## FCT Fundação para a Ciência e a Tecnologia

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR



# Concursos de Projectos de I&D

Calls for R&D Projects

- Voltar à descrição do projecto Back to project description
- Imprimir esta página Print this page

### Visão global da candidatura

Application overview

#### Ocultar todos as secções desta candidatura Hide all sections for this application

Referência do projecto

Project reference PEst-OE/EEI/UI0027/2011 (Lacrado a 19-04-2011 às 14:15)

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#### 1. Identificação do projecto

1. Project description

# Área científica principal

Main Area Engenharia Electrotécnica e Informática

#### Área científica Secundária Secondary area (Vazio) (Void)

**Título do projecto (em português)** Project title (in portuguese) Projecto Estratégico - UI 27 - 2011-2012

**Título do projecto (em inglês)** Project title (in english) Strategic Project - UI 27 - 2011-2012

Financiamento solicitado Requested funding 120.808,00€

Palavra-chave 1 Inteligência Artificial Distribuída

Palavra-chave 2 fiabilidade de software

Palavra-chave 3 Sistemas Multi-Agente

Palavra-chave 4 Programação Declarativa Keyword 1 Distributed Artificial Intelligence

**Keyword 2** software reliability

**Keyword 3** Multi- Agent Systems

**Keyword 4** Declarative Programming \_

Data de início do projecto Starting date	Duração do projecto em meses Duration in months
01-01-2011	24
<ol> <li><b>2. Instituições envolvidas</b></li> <li>2. Institutions and their roles</li> </ol>	-

#### Instituição Proponente Principal Contractor

Universidade do Porto (UP)

Praça Gomes Teixeira 4099-002Porto

#### Unidade de Investigação Research Unit

#### Laboratório de Inteligência Artificial e Ciência de Computadores (LIACC/UP)

FEUP-DEI, Rua Dr. Roberto Frias, s/n 4200-465Porto

#### 3. Componente Científica

#### 3. Scientific Component

## 3.1. Sumário

#### 3.1 Abstract

#### 3.1.a Em português

#### 3.1.a In Portuguese

O Projecto Estratégico aqui proposto pretende contribuir para suportar a Unidade de Investigação LIACC em 2011-2012. LIACC, Laboratório de Inteligência Artificial e Ciência de Computadores da U. Porto, existe desde 1988 e integra 19 doutorados e mais cerca de 20 outros membros pertencentes a 2 grupos de investigação (Ciências da Computação – CS, e Inteligência Artificial Distribuída e Robótica – DAI&R), essencialmente residentes na Faculdade de Ciências (FCUP) e na Faculdade de Engenharia da Universidade do Porto (FEUP).

Os doutorados não investigam a tempo integral, estando fortemente envolvidos na docência (8 a 12 horas/semana), mas o compromisso com a investigação é inquestionável.

DAI&R, localizado na FEUP, direcciona os seus esforços de R&D para modelos de software e implementações de protótipos como provas de conceitos relevantes. O grupo CS, da FCUP, dedica-se, mas não exclusivamente, à investigação teórica. Ambos estão fortemente envolvidos na supervisão de pós-graduações.

Nos próximos dois anos, o LIACC mantém o objectivo de ajudar a encontrar soluções para:

- ambientes Distribuídos, Dinâmicos e Descentralizados (DDD).

Abordamos classes de problemas de natureza distribuída, dinâmica e descentralizada, como os que ocorrem quando entidades heterogéneas necessitam de inter-operar numa rede de computadores para, alcançarem objectivos conjuntos. Para lidar com estes problemas organizacionais, desenvolvemos plataformas chamadas de Instituições Electrónicas (IE). Uma IE oferece serviços como negociação automática, mapeamento de ontologias, especificação de contratos, monitorização de mensagens e aplicação de normas institucionais, bem como a avalia indicadores de confiança e reputação, para assistir na automatização do ciclo de vida de consórcios e organizações virtuais.

Para gestão de tráfego, os Sistemas Artificiais para Transporte (SAT) terrestres ou aéreos existem também problemas do tipo DDD. Mapeando em domínios virtuais modelos e soluções de transporte, SAT ajudam na tomada de decisão em ambiente controlado e seguro. No projecto MASDIMA usamos tecnologia Multi-agente para representar as operações no Centro de Controlo Aéreo e aplicamos negociação automática para resolver problemas inesperados durante a execução do plano prévio. Estes problemas são melhor abordados por meio do paradigma dos Sistemas Multi-Agentes (SMA). Uma melhor interoperabilidade e coordenação de agentes implicam capacidades de negociação e adaptação, ambientes normativos, arquitecturas cognitivas de agentes e plataformas de simulação baseadas em agentes. Domínios de aplicação incluem Instituições Electrónicas para B2B, estratégias de coordenação para equipas de robôs e gestão de tráfego. Avanços relevantes são esperados na investigação em técnicas para "Text mining" e Extracção de Informação focadas nos conteúdos jornalísticos (notícias e conteúdos gerados "on-line"), como os dos microblogs e comentários "on-line".

#### - Fiabilidade e Segurança de Software e Processamento de Dados

A fiabilidade do software é ainda o principal desafio da ciência de computadores. A engenharia de software não cumpriu as suas promessas; abordagens formais baseadas em especificações formais e demonstração de teoremas não lidam bem com programas reais de especificações fluidas; testes unitários melhoram a fiabilidade de partes de um programa, mas não do seu todo; projecto por contrato, combinado com inferência de tipos, ajuda à fiabilidade mas sem garantia de correcção. Acreditamos ser necessária uma combinação destas abordagens, por exemplo um esquema integrador de metodologias de programação declarativa, métodos de verificação formal e geração/validação de testes.

A segurança de software e comunicação de dados é uma preocupação central em ciência de computadores. A criptografia de

chaves públicas baseia-se na intratabilidade do problema associado de quebra do código, mas isto é normalmente avaliado em complexidade do pior caso, sendo necessárias melhores medidas de segurança; um candidato interessante é a versão de tempo limitado da complexidade de Kolmogorov. Outro problema de segurança deriva da necessidade de executar código externo, que pode abrir a porta a ataques; uma solução é forçá-lo a incluir uma prova de que não quebra a segurança, o que exige suporte ao desenvolvimento de provas de propriedades de programas. A representação de informação é um tópico crucial em ciência de computadores. A coerência e fiabilidade da informação ainda são deixadas ao cuidado do programador, e não induzidas pelos métodos e ferramentas de software para armazenamento de dados e a sua migração entre representações. Há uma forte necessidade de modelos, arquitecturas e ferramentas baseadas em modelação conceptual, dirigidas à fiabilidade no processamento de informação.

Tendo como áreas de trabalho as especificadas acima, o LIACC visa desenvolver investigação através de modelos, protótipos e publicações, e apoiar teses de jovens investigadores.

#### 3.1.b Em inglês

#### 3.1.b In English

This strategic Project proposal intends to help on supporting LIACC Research Unit for 2011-2012. LIACC, Laboratory of Artificial Intelligence and Computer Science at the U. of Porto, exists since 1988 and includes 20 PhDs plus about 20 other members belonging to two research groups (Computer Science-CS, and Distributed Artificial Intelligence & Robotics-DAI&R) mainly residing in the Faculty of Sciences (FCUP) and the Faculty of Engineering (FEUP). Although none of the researchers holding a PhD is doing research in full-time, once they are also heavily involved in lecturing (8 to 12 hours/week), our commitment to research is unquestionable.

DAI&R, mainly located at the FEUP, directs its R&D efforts both towards software models and prototype implementations as relevant proof of concepts. CS, FCUP group, is devoted, though not exclusively, to theoretical research. Both groups are heavily involved in post-graduation supervision. In the next two years, LIACC aims at helping to find solutions for: - Distributed, Dynamic and Decentralized (DDD) problems

We address classes of problems that are of a DDD nature as those occurring when heterogeneous entities need to inter-operate over a computer network to jointly achieve their goals. To deal with these organizational problems, we aim at develop platforms called Electronic Institutions (EI). EI provides services like negotiation mediation, ontology mapping, contract drafting, monitoring of messages exchanging norms enforcement, as well as evaluation of trust indicators for consortia and Virtual Organizations life-cycle automatic assistance.

In the traffic management domain, Artificial Transportation Systems (ATS) both in terrestrial and aerial environments are DDD problems. With the ability to integrate different transportation models and solutions in a virtual environment, we investigate how to support decisions made in a controlled and safe manner. In the context of MASDIMA project, we use Multi-Agent Systems (MAS) to represent the Airline Operational Control Center and negotiation to solve unexpected problems that might appear when executing the airline plan.

These problems are better addressed through MAS paradigm. However, improvements are required for better interoperability and team coordination. Approaches to tackle these issues include using Negotiation and Adaptation capabilities, normative environments design, agent cognitive architectures and agent-based simulation platforms. Selected application domains are Electronic Institutions for B2B, agents' team coordination strategies for robotics and traffic management.

Important advances are expected in text-mining and information extraction techniques specially focusing on journalistic content (online news and user-generated contents), such as microblogs, blog, and on-line comment. - Reliable and Safe Software and Data Processing

Software reliability is still the main challenge in computer science. Software engineering approaches have not fulfilled their promise; formal approaches based on logic specifications and theorem proving have trouble handling real programs with loose specifications; unit tests improve the reliability of parts of the program but fail to guarantee reliability of the whole; design by contract approaches combined with type inference can improve reliability but do not guarantee correctness. We believe that a combination of different approaches should be used, e.g. frameworks integrating declarative programming methodologies, formal verification techniques and test generation and validation.

Security of software and data communication is also a major concern. Public key cryptography is based on the computational intractability of the associated code breaking problem, but this is normally judged on worst case complexity and better measures of security are needed; one promising approach is the use of time bounded versions of Kolmogorov complexity. Another safety problem arises from the need to execute foreign code that may open the door to attacks; one solution is to force foreign code to include a proof that it will not break security, an approach requiring support for the development of proofs of program properties.

Representation of information is a crucial topic in computer science. Coherence and reliability of information is still almost completely left to programmers, and not induced by current software methods and tools for data storage and migration between representations. There is a strong need for concept-based models, architectures and tools aimed at achieving reliability in information processing. The above areas and topics are those in which LIACC aims at developing further research through models, prototypes and publications as well as to assist young researchers to develop their thesis work. LIACC intends to enlarge its outreach looking for impact, not only on our academic peers, but also on the society through joint projects with companies, seminars and exhibitions.

3.2. Descrição Técnica

3.2 Technical Description

3.2.2. Plano e Métodos

3.2.2. Plan and Methods

In last decade LIACC has incorporated several specialization capabilities and embraced new research directions that seemed promising. Several researchers came in and went, resulting in a frequent reconfiguration, with a proper adjustment to the environment.

LIACC encompasses two research groups with complementary backgrounds and sensibilities, both the pragmatic, engineeringdriven approach to science and a more theoretical and fundamental one. This split relies on the origin of the groups: Faculty of Engineering and Faculty of Sciences.

The main motto of LIACC could be "To develop and deploy intelligent, reliable, declarative software solutions to problems recognized as being hard, large, distributed and/or critical".

The nature of these problems demands methods for dealing with:

a) Reliable and Safe Software and Data Processing;

b) Coherent, coordinated and decentralized inter-operability of programs;

c) Intelligent methods for inference, evolution and adaptation of programs.

A different clustering of research themes can be done according to the potential application domains. LIACC pursues multidisciplinary research for the following: Health and Bioinformatics, Automatic Electronic Business, Web-based media and text analysis, Traffic Management, Organizational Information Systems, Robotics and Games, and Architectures for Real-time systems.

a) our plan encompasses studies and software implementations addressing many of the corresponding concerns expressed in LIACC's objectives, grouped as follows.

- Towards declarative information systems

A major problem in building organizational information systems is the speed and versatility required by the business. We address the problem through an innovative approach based on three main axes: declarative programming as the base paradigm; high-level languages for specifying conceptual models and queries/commands to corresponding databases; and an architecture based on conceptual modelling, used to structure a hierarchy of parametric themes for services, navigation channels and authorization groups.

Having recently consolidated the scientific basis of this vision, we will now develop and integrate the pieces into a solid declarative environment for building information systems incorporating tools for concept-based development and testing. We shall assess and demonstrate the virtues of the approach by building a concrete system for our own research centre.

- Resource handling by programs

Linearity—when an argument to a function is used exactly once—is a property that a compiler can use to optimise code, using fewer resources. This is related to several program analyses such as strictness or pointer analysis, and linear functions naturally occur in hardware compilation. Linear versions of functional programming were proposed, but they're too restrictive. Focusing on functional programs in the near future, our long-term goals are to extend previous linearization techniques to general computation models (Turing complete) and to define new linearization algorithms for other paradigms: concurrency, logic programming and rewriting. In complement to imposing linearity we will also work on reasoning about resources in more general programming contexts, e.g. performing type-based amortized analysis for resource usage of lazy functional programs. - Sequential data manipulation

In the context of Web programming we see a proliferation of languages for querying XML, explicitly or implicitly using sequences of terms. A single XML processing model would help, so we aim to define it with a strong theoretical basis to deal with arbitrary length sequences of terms. We then want to design and implement a language based on the new model, hoping that our foundational work will lead to a better understanding of the relevant features to consider for good sequence manipulation.

- Formal verification

In this very broad topic we restrict our efforts to two contexts.

One is safety and reliability of real-time systems. In particular, we will study deductive calculi and associated proof systems able to capture low-level contingencies of hardware such as pipelining and caches.

The other focus is on particular axiomatic semantics for distributed and concurrent systems, namely those based on rely-guarantee mechanisms and separation logic, to allow the automation of resulting obligation proofs.

- Kolmogorov complexity

Our aims here involve three main threads: to proceed with an individual characterization of cryptographic primitives using Kolmogorov complexity, to relate entropy measures with Kolmogorov complexity, and to study the communication complexity of random functions.

b) mostly encompasses methods, techniques and tools to tackle Distributed, Dynamic and Decentralized (DDD) problems. In the Automatic Electronic Business domain, heterogeneous entities need to inter-operate over a computer network to jointly achieve their goals [HCarDTEOI 09]. To deal with these organizational problems, we aim to develop platforms called Electronic Institutions (EI) [HCar 10] [HCarEOI 08]. Our own approach clearly differs from parallel efforts under development in other research centers [FDig 01] [ArCS 05].

The emphasis will be on: i) improving a platform (EI) for agent-based Electronic Business, and aggregating research on negotiation protocols, ontology mapping, normative environments for contract monitoring and computational trust; ii) proposing a model for trust-aware contract negotiation; iii) developing adaptive mechanisms allowing a normative environment to change according to agent population; iv) Dynamic Profiling of E-Business entities v) developing Argumentation-based negotiation for cooperative environments.

Traffic management domain, both in terrestrial and aerial environments, are DDD problems. These problems are better addressed through Multi-Agent Systems (MAS) paradigm.

LIACC (R.Rossetti) is represented in the IEEE Intelligent Transportation System Society's Board of Governors. We use Artificial

TS to integrate different transportation models and solutions in virtual environments for transport management and control as well as for advanced traveller information systems. In MAS-T2er Lab Project we intend to develop an integrated MAS allowing for the assessment of today's intelligent transportation solutions through the metaphor of agents. The application domain is conceptualised through three basic subsystems: real world, virtual domain where agents are instantiated, and control strategies inductor observing the virtual domain to infer better control policies. A network editor, a Pedestrian Modelling Platform, an Agent-based API to support multi-paradigm traffic simulation are under development [RREOI 08] [PFeOI 08]. In the MASDIMA project [ACaEOI 11] we will use MAS technology to represent the Airline Operational Control Center, with algorithms for automated negotiation to solve unexpected problems appearing when executing the airline plan. MASDIMA will include: learning capabilities, including CBR, in the agents strategy; human-in-the-loop capability as an ultimate decision-maker; and argumentation-based negotiation during the global solution finding process.

Regarding MAS for team's coordination strategies, we will tackle vehicles and robotsoccer teams' coordination. A platform providing a realistic simulation with teams of autonomous vehicles is being developed. The vehicles are heterogeneous in type (aircraft, ground vehicles, boats and submarines) and capabilities (speed and sensors perception). Also, the construction and application of an intelligent system for the analysis and simulation of soccer tactical behaviours is now starting. It is based on a RFID tracking system, leading to game analysis and new tactics simulation.

MAS and Service-oriented architecture will be combined for manufacturing scheduling and control. Agent-based systems will be deployed in electronic automation controllers (PLCs and microcontrollers) and integrated with SCADA systems. Also, work on Cloud computing will address topics related to scheduling, availability and Service Level Agreement requirements (SLA).

#### c) Intelligent methods for inference, evolution and adaptation

We will pursue (in co-operation with Imperial College) the development of bioinformatics processes and strategies based on AI methods (machine learning, biostatistics), for the analysis and integration of gene expression, genetic variation and metabolic profiles [MaACAI 10]. The focus is on inflammatory and immune mediated diseases.

In Text Mining our research will continue along four lines [GLaLSaEOI 10]: i) Pre-processing of user-generated contents (UGC) to filter noisy information (spam, robot generated contents, spelling errors, non-standard use of language and idiosyncratic lexical variations); ii) Information extraction over on-line news content (biographic information, event information, quotations and relations between entities); iii) Opinion-mining over UGC, essentially from Twitter messages; iv) Topic Classification of news items for filtering and recommendation purposes.

We will also develop a Web based search tool using Text Mining methods to help find relevant literature in specific topics [CGCeTa 10]. A classifier will identify, for each set of genomic or proteomic sequences given by the user, the most relevant available related scientific publications. For this we need techniques to reduce the number of attributes characterizing documents, different Machine Learning algorithms including ILP, and ranking algorithms for the retrieved documents.

In all the above areas and topics LIACC aims at furthering its research through models, prototypes and publications as well as assisting young researchers in their thesis work.

LIACC also clearly looks for ways to enhance its outreach, achieving impact not only on our academic peers but also on society at large, through joint projects with companies, seminars and exhibitions.

# **3.2.3. Planeamento de grupos e linhas 3.2.3. group planning**

# Grupos e linhas<br/>GroupsNome do grupo ou linhaData de inícioData de fimDuraçãoGroup nameStart dateEnd dateDurationComputer Science Group01-01-201131-12-201224

## Planeamento do grupo ou linha

Group planning

The planned activities of the CS group address mainly LIACC's global objective of "reliable and safe software and data processing", encompasses several studies and corresponding implementations on these topics: declarative software architecture for building large organizational information systems, linearity and resource analysis in functional programs, models and languages for data manipulation, formal verification of safety and liveness properties for real-time and distributed systems, and safety applications of Kolmogorov complexity.

- Towards declarative information systems

The attempt by organizations to build their own information systems usually hits a hard reality: the inability, with current IT technology, to create and maintain such systems with the speed and versatility required by the business. We envisage a qualitative jump in the attack to this problem, through an innovative approach based on three main axes: 1) the use of declarative programming as the base paradigm, namely a logic programming variant designed for professional applications; 2) high-level languages for specifying conceptual models and queries/commands to corresponding databases, borrowing compositional principles from natural language that strongly contribute to conciseness and legibility; and 3) an architecture for information systems based on conceptual modelling, used to structure a hierarchy of parametric themes (where services reside), navigation channels among them, and authorization groups, inducing compositions of declarative elements through inheritance with fine-level overriding.

In recent years the scientific basis of this vision has been consolidated, namely with a simple compositional semantics for the base language Cube (a structured alternative to Prolog), a formalization of the powerful language NADI for natural interaction with databases, and the design of the forms of composition inherent in the COMPASS architecture based on concepts, themes, channels, services and groups. Our workplan for the next years rests on the research and development that are needed to achieve a solid version of a declarative environment for building information systems, based on COMPASS and incorporating powerful tools for development and testing, namely addressing the tough problem of change management for the conceptual scheme. A complementary work of more applied nature is the practical assessment and demonstration of the virtues of the approach, by building a concrete system for our own research centre. These activities will be conducted in collaboration with SQIMI, a young startup company interested in basing its software solutions in this kind of technology.

#### - Resource handling by programs

Knowing that an argument to a function is used exactly once—linearity—is a property that a compiler can make use of to produce optimized code to use fewer resources. Linearity is related to several kinds of program analysis, e.g. strictness and pointer analysis. Linear functions are also naturally occurring in hardware compilation. Some linear versions of functional programming have been proposed and studied, but they're too restrictive. Focusing on functional programs in the near future, our plan is to try to extend previous linearization techniques, starting from our own contribution [AFFM 10] to general computation models that are Turing complete, and to define new linearization algorithms for other paradigms such as rewriting, logic programming and concurrency.

In a complementary position to devising languages with restrictions such as linearity, we plan to work on how to reason about resources in more general programming contexts, e.g. performing type-based analysis of the usage of the heap in functional programs.

#### - Sequential data manipulation

In the context of Web programming we see a proliferation of languages for querying XML, all using explicitly or implicitly the notion of sequence of terms. Standardization being crucial for collaborative work, a single XML processing model would be ideal, so we aim to define a computation model to deal with programming with arbitrary length sequences of terms, with a strong theoretical basis on sequence, context and second-order unification. We then want to design and implement a language based on the new theoretical model, hoping that this foundational aspect will lead to a better understanding of what are the relevant features to consider for a good language for sequence manipulation.

#### - Formal verification

This being a very broad topic, we restrict our efforts to two contexts.

One is safety and reliability of real-time systems. In particular, we will study deductive calculi (and associated proof systems) allowing us to capture low-level contingencies of hardware such as pipelining and caches.

The other focus is on particular axiomatic semantics for distributed and concurrent systems, namely those based on rely-guarantee mechanisms and separation logic, to allow the automation of resulting obligation proofs.

#### - Kolmogorov complexity

Our aims in the application of Kolmogorov complexity to security involve three main threads: to proceed with an individual characterization of cryptographic primitives using Kolmogorov complexity, to relate entropy measures with Kolmogorov complexity, and to study the communication complexity of random functions.

Nome do grupo ou linha	Data de início	Data de fim	Duração
Group name	Start date	End date	Duration
Distributed AI and Robotics Group	01-01-2011	31-12-2012	24
Planeamento do grupo ou linha			

#### Group planning

DAI&R addresses classes of problems that are, mostly, of a Distributed, Dynamic and Decentralized nature. We divide our research into four different lines:

a) MAS interoperability for B2B; b) Robotics and Teams coordination; c) Text Mining; d) MAS-based simulations and Applications.

We pursue multi-disciplinary research illustrating proof of concepts for different application domains: Electronic Business, Web-based text analysis, Traffic management, Health and Bioinformatics, Robotics and Games.

a) For MAS inter-operability, we integrate new features in an agent-based platform for the Electronic Business domain. Here, heterogeneous entities need to inter-operate over a computer network to jointly achieve their goals [HCarDTEOI 09]. We aim at developing Electronic Institution (EI) platform [HCar 10] [HCarEOI 08] which clearly differs from parallel efforts in other research centers [FDig 01] [ArCS 05].

Emphasis will be on: i) improving the EI aggregating our research on negotiation protocols, ontology mapping, normative environments for contract monitoring and computational trust; ii) proposing models for trust-aware contract negotiation.

(pre-selection and selection of contractual peers and for negotiation of specific contractual terms). Furthermore, we aim at including argumentation techniques in this framework; iii) developing adaptive strategies allowing dynamic normative environments depending on agent population (different risk tolerances). This social sanctioning mechanism will preclude contract violations while enforcing a non over-constraining level of control; iv) dynamically assigning a profile to a business entity according to information related to economic activity and gathered from social networks; v) Developing Argumentation-based negotiation approaches for cooperative environments.

b) For Robotics and Team Coordination we will: define high-level languages for missions description and coordination strategies (tactics, flexible formations or setplays) to execute tasks in dynamic environments; develop a common framework to control different agents/robots for cooperative tasks; develop strategies for cooperation of humanoid robots and human teams; validate our approaches through participation in RoboCup. We are also developing: A platform for realistic simulation of heterogeneous vehicles in terms of type (aircraft, ground vehicles, boats and submarines) and capabilities; an Intelligent Wheelchair (IW) including: Safe autonomous navigation, obstacles avoidance; intelligent Users interface; communication with the environment (automatic doors and other IW); an intelligent system for the analysis and simulation of soccer tactic behaviors, based on RFID tracking system.

c) Research on text-mining and information extraction will focus on journalistic content of online news and user-generated contents (UGC), such as microblogs, blog, and on-line comment. We here distinguish four tracks: i) Pre-processing of UGC, for filtering noisy information (spam, robot generated contents, spelling errors, non-standard use of language and idiosyncratic lexical variations) and developing tools for language processing in UGC (tokenization, sentence segmentation, name normalization and robust named-entity recognition and resolution) [GLaLSaEOI 10]; ii) Information extraction from on-line News content (biographic and event information, quotations and relations between entities) [LSaAKEOLUN 09]; iii) Opinion-mining over UGC about entities on Twitter messages (due to its instant nature); iv) Topic Classification of News items for recommendation purposes, including classification with scarce supervised information for training classification models [LSaSNJTEEOI 09].

A related issue is a Web based search tool for finding relevant literature in specific topics [CGCeTa 10]. The classifier will identify, for each set of genomic or proteomic sequences given by the user, what are the most relevant available related scientific publications.

d) MAS based simulation and Applications

We intend to integrate different transportation models in virtual environments for transport management and control and for advanced traveller information systems. We will further develop the Lab for MAS-based Traffic and Transportation Engineering Research as an integrated MAS for the assessment of today's transportation solutions, through the agents metaphor. This framework includes 3 basic subsystems: real world, virtual domain where agents are instantiated, and control strategies inductor to infer better control policies by observing the virtual domain. A network editor, a Pedestrian Modelling Platform and an Agent-based API to support multi-paradigm traffic simulation are under development [RREOI 08] [PFeOI 08]. In MASDIMA project [ACaEOI 11], we use MAS to represent the Airline Operational Control Centre and negotiation to solve unexpected problems appearing during airline plan execution. MASDIMA will include: i) learning capabilities in the agents' strategy; ii) Human-in-the-loop capability as an ultimate decision-maker; iii) Argumentation-Based Negotiation to find a global solution.

A broader scope for agent-based simulation includes Intelligent Simulation of Social Systems. A tool to discover, compile and present information deeply hidden in dense and complex social networks is under development.

MAS and SOA, will be combined for manufacturing scheduling and control. We pursue the deployment of MAS based systems in electronic automation controllers and integration with SCADA systems. Cloud Computing will address topics related to scheduling, availability and Service Level Agreement requirements. Finally we will extend our method for accurate three-dimensional reconstructions of the human spine.

DAI&R hopes at improving its influence on the non-academic environment by increasing contacts with organizations and companies. We will continue scientific supervision of post-graduate students and improve publications impact.

#### 3.3. Referências Bibliográficas 3.3. Bibliographic References

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[JurHCaEOI 10]	2010	Joana Urbano, Henrique Lopes Cardoso, Eugénio Oliveira (2010). "Making Electronic Contracting Operational and Trustworthy", in Advances in Artificial Intelligence – Proceedings of the 12th Ibero-American Conference on Artificial Intelligence (IBERAMIA 2010), Lecture Notes on Artificial Intelligence V. 6433, Springer, ISBN 978-3-642-16951-9, pp. 264-273, Bahía Blanca, Argentina, November 1-5, 2010.
[LSaAKEOLUn 09]	2009	Sarmento, L., Kehlenbeck, A., Oliveira, E., Ungar, L. (2009). "Efficient clustering of web-derived data sets", Proceedings of the International Conference on Machine Learning and Data Mining (MLDM) 2009, Leipzig, Lecture Notes in Artificial Intelligence,Springer Verlag V.5632, pp.398-412.
[LSaSNJTeEOI 09]	2009	Sarmento L., Nunes S., Teixeira J., Oliveira E. (2009) "Propagating Fine-Grained Topic Labels in News Snippets" in the Workshop Intelligent Analysis and Processing of Web News Content integrated in IEEE/WIC/ACM International Joint Conference on Web Intelligence and Intelligent Agent Technology 2009. pp.515-518, Milan, Italy, 15 September 2009.
[MaACAI 10]	2010	P.Masson, A.C.Alves, T.M.D.Ebbels, J.K.Nicholson and E.J.Want, "Optimization and Evaluation of Metabolite Extraction Protocols for Untargeted Metabolic Profiling of Liver Samples by UPLC-MS", Analytical Chemistry, 82, 7779-7786.
[PFeOI 08]	2008	Paulo A.F. Ferreira, Edgar F. Esteves, Rosaldo J.F. Rossetti, Eugénio C. Oliveira, " A Cooperative Simulation Framework for Traffic and Transportation Engineering", in Y. Luo (Ed.) Cooperative Design, Visualisation, and Engineering, Proceedings of the 5th International Conference, CDVE 2008, Calvia, Mallorca, Spain, September 21-25, 2008, LNCS, Springer, Volume 5220/2008, pp. 89-97, ISBN 978-3-540-88010-3
[RREOI 08]	2008	Rosaldo J. F. Rossetti and Paulo A. F. Ferreira and Rodrigo A. M. Braga and Eugénio C. Oliveira,"Towards an Artificial Traffic Control System", in 11th International IEEE Conference on Intelligent Transportation Systems, ITSC 2008,pp.14-19, Beijing, China,Oct. 12-15,2008
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[AFFM 10]	2010	Sandra Alves, Maribel Fernández, Mário Florido and Ian Mackie. Linearity and Iterator Types for Gödel's System T. International Journal on Higher-Order and Symbolic Computation, doi:10.1007/s10990-010-9060-x, Springer Netherlands, 2010.

#### **6. Indicadores previstos**

6. Expected indicators

Indicadores de realização previstos para o projecto Expected output indicators -

- Public Pois           Living Statistics           Living Statistics           Living Statistics           Living Statistics           Artigos en revistas intermacionais           Pages in international journals           Artigos en revistas intermacionais           Pages in international journals           B - Comunicações           Comunicações en encortos científicos internacionais           Comunicações en encortos científicos en acionais           Comunicações en encortos científicos en acionais           Pagos in atendon atentos           Comunicações en encortos científicos en conferências           D - Organização de seminários e conferências           D - Organização de actividade semination           C - Aplicações computacionais           D - O         0           D -	<b>Descrição</b>		2011	2012	2013	2014	2015	5 Total
Intrast         Intrast <thintrast< th=""> <th< td=""><td>A - Publicações</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></th<></thintrast<>	A - Publicações							
Books         0         1         0         0         0         0         2           Artigs em revistas internacionais         12         12         0         0         0         24           Artigs em revistas internacionais         2         2         0         0         0         4           Artigs em revistas internacionais         2         2         0         0         0         4           Artigs em revistas internacionais         2         2         0         0         0         4           Comunicações em encontros científicos internacionais         2         2         0         0         0         8           Comunicações em encontros científicos internacionais         2         2         0         0         0         8           Comunicações em encontros científicos internacionais         2         2         0         0         0         8           Porganização de seminários e conferências         10         10         0         0         0         20           Constructuraçõe avançada         2         2         0         0         0         4         0         0         0         4           Cotas avançada         15         15	Livros		0	1	0	0		) 1
Artigos en revistas internacionais       12       12       0       0       0       24         Artigos en revistas nacionais       2       2       0       0       0       4         Be - Comunicações       Comunicações       80       60       0       0       0       4         Comunicações en centros clintíficos internacionais       2       2       0       0       0       4         Comunicações en encortos clintíficos internacionais       2       2       0       0       0       4         Comunicações en encortos clintíficos internacionais       2       2       0       0       0       8         Comunicações en encortos clintíficos internacionais       2       2       0       0       0       8         Organização de seminários e conferências       10       10       0       0       0       40         Outros       2       2       0       0       0       40       40       0       0       40         Protogos avançada       2       2       0       0       0       0       40       40       40       40       40       40       40       40       40       40       40       40	Books		0	T	0	0	C C	· ·
Artigios em revistas hactorianis       2       2       0       0       0       4         B - Comunicações       Comunicações em encontros científicos internacionais       80       80       0       0       0       160         Comunicações em encontros científicos internacionais       2       2       0       0       0       4         Comunicações em encontros científicos nacionais       2       2       0       0       0       4         Comunicações em encontros científicos nacionais       2       2       0       0       0       4         Comunicações em encontros científicos nacionais       2       2       0       0       0       8         Comunicações emenas and conterências       10       10       0       0       0       40         Organazton of semanas and conterências       20       20       0       0       40         Avanced tarianig       2       2       0       0       0       40         Outras       2       2       0       0       0       16         Outras       2       0       0       0       2       0       0       2         Outras       0       0       0	Artigos em revistas internacionais Papers in international journals		12	12	0	0	C	) <b>24</b>
B - Commit Catgoes Communications Communications in menonitros científicos internacionais Communicatos em encontros científicos nacionais Communicatos em encontros científicos nacionais Communicators em encontros científicos nacionais Reports         80         80         0         0         4         4         0         0         4           C - Relatórios Reports         4         4         0         0         0         8           D - Organização de seminários e conferências Construitorios avançada Avanced training Teses de Mostrado         2         4         0         0         0         6           Teses de Mostrado         20         20         0         0         4         4           Avanced training Teses de Mostrado         2         2         0         0         0         4           Others         2         2         0         0         0         0         16           G - Aplicações computacionais Software         15         15         0         0         2         0         0         2           I - Prototipos laboratoriais Prototyces         0         0	Artigos em revistas nacionais Papers in national journals		2	2	0	0	C	) 4
communicações em encontros científicos internacionais         80         80         0         0         0         160           Communicações em encontros científicos internacionais         2         2         0         0         0         4           Communications in netrohom meetings         4         4         0         0         0         8           Communications in netrohom meetings         10         10         0         0         0         20           C - Relatórios         4         4         0         0         0         0         20           Communications in netrohom meetings         2         4         0         0         0         0         20           Corganização de seminários e conferências         10         10         0         0         0         4           Corganização de seminários e conferências         20         20         0         0         40           Advanced trainig         Teses de Mostrado         20         20         0         0         4           Reser de Mostrado         20         2         0         0         0         16           Cotaris         6         - Allegot         8         8         0	B - Comunicações							
Consultações em encontros científicos nacionais communications in national meetings         2         2         0         0         4           Consultações em encontros científicos aconferências Organização de seminários e conferências Organização de seminários e conferências         10         10         0         0         20           Cancel aconstructuras en diconferences         2         4         0         0         0         6           E- Formação avançada Advanced training         Teses de Doutoramento         2         4         0         0         0         40           Pho Theses         2         2         0         0         0         40           Outras         2         0         0         0         0         30           H- Instalações piloto         0         2         0         0         0         0           Patentes         0         0         0         0         0         0         0	Comunicações em encontros científicos internacion	ais	80	80	0	0	C	) <b>160</b>
C - Relatórios       4       4       0       0       0       8         Reports       10       10       0       0       20       20         Organização de seminários e conferências       10       10       0       0       20       20         Organização de vançada       Advancet training       -       -       7       8       0       0       0       40         Advancet training       -       2       4       0       0       0       40         Pho theses       2       2       0       0       0       40         Outras       2       2       0       0       0       40         Outras       2       2       0       0       40         Outras       2       2       0       0       40         Outras       2       0       0       0       30         Software       15       15       0       0       0       20         Protótipos laboratoriais       0       0       0       0       0       0       0         Patentes       0       0       0       0       0       0       0	Comunicações em encontros científicos nacionais		2	2	0	0	C	) 4
Reports       4       4       0       0       0       35         D - Organização de seminário e conferências       10       10       0       0       0       20         E - Formação avançada       Advanced training       2       4       0       0       0       6         Advanced training       2       2       0       0       0       4         Teses de Mestrado       20       20       0       0       4       6         Master theses       20       20       0       0       4       6       6         Master theses       2       2       0       0       4       6       6       6         Master theses       2       2       0       0       0       4       6       6       6       6       6       6       6       6       6       7       6       7       6       7       7       0       0       7 <td>C - Relatórios</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>	C - Relatórios							
D - Organização de seminários e conferências         10         10         0         0         20           E - Formação avançada Avanced training         2         4         0         0         6           Teses de Duotoramento Pho theses         2         2         0         0         0         40           Outras         20         20         0         0         0         40           Outras         2         2         0         0         0         40           Outras         2         2         0         0         0         40           Mater theses         0         2         0         0         40           Outras         2         2         0         0         40           Mades         8         8         0         0         0         30           H - Instalações piloto         0         2         0	Reports		4	4	0	0	Ĺ	) 8
E - Formação avançada Avanced training Teses de Doutoramento         2         4         0         0         6           Pho theses         20         20         0         0         40           Master theses         20         20         0         0         40           Outras         2         2         0         0         40           Others         2         2         0         0         4           F - Modelos         8         8         0         0         16           Mades         8         8         0         0         2         0         0         2         0         0         2         0         0         2         0         0         2         0         0         2         0         0         2         0         0         2         0         0         2         0	<b>D</b> - Organização de seminários e conferências Organization of seminars and conferences		10	10	0	0	C	) <b>20</b>
Advanced training       2       4       0       0       0       6         PhD theses       20       20       0       0       0       40         Matter theses       20       2       0       0       0       40         Outras       2       2       0       0       0       40         Outras       2       2       0       0       0       4         F - Modelos       8       8       0       0       0       4         Models       8       8       0       0       0       30         Software       15       15       0       0       0       2       0       0       2       0       0       2       0       0       2       0       0       2       0       0       2       0       0       2       0       0       2       0       0       2       0       0       2       0<	E - Formação avançada							
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Outras Others         2         2         0         0         0         4           F - Modelos Models         8         8         0         0         0         16           G - Aplicações computacionais Software         15         15         0         0         0         30           H - Instalações piloto Piót plants         0         2         0         0         0         2           I - Protótipos laboratoriais Prototypes         0	Teses de Mestrado Master theses		20	20	0	0	C	<b>40</b>
Others       - <td>Outras</td> <td></td> <td>2</td> <td>2</td> <td>0</td> <td>0</td> <td>C</td> <td>) 4</td>	Outras		2	2	0	0	C	) 4
8       8       0       0       0       16         Models       15       15       0       0       30         H - Instalações computacionais       0       2       0       0       2         Software       0       2       0       0       2       0       0       2         H - Instalações piloto       0       2       0       0       0       2       0       0       2         I - Protôtipos laboratoriais       0	Others		-	-				· -
G - Aplicações computacionais Software       15       15       0       0       0       30         H - Instalações piloto Pilot plants       0       2       0       0       0       2         I - Protótipos laboratoriais Prototypes       0       0       0       0       0       0       0         J - Patentes Patents       0       0       0       0       0       0       0       0         L - Outros Other       1.5       0.5       0 <td>r - Modelos Models</td> <td></td> <td>8</td> <td>8</td> <td>0</td> <td>0</td> <td>C</td> <td>) <b>16</b></td>	r - Modelos Models		8	8	0	0	C	) <b>16</b>
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Interpreter00000000J - Patentes0000000000Prototypes000000000000L - Outros Other00 <td>H - Instalações piloto</td> <td></td> <td>0</td> <td>2</td> <td>0</td> <td>0</td> <td>C</td> <td>) <b>2</b></td>	H - Instalações piloto		0	2	0	0	C	) <b>2</b>
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L - Outros Other Acções de divulgação da actividade científica Scientífic activity spreading actions LIACC will be present at the University of Porto open days ("Mostra da UP"). Every year LIACC hosts organized visits from high schools. We also have a policy of frequent dissemination of relevant results through newspapers and other media. 7. Orçamento 7. Orçamento 7. Budget Instituição Proponente Principal Contractor Universidade do Porto Descrição Descrição Descrição 13.310,00 15.620,00 0,00 0,00 0,00 28.930,00 Missões 20.224.00 27.124.00 0,00 0,00 0,00 28.930,00	Patents		0	0	0	0	C	) 0
Acções de divulgação da actividade científica Scientífic activity spreading actions LIACC will be present at the University of Porto open days ("Mostra da UP"). Every year LIACC hosts organized visits from high schools. We also have a policy of frequent dissemination of relevant results through newspapers and other media. 7. Orgamento 7. Budget Instituição Proponente Principal Contractor Universidade do Porto Descrição Descrição Descrição 13.310,00 15.620,00 0,00 0,00 0,00 28.930,00 Missões No 2014 00 27.124.00 0,00 0,00 0,00 0,00 28.930,00	L - Outros							
Acções de divulgação da actividade científica         Scientific activity spreading actions         LIACC will be present at the University of Porto open days ("Mostra da UP").         Every year LIACC hosts organized visits from high schools.         We also have a policy of frequent dissemination of relevant results through newspapers and other media.         7. Orçamento         7. Budget         Instituição Proponente         Principal Contractor         Universidade do Porto         Descrição       2011       2012       2013       2014       2015       Total         Recursos Humanos       13.310,00       15.620,00       0,00       0,00       28.930,00         Missões       20.234.00       27.124.00       0.00       0.00       0.00       20.00	Other							
LIACC will be present at the University of Porto open days ("Mostra da UP"). Every year LIACC hosts organized visits from high schools. We also have a policy of frequent dissemination of relevant results through newspapers and other media. 7. Orçamento 7. Budget Instituição Proponente Principal Contractor Universidade do Porto Descrição Descrição Description Recursos Humanos Human resources 20 224 00 27 124 00 00 000 000 000 28.930,00	Acções de divulgação da actividade científica Scientífic activity spreading actions							
Every year LIACC hosts organized visits from high schools. We also have a policy of frequent dissemination of relevant results through newspapers and other media. 7. Orgamento 7. Budget Instituição Proponente Principal Contractor Universidade do Porto Descrição Descrição Description Recursos Humanos Human resources 20 224 00 22 124 00 0,00 0,00 0,00 28.930,00 Missões 20 224 00 22 124 00 0,00 0,00 0,00 0,00 0,00 0,00 0,00	LIACC will be present at the University of Porto ope	en days ("Most	ra da UP").					
We also have a policy of frequent dissemination of relevant results through newspapers and other media.7. Orçamento 7. Budget-Instituição Proponente Principal ContractorUniversidade do PortoDescrição Description20112012201320142015TotalRecursos Humanos Human resources13.310,0015.620,000,000,000,0028.930,00	Every year LIACC hosts organized visits from high schools.							
7. Orçamento 7. Budget-Instituição Proponente Principal ContractorUniversidade do PortoDescrição Description20112012201320142015TotalRecursos Humanos Human resources13.310,0015.620,000,000,0028.930,00Missões20.224.0027.124.000.000.000.000.000.00	We also have a policy of frequent dissemination of relevant results through newspapers and other media.							
Instituição Proponente Principal ContractorUniversidade do PortoDescrição Description20112012201320142015TotalRecursos Humanos Human resources13.310,0015.620,000,000,000,0028.930,00	<b>7. Orçamento</b> 7. Budget							-
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Universidade do PortoDescrição Description20112012201320142015TotalRecursos Humanos Human resources13.310,0015.620,000,000,000,0028.930,00Missões20.224.0027.124.000.000.000.000.000.000.00	Instituição Proponente Principal Contractor							
Descrição Description         2011         2012         2013         2014         2015         Total           Recursos Humanos Human resources         13.310,00         15.620,00         0,00         0,00         0,00         28.930,00           Missões         20.224.00         27.124.00         0.00         0.00         0.00         20.00         20.00	Universidade do Porto							
Recursos Humanos         13.310,00         15.620,00         0,00         0,00         28.930,00           Human resources         20.224.00         27.124.00         0.00         0.00         20.00         27.00         0.00         0.00         0.00         20.00         0.00	Descrição Description	2011	2012	201	3 2	014	2015	Total
Missões 20.224.00.27.124.00 0.00 0.00 0.00 0.00 0.00 0.00	Recursos Humanos	13.310,00	15.620,00	0,0	0 (	0,00	0,00	28.930,00
	Missões	30 234 00	27 124 00	0.0	0 4	0.00	0.00	57 359 00

9 of 11

Missions

Consultores Consultants	2.300,00	3.100,00	0,00	0,00	0,00 <b>5.400,00</b>		
Aquisição de bens e serviços Service procurement and acquisitions	6.540,00	6.540,00	0,00	0,00	0,00 <b>13.080,00</b>		
Registo de patentes Patent registration	0,00	0,00	0,00	0,00	0,00 <b>0,00</b>		
Adaptação de edifícios e instalações Adaptation of buildings and facilities	0,00	0,00	0,00	0,00	0,00 <b>0,00</b>		
Gastos gerais Overheads	3.020,00	3.020,00	0,00	0,00	0,00 <b>6.040,00</b>		
TOTAL DESPESAS CORRENTES TOTAL CURRENT EXPENSES	55.404,00	55.404,00	0,00	0,00	0,00 110.808,00		
Equipamento Equipment	5.000,00	5.000,00	0,00	0,00	0,00 <b>10.000,00</b>		
Total	60.404,00	60.404,00	0,00	0,00	0,00 120.808,00		
<b>Instituições Participantes</b> Participating Institutions (Não se encontram registadas Instituições Participantes para este projecto) (No Participating Institution has been registered for this project)							
Orçamento Global							

Global budget

Descrição Description	2011	2012	2013	2014	2015	Total
Recursos Humanos Human resources	13.310,00	15.620,00	0,00	0,00	0,00	28.930,00
Missões Missions	30.234,00	27.124,00	0,00	0,00	0,00	57.358,00
Consultores Consultants	2.300,00	3.100,00	0,00	0,00	0,00	5.400,00
Aquisição de bens e serviços Service procurement and acquisitions	6.540,00	6.540,00	0,00	0,00	0,00	13.080,00
Registo de patentes Patent registration	0,00	0,00	0,00	0,00	0,00	0,00
Adaptação de edifícios e instalações Adaptation of buildings and facilities	0,00	0,00	0,00	0,00	0,00	0,00
Gastos gerais Overheads	3.020,00	3.020,00	0,00	0,00	0,00	6.040,00
TOTAL DESPESAS CORRENTES TOTAL CURRENT EXPENSES	55.404,00	55.404,00	0,00	0,00	0,00	L10.808,00
Equipamento Equipment	5.000,00	5.000,00	0,00	0,00	0,00	10.000,00
Total	60.404,00	60.404,00	0,00	0,00	0,00	L20.808,00
<b>Plano de financiamento</b> Finance plan						
Descrição Description	2011	2012	2013	2014	2015	Total
Financiamento solicitado à FCT Requested funding	60.404,00	60.404,00	0,00	0,00	0,00	120.808,00
Financiamento próprio Own funding	0,00	0,00	0,00	0,00	0,00	0,00
Outro financiamento público Other public-sector funding	0,00	0,00	0,00	0,00	0,00	0,00
Outro financiamento privado Other private funding	0,00	0,00	0,00	0,00	0,00	0,00
Total do Projecto Total of the project	60.404,00	60.404,00	0,00	0,00	0,00	120.808,00

Comentários e Justificações

#### Comments and Justifications

LIACC mostly needs to fund researchers ( many young PhD students and recent PhD holders) traveling to present their scientific works and to visit other research centers. This fact justifies that the largest amount of funding goes to "missions".

10% of our entire budget goes to financial services to run LIACC's accounting and financial reporting. 5% more goes to other general institutional expenses.

We assign a small amount to new equipment since we recently upgraded most of our equipment.

We also intend to fund a few visitors to LIACC in the next two years.



🔋 Financiado por fundos estruturais da UE e fundos nacionais do MCTES 🧃