings at the point of care*

BMI collaborates closely with both national and international research institutions, and industries, and is a key contributor of ERCIM. Funding for BMI activities is obtained from the European Commission and national programme funds.

The central mission of the Biomedical Informatics Laboratory is to provide the technical and scientific knowledge and infrastructure to allow evidence-based, individualised healthcare using all relevant sources of information.



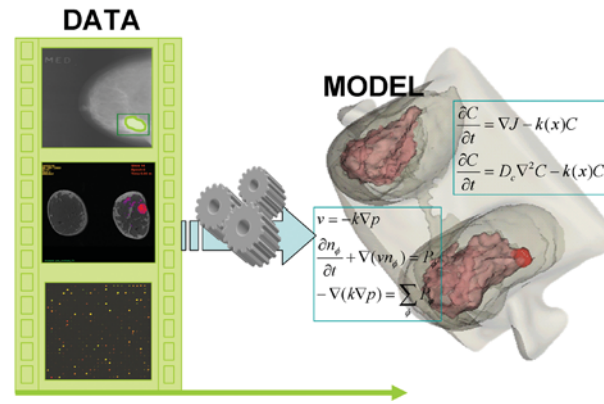
BMI

Research activities

The convergence of life sciences, healthcare, and information technology is revolutionising the discovery of new treatments and the practice of medicine. Central to the field of biomedical informatics is the concept that full understanding of health and disease can only be obtained through the integration of knowledge from different levels of organisation such as molecules, cells, tissues, organs, clinical data and environmental data. Use of data from a patient's clinical information, biomedical images, the environment, genetic profiles, as well as molecular and genomic research efforts have resulted in the emergence of Information-based medicine for individualised healthcare. BMI conducts research on the following: advanced computational methods in support of the Virtual Physiological Human project; the structure and content of the clinico-genomic Electronic Health Record (EHR); simulation and modelling of complex biomedical processes; development of tools for novel and prototypical data mining, and knowledge discovery for databases.

The **Virtual Physiological Human (VPH)** initiated by the European Commission is a major scientific multi-disciplinary challenge which aims to develop robust physiology or pathology in silico models. Thus, individualised models of human function might serve as virtual test-beds for better understanding pathophysiological processes, as well as evaluating potential therapeutical regimes. Multidisciplinary research efforts at BMI focus on:

- Computational frameworks for multi-level (from molecular/genetic to tissue/organ) modelling and simulation of pathophysiological human function.



Digital Patient Modelling

- Multiparameter data and information visualisation at all levels (from cellular processes to organ function), as well as tools and novel interaction paradigms relevant to this domain, for example, developing methods and tools for mixed reality (e.g., tumour growth simulation in real 3D patient data), and user interfaces for specific medical applications.
- The modelling issues related to coupling/fusion of anatomical models with imaging data of tissue properties (e.g., CE MRI, X-ray, PET, etc.).

Research on **database data mining and knowledge discovery (DM/KDD)** is targeted towards four directions aiming to expose the utility of data-mining in the respective disciplines and application areas:

- Design and development of novel and prototypical DM/KDD methods, techniques, algorithms, tools and systems.

- Intelligent analysis approaches, based on DM/KDD techniques, for the recognition of genes (promoters) in DNA sequences, and Intelligent analysis of microarray/gene-expression data for the discovery of molecular markers (i.e., gene-markers) based on classification approaches, and the discovery of families of co-regulated genes (metagenes) based on clustering approaches.
- Design of methodologies and development of algorithms, tools and systems for mining distributed and heterogeneous clinical data sources. The aim is to add intelligent capabilities into the integrated electronic healthcare record (I-EHR), towards internet-based epidemiology.
- Design and development of techniques, algorithms, systems and tools for the automated indexing of Web-documents, the automated construction of controlled-vocabularies (CV) and concept hierarchies (CH).

Bioimaging Informatics aims at providing the necessary technology and tools for clinicians and biologists to optimally extract and use biomedical information. Bioimaging at BMI is involved in:

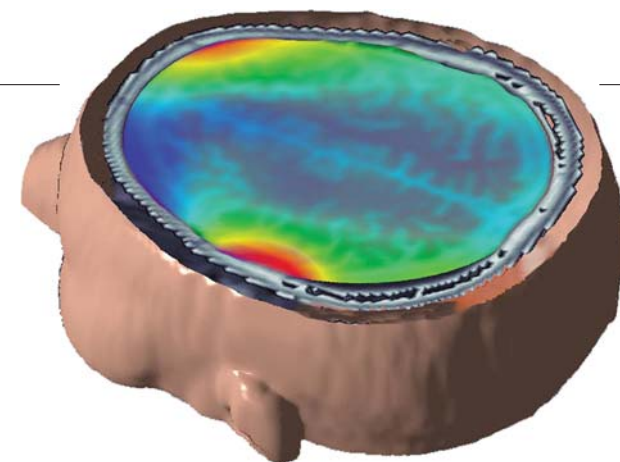
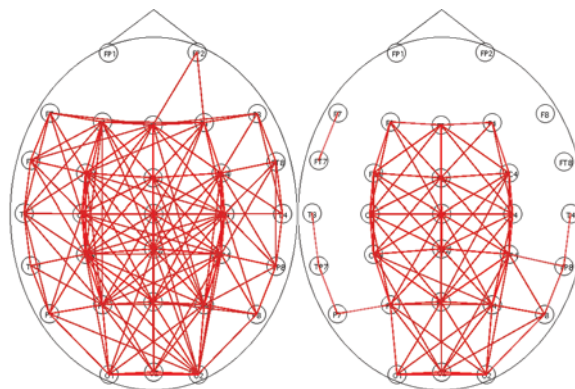
- Medical and Molecular Imaging to develop methods for multi-modality image alignment and fusion that enables temporal studies (e.g., cell trafficking, fluorophore detection etc.) to be carried out more efficiently.
- Gene Expression Imaging to develop sophisticated image analysis algorithms for signal normalisation.
- Systemic Imaging Informatics approaches for developing mathematical models of human physiology and pathology.

The **bioinformatics** activity develops novel mathematical and computational tools that can be used to solve complex, data intensive biological problems. Methods developed and used include symbolic and sub-symbolic machine learning algorithms, as well as global optimisation methods. These developments are compared and combined with existing tools. Specific objectives include:

- Prediction of novel precursors microRNA (miRNA) from genomic sequences using novel methods for the calculation of RNA secondary (2D) / tertiary (3D) structure
- Prediction of mature miRNA from precursor miRNA
- Computational approaches for prediction of miRNA targets
- Graph-theoretical analysis and visualisation of regulatory networks and cellular simulation
- Correlation of expression profiles of miRNAs and their target genes
- Support for the development of novel nanotechnology Lab-on-chip devices for diagnostic miRNA-gene expression profiles
- Proteome annotation for cellular localisation

BMI

Expertise in the area of **network analysis and visualisation** has been successfully applied to comprehend and represent biomedical data. Biomedical data are rich in networks, from protein interaction networks to gene (and miRNA) regulatory networks, from patient-to-gene interaction networks to molecular networks, and from neuronal networks to brain networks. A central goal in this respect is to devise strategies and techniques to assist in the analysis, visualisation, and motif discovery in large, dynamic, and heterogeneous network data. In addition, network analysis and interaction with network visualisations are new research tools that will facilitate understanding and knowledge discovery.



Research on **ambient Intelligence eHealth environments** focuses on the development of innovative ambient intelligence service platforms for automatic, context sensitive eHealth and mobile Health (mHealth) services across heterogeneous networks. The service platforms are designed to support mobility among users through integration with seamlessly accessible ubiquitous intelligent surroundings. Central to these services are self-configuring devices of semantic agents and tools for ambient awareness and decision support. Also, in accordance with the emergence of individualised health care, research activities include design and development of ambient technology platforms and intelligent systems as well as wearable and portable technology platforms for clinical decision making, and post-genomic lab-on-chip technologies.

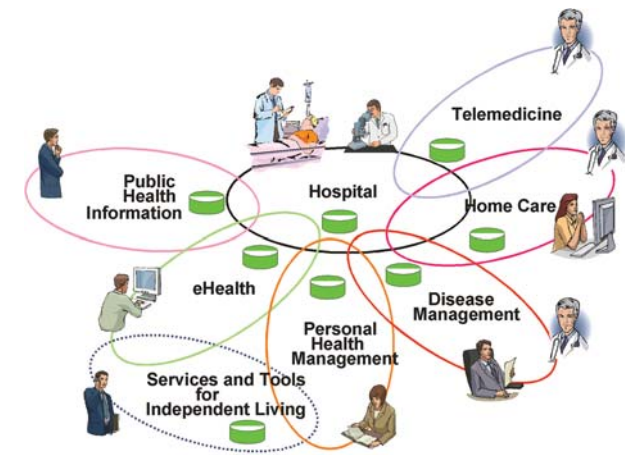
Development & Technology transfer

For a number of years, the BMI Laboratory has worked on the development of **HYGEIAnet**, the Integrated Regional Health Information Network of Crete, as a pilot and a model for similar developments at a national and European level. HYGEIAnet was awarded an Honourable Mention at the "Ministerial Conference and Exhibition eHealth 2003", held in Brussels. HYGEIAnet represents a systematic effort toward the design, development and deployment of advanced e-health and m-health services at various levels of the healthcare hierarchy, including primary care, pre-hospital health emergency management, and hospital care. HYGEIAnet is based on a scalable architecture and conforms to the requirements for interoperability of systems and services, based on an open architecture and the use of standards. Building on HYGEIAnet, BMI guides the production level implementation of **integrated care solutions** in other regions on the mainland and islands of Greece. These projects include the regional health authorities of:

- West Attica that consists of 9 Hospitals (H), 6 Primary Care Centres (PCC), and 17 Community Doctor Offices (CDO)
- West Greece, 6 H, 5 PCC, and 41 CDO
- South East Aegean, 4 H, 4 PCC, and 9 CDO in the Dodecanese islands
- Athens, 10 H

In addition to providing Regional Health Information Network solutions, the **development and technology transfer activities of BMI** also include supporting a number of healthcare providers throughout Greece through specific maintenance contracts. Available products developed at BMI include:

- The **Hospital Information System** supporting EHR management in the context of a hospital environment. All involved functional areas of a hospital, including the admissions office, the outpatient department, the emergency department, the patient accounting office, and the ward/clinic, have access to EHR functionalities through the corresponding modules.
- The **Integrated eBooking System** covering scheduled appointment booking both for inpatient and outpatient departments within a healthcare organisation. It supports appointment booking and management at a cross-enterprise level, allowing for the improvement of the organisational performance and cost savings.
- The **Primary Health Care Information System** supporting EHR management in the context of a primary health care provider setting. It follows high quality international trends regarding both the structure of the EHR, as well as integration with third party systems. The EHR is based upon internationally accepted models for primary care, and supports visit-oriented and problem-oriented views, and process automation.
- The **Integrated Electronic Health Record (I-EHR)** provides a uniform way for professionals and citizens to access patient record data that are physically located in different clin-



The future healthcare environments and services

ical information systems across different organisations. I-EHR provides fast, secure and authorised access to distributed patient record information from multiple disparate sources. It builds upon a **Health Information Infrastructure** that supports a wide range of services, including Person Identification Services, Clinical Observations Access Services, Health Resource Services, I-EHR Indexing Services, and Terminology Services.

The I-EHR addresses key challenges such as the provision of a framework for the integration of a diverse set of heterogeneous and distributed information sources into a seemingly uniform collection of data and knowledge, hence increasing the availability of previously inaccessible information. Addressing the need to transform the I-EHR from a passive into an active service, the BMI Laboratory focuses on issues related to (a) linking the I-EHR to external knowledge sources such as clinical guidelines/protocols and genetic information; and (b) development of predictive and context sensitive models for clinical decision support for disease management and treatment planning.

Horizontal activities

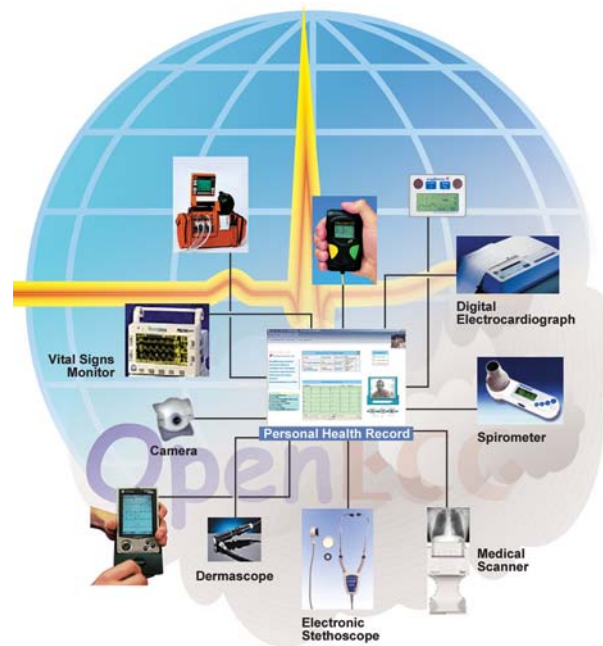
To support all the above, BMI has established horizontal activities pertaining to:

- the promotion of interoperability standards
- research on policy, organisation and change management in the implementation of biomedical informatics technologies
- education and training in collaboration with national and international research institutes and universities

INTEROPERABILITY STANDARDS

BMI is committed to eHealth interoperability and the consistent implementation of standards. Implementation of standards is the only way towards high-quality active and pervasive EHRs that seamlessly support clinical procedures, reducing medical errors and improving integrated health care in and out of the hospital. In recognition of the central importance of standards in biomedical informatics, BMI operates the OpenECG network and is a founding member of HL7-Hellas. HL7-Hellas is one of the 27 international affiliates of HL7.org, an organisation that creates standards for the management, integration and exchange of healthcare information, and promotes their use within and among healthcare organisations.

OpenECG (www.openecg.net) is a world wide network with 683 members from 56 countries that promotes interoperability in electrocardiography by raising awareness about relevant standards. OpenECG services test conformance to the European SCP-ECG standard (EN1064:2005) and provides standardisation bodies with feedback from implementation.



Personal Health Record

POLICY, ORGANISATION & CHANGE MANAGEMENT

Experience with research, development and implementation of eHealth technologies has shown that social and organisational aspects are often the most critical for successful introduction of technological innovation in the health sector. The principal aim of this activity is to promote research on the relationship between technology and organisations in the context of the emerging information society. Through this critical approach, the BMI Laboratory seeks to promote a deeper, more substantive perspective on technology and organisations. Emphasis is placed on the social, organisational and political factors and processes

through which technologies are developed and implemented to improve health services. Examination of the ongoing development of the organisation-technology nexus, as well as considering its significance and its social and ethical implications, contribute to a greater understanding of innovation in health care and inform R&D activities in the area of eHealth.

EDUCATION AND TRAINING

The Biomedical Informatics Laboratory provides support to both the graduate and undergraduate programmes of study of the Departments of Computer Science and Biology, University of Crete, through teaching and supervising undergraduate, M.Sc. and Ph.D. students. Members of the Biomedical Informatics Laboratory contribute to teaching and research supervision of the Inter-departmental graduate program in Molecular Biology - Biomedicine and in Computer Science programmes. Collaborations for teaching and training also exist between BMI and various national and international research organisations and universities.



Research projects

ACGT

ACGT brings together internationally recognised leaders in their respective fields, with the aim to deliver to the cancer research community an integrated Clinico-Genomic ICT environment enabled by a powerful GRID infrastructure. (<http://eu-acgt.org/>)

INFOBIOMED

The EC-funded BIOINFOMED Study has carried out a prospective analysis of the relationships and synergy between Bioinformatics (BI) and Medical Informatics (MI). (<http://www.infobiomed.org/>)

TWISTER

The objective of the TWISTER Integrated Project is to support the development and widespread adoption of satellite communication services to deliver broadband services for rural areas. (<http://www.twister-project.net/>)

HEARTFAID

HEARTFAID is a R&D project aimed at devising, developing and validating an innovative knowledge-based platform of services, able to improve early diagnosis and to make more effective the medical-clinical management of heart diseases within the elderly population. (<http://www.heartfaid.org/>)

Rural Wings

Rural Wings is an ambitious project that proposes to develop an advanced learning platform through satellite DVB-RCS access technologies, promoting a user-centred methodological approach, which constitutes its major innovation. (<http://www.ruralwings-project.net/>)



LOCCANDIA

The project aims to integrate a full proteomics analysis chain, from blood sample to the diagnosis information, combining bio-, nano-, and information-related technologies. (<http://www.loccandia.eu/>)

HEALTHWARE

The HEALTHWARE project focuses on the integration of the two-way DVB-RCS technology with existing standard technologies to guarantee the delivery of sustainable end-to-end healthcare services. (<http://healthware.alcasat.net/>)

EHR-IMPLEMENT

The general objective of EHR-IMPLEMENT is to collect, analyse and compare broad scale electronic health record (EHR) implementations among European countries and provide best practice, policy and strategic recommendations. (<http://www.eurorec.org/>)

eHealth Trends

The main objective of the project is to monitor European health consumer use of, their attitudes to, and their needs with regards to, information and communication technology for health purposes. (<http://www.telemed.no/eHealthTrends>)

SAFE: Satellites for epidemiology and health early warning

SAFE, a European Space Agency project, aims to establish a roadmap on the integration of co-operative working and geolocation in European healthcare systems and civil protection for all phases of biological crisis management, including prevention and health early warning. (http://www.medes.fr/home_fr/telemedecine/projets/safe.html)



The Twister Network



The HYGEIA Award

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Computer Architecture & VLSI Systems

CARV

The Computer Architecture and VLSI Systems (CARV) Laboratory of FORTH-ICS conducts Research and Development in the Architecture, Design, and Implementation of Computer, Storage, Communication, and Network Systems, at the Hardware and Systems Software level.

CARV aims at addressing realistic problems in real systems, thus heavily relying on experimental setups to demonstrate the validity of its ideas and the viability of its solutions. As part of such work, state-of-the-art prototypes and infrastructures have been, and continue to be, built.

Information Systems are built with technology layers (levels of abstraction). The upper layers are based on the lower ones, and the "raison d'être" of the layers below is to support and make possible the layers on top. Roughly, from bottom to top, these layers are: (1) Physics, Chemistry, Materials; (2) Nanoelectronics, IC Fabrication; (3) VLSI, Electronic Design Automation (EDA); (4) Digital Systems Architecture; (5) Systems Software; (6) Applications Software; (7) Services.

The CARV Laboratory addresses the three middle layers: VLSI, Electronic Design Automation (EDA); Digital Systems Architecture; and Systems Software.



TECHNOLOGIES FOR THE NEXT DECADE:
A THOUSAND PROCESSORS WORKING TOGETHER

Interconnection and Interprocessor Communication Architectures

Future computing, embedded, storage, and communication systems will contain increasing numbers of cooperating processors, within and across chips. The central open architectural question is how to organise such Scalable Systems –systems made out of building blocks, where one can increase performance by using more components, or reduce cost by using less components. The Computer Architecture and VLSI Systems (CARV) Laboratory has been highly active in this area since 1985 –recently within the framework of the European Network of Excellence on High-Performance Embedded Architecture and Compilation (HiPEAC).



Scalability depends critically on the interconnection network used, and on how that interfaces to the components of the system. CARV has been working on interconnects since 1985, and on network interfaces in 1993-95 and again since 2005. Old, low-performance interconnections were based on buses, but newer systems use packet switches and networking fabrics made of the latter. CARV has worked on the architecture of both individual switches and switching fabrics.

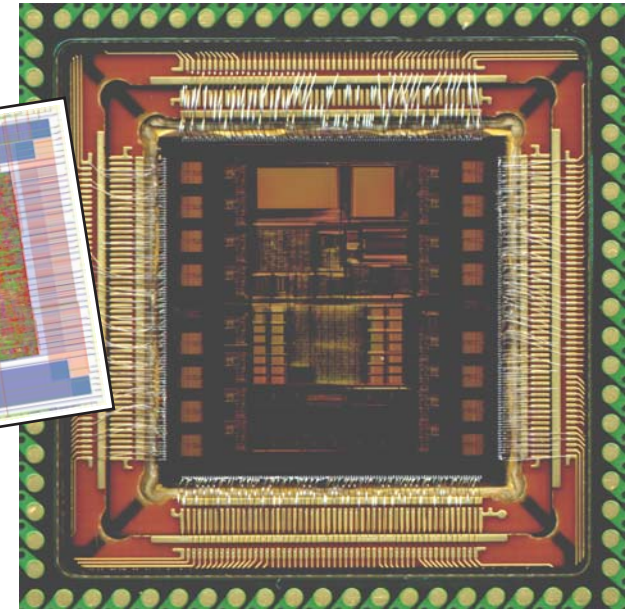
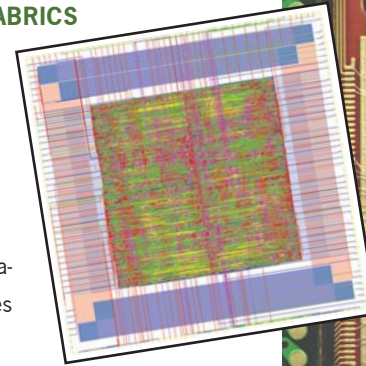
MULTI-GIGABIT SWITCHING FABRICS

Buffered Crossbars

Crossbar switches are internally non-blocking, but require complex centralised schedulers and only work with fixed-size cells. However, by including small buffers at each crosspoint, operation with variable-size packets becomes feasible and scheduling is dramatically simplified. The CARV Laboratory has shown (2001-02) that such distributed WFQ scheduling approximates very well the ideal weighted max-min fair allocation. Next (2003 onwards), CARV has designed, shown the advantages, and prototyped variable-size-packet buffered crossbar switches. (<http://archvlsi.ics.forth.gr/bufxbar/>)

Backpressure in Buffered Switching Fabrics

Multi-stage switches scale to very large numbers of ports. Scalability requires distributed packet scheduling which, in turn, implies internal buffering in the switching elements. Multilane backpressure (credit-based flow control) in the fabric allows the switching elements to only use on-chip buffer memory, while the majority of the packets are buffered at the inputs, in virtual-output queues (VOQ), thus greatly reducing the cost of the fabric. In 1987, the CARV Laboratory proposed the use of backpressure, and subsequently applied it to the development of the Telegraphos (1993-95) and ATLAS I (1995-98) switches.



ATLAS I (CARV-FORTH-ICS, 1995-98): Single Chip ATM Switch for High-Speed Networking, 10 Gigabit-per-second, 6-million transistors

ATLAS I, a 10 Gb/s single-chip 16x16 ATM switch with backpressure: This 6-million-transistor 0.35-micron CMOS chip - a general-purpose building block for gigabit networking - was designed at CARV, (1995-98) and was fabricated by ST Microelectronics. It provided credit-based flow control (multilane backpressure) with 32,000 virtual channels, sub-microsecond cut-through latency, logical output queues in a shared buffer, 3 priority levels, multicasting, and load monitoring. (<http://archvlsi.ics.forth.gr/atlas/>)

CARV

Pipelined Memory is a novel organisation (USA patent 5,774,653, owned by FORTH) that CARV designed (1993-95) for the shared buffer and associated switching and cut-through functions in a crossbar switch.
(http://archvlsi.ics.forth.gr/sw_arch/pipeMem.html)

Benes Fabrics with Internal Backpressure: The Benes topology is a multi-stage fabric known to yield, for large N, the lowest-cost NxN non-blocking interconnect. CARV applied its buffered fabric architecture to this topology (2001-2002) by combining per-flow backpressure, flow merging, multipath routing (inverse multiplexing), and cell resequencing. Next (2006 onwards), CARV designed a very effective scheduling and congestion management mechanism for such fabrics.
(<http://archvlsi.ics.forth.gr/bpbenes/>)

QUALITY-OF-SERVICE (QoS)

Per-Flow Queueing

Providing guarantees for Quality of Service (QoS) through modern, advanced-architecture network systems requires the decomposition of traffic into multiple flows and the provision of a separate queue for each of them. Managing a large number of queues (hundreds or thousands to possibly millions) at high speed typically requires the assistance of specialised hardware. CARV has been active in such multi-queue management implementations, which have varying cost and performance characteristics.
(<http://archvlsi.ics.forth.gr/muqpro/queueMgt.html>)

Weighted-Round-Robin Scheduling

After the competing flows have been isolated using per-flow queueing, fair allocation of the available bandwidth requires a weighted-round-robin scheduler. In 1986, CARV initiated a detailed investigation of various methods to perform this at different cost and performance levels (IEEE JSAC Oct. 1987). In 2000-2003, CARV developed a pipelined heap manager for weighted fair queueing (WFQ) at 20 to 40 Gbps, and a fast parallel comparator tree for WFQ at 40 Gbps and beyond, under fast changes to the set of eligible flows.
(<http://archvlsi.ics.forth.gr/muqpro/wrrSched.html>)

INTERPROCESSOR COMMUNICATION ARCHITECTURE

To be effective, faster interconnects also need faster network interfaces (NI). Traditional interprocessor communication goes through NI's residing on slow I/O buses, and requires passing through the operating system; changes are urgently needed. A decade ago (1993-95), CARV was one of the pioneers for several of the ideas in solving this, with its Telegraphos system design and prototype, which included protected user-level network access for low latency communication, user-level DMA, and fast notification of message arrival.
(<http://archvlsi.ics.forth.gr/telegraphos.html>)

Since 2005, CARV has been working again on the architecture of future high-speed NI's, testing its ideas on an FPGA-based prototyping platform that it has built for this research, linking 8 PC's at 80 Gbits/s through its own custom, reconfigurable NI's and



interconnect. The next step is fully virtualised NI's tightly coupled to the L1 cache controllers, enabling message send and receive within a few clock cycles, and providing effective support for remote DMA, synchronisation based on remote queues, data migration, and hardware-assisted software-controlled cache coherence.

OTHER TOPICS

Wormhole IP over ATM: Inspired from the wormhole-routing multiprocessor interconnection networks of the 80's, CARV has proposed (1998) this technique to turn existing ATM networks into gigabit IP routers with the mere addition of low-cost wormhole-IP devices. An FPGA-based prototype for a 155 Mbps link was built and successfully tested in 1999.
(<http://archvlsi.ics.forth.gr/wormholeIP.html>)

Other topics of past research and development at CARV include branch penalty reduction (1990), parallel supercomputer architectures (1991-94), interleaved Rambus memory controller (1994), JPEG entropy encoder chip (1994), and consulting for high-tech companies, within Greece and internationally.

Scalable Computing and Storage Infrastructure

Research and development activities in scalable computing and storage infrastructure investigate cost-effective architectures of commodity components and their applications. In particular, the focus is on:

- **Interconnects:** network interface architectures and communication protocols
- **Computing:** programming abstractions and fault tolerance in scalable systems
- **Storage:** Block-level storage architectures, storage protocols, and storage virtualisation

The architectural level and all software layers (firmware, operating systems, user-level applications) of today's systems, as well as the interactions between these layers, are addressed. Specific issues currently under research are:

System Interconnects

Activities in this field aim at developing the technology required to unify the network interconnects used today in data-centres, and at providing the fundamental technology for evolving to more flexible and effective data-centre architectures. In particular, focus is on the lower layers of the communication protocol stack, and on how higher-level protocols designed for different application areas can be provided on top of the same physical layer. The overall goal is to use next-generation commodity physical layers and networking equipment to achieve scalability and performance currently available at more specialised system and storage area networks.

Storage access and virtualisation

Given current trends in technology, storage is increasingly being detached by application servers in various networked storage configurations. In this model, two important problems are: (a) How large numbers of disks can be integrated in a single system? Work in this area investigates protocol and I/O path mechanisms that can achieve this on top of scalable, commodity interconnection technologies. (b) How scalable systems can be shared and managed efficiently? Current work examines novel virtualisation techniques that allow for easy extensions of storage stacks with new mechanisms and flexible combinations of these mechanisms to provide rich semantics.

Programming abstractions for scalable systems.

Modern scalable systems rely increasingly on multiple CPUs both at the system as well as the chip level. Programming such systems has traditionally been a challenging and expensive task. Today, the effort and cost required are multiplied by the fact that such systems are used in more and more application domains, from embedded systems to application servers. Current work in this area explores low-level programming paradigms that (1) can offer a higher-level of semantics than traditional message-passing and shared memory approaches and (2) can map efficiently to novel architectural mechanisms in CPUs and interconnection networks.

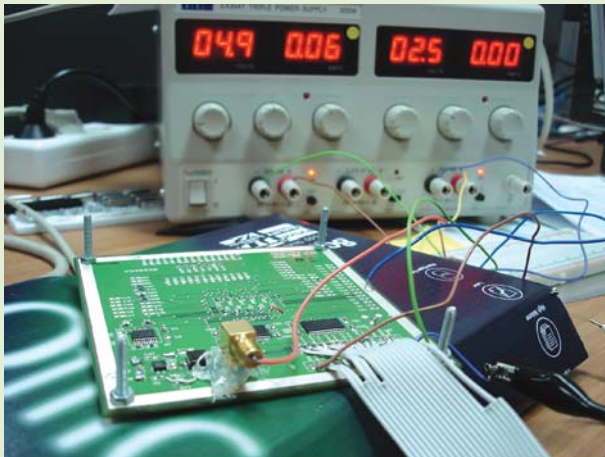


Miniaturisation of computer systems

Recent progress in technology makes it possible to build miniature, networked systems that may have a profound effect on computing infrastructures. Autonomous, networked micro-systems with processing capabilities can enable new areas of applications, such as diagnosis of epidemic diseases, forest and crop protection, safety, and monitoring of fine grain parameters in our environment. Driven by rapid progress in underlying technologies, early research in this area tended to focus on experimental prototypes of infrastructure, devices and applications. As the field progresses, more fundamental challenges emerge, which are the focus of related CARV activities. There is an increasing need to investigate and build advanced and generic functionality in the runtime system of future microsystems. The objective of this line of work at CARV is to offer a new stable framework that will allow researchers to decouple systems issues from application requirements, and will lead to easy deployment of microsystems in advanced application domains.

Electronic Design Automation tools, System Timing and Synchronisation

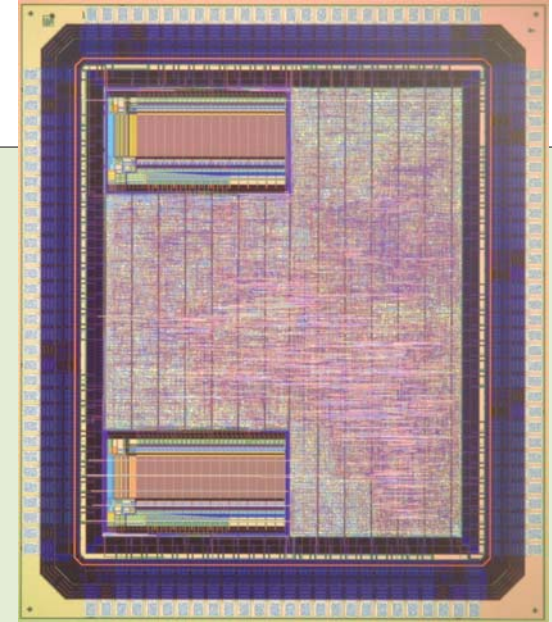
As the number of circuit gates in a single chip constantly grows towards and beyond the billion point, the operation of gates under a single centralised clock or even multiple rationally related clocks becomes impossible. To solve this problem, researchers are now investigating "globally-asynchronous locally-synchronous" systems, or even fully-asynchronous designs. Circuits that are partly or fully asynchronous exhibit additional advantages. For example, they significantly reduce electromagnetic emissions and often reduce power consumption as well. However, the synchronous paradigm is currently dominating today's circuit design methodologies. The key obstacle to widespread adoption of asynchronous design technology is the lack of a commercial-quality RTL-to-GDSII asynchronous design methodology that is based as much as possible on existing best-practice tools and flows.



CARV has been actively investigating this problem since 2001. Current research activities in this area focus on methods and tools for asynchronous circuit design; techniques for desynchronisation, that is, progressive relaxation of local synchronisations; asynchronous support for commercial-quality Electronic Design Automation (EDA) tools; asynchronous interconnect design and asynchronous processor design.

THE ASPIDA CHIP

CARV recently completed the coordination of the EU-funded research project, "ASPIDA" (Asynchronous open-Source Processor Ip of the Dlx Architecture). Within this project, FORTH-ICS designed an open-source asynchronous RISC processor implementing the DLX integer ISA, a five pipeline stage design with 32 registers and hazard-detection logic. This processor supported two possible modes of operation: the conventional synchronous approach and the desynchronised one. Desynchronisation is a design methodology which allows the replacement of clock signals by coordinated handshaking components, albeit using conventional synthesis tools and flows. ASPIDA fabricated a total of two IC designs, both of which were shown to be fully functional. The first chip was fabricated in early 2005 and post-manufacturing measurements verified its correct operation on first silicon. Extensive tests over about 90 fabricated chips yielded very interesting results. The desynchronised mode of operation was demonstrated to be 25% faster on average, over the range of

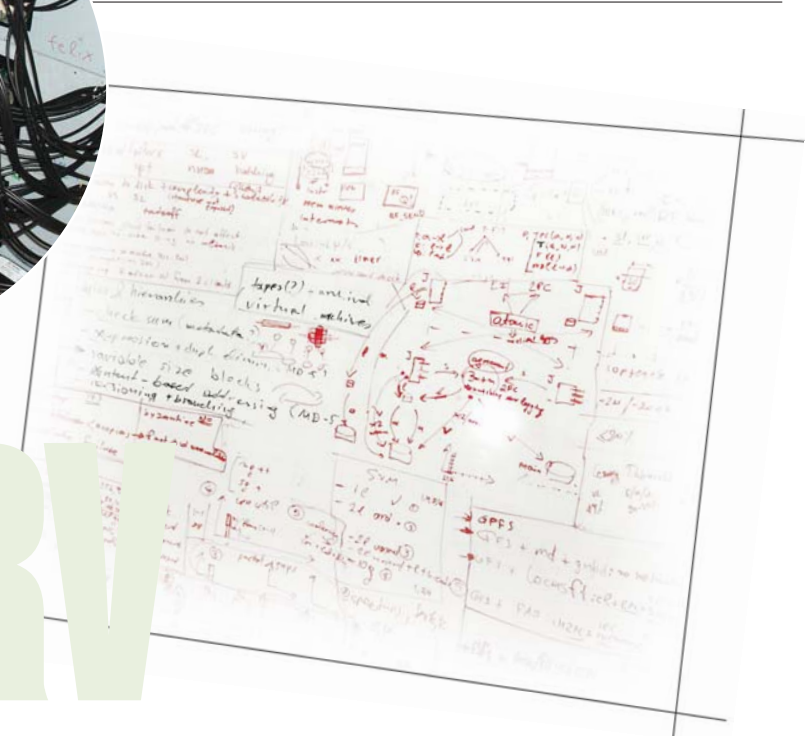
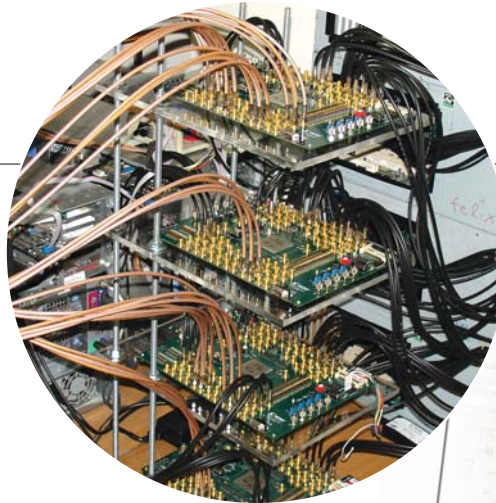
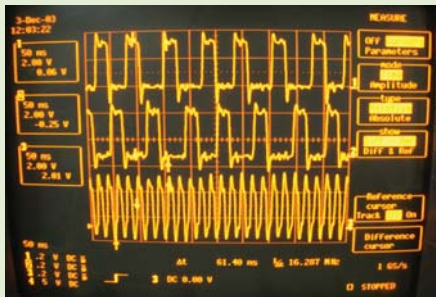


chips, than the worst-case synchronous operation as predicted by EDA tools. The chip's supply voltage could be scaled all the way down to 0.95V (from a nominal 2.5V) with no functionality problems, and its power and speed could be controlled solely by controlling the supply voltage. The second chip, fabricated in April 2006, along with a special PCB suitable for industrial fidelity electromagnetic emissions (EME) measurements, demonstrated the first-ever EME results in a dual-mode chip design. The results from the EME measurements were indeed impressive. Asynchronous mode of operation was shown to generate significantly less EME in all regions of the spectrum, reaching up to a 50dB reduction for some parts of it. In the EME spectral analysis, it was apparent that synchronous EME peaks were translated to lower, wider EME emissions in the asynchronous version.

ASPIDA results represent a unique technical contribution. ASPIDA is the first chip ever capable of working in both synchronous (WC corner) and asynchronous modes (TYP conditions). It has demonstrated the capability of the Desynchronisation methodology to: reduce power; allow for simple and effective static and dynamic voltage scaling; increase performance by reducing timing margins; cope with manufacturing variability; and reduce Electromagnetic Interference (EMI). Desynchronisation is a viable alternative to the conventional synchronous approach that can be used to improve nanotechnology IC designs by offering lower power consumption and higher performance.

NANOCHRONOUS LOGIC, INC.

These highly successful research results attracted worldwide attention. Nanochronous Logic, Inc., a FORTH-ICS spin-off company, will commercialise them by providing Desynchronisation-related products to the global EDA market. Nanochronous Logic, Inc. will have its Corporate, Sales and Marketing departments in San Jose, California, and its Research, Development and Engineering departments in Heraklion, Crete.



CARV

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Computational Vision & Robotics

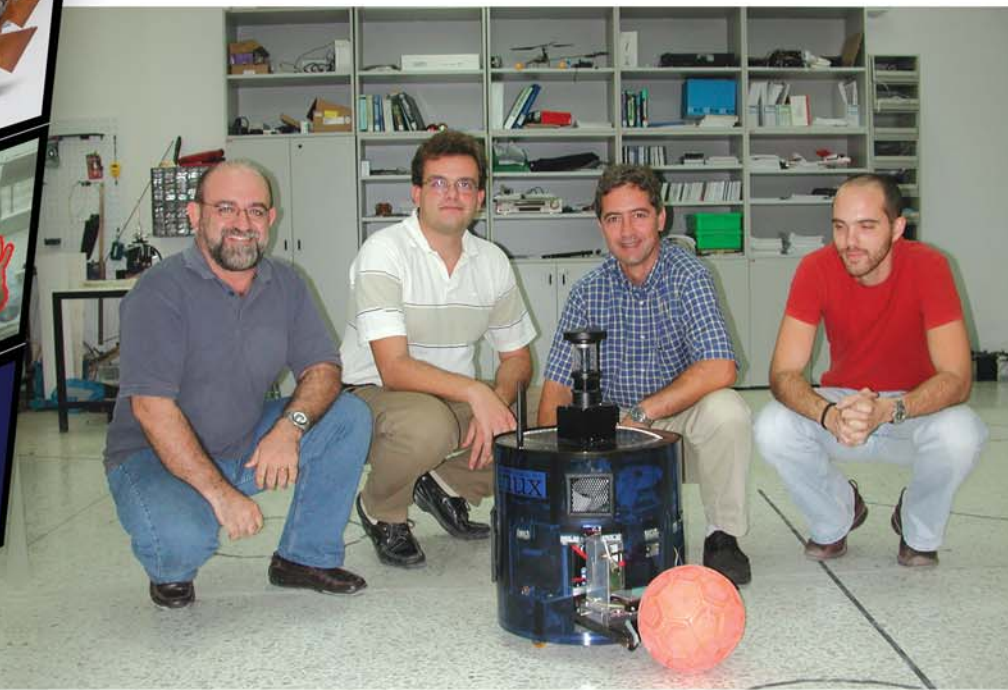
The Computational Vision and Robotics Laboratory (CVRL) of FORTH-ICS was established in 1985. The research and development efforts at CVRL focus on the areas of computational vision and autonomous mobile robots that perceive their environment and exhibit intelligent behaviours.

Research in this field has theoretical interest because it leads to the computational and mathematical modelling of perception and action, and contributes to a better understanding of the mechanisms involved in the corresponding capabilities of biological organisms. Furthermore, this research is of practical interest because it forms the basis for the development of interesting and often significant robotic systems, such

as robotic wheelchairs for people with disability, tour-guide robots in museums and other exhibitions, robots performing routine tasks such as cleaning and surveillance. Moreover, by-products of this research prove extremely useful in other application areas that are not directly related to robotics, such as virtual and augmented reality, 3D modelling and environmental monitoring, event detection, and content-based image retrieval. Efforts at CVRL are balanced between basic and applied research, resulting in the construction of robust vision and robotic systems for various application domains.



CVRL



HUMAN - ROBOT SYMBIOSIS

RESEARCH AGENDA

Research and development activities at CVRL address the following fundamental questions in an effort to achieve robust solutions to corresponding theoretical, computational, and design problems:

Computational perception: What is the maximum information that a robot can extract by sensing its environment? More importantly, what is the actual information that a robot needs to extract from its environment in order to exhibit certain desired and possibly intelligent behaviours?

Robot behaviours and biomimetic control: How should perceptual capabilities and control strategies be combined to obtain the desired robot behaviours? How can we design robot locomotion and control mechanisms with capabilities comparable to that of biological organisms? How should the characteristics of the environment and the mechanical properties of a robot be taken into account in this process?

Robot cognition and learning: How can we make robots exhibit autonomous behaviour and cognitive abilities comparable to that of higher-level biological organisms? How can a robot acquire new skills through interaction with its environment? How can a robot accumulate experience, thus improving its acquired skills?

RESEARCH INFRASTRUCTURE

CVRL has a modern research infrastructure (including robotic platforms, active vision systems, state of the art workstations, etc.), which facilitates experimentation and demonstration of research results. The CVRL robotic platforms are:

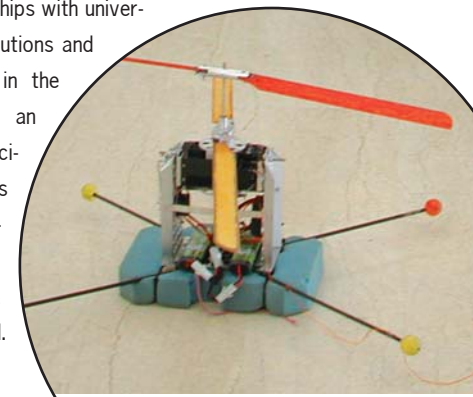


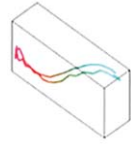
- **TALOS**, an RWI B21 robotic platform equipped with sonar, infrared and bumper sensors, as well as a TRC stereoscopic system.
- **LEFKOS**, an RWI B21r robotic platform equipped with a SICK PLS laser scanner, sonar, infrared and bumper sensors.
- **A robotic wheelchair** equipped with sonar sensors and panoramic vision.

- **Plato**, a 4-wheel skid-drive robotic platform (Activmedia Pioneer 3 AT) capable of performing both indoors and outdoors. Furthermore, CVRL has extensive expertise in the development of prototype robotic systems, and therefore the possibility to extend its research infrastructure. Examples of such systems are:
- **Peleas**, an in-house designed and constructed robotic platform equipped with a SICK LMS laser scanner, infrared sensors and both panoramic and wide angle cameras.
- **Flybot**, an in-house designed and currently under-construction flying robotic platform, employing electric motors and two contra-rotating rotors.
- **Nereis**, an in-house designed and constructed *pedundulatory* robotic platform, locomoting on sand, pebbles and hard floor by body undulations, combined with the action of numerous fin-like appendages.

COLLABORATIONS

Since its founding in 1985, CVRL has established a large number of collaborations and partnerships with universities, other research institutions and industries in Europe and in the United States. CVRL has an impressive record of participation in funded projects and has acted as coordinating partner in projects and thematic networks at a national and European level.





Computational Vision

CVRL is very active in the area of Computational Vision, the research field that aims at developing computational methods which enable machines to perceive their environment through the analysis of images. Research in this field is of theoretical interest because it leads to the computational and mathematical modeling of perception and contributes to better understanding the mechanisms involved in the corresponding capabilities of biological organisms. At the same time, Computational Vision is a key ingredient of intelligent systems in application domains such as security, safety, urban planning, robotic assistants, process automation, health, entertainment, edutainment, telepresence, advanced human-computer interaction, ambient intelligence environments, and efficient and intuitive retrieval of information.

Several vision problems have already been investigated at CVRL leading to robust and efficient computational solutions and systems. Extensive efforts have been devoted to studying the problem of Structure and Motion estimation (SaM). Given a set of images acquired by one or more cameras, this analysis permits the automatic extraction of information related to the pose and the optical parameters of the employed cameras, as well as to the geometry and motion of the imaged scene. Effective solutions to the SaM problem require robust and efficient solutions to important subproblems such as feature extraction and matching, camera calibration, reconstruction, and bundle adjustment.

The reconstruction of an accurate geometric representation of the 3D world, although extremely rich and useful, is very difficult to achieve. The purposive approach to vision suggests that vision processes can rely upon disjoint, partial environment repre-

sentations, rendering the reconstruction of a complete, general-purpose environment representation unnecessary. Several visual capabilities have been studied at CVRL in such a context, including egomotion estimation, independent motion detection, obstacle detection, camera tracking, plane detection, matching and tracking. In certain cases, the perceptual requirements of specific robotic behaviours such as centering and homing have been investigated in such a framework.

Vision systems should be able to function in a dynamic world that evolves over time. To achieve this goal, they should be able to perform tracking, i.e., temporal association of the instances of detected features and objects. A characteristic example of such an effort at CVRL is the development of a system that combines colour, motion and structure information to track the 3D position of the hand(s) of a human carrying out a specific task.

CVRL is also studying and exploiting alternative visual sensors towards the development of visual perception capabilities. Fuelled by technological advancements in the areas of imaging sensor development and mirror/lens manufacturing, alternative camera designs, such as the 360 degrees field-of-view panoramic camera, have proven potential of overcoming some of the limitations of conventional camera models, and facilitate the solution of particular perceptual problems.

Basic research on individual fundamental topics such as the ones described above has provided acceptable algorithmic solutions to the corresponding problems, thus paving the road for more ambitious research goals. The individual topics identified below constitute hot research issues worldwide and central themes of current RTD activities at CVRL:

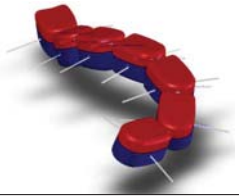
Cognitive vision systems: Despite the advances that have been made on individual problems, limited progress has been achieved on cognitive tasks such as "general" recognition, scene understanding and visual reasoning functioning in natural environments. Research activities at CVRL aim at developing robust cognitive vision systems that integrate effectively a coherent set of visual tasks with appropriate learning and adaptation mechanisms, suitable knowledge representations and memory.

Perceptual support for robot behaviours: Reliable perception is a prerequisite for building truly autonomous robotic systems for which the issues of embodiment and purposiveness are of primary concern. The perceptual capabilities of such systems should include mechanisms for attention control, information fusion, integration of evidence over time, tolerance to unexpected deviations and timely response to external stimuli while taking into account physical and computational constraints.

Camera networks: The dramatic reduction in the cost of low-end electronics made possible the deployment of several, usually identical, cameras connected to the same computer system. Such camera configurations have clear advantages in terms of large-scale space coverage and permit novel applications to be envisaged.

Extraction of 3D models from video streams: The last decade has witnessed groundbreaking developments in the area of obtaining 3D models directly from images, with limited manual intervention. This is of great market potential in several application domains. However, many issues related to their applicability, robustness and efficiency still remain to be solved.

Robot Behaviours and Biomimetic Control



In robotics, behaviours are functional mappings from the domain of perceived stimuli to a range of possible actions. CVRL's goal is to design appropriate reaction mechanisms, taking into account both the mechanical properties of robots, as well as the characteristics of their working environments, in order to enable autonomous operation.

In many cases, design methodologies are found by drawing inspiration from biology, in particular from the evolutionary process, which has produced a large variety of efficient solutions to a diverse array of motion control problems. For example, a reactive corridor-following behaviour has been developed, which enables a mobile robot to move in corridors and narrow passages, based on trinocular or on panoramic vision. This technique has been inspired by the navigation of bees in restricted spaces, and by their efficient exploitation of motion vision information. Insect homing has also motivated the conception of a robot homing behaviour, which can solve the problem of docking efficiently, with minimal perceptual requirements.

Other behaviours studied include obstacle avoidance, motion towards a desired target, following moving objects at a fixed dis-

tance, landmark-based robot navigation, construction of metric and topological maps of the environment, and path planning. A hybrid probabilistic framework has been developed to model the uncertainties involved in robot navigation, leading to accurate and efficient robot state estimation (localisation) and feature mapping. In a predictive navigation approach, the robot moves in space based on its perceived state and on predictions about the future states of moving objects, in an effort to optimise the tracked path towards its goal. All these behaviours exploit the information provided by a variety of sensors (vision, laser, sonar, etc.).

Research on robot behaviours becomes particularly challenging when the mechanical properties of the robotic systems involved, such as the nonholonomic kinematic constraints of wheeled



mobile robots, have to be taken into account. Reactive behaviours for such robots have been developed, based on sensor-based motion control strategies like visual servoing. These strategies take, in this instance, the form of a trajectory tracking problem or a robot stabilisation problem, at an appropriate desired state. The effect of noise and delays in sensory information processing, in the overall behaviour, needs to be explicitly considered.

The robotic behaviours described above are typically exhibited by wheeled robots that operate in man-made environments. Other types of robots, able to operate in very different environments and exhibit different behaviours, are also currently under investi-

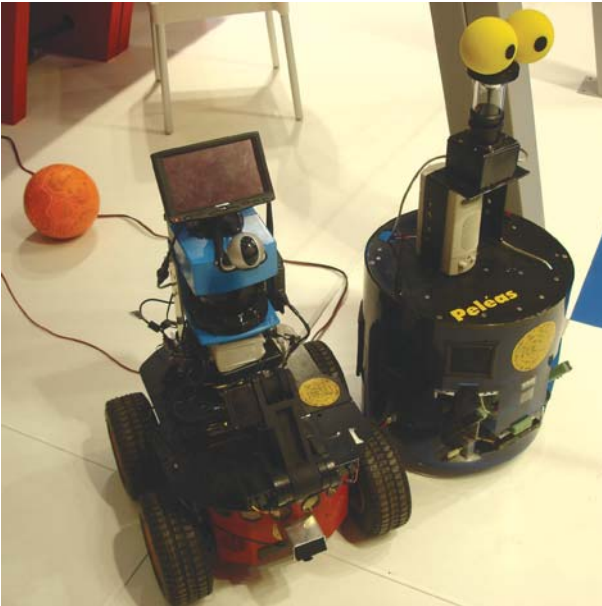
gation. For example, an autonomous helicopter is being constructed, and will be used to study the behaviours of flying robots.

Biological inspiration may also play a significant role in the design of novel locomotion systems: certain marine worms, and their underlying neural control mechanisms, are used to motivate the design and construction of robots exhibiting a similar morphology and behaviour. These robotic systems propel themselves by a unique combination of tail-to-head body undulations with the synchronised action of numerous parapodial lateral appendages. They demonstrate successfully this advanced form of pedunculatory locomotion on challenging unstructured substrates, such as sand, pebbles, mud or grass. Moreover, bio-inspired reactive behaviours and neuromuscular motion control strategies have been developed for such robotic systems. Significant long-term applications of this type of research exist in search-and-rescue operations, in planetary exploration, and in the development of miniature robots able to operate inside the human body.



CVRL

Robot Cognition and Learning



Cognitive robots are artificial systems that, inspired by human cognitive processes, take a more biological approach towards achieving artificial intelligence. As a scientific study, it is influenced by a number of overlapping fields, such as brain sciences, symbolic AI, computational vision, dynamical systems, autonomous mobile robots, cognitive sciences, linguistics, philosophy, and mathematics.

Recognising the importance of the domain and its potential, CVRL has been among the pioneers in the field of cognitive robotics, concerned with a variety of associated disciplines, including

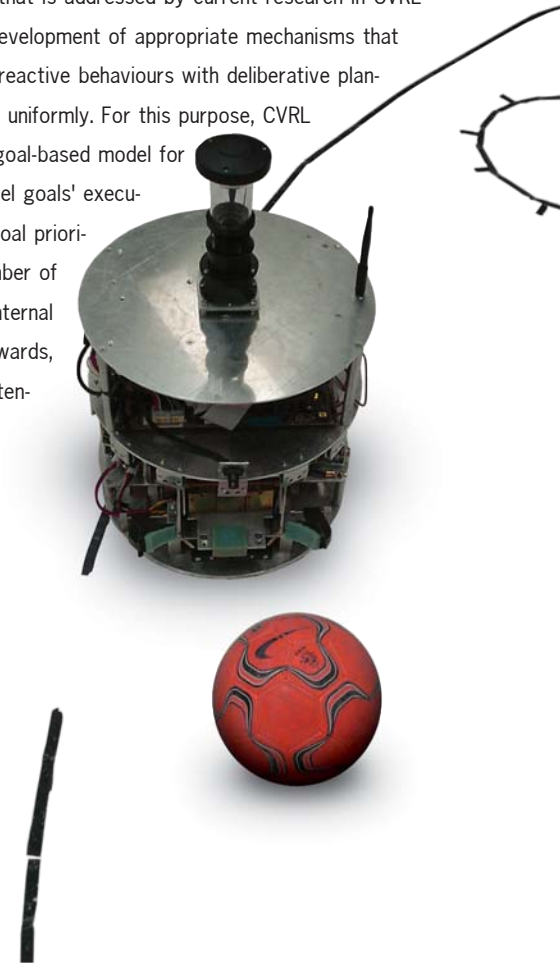
knowledge representation, reasoning, learning, and planning. The ultimate goal is to develop a new generation of robotic systems capable of abstract reasoning and other higher-level cognitive functions. The developed systems should be able to learn and self-develop while they interact with their environment and gather experience, thus improving their perceptual capabilities and skills.

Towards this goal, CVRL has adopted an ambitious, developmental approach to learning. According to this approach, robots are modelled as agent-based architectures, initially equipped with intentions, instincts, goals, as well as with some elementary perceptual capabilities and skills. Improvements in the robot's perceptual capabilities, skills and behaviours are expected to emerge through the continuous interaction of the robot with its environment, based on which it discovers and exploits possible relations among goals, memory, sensory input and motor capabilities.

A major scientific challenge is related to the development of new ways to fuse and understand information from heterogeneous input streams. To this end, new ways to integrate contextual information from multiple sensing modalities are being developed, permitting the detection of complex spatiotemporal patterns and causality relations that would be impossible with separate processing of different information channels. Understanding and interpreting the gathered situational and contextual information will lead to the development of means to go from images to recognised concepts of objects, persons, actions and context. Also related is the ability of the reasoning process to cope with missing and conflicting input data. By the same token, one of the

major challenges is the organisation of concepts in hierarchies that can be flexibly re-organised and fused in new "blends", as required.

Another challenge that is addressed by current research in CVRL is related to the development of appropriate mechanisms that combine low-level reactive behaviours with deliberative planning, smoothly and uniformly. For this purpose, CVRL utilises a uniform goal-based model for user and agent level goals' execution that selects goal priority based on a number of factors including internal drives, external rewards, current level of attention, contextual information and forward planning.



Achievements

- **TOURBOT**, an advanced robotic tour-guide used in museums and other exhibition sites. TOURBOT is able to autonomously map the environment and then offer guided tours to on-site and web visitors. TOURBOT is capable of operating robustly in crowded environments, and communicates with on-site visitors through computer-generated voice messages, as well as through facial expressions that externalise its internal state.
- A prototype **skin-colour tracking system** that performs real-time 3D tracking of multiple skin-coloured regions in the field of view of a potential moving observer. This system has been developed and used in the context of the EU-IST project ActIPret, where the goal was to develop a cognitive vision system able to automatically interpret the activities of people handling tools. Moreover, the same tracking algorithms have been used to develop a stand-alone human-computer interaction system that allows a human to control an MS-Windows computer through hand gestures.
- A **camera tracking system** that performs on-line estimation of 3D camera position and pose in parallel with 3D scene reconstruction.
- **SBA**, a generic sparse bundle adjustment software package. SBA is a generic sparse bundle adjustment C/C++ software package that is publicly available. Bundle adjustment amounts to a large-scale minimisation problem that is almost invariably solved as the last step of every feature-based structure and motion estimation computer vision algorithm to obtain optimal 3D structure and viewing parameter estimates. SBA implements a numerical optimisation algorithm which exploits the

problem's sparse structure to gain considerable computational benefits. The software can be invaluable to researchers working in fields such as computer vision, robotics, image-based graphics, photogrammetry, and surveying, and is the first and, to date, the only such software package to be offered free of charge.

- **SIMUUN**, a simulation environment for undulatory locomotion studies in robotics and biology. SIMUUN is a user-friendly simulation environment based on the Matlab/Simulink software suite. It has been developed, and is being used, in the context of the EU IST projects BIOLOCH and VECTOR, which are related to the study and implementation of novel biomimetic robotic locomotors as tools for medical robotics (in particular, for locomotion in the tortuous environment of the human gastrointestinal tract).
- **DRIVER**, a robotic wheelchair for people with disabilities, possessing semi-autonomous navigational capabilities. DRIVER can perform collision avoidance, autonomous navigation in corridor environments, and follow a person at a fixed distance. DRIVER has an advanced multimedia man-machine interface that facilitates the control of the overall system. DRIVER also obeys voice commands, provided that the execution of such commands does not pose a threat to the user.

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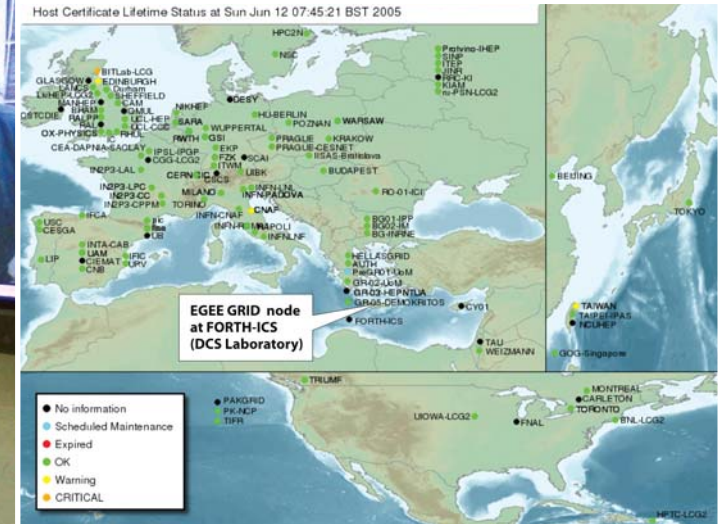


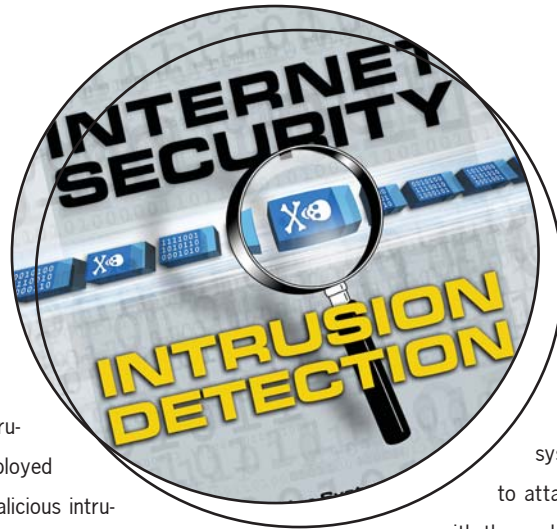
Distributed Computing Systems

DCS

THINK BIG: PLANET-WIDE DISTRIBUTED SYSTEMS

The Distributed Computing Systems Laboratory (DCS), founded in 2005 as a spin-off lab of the Advanced Computing Systems Activity of FORTH's CARV Laboratory, carries out cutting-edge research and development work in the broader area of planet-wide **Distributed Computing Systems**, with a particular focus on **Internet Epidemics**, **Internet Safety**, **Internet Monitoring**, **peer-to-peer systems**, and **GRID computing**.





INTRUSION DETECTION

With the widespread use of the Internet, computer systems are becoming increasingly vulnerable to attacks. To address this problem, intrusion detection systems are being deployed at network boundaries, to prevent malicious intrusions and provide timely alerts regarding possible attacks. Intrusion detection systems examine traffic for a very large number of potential threats, using a variety of techniques. Given the ongoing arms race between attackers and the security community, it is important to stay ahead of the attackers through better detection techniques and methodologies. DCS currently focuses on the design of detection components against highly stealthy polymorphic and metamorphic attacks that state-of-the-art technology cannot currently deal with.

AUTOMATED DETECTION OF LARGE-SCALE ATTACKS

Over the last few years, the Internet has been repeatedly used as a medium to launch large-scale attacks against computer and communication services, including critical infrastructures. Such attacks may not only affect a large number of computers, but could also paralyse critical systems beyond the Internet, including electrical, transportation, water, and financial infrastructures. Traditional manual defences against these cyberattacks are likely to be ineffective, as a large-scale attack can propagate extreme-

ly fast, affecting tens of thousands of computers within minutes. DCS research in this area deals not only with the design of automated, cooperative defence systems that can detect and respond to attacks in a timely manner, but also

with the analysis of new threats before they materialise. Current focus is on the challenges of designing and operating large-scale honeypot infrastructures, with emphasis on pressing issues, such as the risk of attackers blinding the defence system through blacklisting or denial-of-service attacks.

PEER-TO-PEER SYSTEMS

Over the last 6 years, peer-to-peer systems, a new distributed computing paradigm, has captivated most users on the Internet. Starting with file sharing systems such as the well publicised and highly debatable Napster, and continuing with Internet Telephony systems such as the omnipresent Skype, peer-to-peer systems currently dominate all traffic on the Internet. In contrast to the traditional client-server model, peer-to-peer systems do not distinguish between clients and servers: all participating nodes have the capability to act both as servers and as clients at the same time. Within this framework, the main research issue addressed by DCS is how to scale peer-to-peer networks to several millions of nodes while, at the same time, keeping the network robust and coordination costs at tolerable levels. DCS research in this

area also includes designing, implementing, and deploying large-scale peer-to-peer networks for the preservation of online published materials; overlay networks that support anonymous communication over the Internet; perspective-access networks that enable users to view the Internet and access resources from multiple vantage points; and overlay networks that support stream-processing applications.



DCS

SECURITY POLICY

Computing and communication systems are increasingly penetrating every aspect of our lives, becoming more and more critical for the smooth operation of government, business, and private endeavours. As these computing systems become increasingly complex, involving mobile appliances, wired and wireless networks, data repositories, and large grids of computer nodes, their management becomes more challenging. To avoid configuration and control failures for this critical infrastructure, it is necessary for the administrators of such environments to specify, edit, and maintain stringent security policies. DCS conducts research in the areas of security policies for large distributed systems, and has gained a wealth of experience on security management of P2P, GRID, and Internet-wide systems.



SECURITY EDUCATION AND AWARENESS

The ubiquitous presence of networked computing devices in all facets of life has tremendously impacted every aspect of our modern society. Although we view devices such as PDAs, mobile phones, and personal computers, as essential tools for achieving our daily tasks, we are often oblivious to the potential security risks involved in their operation. The possibility of accidental misuse by inexperienced users, or the deliberate exploitation by malicious attackers, has become far too great to be lightly regarded anymore. Confronting such hazards can only be achieved by proper end-user education on the security risks involved in modern computing networks and systems. Capitalising on its experience, DCS actively promotes the raising of awareness in these newly evolving security threats. Indeed, through its instrumental involvement in SAFELINE, the first Greek hotline in the fight against cybercrime, DCS contributes to the Internet safety education of students and parents in the Greek society. In addition, by using its participation in the Permanent Stakeholders Group (PSG) of the European Network and Information Security Agency (ENISA), DCS contributes to the promotion of Internet security awareness at a European Level.

NETWORK MEASUREMENT

Measuring Internet performance and understanding network behaviour continues to be a major challenge. DCS is involved in architecting distributed passive monitoring systems, and building the necessary tools and interfaces to enable operators, users, and applications to be more aware of network characteristics. Our current focus is on MAPI, a programming interface that aims to provide flexibility, ease of use and high-performance in instrumenting networks, and on tools for bandwidth measurement without additional infrastructure support.

DEVICE INDEPENDENCE ACCESS FOR THE WORLD WIDE WEB

Over the last few years, we have been witnessing a proliferation in the use of lightweight devices, such as laptop computers, palmtops, PDAs, and mobile phones. These devices have a wide variety of capabilities, ranging from low-resolution black-and-white screened mobile phones to high-resolution 14-inch screen laptops, and from GPRS-connected mobile phones to 54 Mbps WLAN-connected PDAs. Interestingly enough, we are seeing an increasing demand by most of these devices to access the World Wide Web and to request multimedia content, including pictures, sounds, and streaming video. To efficiently deliver content to all these widely varying devices, DCS conducts research and development in the area of device independent access with an emphasis on delivering images and streaming video to mobile phones and PDAs.

DCS

GRID COMPUTING

As user applications demand an ever-increasing amount of processing power, 24 hours a day, 7 days a week, individual computing sites frequently find their resources inadequate to respond to the growing demand of their users. In this ever-demanding and ever-changing world, GRID Computing can provide a dependable, flexible and seemingly infinite source of computing power. Having recognised the opportunity provided by GRID computing, the Distributed Computing Systems Lab, through the participation in the HellasGRID cluster computing system, participates in the largest European GRID infrastructure ever built: the EGEE Infrastructure. DCS is responsible for the uninterrupted operating of a 128-node cluster in Crete as well as for the monitoring of the clusters in the whole South-East European Region.



be used by concerned citizens to anonymously report material on the Internet that appears to be illegal. SafeLine, in turn, processes each report and forwards it to legal authorities, if appropriate, for further processing. DCS currently hosts and provides daily support for Safeline, historically the first, and currently the only, such hotline in Greece.



PROJECT PARTICIPATION

The Distributed Computing Systems Laboratory currently participates in several Research Projects funded by the European Commission (LOBSTER, NoAH, Safeline2, EGEE, CoreGRID), and by the General Secretariat for Research and Technology (ESTIA, EAR, SecSPeer).

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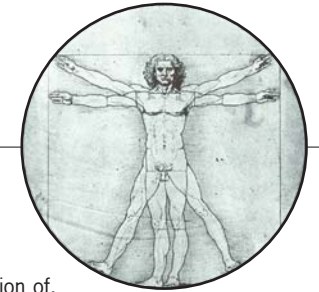
SAFER INTERNET ACCESS

As network technology becomes more user-friendly and accessible to all age groups, it is natural for parents to be concerned about the safety of their children while surfing the Internet. To facilitate safer Internet access for children in Greece, FORTH was among the founding members of SafeLine (www.safeline.gr), the first Greek hotline for reporting of illegal content on the Internet. SafeLine's recent focus has been the reporting of child pornography, but the broader scope of the hotline includes racism, online gambling, as well as data and consumer protection. SafeLine can





Human-Computer Interaction



The Human Computer Interaction Laboratory of FORTH-ICS (<http://www.ics.forth.gr/hci/>), established in 1989, is an internationally recognised centre of excellence, with accumulated experience in user interface software technologies, design methodologies, and software tools. The Laboratory carries out leading research activities focused on developing user interfaces for interactive applications and services that are accessible, usable, and ultimately acceptable for all users in the Information Society, while, at the same time, providing an appropriate framework and tools for reducing development time and cost. The research activities of the Laboratory, rooted in the principles of Universal Access and Design for All, address the development of interactive applications and services for various platforms, such as personal computers, handheld computers, mobile phones, smart appliances, and other computational devices distributed in the environment. Research results include infrastructures, methods, prototypes, architectures, tools, and programming languages, as well as methodologies for maintenance, reuse, modification and extension of the developed systems. Systematic testing, evaluation, validation and integration of the above results are achieved in practice through the development of advanced applications and services, such as mobile information systems, ambient intelligence environments, accessible web portals, entertainment applications (e.g., games), and educational software (e.g., eBooks).

e-ACCESSIBILITY, DESIGN FOR ALL AND UNIVERSAL ACCESS

The overall goal of this research direction is to contribute support, and facilitation of, the adoption and application of the principles of Design for All and Universal Access in the context of the Information Society. In this context, research activities are targeted to establishing the necessary knowledge, instruments and building blocks towards ensuring that interactive applications and services are developed by taking into account the needs and requirements of all target user groups, in potentially any context of use. Such activities include:

- Development and evolution of methodologies, techniques and tools supporting the application of Design for All in Human-Computer Interaction:
 - development of user interfaces that exhibit intelligent runtime adaptation to the characteristics of individual users and contexts of use
 - modelling of user characteristics and requirements
 - usability evaluation for diverse user categories
 - case studies applying the above
- Design and development of special-purpose interaction techniques, supported through user interface development toolkits, for specific target user groups, such as non visual interaction for blind users, and scanning based interaction for users with hand-motor impairments.
- Development of universally accessible applications and services in a variety of application domains which are of particular importance for e-Inclusion, such as e-learning, training, employment and working.

INFORMATION SOCIETY FOR ALL

HCI

INCLUSIVE ONLINE COMMUNITIES

Activities in this domain concern the provision of universally accessible and usable online communities, and aim in particular to:

- Produce novel tools and services for promoting online communication and collaboration (web portals, digital libraries, eServices, etc.)
- Identify user needs and requirements for accessing inclusive online communities and web-based services, both with and without the use of assistive technologies
- Develop methods, platforms and tools for supporting the accessibility of online communities to users with diverse needs, abilities and requirements
- Design novel visualisation and navigation techniques, intuitive metaphors and user-empowering concepts for online communities and web-based services
- Investigate methods and instruments targeted towards assessing the inclusiveness of online communities and related tools

AMBIENT INTERACTIONS, UBIQUITOUS COMPUTING AND PERSVASIVE MULTIMEDIA

The main goal of research in this domain is to support user interaction in ambient intelligence environments through the provision of seamless, high-quality, unobtrusive, and fault-tolerant interaction. In this context, the Laboratory develops software develop-

ment frameworks for implementing future mobile or stationary distributed ambient interactive systems, enabling users to exploit available computing resources (e.g., video displays, speakers, remote processors, sensors) and to combine them in order to enhance functionality (e.g., use both a display and a speaker to have a videoconference).

SOCIAL INTERACTION IN INTELLIGENT GAME WORLDS

Activities in this domain target the construction of development tools, such as software game engines, software libraries, and game editors, to support the development of interaction-rich computer games and worlds which are populated by autonomous characters employing game-oriented artificial life techniques. The main goal of such computer games is to support social interaction and collaboration, as opposed to the vast majority of current computer games that are primarily solitary in nature. Furthermore, the target user group goes beyond the typical "male between 12 and 35 years old" of traditional computer games to embrace people of both genders, and of varying age ranges.

INCLUSIVE GAME-BASED LEARNING

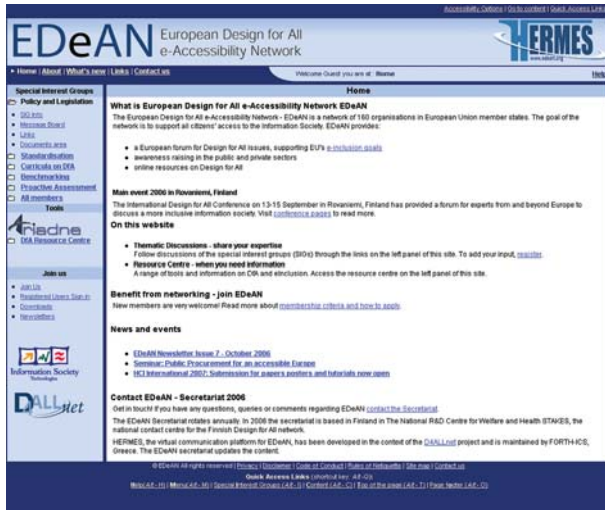
Following the principles of Universal Access and Design for All, this research direction pursues the fusion of inclusive interaction, e-Learning and e-Entertainment, through the development of software applications that:

- Effectively marry learning and fun
- Optimally fit and adapt to different individual user characteristics without the need of further adjustments or developments
- Support concurrent use among people with different abilities
- Support multiple platforms and contexts of use, using a variety of peripheral devices

The underlying vision is that through inclusive game-based learning, people will be better motivated and supported in learning activities, while learning and having fun simultaneously, as well as interacting easily and effectively, irrespective of individual requirements, skills and preferences.

Centre for Universal Access & Assistive Technologies (CUA&AT)

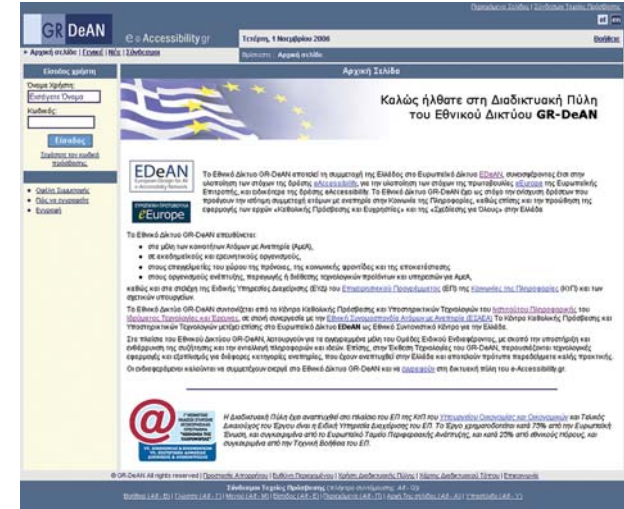
The HCI Laboratory of FORTH-ICS hosts and operates the Centre for Universal Access and Assistive Technologies (CUA - AT, <http://www.ics.forth.gr/hci/cuaat>). The main objective of the Centre is to support the equal participation and socio-economic integration of people with disabilities in the Information Society, by designing products and services accessible and usable by the widest possible end-user population. The activities of the Centre include studies on e-Inclusion, as well as on industrial design practices, user assessment, accessibility guidelines and policy interventions at national and European level.



The Centre is actively engaged in technology development and applications in a variety of domains, including access to the World Wide Web, text processing, electronic books, interpersonal communications, special education and vocational training, Telecommunications, Health Telematics and wearable computing. Additionally, the Centre offers services, consulting, and technical developments, to user organisations, industry agencies, government agencies and non-market institutions. Moreover, the Centre is actively involved in the eEurope/eAccessibility Initiative of the EC, and in the establishment of national measures to implement the recommendations of these initiatives by member states.

The Centre also contributes to international **web accessibility** activities (e.g., W3C-WAI), as well as to international **standardisation activities** to promote accessibility and usability.

The Centre for Universal Access and Assistive Technologies is the co-ordinator of GR-DeAN, the Greek Design for All eAccessibility Network (<http://www.e-accessibility.gr/>) operating as the National Contact Centre in the context of EDeAN, the European Design for All eAccessibility Network (<http://www.eac-accessibility.org>). The GR-DeAN Network aims to promote in Greece the application of the "Universal Access and Usability" and "Design for All" principles, and to support activities towards the equal participation of individuals with disabilities in the Information Society.



CUA&AT

Networking, Outreach and Impact

Over the years, the Laboratory and the Centre have undertaken leadership in a broad range of international networking activities in the fields of Universal Access and Design for All. Examples include:

- The coordination of the ERCIM Working Group "User Interfaces for All" (1995-2006, <http://ui4all.gr/>). The ERCIM Working Group "User Interfaces for All" was the recipient of the ERCIM WG Award for the year 2000.
- The coordination of the International Scientific Forum "Towards an Information Society for All" 1997-2000 (http://ui4all.gr/isf_is4all/)
- The coordination of the EC-funded Thematic Network - Working Group "Information Society for All" 2000-2003, IST-1999-14101 IS4ALL (<http://is4all.ics.forth.gr/>)
- The coordination of the EC-funded Network of Excellence D4ALLnet 2003 - 2005, IST-2001- 38833 (<http://www.d4allnet.gr>)
- The annually rotating Secretariat of EDeAN during 2005. At the end of this period, EDeAN published a White Paper outlining a roadmap for future European initiatives in Design for All, e-Accessibility and e-Inclusion.
- The coordination of the ERCIM Working Group SESAMI "Smart Environments and Systems for Ambient Intelligence", founded in 2006. (<http://www.ics.forth.gr/sesami/>)

Results of R&D work appear in more than 300 publications in leading archival journals, proceedings of international conferences and workshops, tutorials during international conferences, international encyclopaedias and books.

(<http://www.ics.forth.gr/proj/athci/publications.jsp>)

Research results are disseminated through a range of channels:

- Establishment, in 2001, of the Springer international journal "Universal Access in the Information Society". The journal solicits original research contributions addressing the accessibility, usability, and, ultimately, the acceptability of Information Society Technologies by anyone, anywhere, at anytime, and through any media and device. (<http://www.springeronline.com/journal/10209/about>)
- Establishment of the International Conference on Universal Access in Human-Computer Interaction (UAHCI). The UAHCI conference aims at providing an international forum for the exchange and dissemination of scientific information on theoretical, methodological and empirical research that addresses all issues related to the attainment of universal access in the development of interactive software. Since HCI International 2001, held in New Orleans, USA, UAHCI has been an affiliated conference of the series. FORTH-ICS hosted HCI International 2003 in Crete, Greece. HCI International 2005, held in Las Vegas, USA, was one of the biggest conferences ever organised in the fields related to HCI and Information Society Technologies. HCI International 2007 takes place in Beijing, P.R. China, 22-27 July 2007. (<http://www.hcii2007.org/>)

Prof. Stephanidis, Head of the HCI Laboratory and of the Centre for Universal Access and Assistive Technologies, Editor in-chief of the Springer UAIS journal, is also the Editor of the important books:

- User Interfaces for All - Concepts, Methods, and Tools. Mahwah, NJ: Lawrence Erlbaum Associates (ISBN 0-8058-2967-9, 760 pages), 2001.
- Universal Access Code of Practice in Health Telematics., Lecture Notes in Computer Science, Vol. 3041. Springer (ISBN: 3-540-26167-2, 317 pages), 2005.
- The Universal Access Handbook. Mahwah, NJ: Lawrence Erlbaum Associates, (forthcoming, 2007).

HCI2007
International

*12th International
Conference
on Human-Computer
Interaction*



Developed Systems and Tools

The HCI Laboratory designs and develops software for a large variety of technological platforms, such as personal computers, VR systems, hand-held computers (PDAs), mobile phones, home and portable electronic devices. Recent achievements include:

E-ACCESSIBILITY, DESIGN FOR ALL & UNIVERSAL ACCESS

Onyx (2004): a Web browser with off-screen non-visual display transformation and delivery.

MENTOR (2004): a tool for process-oriented support of Unified User Interface Design, providing facilities for the consistency verification of the designed adaptation logic.

PALIO (2003): a system that supports the provision of web-based services exhibiting automatic adaptation behaviour based on user and context characteristics, as well as the user's current location.

DMSL (2003): a decision making specification language for runtime user interface adaptation, with a compiler and a run-time system.

IS4ALL training course (2003): a personalisable on-line course about design approaches and methods that can be used to address the challenges of universal access in the context of Health Telematics. (<http://is4all-tc.ics.forth.gr>)

Fast Scanner (2001): a tool based on Microsoft Active Accessibility, providing accessible interaction with interactive applications through the automatic "on-the-fly" activation of hierarchical scanning facilities.

Hawk (2000): a non-visual interface development toolkit that enables the programming of genuine non-visual interfaces embodying non-visual interaction metaphors.

FORTH Editor (2000): a text processor designed for users with motor impairment of upper limbs, and users with learning or cognitive difficulties.

I-GET (2000): a User Interface Management System with a new programming language supporting the development of unified user interfaces. I-GET provides multi-toolkit programming, agents, and declarative control.

Unified User Interface Software architecture (1998): a novel architectural framework facilitating the development of interfaces that exhibit automatic adaptation behaviour, and best fit dynamic interface assembly.

Unified User Interface Design Method (1998): a design method that facilitates the design of interfaces that exhibit automatic adaptation behaviour based on user and context related diversity factors.

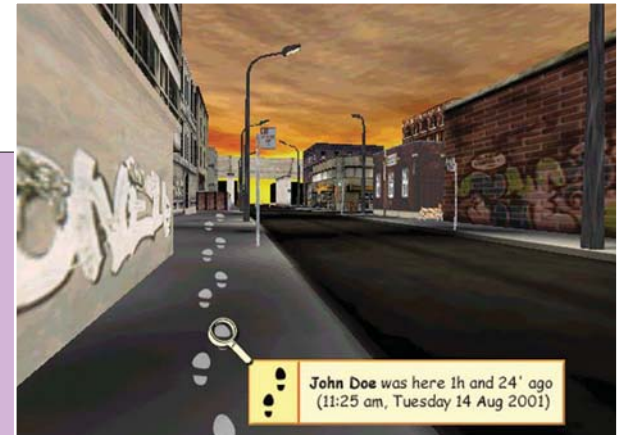
AVANTI browser (1998): a universally accessible web browser with a unified user interface.

SOCIAL INTERACTION IN INTELLIGENT GAME WORLDS

DELTA (2005): a Dynamic Embeddable Language for Extending Applications, employed for behaviour scripting of artificial characters and game logic programming.

SENSAI (2004): (generic AI sensory system module) an open, extensible, modular approach for simulating a generic sensory system for creating intelligent creatures for computer games.

Ambient BreakOut (2003): the "traditional" breakout game implemented with fully distributed wireless wearable dynamic I/O.



UnderGO (2003): a software game engine for animated 2D worlds, supporting fast action and tile-based multilayered terrains.

Virtual Prints (ViPs) (2003): a novel, intuitive, interaction concept for supporting navigation, orientation, way-finding, as well as a number of additional functions in Virtual Environments.

I-doVE (2003): a digital library of design guidelines for the domain of virtual environment applications. (<http://i-dove.ics.forth.gr>)

Animatic (2002): a real-time 3D file manager, and animated windows events with heuristic particle systems.

AMBIENT INTERACTIONS, UBIQUITOUS COMPUTING AND PERVASIVE MULTIMEDIA

Voyager (2004): a User Interface (UI) development framework, delivered as a C++ toolkit, for developing wireless dynamically composed wearable interfaces.

Explorer (2004): a location-aware hand-held multimedia guide for museums and archaeological sites.

Projector (2004): a C++ proxy-toolkit for Java Foundation Classes with split cross-platform execution.

Alternative interaction techniques in UA-CHESS



INCLUSIVE ONLINE COMMUNITIES

WebLecton (2006): a tool for audio browsing and navigation of web content through its transformation in various audio formats (mp3, waw, etc). The tool supports the off-line reproduction of web content for blind users, but also for users on the move.

ORIENT (2006): an assessment tool for the expert-based evaluation, evaluating eServices along various dimensions, including accessibility and acceptability in the long-run.

WebFace accessibility engine (2003): tool for the dynamic transformation of web pages into personalisable and accessible versions.

HERMES (2003): a fully accessible web-based platform to enable systematic cooperation amongst members of the European Design for All e-Accessibility Network (EDeAN) and other thematic networks, stakeholders and actors in the field (www.edean.org).

SEN-IST-NET Web Portal (2002): a portal providing information on Information Society Technologies (IST) for Special Educational Needs (SEN), including a Virtual Library, an extensive Resource Guide and a Case Study section with examples of innovative use of ICT. (www.senist.net)

INCLUSIVE GAME-BASED LEARNING

Starlight (2006): a software platform for developing electronic educational textbooks which are accessible by blind people and people with deteriorated vision. Starlight comprises two components: Starlight Reader, used by end-users for reading and interacting with the electronic textbooks, and Starlight Writer, used

by authors and content creators for developing electronic textbooks. Starlight has been used for developing eight software products for the Greek Primary and High school.

UA-Chess (2004): a universally accessible multi-modal chess game, which can be played between two players, including people with disabilities (low-vision, blind and hand-motor impaired), either locally on the same computer, or remotely over the Internet (www.ics.forth.gr/uachess). UA-Chess is worldwide the first, and currently, the only game that exhibits the above unique characteristics, and was a finalist for the European Design for All Awards 2004, constituting a practical demonstration of the application of Design for All principles, methods and tools in the development of software applications.

Access Invaders (2005): a fully accessible version of the popular classic "Space Invaders" action game.

King Pong (2005): a fully accessible remake of the classic "Pong" game supporting spatially localised audio, force feedback and advanced graphical effects.

Digital Books (2001): a non-visual digital library of digitised audio books.

HCI



The European DFA Award to UA-CHESS (2004)

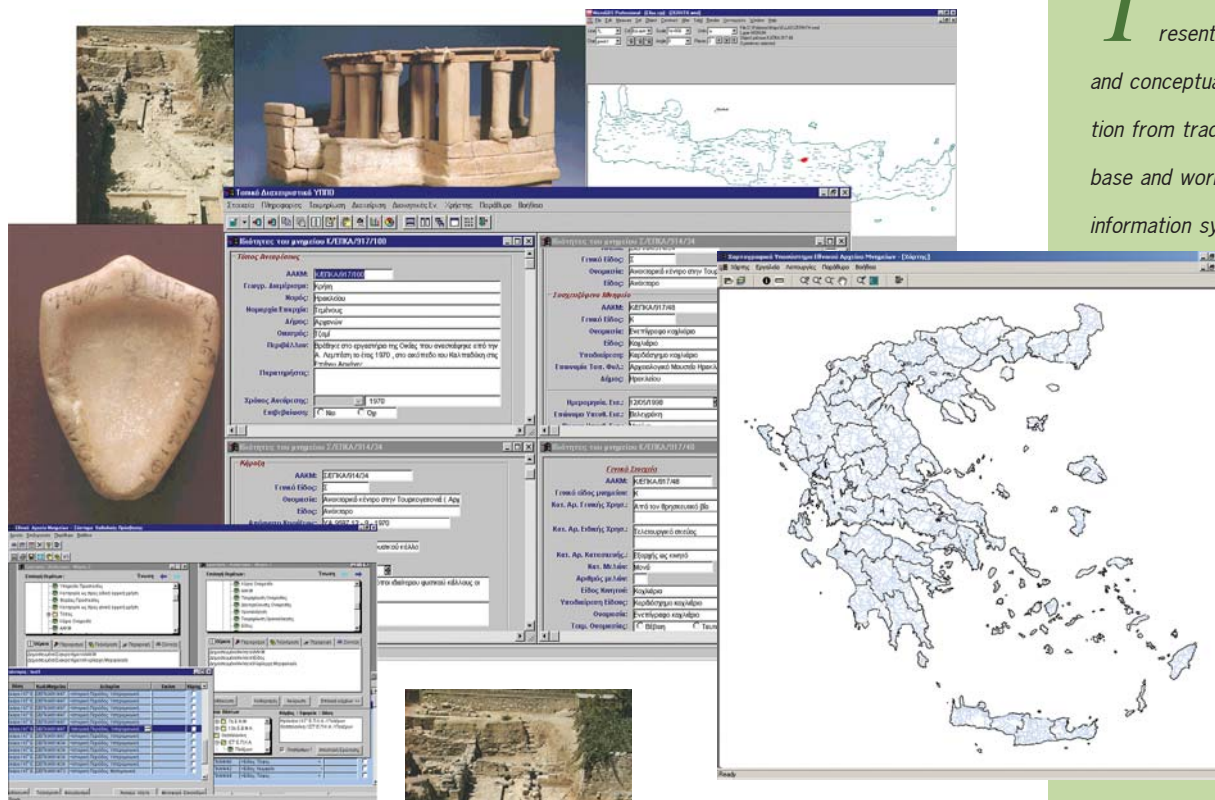
Contact Person: Prof. Constantine Stephanidis
 Head of HCI Laboratory
cs@ics.forth.gr
<http://www.ics.forth.gr/hci>
<http://www.ics.forth.gr/hci/cuaat.html>

ISL

Information Systems

The Information Systems Laboratory (ISL) combines expertise in knowledge representation and reasoning, database systems, net-centric information systems, and conceptual modelling. Its principal research challenge is to succeed in the transition from traditional information systems, such as information retrieval systems, database and workflow management systems, to semantically rich, large-scale, adaptive information systems. Such systems are characterised by large-scale semantic inter-operation, massive distribution, and high level autonomy and self-adaptation.

Besides conducting theoretical work on the above issues, ISL carries out applied research in a number of application domains, including cultural informatics, biomedical informatics, e-learning, e-commerce and IT security. Work in these domains has a strong interdisciplinary character, since it includes the aspect of understanding and modelling the respective domain through an appropriate conceptualisation. Overall, ISL aims to provide enabling technologies for the emergence of the information society and the knowledge economy.



ΠΟΛΕΜΩΝ

POLEMON: NATIONAL MONUMENTS RECORD SYSTEM

Research Activities

The research activities of ISL are structured around four main themes:

(i) KNOWLEDGE REPRESENTATION AND REASONING

Most corporate and scientific worlds are by no means simple, and the corresponding knowledge that must be represented and managed is complex and dynamic in nature. Not only are adequate representation formalisms required, but also elaborate reasoning techniques for producing additional knowledge. ISL has been pursuing, and plans to continue pursuing, basic research in knowledge representation and reasoning. Particular objectives are to: (a) Develop rule-based reasoning languages and systems for the semantic web; (b) Integrate methods from nonmonotonic reasoning with semantic web languages (RDF/S and/or OWL); (c) Study the revision of description logic-based knowledge bases, and apply the results and techniques to ontology revision and the integration of inconsistent ontologies; and (d) Apply the above methods to e-Commerce, pervasive computing, and IT security.

(ii) WEB DATA AND KNOWLEDGE INTEGRATION AND ADAPTATION

The expansion of the Internet, and in particular of the Web, enables accessing a huge number of autonomous information sources managed by heterogeneous systems. Although a large quantity of useful information is made available, users are not properly supported in effectively gathering data relevant to

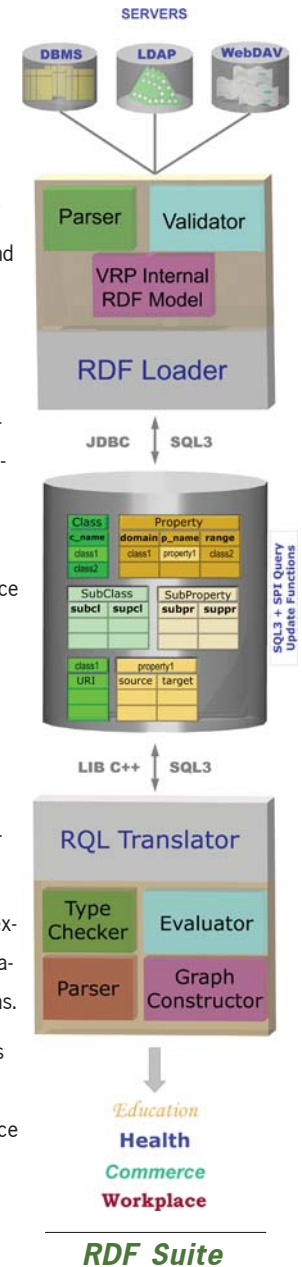
achieve their aims. As a consequence, data and knowledge integration has emerged as a vital requirement in many organisations (e.g., scientific, educational) striving to access useful information available both inside and outside their borders. ISL research and development activities in this area target advanced Semantic Web middleware technology (e.g., XML, RDF/S) enabling large-scale (semantic, structure and syntactic) information interoperability within or across Web communities on an as-needed basis, as well as efficient processing of information requests (i.e., queries).

(iii) SERVICE-ORIENTED COMPUTING

Service-oriented computing (SOC) is the new emerging cross-disciplinary paradigm for distributed computing that is changing the way software applications are designed, architected, delivered and consumed. Service-oriented computing is intended to facilitate business collaboration and application integration on a global scale. The expected impact of service-oriented computing is comparable to the impact that the Internet and the World-Wide Web (WWW) have had to the sharing of documents, information and knowledge. SOC introduces new commodities for production /consumption, namely services. Services are autonomous, platform-independent computational elements that can be described, formally specified, published, discovered, orchestrated and programmed using standard protocols for the purpose of developing massively distributed interoperable applications organised in the form of a network of collaborative applications functioning within or across organisation borders. The activities of the Information

Systems Laboratory in the domain of SOC target the following research and development activities:

- Formal description languages providing enriched service behaviour specification primitives (pre-/post-conditions, service invariants, quality of service) with the use of ontologies for complex services.
- Formal methods for complex service verification building on logic-based and/or state-machine formalisms.
- Semantically-enriched service discovery mechanisms employing semantic similarity measures for matching functional goals and non-functional requirements.
- Composition languages offering flexible, effective and verifiable integration of service-oriented applications.
- Service provisioning methodologies tailored to the distribution model (peer-to-peer and grid-aware service provisioning).



(iv) CULTURAL INFORMATICS

The discourse in cultural heritage is particularly rich, ranging from physical investigation methods (e.g. radiocarbon analysis) to analysis of historical sources to philosophical considerations, and arguments combining all those aspects. The cultural heritage domain provides a particular challenge for knowledge representation and the design of effective information systems supporting this discourse. Therefore, it provides both a rich application field of the research results of ISL and advanced research questions of its own, particularly in ontology engineering and discourse analysis. ISL addresses these challenges through a specialised unit, the Centre for Cultural Informatics (CCI), which is currently the most extensive facility of ISL in terms of manpower and external funding.

The Centre for Cultural Informatics pursues a comprehensive, cross-disciplinary approach to supporting the entire lifecycle of cultural information and documentation procedures for the benefit of preservation, study and promotion of cultural heritage. Special focus is put on semantic interoperability, information integration and integrated access, and the context for existing co-operations with cultural institutions and scientists from the humanities, that range from pure research to real application development (for more on Cultural Informatics see page 37).

OUTREACH

- During 2000-2006 members of the Laboratory published over 200 papers in international conferences and journals. Among them is the international standard textbook in the area of the Semantic Web: G. Antoniou & F. van Harmelen, A Semantic Web Primer, MIT Press 2004. The publications have had a high impact. For example, V. Christophides is 8th ranked Computer Science professor in Greece in a number of citations.
- Prof. Grigoris Antoniou was named ECCAI Fellow in 2006, joining the prestigious list of the best AI researchers in Europe.
- Members of ISL undertook the coordination of the ERCIM Working Group "Semantic Web".
- Best paper award for the 2003 International Semantic Web Conference "Viewing the Semantic Web through RVL Lenses", A. Magkanaraki, V. Tannen, V. Christophides and D. Plexousakis.
- SIGMOD 2004 Test of Time Award for SIGMOD 1994 paper "From Structured Documents to Novel Query Facilities", V. Christophides, S. Abiteboul, S. Cluet and M. Scholl.



ENABLING TECHNOLOGIES

- The Semantic Index System (SIS), a versatile, high performance tool for concept and semantic link management, especially suited for meta-modelling. SIS is offered as a product.
- The RDF Suite, including a parser supporting semantic validation, a database generator, and a declarative query language, all the first of their kind. This is a step towards the realisation of the Semantic Web. The RDF Suite is open source.
- The AZTEC platform supporting discrete services (typically of short duration, and without ability to respond to external asynchronous events) and session-oriented services (typically of longer duration, and typically with ability to respond to asynchronous events) for modern teleconferencing, real-time healthcare teleconsulting, collaborative e-commerce or scientific grid applications.

STANDARDS

ISL members provided conception and leadership of the development of the ISO 21127 (CIDOC Conceptual Reference Model) standard, a core ontology for semantic interoperability for museum, archive and library information, supported by the International Council of Museums (ICOM). They led the development of an ontology joining ISO 21127 with the corresponding model of the International Federation of Library Associations IFLA, the Functional Requirements for Bibliographic Records FRBR, supported by IFLA and ICOM.

PARTICIPATION IN RESEARCH NETWORKS

- **DELOS** Network of Excellence in Digital Libraries (<http://delos-noe.iei.pi.cnr.it>)
- **REVERSE** (IST 2004-2008) Reasoning on the Web with Rules and Semantics

PROJECT PARTICIPATION

ISL is engaged in a series of knowledge management projects, both in terms of the theory of knowledge representation and as a technology provider. Work in current projects includes:

- **Interactive System for Improving the Promotion of Touristic & Historical Aspects** (The Operational Programme "Competitiveness" 2003-2006) Interactive information system for managing and promoting the cultural heritage and natural environment of the Greek islands.
- **PROGNOCHIP** (The Operational Programme "Competitiveness" 2003-2006) Biomedical Informatics for the identification and validation of molecular markers for the classification and prognosis of breast cancer based on DNA Microarray Technology.
- **ACGT** (IST-IP 2006-2010) Advancing Clinico-Genomic Clinical Trials on Cancer: Open Grid Services for Improving Medical Knowledge Discovery
- **KP-Lab** (IST-IP 2006-2011) Knowledge-Practices Laboratory
- **CASPAR** (IST-IP 2006-2009) Cultural, Artistic and Scientific knowledge for Preservation, Access and Retrieval

EDUCATION AND TRAINING

The Laboratory and the Centre for Cultural Informatics have constantly provided substantial support to both the graduate and undergraduate programmes of the Department of Computer Science, University of Crete, through hosting Doctoral dissertations, M.Sc. theses and diploma theses, as well as training internships and laboratory exercises.

The Centre for Cultural Informatics has largely contributed to teaching and research supervision in the Inter-departmental M.Sc. programme in Information Systems for Cultural Heritage. Moreover, the Laboratory has hosted a quantity of doctoral research work diploma theses, and training internships of students from foreign universities (Germany, France, Sweden, Norway, The Netherlands, Great Britain).

Specialised seminar series on Cultural Informatics subjects have been developed, including information modelling, digitisation, encoding and exchange of information.

Seminars on architectural design systems are also offered on a regular basis.



APPLICATION SYSTEMS

- **SIS-TMS**, a multilingual thesaurus management system, developed through co-operation with the Getty Information Institute, USA, and the AQUARELLE European project. SIS-TMS is offered as product; 35 installations have been completed to date.
- **POLEMON, the National Monuments Record system**, approved by the Central Archaeological Council for application at all units and supervised organisations of the Ministry of Culture. POLEMON is already deployed at 21 locations.
- **Museums DMS** (Museums - Document Management System), a Web based information system developed to assist the handling of administrative and scientific information of Museum objects.
- **Dictionary Lemmas - DMS** (Dictionary Lemmas - Document Management System), a Web based information system developed to assist the creation, progress and maintenance of monolingual and bilingual dictionary lemmas.
- **CREBITEL**, a Conservation Restoration Bilingual Training Electronic handbook
- **Ubi-Erat-Lupa**, a knowledge base for the integration of complementary archaeological information sources based on CIDOC CRM
- The **Online Curriculum Portal** of the Computer Science Department of University of Crete (<http://sisyfos.csd.uoc.gr:1025/jetspeed/>)
- The **MAISTOR** building structural documentation system

Centre for Cultural Informatics

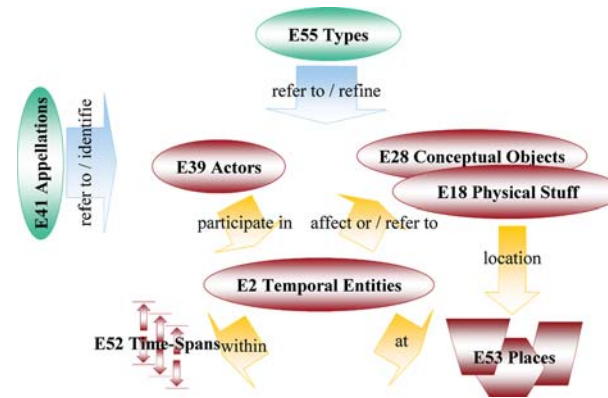
The Centre for Cultural Informatics (CCI) brings together skills in knowledge representation, ontology engineering, knowledge organisation systems, database technology and web technology with expertise in archaeology, museum documentation and management, site and monument management, art conservation, archives and libraries, thesaurus and dictionary management and other cultural disciplines.

The activities of the Centre unfold in three directions:

- Targeted research with focus on the formal representation of information structure and scientific discourse in the humanities, machine-supported communication and semantic interoperability.
- Community building for the promotion of standards, complementary skills and know-how in the creation, processing, integration and presentation of cultural information for the benefit of quality, accessibility and exploitation of digital cultural content.
- Targeted development of advanced information systems that provide a scientific challenge or a proof-of-concept in real settings and feedback to applied and pure research.



*CIDOC CRM Working Group
Paris - Bibliotheque National
de France*



Results of these activities include:

Semantic Interoperability: The CIDOC CRM is a core ontology which is intended to promote a shared understanding of cultural heritage information by providing a common and extensible semantic framework according to which any cultural heritage information can be mapped. It is intended to be a common language for domain experts and implementers to support integration of heterogeneous information sources and to serve as a guide for good practice of conceptual modelling. ISL took the initiative and continues leading its development, in the CIDOC CRM Special Interest Group, a working group of the Documentation Committee (CIDOC) of the International Council of Museums (ICOM). With the finalisation of ISO 21127 both the CIDOC CRM SIG and the CCI continue their work with the harmonisation of the CIDOC CRM with IFLA FRBR and other relevant models.

Monument and Museum Information Systems: systems for administrative and for thematic documentation, geographical information systems, structural documentation of buildings, field research documentation systems.

Source Material Management Systems: digitisation, classification, indexing, annotation and management of resources.

Models and Standards for Cultural Data: content standardisation.

Terminology Systems: design of cultural term thesauri, coordination of heterogeneous, multilingual thesauri.

CONSULTING AND CONTRACTING ACTIVITIES

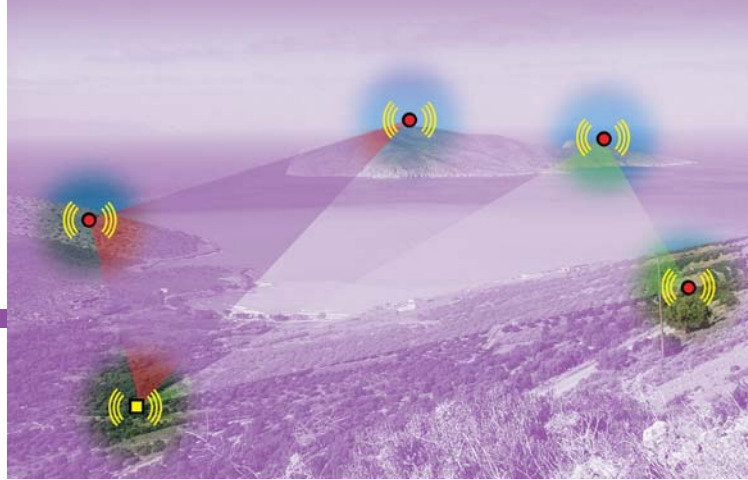
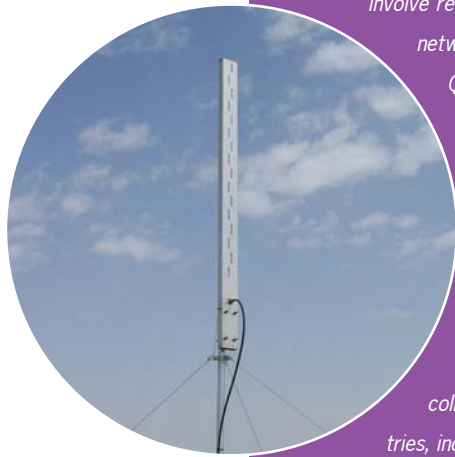
- Germanisches National museum - Nuremberg
- Deutsches Museum - Munich
- European Centre of Byzantine & Postbyzantine Monuments (EKBM) - Thessaloniki
- National Documentation Centre - Athens
- Institut für Museumskunde - Berlin

ISL

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Telecommunications and Networks

The Telecommunications and Networks Laboratory (TNL) of FORTH-ICS is actively involved in the areas of high-performance, wireless networking and mobile communications. In particular, research and development activities involve resource control and traffic engineering in wired and wireless networks, performance evaluation of networks with guaranteed Quality of Service (QoS), traffic measurement and analysis, voice processing, synthesis and compression, mobile positioning, and contactless smartcards. The Laboratory maintains a number of collaborative signal processing, sensor networks, fixed and wireless (based on IEEE 802.11) test beds for experimenting with new network technologies and protocols, and for performing measurement and analysis experiments of real network traffic. TNL collaborates closely with both national and international industries, including network manufacturers and telecommunication service providers, as well as with other research groups having interests in the above areas. Funding of this research has been provided by the European Commission, through ACTS (CASHMAN, MISA, REFORM, MONTAGE, ITHACI) and IST (M3I, SCAMPI) projects, by national programme funds (General Secretariat for Research and Technology - GSRT), and by industrial funded projects.



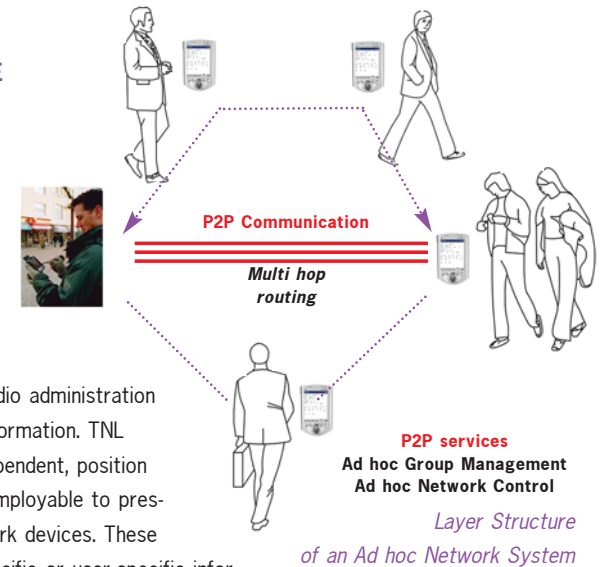
TELECOMMUNICATIONS & MOBILE COMMUNICATIONS



The central themes of this activity cover the broad area of wireless communications and communications security. In wireless communications the interest is focused on mobile communications, W-LAN technology and ad hoc networks. Areas of interest also include wireless and mobile positioning, software defined radio, packet switching and multimedia networking for mobile users, ad hoc and mobile networks security, elliptic curve cryptography, and mobile and electronic commerce applications.

WIRELESS AND MOBILE POSITIONING

Position location in wireless networks is a unique service with many capabilities and extensions. User position information enables a range of services such as emergency tracking, user surveillance and paging, security, radio administration and design, navigation and information. TNL develops novel, standard-independent, position location techniques directly employable to present and future wireless network devices. These techniques need no device-specific or user-specific information and operate in a user-transparent manner. The experimental position location techniques adapt dynamically to the environmental changes and self-adjust to the wireless medium conditions. Simulations have shown high accuracy position location, and developed prototypes are thoroughly studied under real world conditions, using the 802.11b infrastructure.



MOBILE COMMERCE APPLICATIONS

The market for mobile phones, handheld computers and wireless PDAs is increasingly being driven by multimedia-based Internet applications. New demands have arisen, concerning mobile commerce services such as the electronic purchase of tickets, goods, or audiovisual content. TNL develops M-commerce API packages for mobile phones in order to provide mobile commerce services, achieve widespread usage, and offer unique benefits in contrast with alternatives. The design of the corresponding APIs complies with secure hardware modules like SIM cards already existing in mobile phones, and with advanced future secure memory modules. The end-user perception and likely usage of these services are considered before revenue can be guaranteed. In other words, the potential revenue that multimedia and data services can bring to the industry depends on end-user perception of security and trust, that is, on whether users believe that the mobile phone can become a "digital wallet". M-commerce should thus be viewed in the context of the number of ways that end-users will be able to pay for goods and services. Research and development activities at TNL focus on developing secure mobile phone applications, establishing a framework for secure mobile transactions, and supporting a variety of applications and services.

BROADBAND & WIRELESS NETWORKING

This activity deals with the performance evaluation of wired and wireless networks through modelling, analysis, simulation, and prototype implementation on local test-beds.

Resource control and QoS in future wireless networks

Wireless technology:
resource constraints,
control variables that
affect resource usage

+

Economic modelling:
utility functions,
shadow prices,
economic efficiency

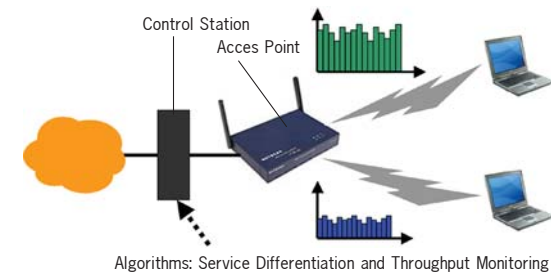
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Framework for efficient resource control in wireless networks

Next generation wireless networks will support real-time and multimedia packet-based services with varying requirements in terms of delay and data loss. Their unique properties will make the provision of end-to-end QoS a challenge that requires the adaptation and extension of existing solutions proposed for current generation wireless systems, and the development of new approaches. Next generation wireless networks will consist of multiple-hop networks of heterogeneous technologies, and may include fixed links. Moreover, multiple wireless LANs can co-exist in the same frequency band, requiring mechanisms to control the resulting interference and spectrum sharing. TNL develops novel models for efficient resource control in wireless third generation (3G) cellular networks and wireless LANs, which take into account not only the rate control and the power control procedures, but also other cross-layer interactions in such networks.

Congestion control and service differentiation in heterogeneous wired and wireless networks

The number of users accessing the Internet and enterprise intranets, through wireless links and IEEE 802.11 based wireless LANs (WLANs) in particular, is expected to grow dramatically with the proliferation of wireless hotspots, enterprise WLANs, and metropolitan wireless networks. Emerging multimedia services over wireless networks will have different bandwidth and delay require



ments and, compared to wired networks, the capacity of wireless networks is limited, since that capacity is determined by the available wireless spectrum. This creates a need for efficient and fair congestion control and service differentiation over heterogeneous networks that include both wired and wireless links.

TNL develops and evaluates procedures to address these issues for networks containing wired and wireless LANs based on the IEEE 802.11 standard, which involve monitoring the wireless network throughput and applying mechanisms for service differentiation.

These procedures are implemented and evaluated in a local IEEE 802.11 testbed, which consists of production and Linux-based access points.

SLA support and monitoring in next generation IP networks

In the area of Service Level Agreement (SLA) support in next generation networks, TNL evaluates the combined operation of QoS mechanisms, such as queueing, traffic policing, and traffic shaping, for supporting SLAs across a provider network. Furthermore, TNL investigates architectures and procedures for flexible management and monitoring of SLAs. Experiments are performed on a local testbed consisting of production (Cisco) and Linux based routers running advanced protocols such as IPv6, and over the Wide Area Network, through the available connection to the Greek Research and Technology Network (GRNET). FORTH-ICS through TNL also participates in the recently approved European COST (Cooperation in the field of Scientific and Technical Research) Activity on Traffic and QoS Management in Wireless Multimedia Networks (WiQoS).

DIGITAL SIGNAL PROCESSING

The Digital Signal Processing Activity focuses on the development of advanced algorithms and systems for multimedia content manipulation and delivery over broadband wireless networks. Research topics of interest include time series analysis, image, speech, audio and video compression, smart antennas, and statistical communication theory. The unifying theme of this activity is the application of statistical theory to characterise the operational environment and to investigate, develop, integrate, and validate novel techniques for information processing and transmission. In particular, R&D activities focus on:

Multiresolution signal modelling, denoising, compression, watermarking, and content-based information retrieval

Research activities at TNL explore the statistical properties of linear time-frequency analysis methods, which include the short-time Fourier transform, wavelets and the discrete cosine transform (DCT). TNL work demonstrates that subband decompositions of actual signals have significantly non-Gaussian statistics that are best described by families of heavytailed distributions, such as the alpha-stable. Modelling information is used to design optimal processors that exploit the signal statistics by performing non-linear operations on the data. The adopted approach is unique in that it relates the optimal non-linearity to the degree of non-Gaussianity of the data. Such a methodology is applied to a wide range of problems, including medical and SAR image denoising and autofocusing, DCT data compression, blind watermark detection, and texture image retrieval.

Acquisition and rendering methods for immersive audio

Immersive audio systems have been making strides in such applications as telepresence, augmented and virtual reality, entertain-

ment, distance learning, and sound and picture editing for television and film. Studies are conducted on signal processing issues that pertain to the acquisition and subsequent rendering and transmission of 3D sound fields. On the acquisition side, advanced statistical methods have been developed for achieving acoustical arrays in audio applications, by addressing two major aspects of spatial filtering, namely localisation of a signal of interest and adaptation of the spatial response of an array of sensors so as to achieve steering in a given direction. On the rendering side, 3D audio signal processing methods have been developed that generate virtual sources around the listener, using only two loudspeakers. Finally, on the delivery side, space-time codes have been elaborated for orthogonal frequency division multiplex (OFDM)-based quality scalable audio transmission systems.

Distributed signal acquisition and representation

Coherent processing issues for real wireless sensor network systems are investigated to enable their operation in a wide range of adverse environmental conditions. Beamforming methods have been developed to collect the power of the dominant sources while also providing high rejection of interference and noise; the objective is to design optimal maximum-likelihood (ML) methods and suboptimal, computationally efficient distributed techniques using sub-arrays yielding cross-bearing information, which will be employed to perform accurate source localisation. The ultimate goal is to allow the network to self organise and dynamically configure the needed sensor nodes to perform complex beamforming operations.

Collaborative detection, classification, and tracking

Research and development activities concentrate on self-organisation of heterogeneous sensors in unstructured and uncertain

environments, and the fusion of the information for intelligent learning and decision making. The key issue of concern is the fusion of sensor data when the relationships among the signals sensed by different sensors, the character of those signals and the environment in which they propagate are uncertain, variable, or simply unknown. TNL develops distributed pattern matching algorithms that are robust to these uncertainties, and that can learn from the observed data and then adapt based on what is learned.

Speech spectrum expansion

The quality of transmitted speech in most of today's telecommunication services is limited due to bandwidth restrictions. Typically, a small portion (4 kHz) of speech bandwidth is coded and transmitted. Statistical methods that estimate the lost spectrum from the transmitted speech are proposed and evaluated. The estimation problem is studied from an information-theoretic perspective and a speech-analysis perspective. In the absence of mutual information between the transmitted and the lost spectrum, collaborative (conditional) vector quantisation techniques are proposed that efficiently encode the lost spectrum, utilising information derived from the transmitted speech signal. Subjective tests indicate that very low bit rates (~ 134 bps) for encoding the high-band spectral envelopes are adequate for high-quality wideband speech reconstruction. The developed methods can be used as building blocks for high quality, hierarchical, multi-stream, wideband speech coding.

MOBILE COMPUTING

The Mobile Computing activity conducts research in the areas of mobile peer-to-peer computing, positioning, analysis, measurements and modelling on wireless networks, positioning, energy conservation, and anomaly detection and traffic sensing in wireless networks.

Wireless Measurement & Modelling

TNL performs extensive real-life wireless measurements, analysis, modelling, and design of well-founded capacity planning, load balancing, device adaptation, and location-sensing mechanisms. The modelling and analysis focus on:

- access patterns, e.g., client arrivals at 802.11 access points (APs), roaming behaviour, prediction of the next AP at which a client will be connected
- traffic load, e.g., information locality, periodicities, temporal dependencies
- traffic forecasting algorithms

TNL has created one of the largest archives of wireless traces, models, and tools. It employed state-of-art testbeds for monitoring large scale wireless networks and collecting extensive wireless traces (e.g. syslog, snmp, TCP flow, and signal strength based data). Such traces enable comparative analysis modelling and validation studies on different wireless networking environments. This repository is publicly available to the international networking community.

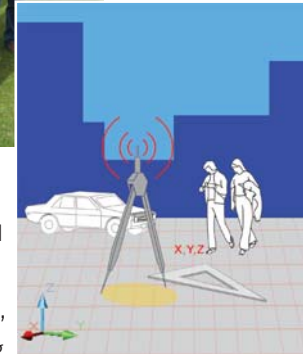


Mobile Peer-to-Peer Computing

To enhance data availability, TNL has proposed a novel mechanism that enables wireless devices to share resources. The focus is on three facets of cooperation, namely information sharing, network connection sharing and message forwarding. Peers communicate via a wireless LAN and may have (intermittent) connection to the Internet e.g., via a Bluetooth, modem or 802.11 AP. In the information sharing facet, peers query, discover and disseminate information. When the network connection sharing is enabled, the system allows a host to act as an application-based gateway and share its connection to the Internet. TNL designed, prototyped and evaluated an architecture and set of protocols that enables this resource sharing in a self-organising fashion without the need of an infrastructure.

Cooperative Location Sensing

Positioning is a critical component of the mobile computing research. TNL designed and evaluated the Cooperative Location-Sensing (CLS) system that adaptively positions wireless-enabled devices without the need of extensive infrastructure or training. CLS employs the peer-to-peer paradigm enabling hosts to cooperate and share positioning information. It allows the easy incorporation of external information (e.g., maps and spatial information, mobility patterns) to improve its accuracy.



TNL

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Ambient Intelligence

INTERACTING WITH AN INTELLIGENT ENVIRONMENT



Throughout their history, humans had to not only continuously adapt themselves to their surrounding environment, in order to survive, but also to make the best of it. Today, Ambient Intelligence (Aml) technologies have the potential to change this status quo through the creation of "intelligent" environments able to proactively adapt to humans, as well as to optimally serve their needs and goals.

Aml technologies integrate sensing capabilities, processing power, reasoning mechanisms, networking facilities, applications and services, digital content, and actuating capabilities distributed in the surrounding environment. While a wide variety of different technologies is involved, the goal of Aml technologies is to either entirely hide their presence from users or to smoothly integrate them within the surrounding context as enhanced environment artifacts rather than as technological gadgets. This way, the computing-oriented connotation of technology essentially fades out or disappears in the environment, providing seamless and unobtrusive interaction paradigms. Therefore, people and

their social situation, ranging from individuals to groups, and their corresponding environments (office buildings, homes, public spaces, etc) are at the centre of the design considerations.

Aml brings a special perspective to the ongoing research associated with technical fields like ubiquitous computing, pervasive and proactive computing, ambient computing, embedded computing, and smart objects. Aml has become well focused by putting people and social contexts at the centre, while at the same time targeting to distribute, embed, coordinate and interactively deliver computing intelligence within the surrounding environment. The notion of Aml, as described above, is becoming a de facto key dimension of the emerging Information Society, since many of the new generation industrial digital products and services are clearly shifted towards an overall intelligent computing environment.

From a technological point of view, Aml is a particularly complex, multifaceted and demanding scientific domain, requiring the presence and seamless integration of most of the key technologies existing today, thus posing numerous challenges in several research areas, and requiring large scale experimentation.

FORTH-ICS is in the process of creating a large-scale, state-of-the-art Ambient Intelligence Facility, unique of its kind, which will act as a research nexus for studying and developing, under a human-centred perspective, related technologies, and for assessing their impact on the individual, as well as on the society as a whole.

Starting with the creation of an intelligent home simulator, the Aml facility will be expanded to address specific indoor and outdoor environments, relevant application domains (e.g., housing,

work, health, security, education, transportation, and entertainment), as well as their related physical, social and cultural characteristics. Each thematic area will be equipped with basic Aml infrastructure components (e.g., sensors, actuators, screens, speakers, networks), as well as with special-purpose equipment required for the specific simulated environment, supported user activities and deployment scenarios (e.g., home electronics and healthcare equipment for the home).



The key thematic areas in the context of Aml Programme

Additionally, a control centre will be created, which will incorporate all the necessary equipment (e.g., servers and routers, chargers, video recorders) to effectively operate and monitor all the thematic areas. Thematic areas will act as inspiration drivers for envisioning realistic, meaningful and added value application scenarios for Aml technologies, as well as as test-beds for assessing and validating constituent Aml technologies in simulated real-life contexts.

The Aml Facility will also provide a showcase for demonstrating the potential added-value and benefits of Aml technologies in different aspects of everyday life and activities. In this direction, the Aml Facility will foster the vision of Ambient Intelligence, facilitate multidisciplinary international collaborations, and provide a focal point for technology transfer and dissemination of know-how to European industry, adding to its competitive advantage. It will also contribute to the European strategic priority towards "an Information Society that is inclusive, provides high quality public services and promotes quality of life", while also promoting synergies and knowledge diffusion in the context of relevant European research projects and actions.

The creation of this Facility builds on the scientific know-how and technical expertise of FORTH-ICS in a number of contributing critical domains such as Human-Computer Interaction, Universal Access, Artificial Intelligence, Semantic-based Knowledge Systems, Robotics, Computational Vision, Networks and Telecommunications, Information Security, Distributed Systems, Computer Architecture, Microelectronics, Sensors and Biomedical Informatics. All Laboratories of FORTH-ICS are actively engaged in this effort, and collaborations are promoted with other FORTH Institutes, as well as other organisations at national and international levels.

In the context of promoting research in the domain of Aml, FORTH-ICS has played a key role in the establishment of the new ERCIM Working Group "Smart Environments and Systems for Ambient Intelligence" (<http://www.ics.forth.gr/sesami/>). The ERCIM Working Group SESAMI aims to facilitate the continued collaboration of researchers and practitioners working on the design, implementation and evaluation of Ambient Intelligence systems and applications, on the grounds of on-going, and potentially cross-domain, basic and applied, research and development. In this context, SESAMI will pursue novel insights on designing, implementing, managing and maintaining smart computational environments of any scale, in order to effectively enhance and go beyond traditional support of human activities for any given situation, context, role, mission, and task.

The Aml Facility of FORTH-ICS will promote and support active collaboration and synergies among the members of this ERCIM Working Group, by offering a technological platform and an experimental testbed for research and development activities

Private/restricted environment simulation		Public environment simulation
Home, Intelligent Living room Extra equipment Home electronics, Robots, Electrical Devices, Healthcare Devices Related domains Healthcare, Security, Entertainment, Social interaction / Communication, Independent	Control Centre Servers Workstations Routers	Transportation, Intelligent Station Extra equipment Digital timetable, GPS, Card reader Related domains Mobility, Personalised Information delivery
Work, Intelligent Office Extra equipment Office equipment, Robotic Arms, Appliances Related domains Working, Collaboration, Communication	Main power supply Applications Connectors Chargers	Commerce, Intelligent Exhibition Extra equipment Digital glasses, head-mounted display, position and direction trackers, digital gloves Related domains Virtual and Augmented Reality
Education, Intelligent Classroom Extra equipment Classroom equipment, Tablet computers, Digital gloves, Digital glasses Related domains Education, Edutainment, Collaboration, Entertainment, Physical Exercise	Robot stations Video recorders Power switches	Leisure, Intelligent Playground Extra equipment Digital carpet, robotic pets, digital toys Related domains Entertainment, Edutainment, Safety
Basic Aml Infrastructure		
Sensors Handheld / wearable devices Actuators Projectors & projection screens	Special I/O devices Multi-channel surround audio Plasma/TFT screens Furniture	Wireless network Speakers Cameras Device LAN

Structural overview of the foreseen laboratory facilities for the Aml Programme

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infosec



Information Security

The Programme on Information Security (INFOSEC) at FORTH-ICS was established to address security issues in modern information systems, with regards to storing, processing, communicating, and sharing information. Security relates to technological aspects of information systems, as well as to social, economic, and legal issues. On the technology side, security spans a broad range of topics and requires expertise at all levels of computer and communication systems, networks, information management, and visualisation. For this reason, the Programme is multidisciplinary and brings together researchers from various ICS laboratories.

Broadly, the Programme's goals are:

- To conduct research in underlying technologies related to the security of networks, computer and communication systems, and information processing, and to demonstrate solutions to security problems in real-life applications.
- To be a centre of expertise towards establishing a high level of security in networks, systems, and information, and to train specialised personnel, both in the private and public sectors in dealing with security issues in these areas.
- To participate in standardisation activities in the field of security.
- To create and maintain a catalogue of best practices in the security of networks, systems and information.
- To contribute to the creation and promotion of appropriate policies, methods for risk analysis and management, and to support policy standardisation.
- To function as a consulting body for public and private institutions in the area of information security.



The main research issues addressed by the Programme are:

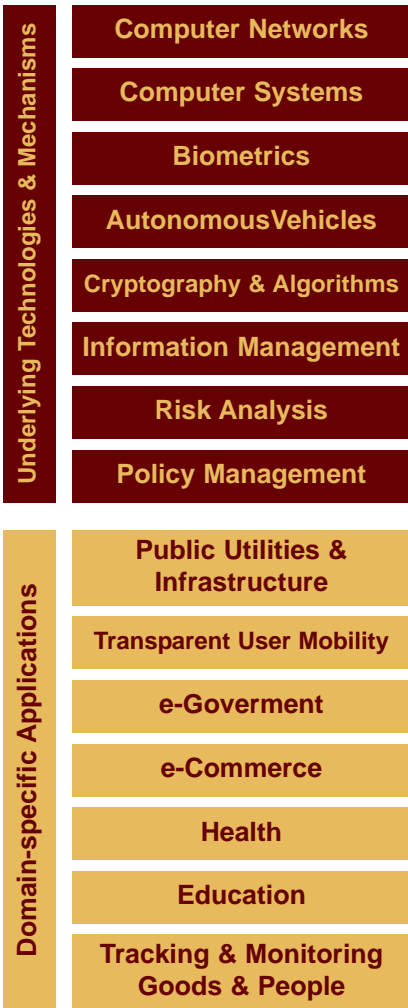
Network Security. Over the last few years, the Internet has been repeatedly used as a medium to launch attacks against computer and communication subsystems, or to cripple the capacity of the network itself. Such attacks, usually called cyber-attacks, may disable a large number of computers, which may in turn paralyse critical infrastructures including telecommunications, electricity and water supply, transportation, and commerce. To limit the spread of such attacks and to contain their impact after they are launched, INFOSEC conducts research in Intrusion Detection, Zero-Day Worm Detection, Denial-of-Service Attack Detection, and in architectures for mitigating the negative effects of security attacks. The underlying goal is to design and implement systems that can efficiently and accurately detect and forestall attacks (DCS, CARV).

Wireless and mobile networks present some unique challenges to security due to their broadcast nature. In this area

INFOSEC is conducting research on detection of attacks through monitoring of the wireless channel activity, protection against man-in-the-middle attacks, cryptographic key agreement methods, and contactless smartcards (TNL, CARV).

Computer systems security. Many aspects of today's computer architectures and systems have not been designed with security in mind. Thus, there is current rethinking how systems should be built and what architectural features will improve system and application security. In this context, INFOSEC is looking at: architectural and systems software support for security in the memory, processor, network, storage subsystems of modern systems; novel API and hardware/software interfaces; network flow isolation (per-flow queueing); digital system design for low electromagnetic emissions/interference; and hardware and software techniques for efficient cryptographic support (CARV, DCS).

Authentication of high volumes of data in nontrusted distributed environments. Current solutions are typically centralised, expensive and non-scalable. INFOSEC is developing a distributed system for authenticating data in non-trusted environments, at the network edge and outside the firewall. The Programme is currently experimenting with caching the authentication information over the network on inexpensive servers, as well as with other approaches. The system under development is expected to dramatically lower the cost of authentication in distributed storage, end-to-end integrity, tamper detection, electronic commerce exchanges, wireless authorisation, certificate revocation checking, and other such applications (ISL, BMI).



INFOSEC

Sensor networks and system miniaturisation. INFOSEC examines issues in building middleware for miniature systems with extreme resource limitations on power, CPU cycles, memory size, and network speed. This enables the deployment of net-

works of miniature devices and sensors in advanced application domains, such as monitoring and safety applications. The Programme is also designing intelligent sensor devices, based on experiences from building the middleware that controls them (CARV, TNL).

Autonomous robotic vehicles for monitoring. INFOSEC investigates how situation awareness in large-scale premises can be improved by deploying, under a common framework, autonomous robotic vehicles combined with large numbers of intelligent sensors. Autonomous robotic vehicles provide an automatic mechanism for tag locating and continuous tag mapping, as well as surveillance and specialised sensing capabilities during site patrolling, or in case of alarms. The Programme capitalises on cutting edge technologies it has developed for automated tracking, identification, mapping, and inventory control for assets and persons, as well as patrolling by autonomous mobile vehicles in large-scale premise (CVRL, CARV).

Cryptographic algorithms and digital signatures. Related topics include number theoretic and algebraic problems that underlie cryptographic algorithms; cryptographic key agreement methods; group authentication procedures; efficient cryptographic algorithms and protocols; classical and identity-based cryptographic schemes which are based on algebraic curves; and trust management schemes that provide high-level security services within dynamically varying network environments. (TNL, Institute of Applied and Computational Mathematics at FORTH).

Besides research, the Programme also **promotes public awareness and dissemination.** For instance, FORTH was instrumental in the establishment of the "SafeLine" hotline, which offers a direct and responsible point of contact in Greece for



FORTH-ICS organised CMS'2006 (<http://www.ics.forth.gr/cms06>), the 10th Conference in the "Communications and Multimedia Security" series. The series is a joint effort of the International Federation for Information Processing (IFIP) Technical Committees TC6 (Communication Systems) and TC11 (Security and Protection in Information Processing Systems).

The conference provides a forum for engineers and scientists in information security, and in 2006 particularly addressed network and information security issues. CMS'06 took place in Heraklion, Crete, 19 -21 October and was jointly organised by FORTH-ICS, A-SIT (Advanced Security & Identification Technology), and ENISA (European Network and Information Security Agency). Prof. Evangelos Markatos (FORTH-ICS) co-chaired the Technical Program with Dr. Herbert Leitold (A-SIT). Prof. Angelos Bilas (FORTH-ICS) chaired the Organising Committee.

users demanding the removal and criminal prosecution of illegal Internet content. SafeLine can be used to report material on the Internet which appears to be illegal or objectionable. The SafeLine personnel process each report and take the appropriate action by forwarding the report to legal authorities for further processing. Users' personal data is treated as strictly confidential, and users submitting reports may remain anonymous if they so wish. Users are also informed of the outcome of their reports (DCS).

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Department of Education and Training

The main purpose of the Department of Education and Training (DET) of FORTH-ICS is to provide training for human resources, in particular in the Region of Crete, in the area of Information Technology. DET offers training courses in a wide range of subjects, from introductory MS-Office applications to advanced programming techniques and cutting-edge technologies developed by ICS. Established in 1984, DET is an important source of information technology education, providing high quality training to more than 10.000 persons in the region of Crete. DET offers innovative and customised training to cover specific market needs, and uses advanced methods and practices. DET provides innovative and customised training to cover specific market needs, and uses advanced methods and practices in communicating information technology knowledge.

Activities include:

- **Specialised training for university graduates towards expanding their career opportunities:** The primary goal of DET is to provide specialised training and re-training to university graduates in cutting-edge technologies in order to enrich their career opportunities.

- **Training in Information Technology for high school graduates:** DET provides training to high-school graduates in order to strengthen their qualifications upon entering the work force.
- **Training human resources of organisations and companies:** DET provides customised training, on demand and upon request, to private companies and public organisations that wish to maximise the effectiveness of their personnel in Information Technology.
- **Certification and Testing:** Upon completion of any course, the students are provided with certificates of participation. DET also provides testing and certification facilities for ECDL (European Computer Driving License).
- **SUN Academic Education Centre:** DET is the first Academic Initiative Authorised Sun Education Centre (ASEC) in Europe, offering training courses for SUN Microsystems products. Upon completion of such courses, students are provided with certificates of participation and can apply for certification testing for Sun Certified Solaris Administrator and Sun Certified Java Programmer via the Prometric Testing Centre (on site).

Research programs: DET participates in research programs related to the latest developments in the areas of education and training, focusing on distance learning and health care information technology.

Facilities: DET has specially equipped facilities in Heraklion for seminar presentation, certification and examinations. DET's high-quality equipment provides the opportunity to demonstrate and use cutting-edge technologies in education (e.g., voice over IP, teleconferencing, distance learning, etc.).

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Department of Systems and Networks Administration

The mission of the Department of Systems and Networks Administration (DSNA) of FORTH-ICS is to provide support in information technology planning, to implement efficient technology infrastructures, to develop and deploy effective information systems and to deliver responsive IT support services. The Department develops administrative applications, offers networking and telecommunication services, technical services and support, as well as end user support. The operational environment includes a switched gigabit network as well as switched Ethernet

for the end-users. The telecommunications infrastructure offers data, voice and video services to more than 1.000 users. A central computing facility provides shared computing access to more than 120 servers and over 2 terabytes of networked disk space. The DSNA also supports various research projects within the FORTH-ICS, offering implementation and operational support. The team consists of 10 members offering support services on a 24-hour basis.

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Registry of .gr Domain Names Department



The Registry of .gr Domain Names has been the Administrative body of the [.gr] country code Top Level Domain (ccTLD) name space since 1989.

Activities include maintenance of the Registry's web site (<http://www.gr>), the domain name database, the primary and secondary name servers situated in geographically diverse locations, the accredited Registrars database and the connections of Accredited Registrars with the Registry's infrastructure. Through its participation in various International Organisations, the [.gr] ccTLD is able to follow global trends and issues common to Domain Name Systems across all 245 ccTLDs.

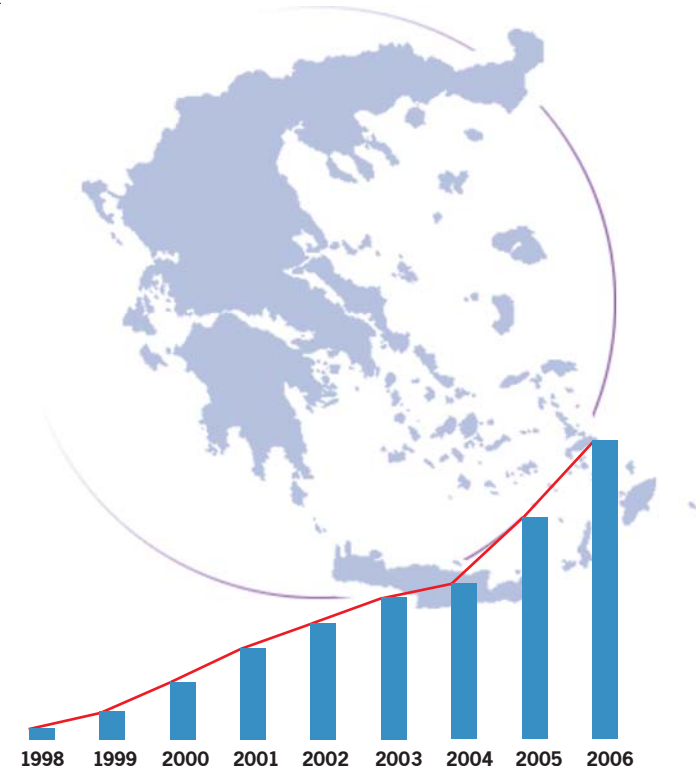
The [.gr] Registry Department employs skilled personnel that cover the needs of all daily operations of the registry. These operations include the maintenance of:

- The [.gr] registry informational web site (<http://www.gr>) which includes a WebWhois utility allowing interested parties to search for available [.gr] domain names.
- The [.gr] registry database, which includes all domain names and their respective contacts (registrant, administrative, technical, billing & full contact information) and relevant DNS information.
- The [.gr] database of registrars
- In-house developed proprietary software. The purpose of this software is the processing of domain name applications, registrar transfers, ownership transfers and domain name modifications submitted by [.gr] registrars, either through the available Web interface or through their own custom-built applications.

- A web interface for [.gr] registrars that allows them to handle all aspects of the domain names they manage.
- An EPP (Extensible Provisioning Protocol) server for [.gr] registrars that allows them to create and utilise their own applications for the domains they manage.
- In-house developed proprietary software utilised by the National Telecommunications & Posts Commission (<http://www.eett.gr>) in order to monitor and approve [.gr] domain name applications and ownership transfers.

With the publication of the 288/154/4-7-2003 decision of the National Telecommunications and Post Commission (NTPC), the Registry of .gr Domain names Department of FORTH-ICS was selected to continue as the official Registry of the [.gr] domain name space for a period of five (5) years under the direct supervision of the NTPC, the National Authority for domain name registrations under the [.gr]. With the adoption of the 351/76/20-5-2005 decision of the NTPC, the Registry of .gr Domain names Department began to register Domain Names in Greek characters on July 4th, 2005.

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W3C Office in Greece



The World Wide Web Consortium (W3C) Office in Greece was founded in 1998 and is hosted by FORTH-ICS. The Greek W3C Office is the only Greek organisation authorised to enroll new W3C Members in Greece. The Office also disseminates information regarding W3C cutting-edge technologies, including the work performed on the potential of the present Web so that it evolves to the Web of the future. The W3C Office in Greece has managed to assemble a critical mass of Greek Web users through its activities, which include the dissemination of Greek, translations of W3C News and Press releases, an electronic monthly newsletter as well as dissemination of information material to interested parties, such as private companies and academic institutes that are active in the area of Web technologies. Finally, the Office extends its range to European Organisations residing in Greece, including the latest W3C member, ENISA, the European Network and Information Security Agency, which recently joined W3C through the Greek Office.

The Web page of the W3C Office in Greece (<http://www.w3c.gr/>), the main vehicle for communication with the Office's community, is frequently updated with current W3C news, press releases and translations of W3C recommendations. To consolidate the Greek Web community, the W3C Office in Greece organises information events where participants have the opportunity to exchange information and views, as well as to be informed regarding W3C cutting edge technologies. Besides contacting Greek companies and academic institutes regarding W3C technologies, the W3C Office in Greece communicates with the Greek media, magazines and newspapers that publish technology-related articles (<http://www.w3c.gr/office/in-press.html>). The W3C Office in Greece has also been involved in research activities funded in part by the European Commission.

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ERCIM - The European Research Consortium for Informatics and Mathematics



The European Research Consortium for Informatics and Mathematics (ERCIM, <http://www.ercim.org>), founded in 1989, comprises leading research institutions from 18 European countries, committed to the advancement of information technology and applied mathematics. ERCIM promotes European research and development in these areas as well as linking research to the industry sector. ERCIM is a de facto network of excellence and a "think tank" that contributes to the definition of research policies at a European and at an international level. ERCIM has established a strong presence, with more than 12,000 researchers, providing solid foundations for creating knowledge networks and potential for research collaborations throughout Europe. FORTH-ICS has been an ERCIM member since 1992 and since then members of the Institute have been very actively involved, or played a leading role, in various ERCIM activities.



ERCIM aims to foster collaborative work within the European research community, and to increase cooperation with European industry, through:

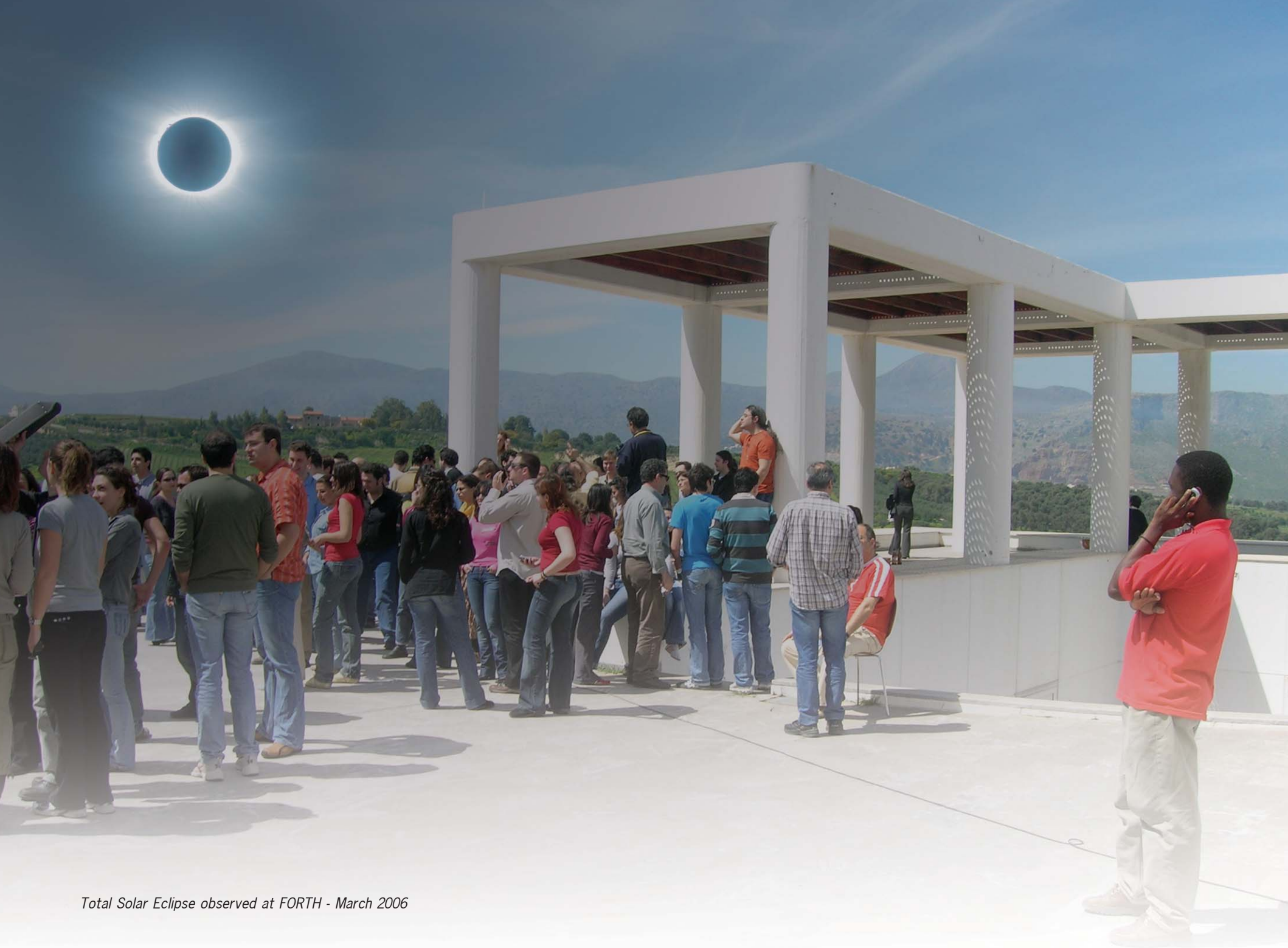
Joint Research Projects: ERCIM participates in several collaborative projects as co-ordinator or associated partner, such as DELOS and COREGRID.

Working Groups: The purpose of ERCIM working groups (WG) is to build and maintain a network of ERCIM researchers in a particular scientific field. Their main activities are the organisation of workshops and the preparation of common project proposals. The Working Groups (WG) are also the focus of internal mobility within ERCIM. Members of FORTH-ICS lead the User Interfaces for All WG, the Semantic WEB WG, the Bioinformatics WG, the Smart Environments and Systems for Ambient Intelligence WG, and the Digital Patient WG.

Training and Mobility: ERCIM supports researchers' post-doctoral specialisation, as well as mobility, through its fellowship programmes.

Sponsorships: ERCIM supports established conferences with substantial overlap between the conference topic and ERCIM areas of activity, as well as workshops and summer schools.

W3C European Host: ERCIM is the European host of the World Wide Web Consortium. This constitutes a strategic factor that further enhances the European role of ERCIM.



Total Solar Eclipse observed at FORTH - March 2006

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