

**CENTRIA**

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# **Knowledge Representation and Reasoning & Logic Programming**

**CENTRIA Subarea activities in  
1999-2001 and 2002-2003**



## Description of the Subarea

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- Foundations of rational computational logic agents, logic programs, knowledge base updates, and implementation
  - Knowledge Base Updates and Evolution
  - General framework for integrating several reasoning forms (fuzzy, possibilistic, probabilistic, and non-monotonic)
  - Distributed tabling and revision systems
  - Computational models and their implementation for a parallel and distributed logic programming language
- These topics have strong relations amongst themselves
  - Implementations are guided by the foundational results and their use in applications
  - They also relate to work in other areas of CENTRIA, such as those of Semantic Engines for the Web and of Intelligent Information Systems



# Objectives being pursued

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- Unified logic programming language for specifying updates in knowledge bases
  - declarative specification of knowledge about a domain, and the knowledge of how it evolves, including self-evolution
  - establishing of the language and corresponding semantics
  - development of proof procedures for reasoning in this language, and implementing them
  - studying its application to various domains, including legal reasoning and rational epistemic agents
- Integration in the LP language several uncertainty reasoning forms
  - including fuzzy-logic, possibilistic logic, probabilistic systems, Bayesian networks, and non-monotonic and paraconsistent logics
  - foundations and declarative semantics, and the definition of proof systems and corresponding implementations
- Efficient implementations of logic programming
  - further developments of the GNU Prolog system for making it more efficient and amenable for the other goals
  - distributed tabling; ISO modules; contextual LP; multiple threads



# People 99-01

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- Core team:

- **UNL:** L. M. Pereira, J. J. Alferes, C. V. Damásio
- **U. Évora:** P. Quaresma, S. P. Abreu, I. P. Rodrigues

- Collaborators:

- **Co-authors :**

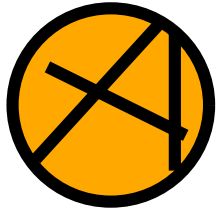
A. Brogi, A. Cardoso, N. Chang, V. S. Costa, P. Dell'Acqua, M. Ferrand, P. Froehlich, J. Gartner, M. Hermenegildo, H. Herre, E. Lamma, R. Lopes, T. Maia, W. Nejdl, D. Pearce, F. C. Pereira, H. Przymusinska, T. C. Przymusinski, F. Riguzzi, F. Silva, D. de Schreye, M. Schroeder, T. Swift, A. Tien

- **Co-editors:**

M. O. Aciego, G. Brewka, V. Dahl, U. Furbach, I. P. de Guzmán, M. Kerber, K. Lau, J. Lloyd, C. Palamidessi, Y. Sagiv, P. J. Stuckey

- Graduate Students:

- **PhD:** J. A. Leite, I. Móra
- **MSc:** J. F. de Castro, V. B. Nogueira



## People 02-03

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- Core team:

- **UNL:** L. M. Pereira, J. J. Alferes, C. V. Damásio, J. Leite, R. Kahle, G. Wheeler
- **U. Évora:** P. Quaresma, S. P. Abreu, I. P. Rodrigues

- Collaborators:

- **Co-authors:**

M. Ojeda-Aciego, A. Brogi, M. Bruynooghe, G. David, P. Dell'Acqua, D. Diaz, J. Dix, M. van Emden, P. Froehlich, N. Graça, E. Lamma, J. Maluszynski, U. Nilsson, W. Nejdl, D. Pearce, V. Peckhaus, H. Przymusinska, T. C. Przymusinski, F. Riguzzi, K. Satoh, M. Schroeder, J. Siekmann, T. Swift, P. M. Todd, A. Vitória

- **Co-editors:**

M. O. Aciego, G. Brewka, J. Dix, I. P. de Guzmán, A. Omicini, K. Satoh, L. Sterling, P. Torroni

- Graduate Students:

- **PhD:** J. Alcântara, I. Almeida, F. Banti, J. Acosta Guadarrama, I. Móra, V. B. Nogueira, J. Simão
- **MSc:** M. B. Alves, M. Engberg, R. D. Jorge, D. Mendes, A. Monteiro, P. Patinho, A. Pinto



# Projects

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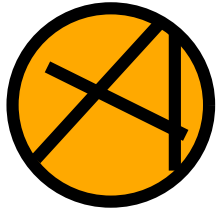
	1999	2000	2001	2002	2003	2004	2005
REAP	◀						
MENTAL	◀						
OAR							
TARDE							
CompulogNet	◀						
SIIUE							
NetBE							
IQN							
RRA							
POLAR							
FLUX							
GNU							
REVERSE							▶



## Projects 99-01

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- REAP (96-00)
  - Reasoning in Logic Programming
- MENTAL (98-00)
  - An architecture for mental agents
- OAR (99-01)
  - Object-oriented And-Or tree rewriting systems
- TARDE (99-01)
  - Tabulation and Revision in a Distributed Prolog Environment
- CompulogNet (99-01)
  - Network of Excellence in Computational Logic
- SIIUE (00-...)
  - Universidade de Évora's Integrated Information System
- NetBE (01)
  - Business to Business Software
- IQN (01-03)
  - Rational mobile agents and systems of agents
- RRA (01-02)
  - Rational and Reactive Agents

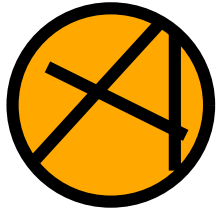


## Projects 02-04

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- SIIUE (00-...)
  - Universidade de Évora's Integrated Information System
- TARDE (02-04)
  - Tabulation and Reasoning in a Distributed Prolog Environment
- CoLogNet (02-04)
  - Computational Logic Network of Excellence
- POLAR (02-03)
  - Residuated Logic Programming
- FLUX (02-04)
  - Flexible Logical Updates
- GNU (02-05)
  - Extensions au Logiciel Libre GNU Prolog
- REVERSE (04-07)
  - Reasoning on the Semantic Web with Rules and Semantics





# Visitors 99-01

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- 2001
  - Daniel Diaz, University of Paris I and INRIA, France
  - Fabrizio Riguzzi, University of Ferrara, Italy
  - Pierangelo Dell'Acqua, Senior Lecturer, Linkoping University, Sweden
  - Reinhard Kahle, U. Tübingen, Germany
  - Terrance Swift, State University of New York at Stony Brook, USA
  
- 2000
  - Antonio Brogi, University of Pisa, Italy
  - Fabrizio Riguzzi, University of Bologna, Italy
  - Jürgen Dix, Manchester University, UK
  - Pierangelo Dell'Acqua, U. Uppsala, Sweden
  - Terrance Swift, U. Stony Brook, USA
  - Thomas Eiter, Technical University of Wien, Austria
  - V.S. Subrahmanian, University of Maryland, USA
  
- 1999
  - Pierangelo Dell'Acqua, U. Uppsala, Sweden
  - Terrance Swift and Bouoqiu Cui, State University of New York at Stony Brook, USA
  - David Pearce, Univ. of Saarbruecken, Germany
  - Michael Schroeder, City University of London, UK
  - Manuel Vilares Ferro, U. Vigo, Spain



## Visitors 02-03

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### ■ 2003

- Martin Balaz, U. Bratislava, Slovakia
- Harold Boley, National Research Council, Canada
- Pierangelo Dell'Acqua, U. Linköping, Sweden
- Bertram Franhofer, T.U. Dresden, Germany
- Dov Gabbay, King's College, London, UK
- Manuel Hermenegildo, U.P Madrid, Spain
- Susana Munoz Hernandez, U.P Madrid, Spain
- Steffen Hoelldobler, T.U. Dresden, Germany
- Peter Novak, U. Bratislava, Slovakia
- David Pearce, U. Rey Juan Carlos, Madrid, Spain
- Francesca Rossi, U. Padova, Italy
- Joerg Siekmann, DFKI, Saarbrücken, Germany
- Jochen Trommer, U. Osnabrück, Germany
- Aida Vitória, University of Linköping, Sweden
- Toby Walsh, U. Cork, Ireland

### ■ 2002

- Manuel Ojeda-Aciego, University of Málaga, Spain
- Federico Banti, University of Pisa, Italy
- Antonio Brogi, University of Pisa, Italy
- Pierangelo Della'Acqua, University of Linköping, Sweden
- Daniel Diaz, University of Paris I and INRIA, France
- Pascal Hitzler, T.U. Dresden, Germany
- Reinhard Kahle, University of Tübingen, Germany
- Paolo Torroni, University of Bologna, Italy
- Aida Vitória, University of Linköping, Sweden



# Cooperation with other Institutions

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## ■ 1999-2001

- CITI, Univ. Nova de Lisboa
- City University London, UK
- Federal University of Rio de Janeiro, Brazil
- INRIA, France
- State University of California at Riverside, USA
- State University of New York at Stony Brook, USA
- U. of Bologna, Italy
- U. Dresden, Germany
- U. de Coimbra, Portugal
- U. of Ferrara, Italy,
- U. of Leipzig, Germany
- U. Málaga, Spain
- U. of Paris-I, France
- U. of Paris-VI, France
- U. Pisa, Italy
- U. of Uppsala, Sweden

## ■ 2002-2003

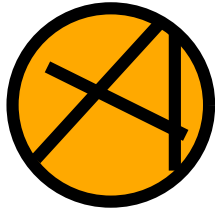
- CITI, Univ. Nova de Lisboa
- INRIA, France
- Nat. Inst. of Informatics, Tokyo, Japan
- NRC, Canada
- St. U. California at Riverside, USA
- St. U. of New York-Stony Brook, USA
- T. U. Dresden, Germany
- T. U. Vienna, Austria
- U. of Bologna, Italy
- U. Bratislava, Slovakia
- U. de Coimbra, Portugal
- U. of Ferrara, Italy,
- U. Málaga, Spain
- U. of Manchester, UK
- University of Melbourne, Australia
- U. Pisa, Italy
- U. P. Madrid
- U. Rey Juan Carlos, Madrid
- U. of Linkoping, Sweden



## Publications

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	1999	2000	2001	2002	2003
Books, J.SI and Ed. Proc.	<b>1</b>	<b>2</b>	<b>3</b>	3	2
Chapters	<b>1</b>			4	1
Journals	<b>4</b>	<b>3</b>	<b>7</b> <b>2I+5Nat</b>	8	6
Conf. SCI	<b>6</b>	<b>7</b>	<b>11</b>	6	9
Other Conf.	<b>8</b>	<b>10</b>	<b>8</b>	10	13



# Organized Events

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- **1999**
  - EPIA'99, the 9th Portuguese Conference on Artificial Intelligence, Évora, Portugal
- **2000**
  - Co-chairing of Computational Logic 2000 (CL'2000), London, UK
  - Co-chairing of Logics in Artificial Intelligence 2000 (JELIA'2000), Málaga, Spain
- **2001**
  - Organization and chairing of Joint Conf. on Declarative Programming AGP'01, Évora, Portugal
  - Organization and chairing of Logic Programming for Artificial Intelligence and Information Systems, ws. of EPIA'01, Porto, Portugal
- **2002**
  - Co-chairing of the 2nd Workshop on Computational Logic in Multiagent Systems (CLIMA'02), Copenhagen, Denmark
- **2003**
  - Chairing and Organization of EPIA'03, the 11th Portuguese Conference on Artificial Intelligence, Beja, Portugal
  - Co-chairing of 1st Workshop on Declarative Agent Languages and Technologies (DAL'T'03), Melbourne, Australia
  - Co-chairing of the Multi-Agents and AI for the Internet, a Ws. of EPIA'03
- **2004**
  - Co-chairing of 2nd Workshop on Declarative Agent Languages and Technologies (DAL'T'04), New York, USA
  - Co-chairing and co-organisation of 4th Ws. on Computational Logic in Multiagent Systems (CLIMA IV), Fort Lauderdale, USA
  - Co-chairing and Organisation of 5th Workshop on Computational Logic in Multiagent Systems (CLIMA V), Lisbon, Portugal
  - Chairing and Organisation of 9th European Conference on Logics in Artificial Intelligence (JELIA'04), Lisbon, Portugal



## Advanced Education

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- 1999-2001
  - Three MSc. students completed their degrees:  
José Ferreira de Castro, Vítor Nogueira, Sílvia Pinheiro
  
- 2002-2003
  - One PhD completed his degree: João Leite.
  - Two MSc. Students completed their degrees:  
Mattias Engberg and Agostinho Monteiro.
  
- 2004
  - On-going PhDs: I. Almeida, J. Alcântara, F. Banti,  
J. Guadarrama, J. Simão (viva next Feb. 27th)
  - On-going MScs: M. B. Alves, R. D. Jorge, D. Mendes,  
P. Patinho, A. Pinto



## Other

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### ■ 2001

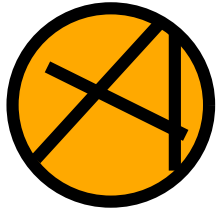
- Luís Moniz Pereira was elected "Fellow of the European AI Society".

### ■ 2002

- José Alferes participated in several evaluation panels of European projects (Future and Emerging Technologies).
- CENTRIA Joined the RuleML initiative
- João Leite is founding member of the Steering Committee for CLIMA Workshops.

### ■ 2003

- Carlos Damásio was member of the REVERSE NoE taskforce.
- Luís M. Pereira ranks #1998 in CiteSeer's most cited authors

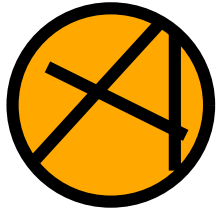


# Applications

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- **Abductive Reasoning**  
<http://www.cs.sunysb.edu/~tsswift/webinterps/abdual.tar.gz>
  - ABDUAL
- **Logic Programs with Updates**  
<http://centria.di.fct.unl.pt/~jja/updates/>
  - DLP (Dynamic Logic Programming)
  - MDLP (Multi-dimensional Dynamic Logic Programming)
  - LUPS (Language for Update Specification)
  - EVOLP (Evolving Logic Programs)
- **Contextual Constraint Logic Programming (CCxLP)**  
<http://dev.si.uevora.pt/debian/>
  - GNU Prolog/CX native code compiler
- **RuleML engine**  
<http://centria.di.fct.unl.pt/~cd/projectos/w4>
  - Paraconsistent Well-founded Semantics with Explicit Negation inference engine integrated with the RuleML parser
- **Proof-of-principle applications in two MSc dissertations**
  - Abductive Validation of a Power-Grid Expert System Diagnoser
  - Updating legal documents – the case of phytosanitary protection of vegetables





# Results achieved 99-01

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- Languages, Semantics, Applications and Implementations for Updating Logic Programs.
  - Actions and (Abductive) Planning
  - Multi-agent architectures and societies
  - Multi-dimensional updates
  - Preferences and Updates
- Reasoning with uncertainty
  - Specification of general frameworks for monotonic, residuated and antitonic logic programming
  - First embedding results
- Abductive Proof Procedures implemented in XSB Prolog
  - Applications to Diagnosis (alarm-correlation and psychiatric diagnosis)
  - Planning
- CCxLP prototype implementation
  - In actual use in a large-scale application (SIIUE.sac)
  - See <http://sac.si.uevora.pt>
- Distributed Tabling
  - Definition of the architecture and proof-procedures with global completion of tables



## Results Achieved 02-03

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- Languages, Semantics, Applications and Implementations for Updating Logic Programs.
  - Simplification of the languages and comparative study of the semantics proposed in the literature
  - Exploration of new applications
  - Applications to the Semantic Web
- Reasoning with uncertainty and paraconsistency
  - Treatment of Paraconsistency in the general framework
  - Embedding of the major LP semantics dealing with uncertainty, vagueness and imprecision, and statistical default reasoning
  - Development of a full declarative model theory
- CCxLP prototype implementation
  - In actual use in a large-scale application (SIIUE.sac)
  - See <http://sac.si.uevora.pt>
- Distributed Tabling
  - Under way is the definition and implementation of distributed completion of tables.



# Self-evaluation

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## ■ Positive Aspects

- Clearly defined and mostly achieved objectives published in recognized International Journals
- International Visibility and Cooperation
- Real-world applications of Logic Programming (SIIUE and Declarativa)

## ■ Negative Aspects

- Difficulty in recruiting Portuguese graduate students. This has been attacked by promoting the Centre internationally and we were able to obtain several foreign PhD students.
- Industrial impact needs improving. We have promising applications and several attempts have been made to contact potentially interested companies, but still with not enough success (the exceptions are the NetBE project and the collaboration with Declarativa). The new REWERSE project can reverse things.



## Medium and long term goals

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- Specification of a global framework resulting from convergence of the lines of research
- Exploitation of the theory for Knowledge Representation in the Semantic Web
- Development of systems for the above