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HUMAN RESOURCES AND MOBILITY (HRM) ACTIVITY

MARIE CURIE ACTIONS
Marie Intra-European Fellowships (EIF)

PART B Section 2

ASFIX

B2.1 Quality of the Research Training

Clarity and Quality of the Research Training Objectives for the Researcher

The main research training objectives for Ugo Dal Lago are the following:

- Acquiring stronger research skills on programming language semantics. This research proposal involves the investigation of possible correlations between implicit computational complexity and semantics. While the proponent has already worked proficiently on implicit complexity, he is not an expert on game semantics and geometry of interaction. PPS represents the ideal environment for improving his knowledge and research skills: many major experts in these two fields currently work at PPS.
- Developing the capability of doing research starting from distinct, apparently uncorrelated areas and exploring relations between them. This is precisely what this proposal is aimed to.
- PPS is a very active research site. The proponent will be in contact with research groups working in areas of theoretical computer science that are not intimately related to implicit complexity but are potentially very interesting from a complexity viewpoint, namely concurrency theory, quantum computing and formal molecular biology.

The above research objectives will strengthen the professional maturity of the researcher. This is particularly true when considering the present status of theoretical computer science, which is becoming more and more interdisciplinary. As a consequence, acquiring broad research skills is even more crucial.

Relevance and Quality of Additional Scientific Training Offerend, Including Acquisition of Complimentary Skills

At least three complimentary scientific skills will be developed by Ugo Dal Lago while implementing the project:

- His communication skills will benefit from continuous interaction with members of the host institution. PPS is large compared to other similar laboratories. Both regular seminars and four distinct workgroups on theoretical computer science are held at the laboratory. This implies that the proponent will have many opportunities to interact with other researchers by both giving seminars and participating to presentations by others.
- He will acquire capabilities on research organization and management. Apart from management activities related to the project itself, he will be involved in the organization of workgroup seminars. Moreover, the next international conference on typed lambda calculi and applications (TLCA) is scheduled for spring 2007 in Paris. The proponent plans to participate to its organization.
- Clearly, his language skills will greatly improve. Fluency in both French and English will benefit from staying one year at a research institution with many international collaborations as PPS (see section B2.2).

Summing up, this project will offer Ugo Dal Lago important complimentary scientific skills that will be useful to reinforce his professional maturity and independence.

B2.2 Quality of the Host

Scientific Expertise in the Field of the Host

Laboratory “Preuves, Programmation and Systèmes” (PPS) as part of “Université Denis Diderot” is the institution hosting Ugo Dal Lago as part of this project.

PPS is CNRS laboratory federating energies of professors, researchers and doctoral students resulting from different research areas (computer science and mathematical logic) in order to work on a rather precise class of themes: programming languages, distributed systems and their logical bases. PPS research project is indeed founded on the conviction that mathematical logic (and in particular proof theory), category theory, and other mathematical theories like homology, homotopy or probability theory can have a significant role in understanding the meaning of programs in order to make it clearer. Conversely, computer science can be a source of renovation for logic and other fields of mathematics.

There are six main research directions pursued at PPS:

- **Game Semantics**. The traditional distinction between syntax and semantics has recently weakened its importance, revealing certain models like purified syntax. This is partly due to game semantics, which has become the object of active research for ten years, and polarities, appeared more recently.
- **Proof Theory and Lambda-Calculus**. In this topic, closely related to the previous one, the stress is laid on syntax, in particular on cut-elimination (the logical counterpart of program evaluation) and proof-nets (which are geometrical representations of proofs made possible by linear logic), but also dualities of computation and good old typed lambda-calculus (the syntactic counterpart of intuitionistic logic and functional programming languages).
- **Realizability**. The ambition here is to understand which program hides behind such or such theorem of mathematics. It was necessary to start with classical logic, then to consider axioms of set theory. The main tool for this study is realizability, which goes in the opposite direction of the two preceding topics because it does not consider formulae before proofs but, on the contrary, regards formulae as specifications, or sets of (untyped) programs having the same behavior.
- **Rewriting**. Here, one goes beyond the framework of logic to study the properties of term rewriting systems and higher-order rewriting (i.e. with binding variables), for which the framework of explicit substitutions is very useful. An interesting case-study for the use of rewriting techniques is that of isomorphisms of types (with computer science applications in search algorithms for program libraries). Axiomatic methods for rewriting have been introduced and studied. Another emergent topic is that of N-dimensional rewriting, where rewriting can be performed on surfaces and volumes as well as terms or words.
- **Programming**. A programming team works at PPS, mainly (but not exclusively) around the functional programming language CAML. The laboratory develops systems around Jaluna and Chorus, and network protocols around IPv6. About half of the researchers of PPS devote a significant share of their time in programming, consider programming as the core of their research activity or consider programming as an additional, complimentary, activity (contributing to free software development, for example).

- **Logic and Concurrency**. There is another, more recent, research line at PPS: models of concurrent and mobile programming languages. The problem here is looking at logical bases (PPS has certain experience in this field), or applying these languages to other scientific areas (formal molecular biology, for example).

Currently, 29 permanent members and 19 doctoral students works at PPS.

Ongoing research projects at PPS include:

- **Applied Semantics (APPSEM - II)** (IST-2001-38957). From 2003 to 2007. Local supervisor: Pierre-Louis Curien. Thematic network. Funded by European Union. Supervisor: Martin Hofmann, Munich. `http://www.appsem.org/`.
- **Environment for the Distribution of Open Source software (EDOS)**. From 2004 to 2007. Local supervisor: Roberto Di Cosmo. Sixth Framework Programme, Priority 2. Funded by European Union. Supervisor: Roberto Di Cosmo. `http://www.edos-project.org/`.
- **CoordinAtion et Répartition des Applications Multiprocesseurs (CARAML)**. From 2002 to 2005. Supervisor: Roberto Di Cosmo. Action Concertée Incitative. Funded by ACI-GRID (Ministère de la Recherche). `http://www.caraml.org/`.
- **Géométrie du Calcul (GEOCAL)**. From 2003 to 2006. Local supervisor: Antonio Bucciarelli. Action Concertée Incitative. Funded by ACI-NIM (Ministère de la Recherche). Supervisor: Thomas Ehrhard. `http://iml.univ-mrs.fr/~ehrhard/geocal/geocal.html`.
- **Contrôle de Ressources et d'Interférence dans les Systèmes Synchrones (CRISS)** From 2003 to 2006. Local Supervisor: Roberto Amadio. Action Concertée Incitative. Funded by ACI-SI (Ministère de la Recherche). Supervisor: Roberto Amadio. `http://www.pps.jussieu.fr/~amadio/Criss/criss.html`.
- **Nouveaux Outils pour la Complexité : Sémantique et Types (NO-COST)** From 2005 to 2008. Local supervisor: Olivier Laurent. Programme jeunes chercheuses et jeunes chercheurs. Funded by ANR. Supervisor: Patrick Baillot. `http://www-lipn.univ-paris13.fr/nocost/`.
- **Vérification de protocoles cryptographiques (ROSSIGNOL)**. From 2003 to 2006. Local supervisor Roberto Amadio. Action Concertée Incitative. Funded by ACI-SI (Ministère de la Recherche). Supervisor: Denis Lugiez. `http://www.cmi.univ-mrs.fr/~lugiez/aci-rossignol.html`.

For more details, see `http://www.pps.jussieu.fr/presentation.html`

Supervisor

Pierre-Louis Curien will be the supervisor of this research project. He is currently the director of PPS. His research interests lie in theoretical computer science, semantics of programming languages and their applications to design and implementation of programming languages, to automated deduction and to program verification. He is the author of more than sixty pubblications in international journals and conferences. He is part of the editorial board of four international journals in the area of theoretical computer science. He participated as a site leader to at least seven European Contracts. In 1990, he was the recipient of "Grand Prix IBM France Informatique". He has been jury membrer of EATCS Gödel prize from 2004 to 2006. For more details,

please see http://www.pps.jussieu.fr/~curien/.

Selected Pubblications by Members of PPS

[1] Martin Abadi, Luca Cardelli, and Pierre-Louis Curien. Explicit substitutions. *Journal of Functional Programming*, 1(4):375–416, 1992.
[2] Roberto Amadio and Pierre-Louis Curien. *Domains and Lambda Calculi*. Cambridge University Press, 1998.
[3] Gerard Berry and Pierre-Louis Curien. Sequential algorithms on concrete data structures. *Theoretical Computer Science*, 20:265–321, 1982.
[4] Guy Cousineau, Pierre-Louis Curien, and Michel Mauny. The categorical abstract machine. In *FPCA*, pages 50–64, 1985.
[5] Vincent Danos and Russell Harmer. Probabilistic game semantics. In *LICS*, pages 204–213, 2000.
[6] Vincent Danos and Laurent Regnier. Local and asynchronous beta-reduction (an analysis of Girard's execution formula). In *LICS*, pages 296–306, 1993.
[7] Olivier Laurent. Polarized games. In *LICS*, pages 265–274, 2002.

Quality of the Group/Supervisors

PPS has hosted a large number of master and doctoral students since its foundation in 1999. In particular, 17 doctoral students have discussed their thesis at PPS so far. Many of them have later found permanent positions in France or abroad.

The **École Doctorale de Sciences Mathématiques de Paris-Centre** involves laboratories of mathematics and computer science of Université Denis-Diderot and other universities of the Paris area. For more details, see http://www.edcsm.jussieu.fr/.

Currently, PPS is involved in the teaching and organization of one of the best French postgraduate programmes, the so-called **Master Parisien de Recherche en Informatique**. This European Master's degree covers all the fundamental aspects of algorithmics, including specification, combinatorics, modelling, computational geometry, computer algebra, cryptography, automata, theory of networking, etc. and all the fundamental aspects of computer programming, like logics, lambda-calculus, program proofs, specification, verification, etc. There are around 90 students every year. Professors teaching in these two postgraduate programmes, who come from Université Denis-Diderot and other French universities, are internationally recognised in their corresponding fields. Students include many who have attended the most prestigious French courses (such as those at École Normale Supérieure and École Polytechnique) and also from the best foreign universities and colleges. For more details, see http://mpri.master.univ-paris7.fr.

Pierre-Louis Curien supervised at least ten doctoral students. He lectured to master and doctoral students in France as well as in international summer schools. He has been member of the admission board at École Normale Superieure from 1999 to 2001. He has been the proposer of a joint student exchange agreement (at master level, in computer science) between Université Denis-Diderot, University of Nanjing, and INRIA (signed in July 2001). For more details, see http://www.pps.jussieu.fr/~curien/.

Expertise in Training Experienced Researchers in the Field and Capacity to Provide Mentoring/Tutoring

During the first stages of this project (see sections B1.1 and B2.3), some mentoring and tutoring will be required. In particular, the semantics group at PPS will help Ugo Dal Lago getting proficient in game semantics and geometry of interaction by pointing to appropriate literature in the field and clarifying his doubts.

As explained in the previous section, PPS has great experience in supervising researchers and, more generally, in training at an advanced level.

Quality of Infrastructure/Facilities and International Collaborations

In carrying out this project, Ugo Dal Lago will not need any facility besides those required by any researcher in theoretical computer science. In particular:

- Some office space will be available for the researcher at 175 Rue du Chevaleret in Paris (at the same building where PPS is located). Moreover, some room will be available for the weekly meeting (see section B2.3).
- Ugo Dal Lago will need access to major research journals and conference proceedings. To this respect, we emphasize that PPS has subscriptions to every major pubblication on computer science and in particular to those by Elsevier, ACM and IEEE. Bibliothèque de Mathématiques (see `http://biblio.math.jussieu.fr/`), the largest research mathematics library in France is located in the same building of PPS.
- The researcher has his own laptop computer. Printing machines will be available at PPS.

Summing up, the facilities PPS can offer to Ugo Dal Lago seem completely adequate for this project.

Concerning international collaborations, this is one of the many stregths of PPS as a research laboratory. Ongoing bilateral research projects involving PPS include the following:

- **Réécriture axiomatique**. From 2002 to 2005. Supervisor: Delia Kesner Bilateral cooperation programme with Argentina (CNRS, CONICET).
- **Interaction et Complexité**. From 2004 to 2005. Supervisor: Olivier Laurent. Bilateral cooperation programme with Italy (CNRS, CNR).

Pierre-Louis Curien has been the supervisor of at least six bilateral research projects (five of them were French-Chinese or Euro-Chinese research projects).

Many researchers from abroad regularly visit PPS and give seminars there (for more details, see `http://www.pps.jussieu.fr/visiteurs.html/`).

B2.3 Management and Feasibility

Practical Arrangements for the Implementation and Management of the Scientific Project

This project will be implemented as follows: it will start around October 2006 and it will end one year later. Ugo Dal Lago will stay full-time at PPS during this period, leaving occasionally to participate to conferences or workshops. At PPS, he will continuously interact with other researchers and in particular with Pierre-Louis Curien (the project supervisor), Olivier Laurent and Paul-Andrè Mellies. The emphasis on continuous interaction is crucial, since different skills are required for studying relations between implicit computational complexity and semantics. Some papers describing the results of this collaboration will be written and submitted to top level international conferences and journals.

Feasibility and Credibility of the Project, Including Work Plan

Regular, weekly meetings between Ugo Dal Lago, Pierre-Louis Curien and researchers at PPS will be held in order to assess the progress of the project. The following timetable strongly reflect our research methodology, as described in section B1.2:

- The first **two months** will be devoted to studying existing literature on game semantics and geometry of interaction, with particular emphasis on models having some relations with computational complexity. This includes works by Ghica, Murawski and Ong, Baillot and Pedicini. At the end of this first stage, a clear picture will be available about what has been already done and what remains to be done.
- In the following **five months**, every effort will be spent to design game semantics and geometry of interaction frameworks reflecting complexity properties of multiplicative and exponential linear logic proofs. As explained in part B1.1 of this proposal, we will proceed by iteratively enlarging the class of properties that can be inferred from interpretations and the class of proofs to which the analysis can be applied. Starting from weak models capturing only some proofs and/or some properties, we aim at reaching strong results in the style of full abstraction.
- In the following **two months**, the results obtained at the previous stage will be extended to more general proof systems, namely multiplicative linear logic with fixpoints (which is enough to represent the whole untyped lambda calculus) and higher-order recursion.
- **Two months** will be devoted to studying the semantics of known systems from implicit complexity induced by game and geometry of interaction models introduced previosuly. This includes subsystems of linear logic such as light linear logic, soft linear logic and elementary linear logic.
- In the **last month**, possible applications for the results obtained in the last two stages will be investigated. This includes the application of game semantics to formal verification of quantitative properties of programs via the well-known algorithmic game semantics parardigm. Every additional result obtained at this stage will be considered a plus.

At the end of every stage, a short progress report will be jointly written by Ugo Dal Lago and Pierre-Louis Curien.

Practical and Administrative Arrangements and Support for the Hosting of the Fellow

PPS secretary Odile Ainardi will help Ugo Dal Lago at administrative arrangements specifically related to his employment at PPS. Moreover, two public institutions provide help to researchers visiting France:

- The **Kastler Foundation** (see `http://www.fnak.fr`), which was created in 1993 by the French Academy of Sciences. The underlying ideas with which it operates are mobility and access to knowledge and cultural exchange, all carried out from a very humanist perspective with the ultimate goal of international cooperation that was dear to Alfred Kastler. Kastler Foundation assists foreign researchers moving to France with any matters linked to their mobility such as entry formalities, health insurance, salary and taxes, other administrative formalities and family matters.
- The **Bureau d'Accueil des Chercheurs Etrangers** (see `http://www.ciup.fr/`), which was created in september 2005 to offer foreign scientists a set of services meant to make their stay in Paris or in the Île-de-France region easier. These services ranges from administrative assistance to housing, from French classes to employment assistance.

B2.4 Added Value and Relevance to the Objectives of the Activity

Relevance of the Proposal to one or More of the Specific Objectives of the Action

One of the specific objectives of Marie Curie Intra-European Fellowships is "permitting the best and most promising experienced researchers to undertake transnational mobility in the European organisations most appropriate to their individual needs, directed towards competence diversification". Ugo Dal Lago's academic curriculum highlights his potential as a researcher in theoretical computer science (see section B1.2). Moreover, PPS is an optimal laboratory for carrying out this project, since the skills in programming language semantics are very broad and strong among researchers in the laboratory. As pointed out in section B2.1, this project is inherently interdisciplinar, since its aim is to study relations between implicit complexity on one side and game semantics and geometry of interaction on the other side. This implies that skills of both Ugo Dal Lago and researchers from the host institution will benefit in terms of diversification.

This project is clearly of a foundational nature. It contributes to the improvement of European excellence in theoretical computer science by exploring possible relations between two research areas which have not communicated much in the past, namely programming language semantics and implicit computational complexity. Outfalls of results in implicit computational complexity include the design of tools for the automatic verification of complexity properties of programs; this research area is very active and would greatly benefit from foundational results (for a list of past and current project in the field, see the following section). Compared to other areas inside theoretical computer science, implicit computational complexity is relatively new and many crucial problems remain open. As a consequence, it is very likely that Ugo Dal Lago will continue to work in this area.

Potential of Acquiring Competencies During the Fellowship

Working in a diverse and rich scientific environment is crucial to gain professional maturity as a researcher. To this respect, PPS laboratory offers exceptional opportunities. In particular, the complimentary scientific competencies offered include the following

- Seminars and workgroups on topics connected but not directly related to the proposal or to Ugo Dal Lago's research background are regularly offered at PPS. This helps in reinforcing a strong and broad preparation on theoretical computer science.
- Together with research on more traditional topics like game semantics, realizability and rewriting, new emerging research areas are represented at PPS. As an example, small groups working on quantum computing and formal molecular biology are present. This allows visitors to acquire new scientific competencies and to possibly start new collaborations.

This will undoubtedly contribute to complete Ugo Dal Lago's research training, after his undergraduate and doctoral studies.

Contribution to Career Development

The applicant is finishing his doctoral education and plans to pursue his career in the academia or in qualified research centers, not necessarily located in his home country. Although skilled in several theory topics, he still needs (a) to broad his interests, and (b) to establish a network of research peers.

Concerning (a), theoretical computer science as a research area is becoming more and more interdisciplinary, while increasing its complexity. In order to be proficient, a researcher should have a clear global picture of ongoing research in related fields. PPS is a broad, qualified and active academic community, both in theory topics and more applied ones regarding programming languages. To be involved in such an environment, and to be exposed to such unique blend of theory and applications is a fundamental contribution to the applicant's career (see section B2.2 for a description of PPS as a research institution).

As for (b), PPS is the (logical and geographical) center of a cluster of research institutions in the Paris area. Besides PPS, research broadly related to the present project (semantics, theory of programming languages, logic in computer science) is conducted at École Normale Supérieure (Longo, Castagna), École Polytechnique (Palamidessi, Miller), INRIA Rocquencourt (Huet, Levy, Fages, Leroy), LIPN (Vauzeilles, Baillot). In addition, PPS has a very active seminar program, where many non French (and non European) researchers are often invited when staying in Paris. The very topic of this project calls for collaboration and exchange with researchers from different fields. The network of such links will remain, well after the project has ended, as an important asset for Dal Lago's career development.

Extent to Which the Research Contributes to the Objectives of the European Research Area or other European Policy Objectives

One of the thematic priorities in FP6[1] is "Information Society and Technology" and one of identified focus topics is computer security. Implicit computational complexity has many applications in the verification of quantitative properties of programs, which can be seen as a security problem (for a thorough presentation of these issues, please refer to projects mentioned in the next section, particularly to EmBounded, MRG and Mobius).

Among activities to promote the European Research Area in the context of FP6[2] are:

- **Mobility and Training**.
- **International Co-operation**.
- **Research and Innovation**.

This project will allow a promising researcher in theoretical computer science to complete and broaden his academic curriculum, allowing him to interact with one of the leading European institutions in the field. Research which will be carried out as part of this project involves crucial, foundational issues with many possible outfalls for computer science.

[1] please refer to `http://europa.eu.int/comm/research/fp6/index_en.html`
[2] please refer to `http://europa.eu.int/comm/research/era/index_en.html`

B2.5 Previous Proposals and Contracts

Ugo Dal Lago was not involved on any previous proposal or contract within FP5 and FP6. Members of PPS participated to many European projects under FP5 and FP6. However, they did not participate to any IHP or HRM program. PPS twice applied to Marie-Curie host fellowships for Early Stage Research Training (EST), but applications were not accepted.

This proposal is not a continuation or a resubmission of a similar application rejected under FP5 or FP6.

The following is a list of European and national projects within the field of theoretical computer science with some emphasis on implicit computational complexity. Many of them provide support for early stage training in the form of postdoc grants.

- European Project MRG IST-2001-33149. `http://groups.inf.ed.ac.uk/mrg/`. Start Date: 2002-01-01. End Date: 2005-04-30.
- European Project EmBounded IST-510255. `http://www.embounded.org/`. Start Date: 2005-03-01.
- European Project Mobius IST-15905. `http://mobius.inria.fr/`. Start Date: 2005-09-01.
- French Project GEOCAL. Funded by ACI. `http://iml.univ-mrs.fr/~ehrhard/geocal/geocal.html`.
- French Project NO-COST. Funded by ANR. `http://www-lipn.univ-paris13.fr/nocost/`.
- German Project Pro.Platz. Funded by DFG. `http://www.tcs.ifi.lmu.de/forschung/ProPlatz/`.
- Italian Project FOLLIA. Funded by MIUR. `http://follia.di.unito.it`.

B2.6 Other Issues

The following table has been filled by the proposers taking into account the subject of this proposal.

Does the research presented in this proposal raise sensitive ethical questions related to:	**YES**	**NO**
Human beings		X
Human biological samples		X
Personal data (whether identified by name or not)		X
Genetic information		X
Animals		X

Proposers confirm that the research presented in this proposal does not involve:

- Research activity aimed at human cloning for reproductive purposes.
- Research activity intended to modify the genetic heritage of human beings which could make such changes heritable.
- Research activity intended to create human embryos solely for the purpose of research or for the purpose of stem cell procurement, including by means of somatic cell nuclear trasfer.

	YES	**NO**
Confirmation: the proposed research involves none of the issues listed above	X	

Summing up, there are no ethical sensitive issues associated with the subject of this proposal.

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