

Information and Communication Technologies Institute  
**Carnegie Mellon | PORTUGAL**

A N I N T E R N A T I O N A L P A R T N E R S H I P

Carnegie Mellon Portugal Program  
2006 - 2011

# FINAL REPORT

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Table of Contents

<b>EXECUTIVE SUMMARY</b>	<b>5</b>
<b>Introduction</b>	<b>11</b>
<b>1. RESEARCH</b>	<b>12</b>
1.1. HIGHLIGHTS	12
1.2. PUBLICATIONS	14
1.3. OTHER RESULTS AND IMPACT	15
1.4. INDUSTRIAL COLLABORATION	16
<b>2. EDUCATION</b>	<b>23</b>
2.1. HIGHLIGHTS	23
2.2. Ph.D. PROGRAMS	24
2.3. PROFESSIONAL MASTER PROGRAMS	26
<b>3. INSTITUTIONAL DEVELOPMENT</b>	<b>28</b>
3.1. FACULTY EXCHANGE AND RECRUITMENT	28
3.2. NEW INSTITUTES	29
3.3. THEMATIC NETWORKS	30
<b>APPENDIX</b>	<b>33</b>
1. PARTICIPANTS	33
2. STUDENTS (PhD & Masters)	33
3. FACULTY EXCHANGE	33
4. JOINT PUBLICATIONS	33
5. ACCREDITED COURSES (PhD & Masters)	33
6. RESEARCH PROJECTS	33
7. FACULTY RECRUITMENT	33
8. UTEN Initiative - Portuguese University Technology Enterprise Network	33
9. EVENTS & COMMUNICATION	33
10. REPORTS (ERC, PROJECT REVIEW, MSc REVIEW)	33
11. STRATEGIC PLAN	33

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## EXECUTIVE SUMMARY

The Carnegie Mellon |Portugal Program, CMU|Portugal for short, was launched at the end of October 2006 as a five year partnership between Portuguese universities and research institutions, Portuguese companies, and Carnegie Mellon University under the sponsorship of the Fundação de Ciência e Tecnologia (FCT) of the Ministério da Ciência, Tecnologia, e Ensino Superior (MCTES). Portuguese participation included nine universities (Universidade de Aveiro, Universidade Católica Portuguesa, Universidade de Coimbra, Universidade Nova de Lisboa, Universidade de Lisboa, Universidade da Madeira, Universidade do Minho, Universidade do Porto, and Universidade Técnica de Lisboa), four associate laboratories (INESC ID, INESC Porto, Instituto de Sistemas e Robótica, and Instituto de Telecomunicações), one applied research institute (Instituto de Soldadura e Qualidade), and more than 80 companies.

The CMU|Portugal Program targeted basic research and educational activities in focused areas of Information and Communication Technologies (ICT), including fundamental technologies, methodologies, applications, and support sciences, as well as associated issues of managing technological change and development of related public policies. The main goals of the Program called for creating in Portugal internationally recognized research and graduate education programs of greatest quality, while promoting a spirit of collaboration that strengthened the connections among universities and academic research institutions with high-tech companies and start-ups. In essence, the program aimed at fostering economic development by creating new knowledge in ICT-related topics that are strategic for Portugal, supporting the recruitment of outstanding talent in the national and international arena, training and educating a significant number of post graduate students, post-doctoral researchers and faculty members, increasing significantly the number of advanced degree programs in highly relevant areas of knowledge, exchanging best practices and promoting a positive change towards a more dynamic, creative and entrepreneurial environment.

Numerous examples, projects and success stories demonstrate how the program has been achieving these goals. Many signs of positive change of culture can be seen in many Portuguese Academic Departments and Universities, which were induced by the exchange of faculty, students and best practices both with Carnegie Mellon and among themselves. The *virtual campus* – a virtual “dual” University spanning the Carnegie Mellon Pittsburgh campus and the nine Portuguese partner Universities is steadily developing with extensive cooperation both in research (in almost all cases involving industry partners) and in graduate education. Numerous successful examples of collaboration demonstrate and illustrate the growing personal and professional relationships among Portuguese and CMU researchers with Portuguese Companies.

In this executive summary, we illustrate how, at the end of four and a half years, the CMU|Portugal Program can claim success in many of its initial ambitious goals:

- Strong educational and research relations have been established with nine Portuguese Universities and associated Research Institutions;
- Eighty one companies participate actively in different research activities and graduate education programs;

- Over 30 collaborative research projects producing science and technology of the highest international standards are carried out, each led by a consortium of research groups of at least two different Portuguese institutions, one or more research groups at CMU, and one or more companies, providing innovative solutions for relevant research and societal challenges. In most cases, these projects leveraged research endeavors at Portuguese Institutions and at CMU leading to a multiplicative effect in terms level of research activity and impact in significant areas of ICT;
- 226 students have been recruited internationally and are enrolled in the dual degree educational programs. These students will strengthen the Portuguese labor force with highly trained experts and the faculty of Portuguese Universities and Research Institutions with pools of new talent;
- Seven dual degree PhD Programs targeting areas of primary relevance to ICT in Portugal were established between 15 Portuguese university departments and 11 CMU Departments, offering technical, policy, and business breadth, while promoting and training future leaders in ICT. These dynamic programs replicate the best practices of graduate programs in top American Universities;
- Five dual degree Professional Masters Programs were launched in partnership between four CMU Departments and four Universities in Portugal, serving multiple purposes: educating and training high quality professionals in highly technological areas and reinforcing the work force in ICT related areas, while providing an essential building block for Portuguese partner universities to extend their offer of first-rate quality programs and enhance their connections to the private sector;
- Over 150 Portugal faculty and senior researchers have been intimately involved in activities of the Program with up to 28 Portugal faculty members having participated faculty exchange stays of at least one term at CMU. They are in their own ways agents promoting change and adopting many of the best practices they experienced as part of the CMU|Portugal Program;
- 56 new faculty members in the ICT areas have been recruited and have been working in partner universities in Portugal;
- The Program promoted a new generation of technology-based companies in the telecom, software, and related areas with four companies started by faculty or students as a direct result of their activities in the Program;

In more detail, some of the highlights and accomplishments of the CMU|Portugal Program include the following:

1. **Collaborative Research:** The growing Carnegie Mellon Portugal research community is producing world-class research. The level of high quality and collaborative research has grown several fold – we need only mentioning that in the fall 2011 there will be 95 PhD students involved in the several dual degree doctoral Programs, all of these pursuing their PhD theses and co-supervised by at least a faculty member from Portugal and one from Carnegie Mellon. Further, there are currently 25 ongoing research projects that involve teams from at least two Institutions in Portugal, one

company, and one research team at CMU. Many of these research projects are being leveraged by research projects carried out by faculty supported by other funding Agencies (for example, NSF, Darpa, European Framework Programs, or FCT itself.) In addition, at least 15 projects have been carried out by teams of 3 to 5 Professional Master students involving faculty and companies. The number and quality of joint publications with authors from one or more Portuguese universities and Carnegie Mellon is increasing steadily (already more than 270 papers in international conferences and journals, in many cases first-tier venues). Several papers received “best paper” awards in the international conferences in which they were presented. Research highlights with real-world impact include a vehicular ad-hoc network of 465 taxi cabs that is currently being deployed in the city of Porto with GPS manufacturer NDRIVE (to the best of our knowledge the largest in the world), wearable technologies by company BioDevices and sensor network support undergoing tests with two corporations of firemen, prototypes for automatic speech translation and reading practice exploiting databases of publisher Porto Editora, web technology platforms developed with software house OutSystems, quantitative analysis of public policies towards broadband deployment with Portugal Telecom, among many other examples.

2. **Economic Impact:** The economic impact of the Program is growing. A large number of highly educated and trained graduates are making a difference in the companies employing them. Universities are developing technology transfer offices and the Carnegie Mellon|Portugal Program is an active participant in the Portuguese University Technology Enterprise Network (UTEN) (Appendix 8). Four spin-offs of the Carnegie Mellon|Portugal Program, e.g. Feedzai and Geo-Link, have entered the market. As already mentioned, the number of companies actively involved in the Carnegie Mellon|Portugal Program (Appendix 1) has reached 81 – a testimony that companies are finding value in partnering in the manifold educational and research initiatives of the Carnegie Mellon|Portugal Program. The commitment of companies to the Program has in fact increased dramatically from the initial core of three Institutional partners (Portugal Telecom, Nokia-Siemens Networks, and Novabase). Several examples show that the Carnegie Mellon|Portugal Program has had direct impact in these companies beyond the training of their employees and providing a source for recruiting highly educated specialists in their areas of interest. For example, the Master of Human Computer Interaction (MHCI) and the Master of Software Engineering (MSE) both divide the cohort of 3 to 5 student groups. Each of these groups develops a project with a company for the period of 16 months. Companies recognize the value of such interactions contributing financial resources (i.e., paying the expenses of the projects with a financial contribution) as well as assigning their own personnel to work in the project. Some of these companies have launched company research Laboratories as a direct consequence of their association with the Carnegie Mellon|Portugal program, e.g. Logica Iberica, which launched in Madeira its Service Design Logica Lab. In the MSIN and MSIT-IS several student projects led to the establishment in September 2009 of the PT-Security Lab, a Portugal Telecom new Laboratory focused on security issues. The PT-Security Lab integrates a core group of alumni of the Professional Masters in Information Security that did their project internship within CyLab at CMU.
3. **Cooperation among Universities:** Beyond the collaborative research, Portuguese universities have expanded their collaboration in graduate education by developing PhD programs jointly and signing protocols whereby they agree to share lectures,

content and practices (e.g., seven Portuguese Departments in the PhD degree Program in Electrical and Computer Engineering, ECE, seven Portuguese Departments in the Computer Science, CS, dual PhD degree Program, and two universities, Católica and Técnica de Lisboa, in Technological Change and Entrepreneurship, TCE). All seven CMU Colleges are involved in the partnership. All educational programs lead to dual degrees – the student being awarded a degree by at least one of the Portuguese University partners and the other by a CMU College. The programs continue to evolve and are in some cases including new partners. Case in point, University of Porto is joining the efforts of the Universidade Técnica de Lisboa and Carnegie Mellon University in offering a dual PhD degree in Engineering and Public Policy (EPP). The first two classes of Professional Master students that graduated (December 2008 and December 2009) received their diplomas in a “Diploma Ceremony” held at the Universidade de Coimbra in February 2010 and co-chaired by the 4 Rectors of the Universities of Aveiro, Coimbra, Lisboa, and Madeira and the President of Carnegie Mellon.

4. ***Institutional Development:*** Several Universities are developing and adopting new practices, extending them to their own Departments and Universities. Portugal partners are vigorously pursuing internationalization in recruiting students, post-docs, and faculty. In several instances Portuguese Universities were able to hire young graduates from top universities in the United States and Europe (e.g. the Universidade do Porto hired graduates from MIT and TU Berlin). The Universidade de Coimbra adopted some of the best practices of Carnegie Mellon, e.g. “black Fridays” in which faculty members discuss how the PhD students are performing. New institutional forms are arising, such as the Madeira–Interactive Technologies Institute (M-ITI). The Universidade de Madeira reorganized itself in five major areas, each patterning itself and adopting the practices of the M-ITI and its involvement with the Carnegie Mellon|Portugal Program. Other examples include the emerging Instituto de Engenharia de Software at Universidade de Coimbra, and several new thematic networks that were launched in early 2010 and congregate faculty from several campuses as well as experts from several high-tech companies working in cross-cutting areas of the Program. These networks include: Future Internet Services and Technologies (NET-FIT), Security and Critical Infrastructure Protection (NET-SCIP), Services and Technologies for Interactive Media (NET-STIM), and Software Engineering (NET-SE). These areas are deliberately aligned with the Digital Agenda of the European Commission in an effort to mobilize the community towards increasing the Portuguese participation in the 7<sup>th</sup> Framework Program.
  
5. ***Collaborative Graduate Education and Distance Learning:*** The educational programs (seven dual degree PhD programs in CS, LTI, SE, ECE, TCE, EPP, and Math; and 5 Professional Master Programs, MSIN<sup>1</sup>, MSIT, MHCI, MSE, and METC) have developed their routines from students applying to the programs, admission committees selecting the students, students joining and pursuing their program of study according to a timeline that includes semesters at the partner university in Portugal and at Carnegie Mellon, joint advising, and satisfaction of requirements of both partners for graduation. The *virtual campus* concept continues to develop. Courses are shared among partners and taught through distance learning facilities either from Carnegie

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<sup>1</sup> The MSIN, Master of Science in Information Networking, has been discontinued in its current format of a partnership between CMU and the University of Aveiro.



Mellon to Portugal campuses, or among Portugal campuses, and, at least in a few instances, from Portugal Universities to Carnegie Mellon. These courses are in the partners' roster of courses offered to students, their physical location being transparent in the student's record. Students at the Carnegie Mellon Pittsburgh campus who are not in the dual degree program have taken courses offered in Portugal by Portuguese faculty members. Likewise, Portuguese PhD students are attending Carnegie Mellon accredited classes, even when they are not dual degree PhD students. The University of Coimbra developed a new course for the master in software engineering, which was adopted by Carnegie Mellon, such that the University of Coimbra was asked to provide training and accreditation for the Carnegie Mellon faculty member who will be teaching this new course at Carnegie Mellon. These are examples of how the exchange of content and best practices is happening in both directions of the Atlantic.

6. ***Combining Technology and Business in Professional Education:*** The Professional Masters Programs are in most cases reaching a mature level of operation – students (150 up to now) being recruited and cohorts ramping to their desired levels, companies recognizing the value of these Programs and supporting students either by providing fellowships or supporting their employees for the full 16 month duration of the Program, classes being offered, projects being pursued, students spending part of their education in Pittsburgh and part at the partner University. The Professional Masters Programs have close to 100% level of employment of their graduates. These Programs are providing a competitive edge to their graduates that are recognized by the companies but also by the students themselves. Some students have preferred not to accept this support, supporting themselves during the 16 months of the Program, so they are free of any obligation at the end of the Program.
7. ***Cultural Immersion through Faculty Exchange Program:*** The Carnegie Mellon|Portugal Program, following the footsteps established since inception of the partnership by the Universidade de Coimbra and the Institute for Software Research (ISR) at Carnegie Mellon, established a nationwide faculty exchange program that supports a semester long visit of a Portugal faculty member at Carnegie Mellon where this faculty member is a visiting Professor team teaching a course and part of the research team of their Carnegie Mellon host. Currently, 28 faculty (mostly young assistant professors) have participated in this faculty exchange Program. For a list see Appendix 3. One faculty member at Carnegie Mellon has accepted a joint position with the Universidade Católica, usually spending the Fall term at Católica and the Spring term at Carnegie Mellon. Another Carnegie Mellon faculty member spent the Fall semester 2010 at Madeira on sabbatical and taught a course and pursued joint research.
8. ***Dissemination and Outreach:*** Many technical meetings were either organized or held under the sponsorship of the Carnegie Mellon|Portugal Program. These include organization of the Second Carnegie Mellon|Portugal Conference in June 2010, with 130 participants; several Workshops on topics such as Future Internet, Smart Grid, Cyber-Security and Interactive Technologies (with 40 to 90 participants, including both academy and industry) and a strong involvement with three sessions organized by the Carnegie Mellon|Portugal Program in the Encontro Nacional de Ciência organized under the sponsorship of the Ministério de Ciência, Tecnologia, e Ensino Superior. The

Carnegie Mellon|Portugal Program and its related activities are reaching out to the general public in Portugal. Practically on a daily basis, small or extensive coverage of Carnegie Mellon|Portugal Program related events are object of dispatches of News Agencies, news in newspapers, or segments in TV stations in Portugal. Research outcomes of the partnership have been highlighted in news programs and science programs in television and radio with demos and interviews with the leading scientists and PhD students. The Carnegie Mellon|Portugal Program was extensively profiled in the Chronicle of Higher Education's issue of September 15, 2010. In this issue, The Chronicle had a first page extensive article on the Portugal's international partnerships.

The numbers and the statistics give ample evidence for the Program's rich, diverse and high-level activity. But, more importantly, this Program is opening minds and changing mentalities, thereby helping to increase the quality of the education and research in ICT and beyond at selected Institutions in Portugal. The Program is also impacting the economic activity in Portugal through the highly trained graduates returning to companies with a specialized skill set and by the collaborative and impact-oriented research activities developed in partnership with the Portuguese industry. In a time when many of the top universities in the world are seeking to establish international partnerships in all continents, the knowledge and experience gained from the CMU|Portugal program on how to build successful collaborative research and educational programs is not to be underestimated. Portuguese universities and industrial partners can now leverage the outcomes of this unique endeavor and the connections they built to Carnegie Mellon and global knowledge networks to foster new alliances with other universities and companies in Europe and around the world.

## Introduction

The Carnegie Mellon Portugal program is a research platform aimed at fostering emergent concepts in information and communication technologies, with an orientation towards new products and services for markets worldwide, while leveraging a vibrant and young research community as well as the unique positioning of Portugal to deploy, test and demonstrate advanced technologies and systems.

Emphasis is given to key focused areas discussed in the scientific and industrial communities:

- . Next Generation Networks for Trusted High-Quality Services
- . Software Engineering for Marge-Scale Dependable Systems
- . Cyber-Physical Systems for Ambient Intelligence
- . Human-Centric Computing
- . Applied Mathematics
- . Public Policy & Entrepreneurship Dynamics in New Information and Communication Technologies

This joint venture was launched in 2006 and is achieving its goals through an open, broad and deep collaboration, including a multi-level partnership among Portuguese research institutions, universities and companies in cooperation with Carnegie Mellon University (CMU).

In 4.5 years the Carnegie Mellon Portugal has experienced significant growth and consolidation. The program has reached a successful steady state, featuring innovative research projects with strong industrial participation, stable educational programs with collaboration across multiple universities, and a constant flow of people and knowledge between Portugal and the United States.

The virtual campus – a virtual “dual” University spanning the Carnegie Mellon Pittsburgh campus and the nine Portuguese partner Universities is progressively developing with extensive cooperation both in research and in graduate education.

Numerous examples, projects and success stories demonstrate how the Program is creating new knowledge and contributing to the development of comparative advantages for Portugal in key focused areas of information and communication technologies (ICT). Signs of a positive change of culture in several Portuguese departments and universities are becoming visible, induced by the exchange of faculty, students and best practices both with Carnegie Mellon and among the participating institutions.

The progress of the Program has been evaluated independently on a yearly basis by the External Review Committee (ERC), which includes world-leading experts in information and communication technologies (Appendix 10). In addition, specific international panels were asked to review the master's programs and the first year progress of the funded research projects. In its most recent evaluation the ERC made the following statement: We congratulate all involved on the excellent way in which the activities in the programme have been

progressed. In our view the Carnegie Mellon Portugal Program is making an important contribution to transformational further development of university research and postgraduate education in Portugal, ensuring that the very highest international standards of excellence are attained.

## 1. RESEARCH

The Carnegie Mellon Portugal research community is producing internationally recognized research with 71 co-supervised PhD students and more than 150 faculty members and senior researchers. There are currently 22 collaborative research projects in strategic areas of ICT selected through two competitive research Calls (I from 2008 and II from 2009) that involve teams from at least two Institutions in Portugal, one company, and one research team at Carnegie Mellon, plus 3 research projects within selected areas of application of mathematics, made jointly by the Carnegie Mellon Portugal Mathematics Program and the UT Austin Portugal Program (Appendix 6). In this section, we elaborate on some of the main research achievements.

### 1.1. HIGHLIGHTS

The strong scientific and societal impact of CMU|Portugal research projects involving Portuguese universities and research institutions, Portuguese companies and Carnegie Mellon University are well illustrated in the following success stories:

- ***Large-Scale Testbed for Intelligent Transportation Systems:*** In a not so distant future almost all vehicles are expected to be equipped with GPS navigation devices and wireless communication capabilities. Vehicles will then be able to exchange information in real time and use it to ensure the most efficient use of the road network, while providing drivers and passengers with the best possible traveling experience. In Porto, Portugal, a large-scale vehicular ad-hoc network of 500 taxi cabs is currently ramping up, offering many practical examples of the economic and social benefits of intelligent transportation systems. The 500 taxi cabs are equipped with a prototype that helps researchers to collect and test data for improving security and efficiency of vehicular transportation. This initiative is being developed in the scope of the research project **DRIVE-IN** – Distributed Routing and Infotainment through Vehicular Inter-Networking. Equipped with a myriad of sensors these communicating vehicles shall further operate simultaneously as a massive urban scanner, providing real-time information about the city's metabolism, including pavement conditions, concentration of certain chemicals, noise levels and other variables that affect our quality of life. Cars and buses can warn each other and also the authorities on traffic accidents and serious hazards they encounter. In addition, they'll see benefits in

sharing not just the speeds at which they go through certain road segments (a good indicator of traffic congestion), but also their destinations and the routes they are taking. These data will enable them to optimize routes in a collaborative way, distributing the traffic around the city in an environmentally sustainable fashion. Thus, the need for rigid traffic light control is reduced and the overall energy consumption can improve dramatically. DRIVE-IN exploits the interplay between real-time navigation and wireless communication applications, correlated with road characteristics and traffic patterns, in order to achieve stable and efficient traffic and information flows. It addresses both foundations and applications of inter-vehicle communication and involves horizontal activities covering realistic large-scale simulation and massive real-life experiments in urban environments. Additional applications offered by vehicle-to-vehicle communications include location-based information dissemination, vehicle-based social networking and distributed interactive games. This project involves researchers from Porto and Aveiro, Instituto de Telecomunicações (IT), public administration (Land Mobility and Transports Institute), a few companies (NDrive, Geolink, RadiTaxis) and Carnegie Mellon University.

- **Human-Computer Interaction Systems for Sustainable Living:** More than 30 families in the Madeira Island, who are collaborating with the SINAIS project, have multi-sensor systems in their homes, which aim to detect and understand significant human activities related to resource consumption in a domestic environment. After collecting data, the researchers inform these families about their energy consumption, and provide feedback for them to modify their behavior. One major goal is to deploy smart meters, beginning with these 30 homes in Madeira and 100 homes in the North of Portugal, subsequently scaling up to 100.000 homes in Évora (in collaboration with EDP). Adding to this, the research team of this project is developing tools and infrastructures to capture individuals' mobility around a city. Currently, some buses at the Madeira Island are equipped with multi-sensors and GPS. The goal is to construct predictive models of personal and public transport and deploy interventions that modify transport behavior, and public transportation passengers. This project involves a team of researchers who are very multi-disciplinary and diverse, featuring computer scientists, software engineers, artists, economists and psychologists, among others. The aim is to generate services that seek ways to motivate people to trigger, think, act, reflect and consume sustainably with respect to their daily resource consumption and transportation activities. The **SINAIS** project involves researchers from Madeira, Porto, and Católica, research institutions such as M-ITI, public administration (AREAM, Horários do Funchal), and companies such as Greenwave, Electricidade da Madeira, Logica, Zon Madeira, as well as Carnegie Mellon University.
- **Cyber-Physical Systems for First Responders in Emergency Scenarios:** Firemen in Portugal and Pittsburgh firemen are participating actively in a project that seeks to develop supporting technologies for higher safety and better response to emergency situations. The research team of the **Vital Responder** project is providing the next generation of smart garments capable of capturing in-depth information about the

vital signs and body condition of first responders in real time. This project also focuses on new protocols and architectures for scattered sensor networks, solutions for fast and effective evacuation in smart buildings and precise in-door localization systems. The goal is to understand how cyber-physical systems and wearable technologies form a network to assist and reduce the risks of first responders in critical events. The Vital Responder project involves researchers from Aveiro and Porto), IT and IEETA, public administration (Bombeiros de Vila Nova de Gaia, Bombeiros de Amarante, Centro Hospitalar de Vila Nova de Gaia/Espinho), several companies (BioDevices, Petratrix, McLaren) and Carnegie Mellon University.

- **Secure Software-Intensive Systems:** The problems involved in software security, interoperability and assurance have real world significance, whether in everyday activities - such as changing profile security settings on popular networking sites - or large scale business endeavors - such as modifying web applications in response to changing requirements. Most often, security malfunctions are the result of “bugs,” or mistakes in the programming. Researchers from the **INTERFACES** project are developing programs, with the collaboration of the company OutSystems that automatically analyze software, helping developers to detect potential errors in the programming before they occur. With these tools they will be able to signal which parts of the system are insecure - for example, by coloring the program code on the screen - and possibly even correct the software. The INTERFACES project involves researchers from Universidade de Lisboa and Universidade Nova de Lisboa and Carnegie Mellon University. Outsystems changed their company roadmap to integrate the outcomes of this project in their web technology platforms.

## 1.2. PUBLICATIONS

The number and quality of joint publications with authors from one or more Portuguese universities and Carnegie Mellon is increasing steadily. The partnership produced so far a total of 292 publications (see the complete list in Appendix 4).

The research component of the Carnegie Mellon Portugal program focuses on strategic areas that resulted from a public consultation process carried out between May and July, 2009. These are: Next Generation Networks for Trusted High-Quality Services; Software Engineering for Large-Scale Dependable Systems; Cyber-Physical Systems for Ambient Intelligence Human-Centric Computing; Public Policy and Entrepreneurship Dynamics in New Information and Communication Technologies, and Applied Mathematics. The External Review Committee and the Review Committee for the research projects reviewed the quality of the publications. Both panels confirmed the high quality of most publications.

Some of the articles appeared in the top journals of the respective fields, including:

- IEEE JSAC
- IEEE Transactions on Networking

- IEEE Security & Privacy
- IEEE Transactions on Parallel and Distributed Systems
- IEEE Transactions on Computers
- IEEE Transactions on Signal Processing
- IEEE Software
- ACM Transactions on Human Computer Interaction
- IEEE Multimedia
- Theoretical Computer Science
- International Journal of Entrepreneurship and Small Business
- Journal of Management Studies

As mentioned before, several papers received “best paper” awards in the international conferences in which they were presented, for example:

. André Martins, a dual degree Ph.D. in the area of language technologies, won the 'Best Paper Award' (prize for best scientific communication) at the 47th annual conference of the Association for Computational Linguistics (ACL) held in Singapore;

. Vikram Gupta, a dual degree Ph.D. student in Electrical and Computer Engineering (ECE), received a Best Paper Award at the ACM Sensys 2009 - Conference on Embedded Networked Sensor Systems.

### 1.3. OTHER RESULTS AND IMPACT

Other research outcomes have had considerable impact, as well. These include the following cases:

- Spillover Effects from Wiring Schools with Broadband: Implications for Universal Service Policy is the titled of a paper published by two researchers, a dual degree Ph.D. student and a Portuguese faculty, of the **Technology, Management and Policy for the Telecommunications Industry project**. This project is looking at several issues at the intersection of technology and economics with application to the telecommunications industry. It involves researchers from Universidade de Lisboa, Universidade Católica Portuguesa, public institutions (UMIC, FCCN), Portugal Telecom, and Carnegie Mellon University.
- Researchers of the **Human Capital, Knowledge Based Firms and Entrepreneurial Life-Cycle project** are studying the Portugal’s database employer-employee: Quadros de Pessoal. This tool gathers mandatory information submitted yearly by Portuguese firms to the Ministry of Social Security and Labor since 1983. A longitudinal dataset is being used by researchers to track the evolution of markets and individual firm performance, as well as individual’s professional and entrepreneurial experiences over time, allowing for the examination of their decisions and behavioral patterns in the labor market. Some conclusions already gave origin to papers published by dual



degree Ph.D. students. This project involves researchers from Portuguese universities (Lisboa, ISCTE, Católica Portuguesa, Beira Interior), companies (Alfama, Critical Software, YDreams) and Carnegie Mellon University.

- Companies are spending more resources on the daily management and operations of their networks than investing on developing and launching new IT services. The researchers of the **NeTS project** are working closely with Portugal Telecom to develop a novel network operation and management framework that departs from conventional approaches through a cross-disciplinary research collaboration based on hierarchical network abstraction modeling, structure learning of probabilistic graphical models for machine learning, and wavelet and kernel-based signal processing technologies. This project involves researchers from Porto and Lisbon, research institutes (IT and INESC Porto) and Carnegie Mellon University.
- The Telecom industry is going through rapid changes leading to what are commonly designated as Next Generation Networks (NGN): different technologies converging into a network tissue able to provide multiple services with on-demand provisioning, in a seamless and technology-independent manner. The research team of the TRONE project aims to investigate innovative ways to apply fault/failure diagnosis, detection and prevention/tolerance techniques, in symbiosis with automatic reconfiguration mechanisms. This project involves researchers from Portuguese universities (Lisboa, Coimbra), companies (Portugal Telecom / PT Security Lab) and Carnegie Mellon University.
- EDP – Electricidade de Portugal is a partner of the project entitled Toward Dynamic Monitoring and Decision (DYMONDS)–Based Smart Distribution Systems, which targets a framework for designing and operating future smart distributed electric power systems. A collaborative effort will be introducing the fundamentals of a smart distribution network system. Such system should be capable of integrating demand-response, and many new distributed resources, such as Electric Vehicles (EVs), Photovoltaic's (PVs) and small-scale wind generation, without creating any reliability problems. The project is led by a consortium that involves researchers from Lisboa and Porto, research institutes (INESC Porto, CIEEE), companies (EDP, EPRI, Logica) and Carnegie Mellon University.

#### 1.4. INDUSTRIAL COLLABORATION

The number of companies actively involved in the Carnegie Mellon Portugal Program has reached more than eighty – a testimony that companies are finding value in partnering in the several educational and research initiatives of the Carnegie Mellon Portugal Program.

The commitment of companies to the Carnegie Mellon Portugal Program has increased dramatically from the initial core of three Institutional partners (Portugal Telecom, Nokia-



Siemens Networks, and Novabase) to more than 80 partner companies (Appendix 1), including 4 start-up companies (Dognaedis, Feedzai, Geolink and Mambu).

Several examples show that the Carnegie Mellon Portugal Program has had direct impact in the products and services provided by these companies. For example the Master of Human Computer Interaction (MHCI) and the Master of Software Engineering (MSE) both divide the cohort of 3 to 5 student groups. Each of these groups develops a capstone or studio project with a company for the period of 16 months. In Appendix 2 find the profile of the MSC students and a description of the project where they were involved. Companies recognize the value of such interactions contributing with financial resources (i.e., paying the expenses of the projects with a financial contribution), as well as assigning their own personnel to work in the project. In the case of the MSE, for example, there are 8 companies (Novabase, Telbit, Critical Software, ISA, Wit Software, Edisoft, Portugal Telecom and Wipro) that offer scholarships and jobs upon graduation to qualified students.

Recently, Google recruited a MHCI alumnus (Boris Smus), and Logica Iberica has created a new Research and Development Center in Madeira, with several partners, the Service Design Lab and invited two alumni of the MHCI to work there (André Dória e Nuno Laginha).

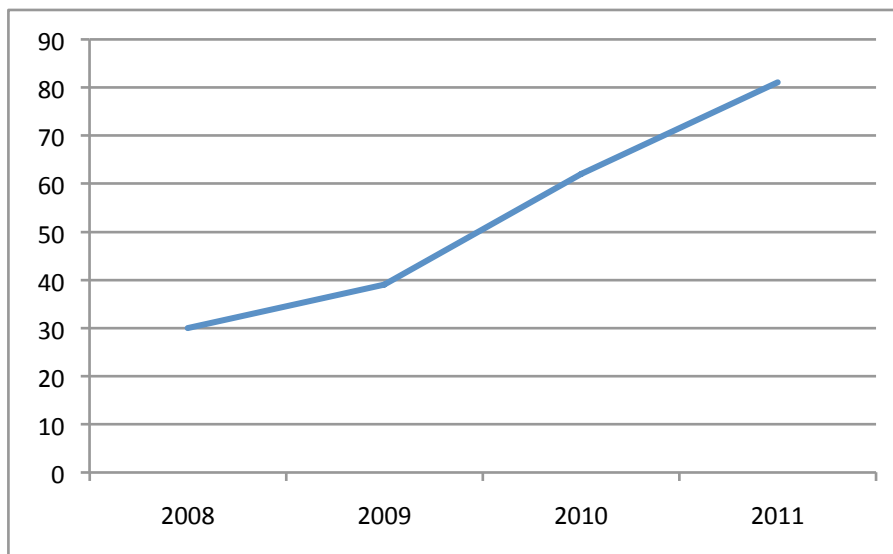
In the Master of Science in Information Networking (MSIN) and Master of Science in Information Technology – Information Security (MSIT-IS) several student projects led to the establishment in September 2009 of the PT-Security Lab, a new laboratory based at Portugal Telecom focused on security and network operations. The PT-Security Lab is headed by José Alegria from Portugal Telecom and integrates a core group of alumni of the Professional Masters that did their project internship under the supervision of Hyong Kim, faculty at Carnegie Mellon.

A common practice at Novabase for employees returning to the company after graduation is to spend 20% of their time devoted to the software engineering group, which is a group composed by the MSE graduates with the objective of contributing to the development of best practices in software engineering within the company.

The type of commitments of the industrial partners can be divided into 6 categories: Involvement in research projects (human resources, logistic support, general support, providing relevant research data, etc.), Involvement in thematic networks, funding students (master students and doctoral students), funding studio projects (projects of master students), participation in training sessions (Summer and Winter and course involvement).

The evolution of the number of participating companies is illustrated in the following figure.

Number of Companies involved in the Program



### Portugal Telecom (PT)

Portugal Telecom is the main private investor in the Carnegie Mellon Portugal program. PT, through its subsidiaries provides telecommunications services mainly in Portugal, Brazil and certain countries in Africa, including wire line services, which include fixed line telephone services for residential & nonresidential custom. Its annual turnover is 3.742 million Euros.

Portugal Telecom participation in the Program can be measured by the funding of 61 master students (MSE (19), MHCI (6), MSIT - IS (22), MSIN (14)) and 2 doctoral students (TCE (1), ECE (1)) and 22 thesis projects (studio projects conducted by master students) were done in collaboration with the PT. 45 students affiliated with PT already successfully graduated from the master programs (13 MSIN, 15 MSIT-IS, 12 MSE and 5 MHCI). PT is involved in 5 research projects approved for funding by FCT through competitive calls: TRONE - Trustworthy and Resilient Operations in a Network Environment, Cyber-Physical Systems Technologies for Energy-Optimized Data Centers, NeTS: Next Generation Network Operations and Management, Technology Management and Policy in the Telecommunications Industry, and Web Security and Privacy (WESP): Weaving Together Technology Innovation with Human and Policy Considerations, The role of PT in the Carnegie Mellon Portugal program is also visible in two thematic networks: NET – SCIP and NET-FIT where PT is a steering committee member.

Portugal Telecom as a global telecommunications operator has a constant commitment to guarantee the security of its client's data and the quality of service. Through the involvement in the Program, Portugal Telecom was able to train and qualify its collaborators in the domain of cyber security and information intelligence, to recruit new talent professionals specialized in this areas and to promote scientific and technological cooperation with Cylab, one of the most renowned R&D Labs worldwide in terms of cyber security

The center of expertise on cyber security, **PT Security Lab**, was created in collaboration with the Carnegie Mellon Portugal Program, with Cylab, and with Portugal Telecom (PT). This center is a unique and cross-sectional framework for PT's cluster, concentrating know-how and resources. This center is being strengthened with the talent of the masters programs in the Carnegie Mellon Portugal Program.

The PT Security Lab has the objective to leverage the capacity of innovation of Portugal Telecom on cyber security, the development of new products and services adapted to the real problems of companies and public institutions, and will reveal Portugal Telecom like a major reference for cyber security in Portugal.

The key lines of the PT Security Lab are:

- Secure mobile networks and systems; Secure computer platforms;
- Secure software engineering;
- Secure home networks and computing;
- Security of cyber-physical systems;
- Usability of security and privacy techniques;
- Advanced security event monitoring, correlation and viewing systems;
- Detection and prevention of internal attacks;
- Detection and prevention of external attacks;
- Security and risk metrics and models.

### **Nokia Siemens Networks**

Nokia Siemens Networks, one of the biggest communications service providers, is one of the main corporate sponsors of the Carnegie Mellon Portugal program. Involvement of Nokia Siemens Networks is visible in the research project approved for funding by FCT through competitive calls: The Role of 'User Innovators' in the Development of Telecom Products and Services. Furthermore, Nokia Siemens Networks was funding one master student enrolled in MHCI program jointly thought by the University of Madeira and Carnegie Mellon University and it was funding one MSIT-IS student (master program taught jointly by the University of Lisbon and Carnegie Mellon University).

### **Novabase**

Novabase, founded in 1989, is one of the largest IT companies in Portugal with an annual turnover of 236 million Euros, currently employs about 1700 people. Novabase is involved in the Carnegie Mellon Portugal program in several ways. Two research projects approved for funding by FCT through competitive calls (Aeminium - Freeing Programmers from the Shackles of Sequentiality and Affidavit - Automating the Proof of Quality Attributes for Large Scale Software Architectures) are also partly supported by Novabase, which provides man power and relevant research data/information. Novabase is funding 13 MSE students and one MSIT-IS student enrolled in the Carnegie Mellon Portugal program. Recently Novabase has become involved in the Thematic Networks - NET-STIM as a steering committee member. Several best practices introduced by Novabase within the program are described at the end of this section.

## Start-Ups

The Carnegie Mellon Portugal program has also provided conditions and opportunities for some of the faculty members, students or alumni to launch their own entrepreneurial initiative. Four start-up companies were created as a result of the activities developed within the partnership:

**Dognaedis** is a startup established by Mário Zenha-Rela, faculty at Faculdade de Ciências e Tecnologia da Universidade de Coimbra (FCTUC) and Francisco Rente, a Ph.D. student. The main business focus of this company is Information Security, focused in three major activity areas: Security Audit and Consultancy, Software Assurance and Business Continuity Support. This startup was created because of all the involvement that Mário Zenha-Rela has had within the partnership: he spent a semester at Carnegie Mellon in the beginning of the Program to get the accreditation to teach some courses. During this stay he felt that Carnegie Mellon faculty where encourage having a strong relation with the industry world, through de consultancy services or even creating their own companies. When he returned to Portugal, he started working in both, and after a while he decided jointly with a Ph.D. student to create his own company. Dognaedis works for the Portuguese central administration: the Internal Affairs, the Ministry of Justice, and the National Health Emergency Institute.

**FeedZai** is another start-up created as a result of the Carnegie Mellon Portugal Program. Paulo Marques and Pedro Bizarro, two faculty members of the Faculdade de Ciências e Tecnologia da Universidade de Coimbra (FCTUC), and Nuno Sebastião, product manager at the European Space Agency (ESA), embarked on the adventure to create a startup specialized in processing large volumes of data with low-latency producing actionable information in real-time. This company brought to the market a revolutionizing product in terms of real-time data processing, which allows companies to look into their data in real-time, as things are happening, and understand in detail what is going on. It allows a telecommunication operator to know in real-time how its network traffic is behaving and if it is following a 'normal' pattern or not; it allows an electrical utility company to understand in detail the load that is taking place in the network and if there are 'unexpected leaks' occurring. The partnership with Carnegie Mellon University was very important in this process. Both, Paulo Marques and Pedro Bizarro were adjunct professors at Carnegie Mellon University which granted the company a high degree of credibility which was critical when trying to convince an established company to try out a new technology. On the other hand, there are a number of activities that the Carnegie Mellon Portugal program has been promoting, where this startup have been present, which opened FeedZai to new markets

**GeoLink** is a startup created by Michel Ferreira, faculty at Faculdade de Ciências da Universidade do Porto (FCUP), focused in the management of geospatial information. This startup is fully involved in the Carnegie Mellon Portugal partnership through the participation on the research project approved for funding in the Call of 2008: DRIVE-IN - Distributed Routing and Infotainment through Vehicular Inter-Networking, which equipped 500 taxi cabs in the city of Porto. Geolink has a team with an expertise in the area of technology systems for

the management of spatial information that joins research and helps to solve problems of high complexity finding innovative solutions grounded in technology.

**Mambu** is a startup company established by two alumni of the Master in Human Computer Interaction, namely Eugene Danilkis and Frederick Pfsifered. This company was designed to support the unique needs of small and medium sized organizations (MFIs) providing microcredit services. It was built by working closely with organizations, observing their work and determining their needs and challenges. The idea to create this company started during their Professional Master when they made their Capstone Project, a mandatory project where students work in interdisciplinary teams with an industry sponsor to produce a working prototype that serves as a proof of concept of a novel service or product idea. Mambu was the name of the project created by these two entrepreneurs with more colleagues, which goal was to build an online portfolio management software service for growing microcredit organizations.

### **OTHER RESULTS AND IMPACT**

The following examples give more testimonies of the impact that the program has had on the industrial arena:

Novabase leadership looks at the Professional Master programs as an important career step for their employees. Every year, Novabase offers a scholarship in the MSE to its best employees. After finishing their Master, Novabase employees return and split their time in: 80 per cent in consulting work with new functions and an improved salary, and 20 per cent are devoted to the software engineering group. This group is composed by the MSE graduated and the goal is to contribute to develop best practices in software engineering inside the company: they work with everyone in the company in the fields of software architectures, and improving the dynamics of software development teams. The trip to Carnegie Mellon, the Novabase Academy Study Tour, is a prize that is offered to the "best" students coming out of the Academy. Students are afforded the opportunity to attend some classes at Carnegie Mellon University as well as met several program researchers and professors. Novabase Academy is a training program for recent college graduates that offer a two week intensive training program prior to becoming full time employees at the company. The program consists of courses, projects and team-building exercises, all designed to prepare participants for their work at Novabase.

After spending a year at Carnegie Mellon, the dual degree Ph.D. student in Language Technologies (LTI) André Martins, started an initiative in Portugal which was able to join the academia to the industry. He launched the Priberam Machine Learning Seminars. These events are held at Instituto Superior Técnico da Universidade Técnica de Lisboa, and are sponsored by the Portuguese company Priberam, the world's leading supplier of natural language processing technologies for the Portuguese language and the market leader in law knowledge management systems in Portugal. André Martins has a scholarship from the Fundação para a Ciência e a Tecnologia and is a former employee of Priberam.

In some research projects, meetings between researchers and employees of partner companies are held on a weekly base. One good example is the INTERFACES project where the meetings with company Outsystems (Portugal-based software company with clients in 16 industries), help the company to solve problems related to the enterprise security by combining map roles, users, security and different modes and functionalities all together.

Biodevices, partner of the Vital Responder project, distributed several Vital Jackets units to all project teams (Portugal and Carnegie Mellon) in order to serve several purposes in the research plan. These units are being used by fireman in emergency situations, which are helping researchers to find better ways to guarantee their survival.

NDrive gave access to the source code of their world-class navigation system to one researcher of the project, Luís Damas, from Faculdade de Ciências da Universidade do Porto. This led to the development of an Application Programming Interface (API) that is now used by team members and students at the University of Porto and IT to incorporate their research with NDrive products and services.

As the third class of the professional masters programs was concluded in December 2010, the number of alumni increased to 97, allowing the CMU Alumni chapter in Portugal to keep growing. It is through the success stories of these alumni that the integration of the knowledge thought in the master programs, in the industry tissue, can also be measured.

Filipa Jervis holds an undergraduate degree in psychology and she was teaching English classes for 4 years before joining the MHCI with the objective of changing her professional life. It turned out to be a winning decision since she was hired by Portugal Telecom where she works now as a product manager.

Nuno Seixas worked as a nurse for 6 years while attending at the same time an undergraduate course in software engineering at Universidade de Coimbra which led him to PT Inovação where he integrated a team developing a telemedicine platform. The MSE was an opportunity offered by the company that allowed Nuno to grow professionally. He is now the responsible for the implementation of the CMMI Program in the company.

The MSIT-IS gave Tiago Carvalho the opportunity to deepen his knowledge in information security matters which was an asset for Portugal Telecom. In fact, PT took the decision to support financially Tiago's aspiration to expand his knowhow in these areas of expertise as he returned to the Program to obtain a PhD in ECE.

## 2. EDUCATION

### 2.1. HIGHLIGHTS

Nine Portuguese Universities, namely Universidade de Aveiro, Universidade Católica Portuguesa, Universidade de Coimbra, Universidade de Lisboa, Universidade Nova de Lisboa, Universidade da Madeira, Universidade do Minho, Universidade do Porto, and Universidade Técnica de Lisboa (Instituto Superior Técnico), have succeeded in establishing advanced training programs with dual degrees awarded by at least one of the Portuguese partner institutions and by Carnegie Mellon University. This means that each student enrolled in any of dual degree programs is simultaneously a student at Carnegie Mellon and at the partner Institution in Portugal, and in satisfying the requirement of both universities the student obtains a degree from both the Portuguese institution and Carnegie Mellon.

Several of these programs involve partnerships and knowledge sharing among multiple Portuguese Universities and Carnegie Mellon in the general areas of Computer Science (CS), Electrical and Computer Engineering (ECE), Applied Mathematics (Math), Technological Change and Entrepreneurship (TCE), and Engineering and Public Policy (EPP). Courses (APPENDIX 5) are shared among partners and taught through video conferencing facilities either from Carnegie Mellon to Portugal campuses, or among Portugal campuses, and, at least in a few instances, from Portugal Universities to Carnegie Mellon. The cooperation agreements set up imply that the students are co-supervised by a faculty member at the Portuguese institution and another faculty member at Carnegie Mellon, thus enabling close research collaborations. Carnegie Mellon Portugal students are pursuing dual degree Programs in more than 10 different Departments in Portugal, extending from the North in Braga and Porto, to Coimbra, Aveiro, Lisboa, and Madeira and 6 different Colleges at Carnegie Mellon, raising the number of co-advisors at Carnegie Mellon and Portugal above 150 faculty members.

One facet of the virtual campus concept is the way in which a variety of situations is being faced while ensuring that individuals remain oblivious to the complexity of the processes carried out behind the scenes. For example, Ph.D. students may start their first year at Carnegie Mellon or at the partner University. They then transition to the partner University in the second or third year. Some students in agreement with their advisors alternate their physical presence every semester. Therefore during the current scholar year practically all possible combinations are happening simultaneously: students that start in Portugal; students that start at Carnegie Mellon; students that spent the first year in Portugal and are now in their second or third year at Carnegie Mellon; students that already spent two years at Carnegie Mellon and now are in Portugal; students that have started in Portugal, then stayed at Carnegie Mellon, and are now back in Portugal; students that started at Carnegie Mellon, went then to Portugal and now returned to Carnegie Mellon.

Besides this degree of freedom, the impact of the Program is actually beyond what even the numbers above indicate, since for the same Educational Program there may be several different partners in Portugal. Seven Computer Science Departments and six Electrical and Computer Engineering Departments in Portugal have signed with the corresponding Carnegie

Mellon Departments an agreement forming a consortium whereby they accept that their students fulfill requirements of their doctoral Programs in other Portuguese Universities. This has strengthened the Carnegie Mellon Portugal Program virtual campus, as now there are nine Universities in Portugal accepting courses taught by partner Universities and providing the opportunity to their students to take for credit courses at other Portuguese Universities. These courses range from technological fields like ECE and CS, to Engineering and Public Policy, to Business, to Technological Change, or to Mathematics. A student in Aveiro in the Professional Masters Program in Information Networking (MSIN) was able to take for credit a course in Public Policy for Telecommunications taught in Lisbon. A dual degree Ph.D. student at University of Porto can take for credit courses taught in Coimbra. And, since Spring 2009, students at Carnegie Mellon in Pittsburgh, including non Carnegie Mellon Portugal students, can take for credit a course taught from Portugal.

## **2.2. Ph.D. PROGRAMS**

To boost relevant research and provide opportunities for world-class graduate education, the Program supports dual degree Ph.D. programs designed to train the most talented young researchers in the context of thriving research collaborations between faculty at Carnegie Mellon and in Portugal, while offering post-doctoral positions to attract bright minds for a scientific career in Portugal.

The partnership aims to foster cooperation among Portuguese universities to further promote the excellence, international visibility and attractiveness of research and graduate education in our country. Professional master programs aim at qualifying skilled personnel for high-tech industries in ICT. The dual degree programs are part of an internationalization strategy that builds on Carnegie Mellon's excellent reputation and explores Portugal's location in Europe, and the special relations with Africa and Brazil. Since scientists and entrepreneurs alike usually have more ideas at hand than they can reasonably solve with the time and the resources that are available to them, the Carnegie Mellon Portugal Program consequently aims at focusing their efforts around common objectives, thus aggregating the critical mass and providing incentives for emerging Initiatives to focus on those problems that have strategic value towards higher comparative advantage for all partners.

Consortia of Portuguese universities cooperate with Carnegie Mellon to offer world-class graduate programs, where Ph.D. students and professionals from the industry are trained partly in Portugal and partly in the United States, develop research projects under co-supervision by faculty on both sides of the Atlantic, and receive a degree both from a Portuguese institution and from Carnegie Mellon. In addition, students in other graduate programs of participating institutions have the opportunity to spend time at Carnegie Mellon's labs and departments, where they are exposed to the best practices of a vibrant interdisciplinary research environment.

There are seven dual degree Ph.D. Programs:



- Computer Science with seven partners in Portugal (IST/UTL, UP, UA, UC, UL, UMinho);
- Electrical and Computer Engineering with six partners in Portugal (IST/UTL, UL, UP, UA, UC, UMinho;)
- Engineering and Public Policy with a partner in Portugal (IST/UTL) – currently, the Faculdade de Engenharia da Universidade do Porto (FEUP) is taking the necessary steps to join the dual degree Program in EPP;
- Language Technologies involving a partner in Portugal (IST/UTL);
- Applied Mathematics involving three partner Universities in Portugal (UL, UNL, and IST/UTL);
- Software Engineering, currently involving one partner in Portugal (UC);
- Technology Change and Entrepreneurship with two partners in Portugal (UCP and IST/UTL).

Irrespective of the institutions that offer the degree, the large majority of Ph.D. students are actively involved in collaborative research projects with multiple teams from different institutions in Portugal, Carnegie Mellon and various industry partners. The resulting multi-disciplinary and multi-institutional interaction from the core of the research networks that the Carnegie Mellon Portugal program is nurturing.

A total of 71 highly qualified Ph.D. students were admitted in the Carnegie Mellon Portugal Program (with more to come in Fall 2011), in addition, to four post-doctoral fellows in Applied Mathematics. Students enrolled in the program come from all over the world. The dual degree Ph.D. students are expected to stay four to five years in the Program, spending on average two years at Carnegie Mellon and three years at the partner University in Portugal. The requirements of the Ph.D. students may vary from Program to Program. As an illustration, the requirements of the dual degree Ph.D. Program in ECE include: 8 courses, which have to satisfy a breadth of three distinct areas; two teaching internships during which students help with teaching an undergraduate and a graduate course; top score (i.e., class I) in a Carnegie Mellon English proficiency test administered by an independent unit at Carnegie Mellon; passing an oral qualifier based on a written conference paper or similar written by the student; successfully presenting a PhD thesis prospectus; and, finally, successfully writing and publicly defending a doctoral thesis. In CS the requirements are similar but change in a few details – the qualifier is on the basis of taking four star courses; there is an oral presentation requirement where the student makes a successful conference like presentation in a public forum but is evaluated by a faculty committee; a writing requirement on the basis of a Conference paper. Other Carnegie Mellon PhD Programs add their own specificity to these requirements. Doctoral Programs at Portuguese Universities in some cases have fewer requirements, but following the implementation of the Bologna process usually demand a minimum number of courses, the defense of a thesis work plan and a successful defense of a PhD thesis. Teaching requirements have been added to at least one of the Portuguese programs following the

experience of a dual degree with Carnegie Mellon. What is significant in this partnership is that Carnegie Mellon and its Portugal Partners have agreed how students satisfy these requirements, some at Carnegie Mellon and some in Portugal, for example, in ECE, courses can be taken in either place; similarly, one teaching internship can be satisfied at the Portuguese partner university. They also agreed in ECE on a joint procedure for the selection of candidates, which was tested this year for the first time. The process is not without challenges, as cultural differences must be embraced and worked out. See Appendix 2 for the complete list of the students and the abstract of their thesis.

### **2.3. PROFESSIONAL MASTER PROGRAMS**

Professional Master's programs in Human-Computer Interaction (MHCI), Information Networks (MSIN), Information Technology and Information Security (MSIT-IS), Software Engineering (MSE) and Entertainment Technology (MET) led to new forms of professional education in Portuguese universities and have been key to strengthening the ties among industry and academia. More than 150 professionals were recruited for training. Companies recognize the value of these Programs and support students either by providing fellowships or supporting their employees for the full 16-month duration.

The Universidade da Madeira has two professional masters: the MHCI, in partnership with the Human Computer interaction Institute in the School of Computer Science at Carnegie Mellon, and one created more recently, the MET, in partnership with the Entertainment Technology Center (ETC) in the School of Computer Science at Carnegie Mellon. Both are taught during four semesters, and it is mandatory for the students to spend a period at Carnegie Mellon. In the HCI professional master, students are grouped into teams of 3 to 5 students with complementary expertise (Psychology, Design, and Computer Science as majors) and have to develop a capstone project sponsored by a company. This professional master has developed several very successful partnerships with different companies, including Sapo, the web based company of Portugal Telecom, Logica, an international company that has decided to open their first Research and development Center in Madeira on the strength of their multiple relations with Carnegie Mellon Portugal education and research initiatives at Universidade da Madeira. At the Entertainment Technology professional master students must produce working artifacts; in the tradition of Carnegie Mellon, this emphasis is on making real things that work. It has emphasized recruiting in the international scene, with at least 50% of international students in the class. The MET and MHCI are now under the umbrella of the Madeira-Interactive Technologies Institute (M-ITI), a partnership between the Universidade da Madeira and the Madeira Tecnopolo (a para-governmental research organization). Carnegie Mellon is a honorary founding member of the M-ITI.

The Universidade de Aveiro and the Information Networking Institute (INI) at Carnegie Mellon launched the dual degree professional master in Information Networks (MSIN), which has had a positive impact in Portugal Telecom. Through this professional master, Portugal Telecom

trained several employees. The MSIN in its current version as a partnership has been discontinued starting Fall 2010.

The Faculdade de Ciências da Universidade de Lisboa (FCUL) and the Information Networking Institute at Carnegie Mellon created the Master of Science in Information Technology – Information Security (MSIT-IS). A professional master which gives students advanced knowledge in security and dependability to prepare them to be leaders in industry and government. Many of the students of MSIT are affiliated with Portugal Telecom, which is developing the Security lab building on the expertise of MSIT-IS alumni and the research carried out with Carnegie Mellon Portugal Program faculty.

The professional master in Software Engineering (MSE) is a partnership between the Faculdade de Ciências e Tecnologia da Universidade de Coimbra and the Institute for Software Research (ISR) at Carnegie Mellon. The class is divided in teams of five students, which then take the responsibility of working on a large software development project defined in partnership with a sponsoring company. Through the students and these projects, the MSE has developed strong relations with companies including PT, Novabase, Critical Software, and numerous small and medium enterprises. The MSE has energized a team of software engineering faculty who are leading of the creation of a new research institute, the Software Engineering Institute. Since the beginning ISR has hosted at Carnegie Mellon six faculty members from FCTUC that spent a full semester at Carnegie Mellon. This example was extended in 2010 to all areas in the Carnegie Mellon Portugal program and to any interested faculty member in Portuguese universities through the newly institutionalized faculty exchange program. Several of the accepted candidates are immersed at ISR thus contributing further to the development of a strong software engineering community in Portugal.

All Professional Master Programs present nearly 100% placements of their graduates in jobs after graduation. Most of the alumni are employed in the Portuguese industry. In some cases, students have declared their interest in starting a new company based on what they learned. See Appendix 2 for the complete list of the students and the abstract of their work within the master program.

### 3. INSTITUTIONAL DEVELOPMENT

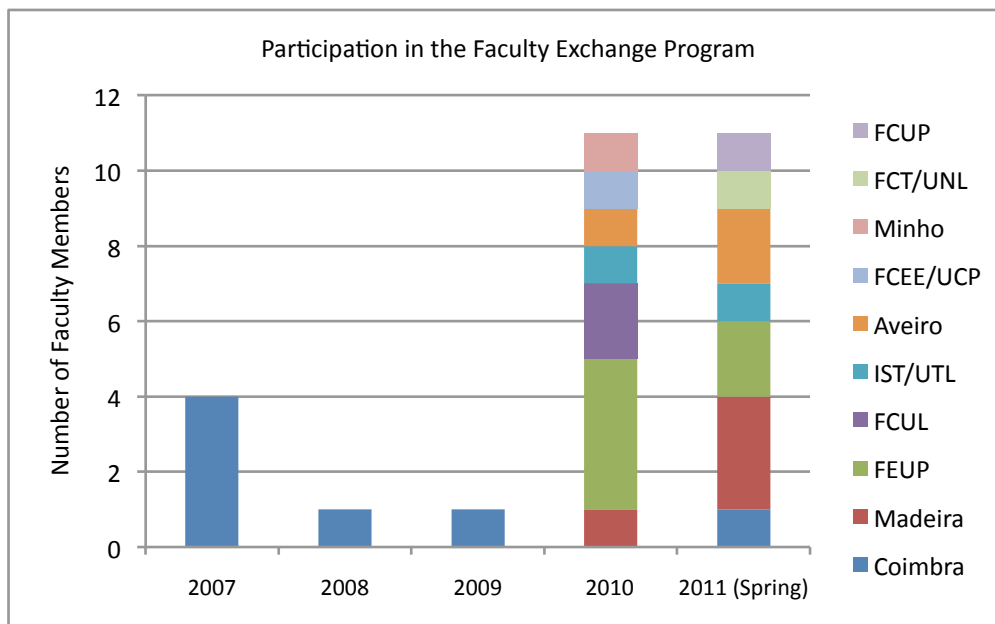
The Carnegie Mellon Portugal Program is having considerable impact at the institutional level, on one hand, by the return of the young assistant professors that participated on the faculty exchange program, and on the other hand with research focus emerging and giving rise to new institutional forms. Examples include: the Madeira–Interactive Technologies Institute (M-ITI), the Software Engineering Institute at Universidade de Coimbra, the PT-Security Lab, a Portugal Telecom research center, and several new thematic networks that were launched in early 2010 and congregate faculty from several campuses as well as experts from high-tech companies working in cross-cutting areas of the Program. These networks include: Future Internet Services and Technologies (NET-FIT), Security and Critical Infrastructure Protection (NET-SCIP), Services and Technologies for Interactive Media (NET-STIM), and Software Engineering (NET-SE). Their focus areas are deliberately aligned with the Digital Agenda of the European Commission in an effort to mobilize the community towards increasing the Portuguese participation in the 7th Framework Program.

#### 3.1. FACULTY EXCHANGE AND RECRUITMENT

The Carnegie Mellon Portugal Program established a nationwide faculty exchange program that supports a semester long visit of a faculty member from a Portuguese University at Carnegie Mellon. Until the end of 2011, more than 30 faculty (mostly young assistant professors) will have participated in this faculty exchange program (Appendix 3).

During their time at Carnegie Mellon, a faculty member from Portugal is exposed to the same environment and working conditions as a colleague at Carnegie Mellon University. The visitor receives a formal appointment as a visiting faculty member, is hosted by a research group, joins the teaching team of a course (undergraduate or graduate level) in a specific area of interest, and is invited to participate in various activities. The goal is to accelerate the adoption of best practices through cultural immersion, giving the opportunity to adopt, adapt, propagate, and consolidate.

Between 2007 and 2009, six faculty members of the University of Coimbra went to Carnegie Mellon where they were formally trained and certified on courses in the context of the Professional Master program in Software Engineering. In order to receive the certification they had to attend graduate courses, teach in graduate courses, prepare new course materials, grade assignments, and mentor student projects. The activities also included participating in weekly research meetings, monthly faculty meetings and, in general, act as full-members of the CMU faculty staff.



In 2010 there were a total of 11 faculty members from 7 different universities that participate in the Faculty Exchange Program, 5 in the spring semester and 6 in the fall semester. Currently in the spring 2011 semester there are 11 faculty members participating in this program raising to 10 the number of Universities participating in this initiative.

On the other hand, there are excellent examples of faculty recruiting. For example, five faculty recruited by Universidade da Madeira with a diversity of backgrounds in HCI coming from a range of places like the (former) Media Lab in Dublin or with PhDs from Carnegie Mellon, Trinity College in Dublin, University College in London, or University of Paris. Other example are the EPP Program hiring researchers from University of California at San Diego (Economics), from Washington University (Statistics), or from the Massachusetts Institute of Technology (MIT) and Universidade Católica Portuguesa using the existence of the Program as successful inducement when recruiting faculty in areas of the Program (APPENDIX 7).

### 3.2. NEW INSTITUTES

The University of Madeira was successful in establishing the Madeira Interactive Technologies Institute (Madeira ITI) in July 2009. The purpose of the institute is to focus on research and graduate education in the areas of information and communication interactive technology. The establishment of the Madeira ITI is a direct result of the success of the educational and research activities in HCI between Carnegie Mellon and the Universidade da Madeira within the Carnegie Mellon Portugal program. The M-ITI now houses the activities in human computer interaction and in entertainment technologies pursued in the context of the Carnegie Mellon Portugal Program at the Universidade da Madeira. The Madeira Interactive Technologies Institute (Madeira-ITI) is a not-for-profit innovation institute of the Universidade

da Madeira, founded by this institution with the Madeira Tecnopolo, and Carnegie Mellon University.

Another example of institutional development is happening in Coimbra. The success of the creation of the Master of Software Engineering program (MSE) in Portugal, hosted by the School of Sciences and Technology of the University of Coimbra, formed the basis for the strategic development of an Excellence Center for Software Engineering, which aims to be renowned in Portugal and abroad.

The University of Coimbra, having a long tradition in software engineering, used the MSE to generate research collaborations with Carnegie Mellon faculty and other faculty groups in Portugal which led to several common research projects approved under the funding call of the Carnegie Mellon Portugal Program. In addition, the strong support from industry led to the creation of the MSE Industrial Affiliates program which has allow a stable relationship with some of the major software companies operating in Portugal.

The establishment of the Institute for Software Engineering will allow to bootstrap the knowledge and experience developed as a result of the Carnegie Mellon Portugal Program. This can be achieved by the synergy among three complementary axes:

- top-level education through the MSE and a PhD program in Software Engineering;
- world-class research in partnership with Carnegie Mellon and industry;
- strong knowledge-transfer to industry by top-quality training and consultancy in software engineering, addressing real problems felt by industry, using experts and knowledge gathered in the center.

To achieve this ambitious goal there is need to setup a knowledge dissemination environment that achieves financial self-sustainability. This requires gathering the adequate expertise, management, and tools which is what the University of Coimbra has focused on with the support of the Carnegie Mellon Portugal Program.

### **3.3. THEMATIC NETWORKS**

The Carnegie Mellon Portugal program launched in 2010 four new thematic networks, whose goal is to consolidate and expand the successful cooperation among all partner institutions and industrial affiliates. These thematic networks gather the expertise of Portuguese research centers, private companies and government agencies. The activities are based on the ongoing research projects and graduate education courses supported under the Carnegie Mellon Portugal Program.

#### **Thematic Network on Security and Critical Infrastructure Protection (NET-SCIP)**

The Thematic Network on Security and Critical Infrastructure Protection (NET-SCIP) gathers the scientific community, the private sector and the main government agencies with the goal of developing comparative advantages for Portugal in new security technologies and services for the protection of critical infrastructures. The steering committee of this network is composed by: Nuno Ferreira Neves (LASIGE/FCUL) [chair], André Zúquete (IEETA, UA) [co-chair], Edmundo Monteiro (CISUC, FCTUC), João Barros (IT, FEUP), José Alegria (Portugal Telecom), José Eduardo Pina Miranda (Multicert), Luís Caires (CITI, FCTUNL), Manuel Barbosa (UMinho), Paulo Mateus (IT, IST/UTL), Vassilis Kostakos (MITI, UMa).

During the year of 2010, this network held two workshops, one in February in Lisbon and the other one in Porto, in October. The workshop held in Porto had 13 abstracts, 2 invited talks and a panel on EU funding, had the participation from 10 research centers spread through the country and a few companies. It covered a reasonable range of topics including: dependable and secure network management, security aspects in sensor and mobile networks, analysis and discovery of vulnerabilities in software, access control to private data, and cryptographic mechanisms.

#### **Thematic Network on Future Internet Services and Technologies (NET- FIT)**

This Thematic Network's goal is to place Portugal at the forefront of innovation in key technologies and services for the Future Internet. The relevance of the Internet for our economy, employment and day-to-day affairs of our citizens is now undisputed. In the future, the global network shall integrate not only a fiber optical backbone, wireless access points and large information systems, but also social networks, intelligent objects, sensor-based cyber-physical systems and communication-enabled vehicles. To maximize the benefits of these new generation networks, NET-FIT is promoting an inter-disciplinary approach, in which engineers, scientists, economists or psychologists can collaborate actively towards the development of new equipment, software architectures and practical applications. Sensitive to the risks of info-exclusion, these technologies should generate new products, services and business opportunities for all kinds of users. The steering committee of this network is composed by : Francisco Moura (UMinho), João Barros (IT, FEUP), Jorge Sá Silva (UC), Luis Miguel Silva (PT-Inovação), Manuel Ricardo (UP), Rui L Aguiar (UA), Teresa Vazão (IST/UTL).

In 2010, this thematic network held an event about Future Technologies and Services, which joined the secretary of state for Science, Technology and Higher Education, researchers, and several CEO's of Portuguese companies.

#### **Thematic Network on Services and Technologies for Interactive Media (NET-STIM)**

The goal of the Thematic Network on Services and Technologies for Interactive Media (NET-STIM) is to place Portugal at the forefront of innovation in key interactive technologies and services for digital media. For this purpose, NET-STIM gathers contributions from the different knowledge areas to foster collaboration towards an innovation cluster of interactive services and technologies for digital media using the international partnerships with Carnegie Mellon University and UT Austin to bootstrap the process. Within the context of these international

partnerships Portugal already provides several world-class graduate education and research initiatives with industry and several research groups from both sides of the Atlantic. The steering committee is composed by: António Câmara (Ydreams), Pedro Branco (Engage Lab, UMinho), Claudia Goya (Microsoft Portugal), Joaquim A. Jorge (INESC-ID, IST/UTL), Miguel Peixoto de Oliveira (Edigma), Verónica Orvalho (IT, FCUP), Diogo Terroso (NearInteraction), Carlos Amaral (Priberam), Isabel Trancoso (INESC-ID, IST/UTL), António Silva (Nonius), Heitor Avelos (UP), Pedro Quintas (Collab/Novabase), Valentina Nisi (Madeira ITI, UMa), José Carlos Gonçalves (Logica Ibérica)

In 2010, the steering committee of this network held an event about Technologies and Services for Interactive Media, which gathered several researchers and CEO's of different companies.

### **Thematic Network on Software Engineering (NET-SEI)**

The Thematic Network on Software Engineering (NET-SEI) intends to raise in Portugal a cluster of innovation in software engineering. Nowadays, software is one of the most important technology, it is “everywhere”, from the most simple household appliance, bank and communication systems, even in the sophisticated systems of defense. In the modern society almost all our activities depend straightly or indirectly of software systems that more and more are necessary, and must work in the intuitive, predictable and robust way. To develop and to maintain software systems it is always an economical activity of enormous relevance and value added for the competitive savings. Since its inception 60 years ago, software engineering has established itself as a discipline of engineering with tremendous economic and social relevance. The study of phenomena related to designing, developing and modifying software systems from a practical point of view is crucial to support the creation of a software industry in Portugal. The network NET-SEI wants to support this development by strengthening the partnership with Carnegie Mellon University (CMU) which is the world's leading research and technology transfer in the area of software engineering, in particular the world-famous Software Engineering Institute (SEI) – Institute who leads the certification and transfer of technology in the area of software engineering. The steering committee is composed by: Ademar Aguiar (FEUP), Alberto Silva (IST/UTL), Ana Moreira (FCTUNL), Antónia Lopes (FCUL), Bruno Cabral (FCTUC), João Cachopo (IST), João M. Fernandes (UMinho), Larry Constantine (UMa), Leonel Nóbrega (UMa), Luís Caires (FCTUNL), Marco Vieira (FCTUC), Nuno Nunes (UMa), Raul Vidal (FEUP), Ricardo J. Machado (UMinho), Vasco Vasconcelos (FCUL).



## **APPENDIX**

### **1. PARTICIPANTS**

#### **1.1. ACADEMIC PARTNERS AND RESEARCH INSTITUTES**

#### **1.2. COMPANY INVOLVEMENT**

### **2. STUDENTS (PhD & Masters)**

### **3. FACULTY EXCHANGE**

### **4. JOINT PUBLICATIONS**

### **5. ACCREDITED COURSES (PhD & Masters)**

### **6. RESEARCH PROJECTS**

### **7. FACULTY RECRUITMENT**

### **8. UTEN Initiative - Portuguese University Technology Enterprise Network**

### **9. EVENTS & COMMUNICATION**

### **10. REPORTS (ERC, PROJECT REVIEW, MSc REVIEW)**

### **11. STRATEGIC PLAN**