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Chitta Baral
Gianluigi Greco
Nicola Leone
Giorgio Terracina (Eds.)

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Diamante, Italy, September 2005
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Chitta Baral
Arizona State University
Department of Computer Science and Engineering
Fulton School of Engineering
Brickyard Suite 572, 699 S. Mill Avenue, Tempe, AZ 85281, USA
E-mail: chitta@asu.edu

Gianluigi Greco
Nicola Leone
Giorgio Terracina
Università della Calabria
Dipartimento di Matematica
via P. Bucci 30B, I-87030 Rende (CS), Italy
E-mail: {ggreco, leone, terracina}@mat.unical.it

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Preface

These are the proceedings of the *8th International Conference on Logic Programming and Nonmonotonic Reasoning* (LPNMR 2005). Following the previous ones held in Washington, DC, USA (1991), Lisbon, Portugal (1993), Lexington, KY, USA (1995), Dagstuhl, Germany (1997), El Paso, TX, USA (1999), Vienna, Austria (2001) and Ft. Lauderdale, FL, USA (2004), the eighth conference was held in Diamante, Italy, from 5th to 8th of September 2005.

The aim of the LPNMR conferences is to bring together and facilitate interactions between active researchers interested in all aspects concerning declarative logic programming, nonmonotonic reasoning, knowledge representation, and the design of logic-based systems and database systems. LPNMR strives to encompass theoretical and experimental studies that lead to the implementation of practical systems for declarative programming and knowledge representation.

The technical program of LPNMR 2005 comprised three invited talks that were given by Jürgen Angele, Thomas Eiter and Michael Kifer. All papers presented at the conference and published in these proceedings went through a rigorous review process which selected 25 research papers and 16 papers for the system and application tracks.

Many individuals worked for the success of the conference. Special thanks are due to all members of the Program Committee and to additional reviewers for their efforts to produce fair and thorough evaluations of submitted papers. A special thanks is due to the University of Calabria Organizing Committee which made this event possible. Last, but not least, we thank the sponsoring institutions for their generosity.

June 2005

Chitta Baral and Nicola Leone
Program Co-chairs
LPNMR'05

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LPNMR 2005 was organized by the Department of Mathematics at the University of Calabria, Italy.

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Table of Contents

Invited Papers

Nonmonotonic Reasoning in FLORA-2 <i>Michael Kifer</i>	1
Data Integration and Answer Set Programming <i>Thomas Eiter</i>	13
Halo I: A Controlled Experiment for Large Scale Knowledge Base Development <i>Jürgen Angele, Eddie Moench, Henrik Oppermann, Dirk Wenke</i>	26

ASP Foundations

Unfounded Sets for Disjunctive Logic Programs with Arbitrary Aggregates <i>Wolfgang Faber</i>	40
Loops: Relevant or Redundant? <i>Martin Gebser, Torsten Schaub</i>	53
Approximating Answer Sets of Unitary Lifschitz-Woo Programs <i>Victor W. Marek, Inna Pivkina, Mirosław Truszczyński</i>	66
On Modular Translations and Strong Equivalence <i>Paolo Ferraris</i>	79

ASP Extensions

Guarded Open Answer Set Programming <i>Stijn Heymans, Davy Van Nieuwenborgh, Dirk Vermeir</i>	92
External Sources of Computation for Answer Set Solvers <i>Francesco Calimeri, Giovambattista Ianni</i>	105
Answer Sets for Propositional Theories <i>Paolo Ferraris</i>	119

Applications

An ID-Logic Formalization of the Composition of Autonomous
Databases
 Bert Van Nuffelen, Ofer Arieli, Alvaro Cortés-Calabuig,
 Maurice Bruynooghe 132

On the Local Closed-World Assumption of Data-Sources
 Alvaro Cortés-Calabuig, Marc Denecker, Ofer Arieli,
 Bert Van Nuffelen, Maurice Bruynooghe 145

Computing Dialectical Trees Efficiently in Possibilistic Defeasible Logic
Programming
 Carlos I. Chesñevar, Guillermo R. Simari, Lluís Godo 158

Actions and Causations

An Approximation of Action Theories of \mathcal{AL} and Its Application to
Conformant Planning
 Tran Cao Son, Phan Huy Tu, Michael Gelfond,
 A. Ricardo Morales 172

Game-Theoretic Reasoning About Actions in Nonmonotonic Causal
Theories
 Alberto Finzi, Thomas Lukasiewicz 185

Some Logical Properties of Nonmonotonic Causal Theories
 Marek Sergot, Robert Craven 198

Modular- \mathcal{E} : An Elaboration Tolerant Approach to the Ramification
and Qualification Problems
 Antonis Kakas, Loizos Michael, Rob Miller 211

Algorithms and Computation

PLATYPUS: A Platform for Distributed Answer Set Solving
 Jean Gressmann, Tomi Janhunen, Robert E. Mercer,
 Torsten Schaub, Sven Thiele, Richard Tichy 227

Solving Hard ASP Programs Efficiently
 Wolfgang Faber, Francesco Ricca 240

Mode-Directed Fixed Point Computation
 Hai-Feng Guo 253

Lookahead in Smodels Compared to Local Consistencies in CSP	
<i>Jia-Huai You, Guohua Liu, Li Yan Yuan, Curtis Onuczko</i>	266

Foundations

Nested Epistemic Logic Programs	
<i>Kewen Wang, Yan Zhang</i>	279
An Algebraic Account of Modularity in ID-Logic	
<i>Joost Vennekens, Marc Denecker</i>	291
Default Reasoning with Preference Within Only Knowing Logic	
<i>Iselin Engan, Tore Langholm, Espen H. Lian, Arild Waaler</i>	304

Semantics

A Social Semantics for Multi-agent Systems	
<i>Francesco Buccafurri, Gianluca Caminiti</i>	317
Revisiting the Semantics of Interval Probabilistic Logic Programs	
<i>Alex Dekhtyar, Michael I. Dekhtyar</i>	330
Routley Semantics for Answer Sets	
<i>Sergei Odintsov, David Pearce</i>	343
The Well Supported Semantics for Multidimensional Dynamic Logic Programs	
<i>Federico Banti, José Júlio Alferes, Antonio Brogi, Pascal Hitzler</i>	356

Application Track

Application of Smodels in Quartet Based Phylogeny Construction	
<i>Gang Wu, Jia-Huai You, Guohui Lin</i>	369
Using Answer Set Programming for a Decision Support System	
<i>Christoph Beierle, Oliver Dusso, Gabriele Kern-Isberner</i>	374
Data Integration: A Challenging ASP Application	
<i>Nicola Leone, Thomas Eiter, Wolfgang Faber, Michael Fink, Georg Gottlob, Luigi Granata, Gianluigi Greco, Edyta Kalka, Giovambattista Ianni, Domenico Lembo, Maurizio Lenzerini, Vincenzino Lio, Bartosz Nowicki, Riccardo Rosati, Marco Ruzzi, Witold Staniszkis, Giorgio Terracina</i>	379

Abduction and Preferences in Linguistics

Kathrin Konczak, Ralf Vogel 384

Inference of Gene Relations from Microarray Data by Abduction

Irene Papatheodorou, Antonis Kakas, Marek Sergot 389

System Track

nomore[<]: A System for Computing Preferred Answer Sets

Susanne Grell, Kathrin Konczak, Torsten Schaub 394

Integrating an Answer Set Solver into Prolog: ASP – PROLOG

Omar Elkhatib, Enrico Pontelli, Tran Cao Son 399

CIRC2DLP — Translating Circumscription into Disjunctive Logic Programming

Emilia Oikarinen, Tomi Janhunen 405

Pbmodels — Software to Compute Stable Models by Pseudoboolean Solvers

Lengning Liu, Mirosław Truszczyński 410

KMONITOR – A Tool for Monitoring Plan Execution in Action Theories

Thomas Eiter, Michael Fink, Ján Senko 416

The nomore++ System

Christian Anger, Martin Gebser, Thomas Linke, André Neumann, Torsten Schaub 422

S MODELS^A — A System for Computing Answer Sets of Logic Programs with Aggregates

Islam Elkabani, Enrico Pontelli, Tran Cao Son 427

A DLP System with Object-Oriented Features

Francesco Ricca, Nicola Leone, Valerio De Bonis, Tina Dell’Armi, Stefania Galizia, Giovanni Grasso 432

Testing Strong Equivalence of Datalog Programs - Implementation and Examples

Thomas Eiter, Wolfgang Faber, Patrick Traxler 437

SELP - A System for Studying Strong Equivalence Between Logic Programs

Yin Chen, Fangzhen Lin, Lei Li 442

CMODELS – SAT-Based Disjunctive Answer Set Solver
 Yuliya Lierler 447

Author Index 453

Nonmonotonic Reasoning in FLORA-2*

Michael Kifer

Department of Computer Science,
State University of New York at Stony Brook,
Stony Brook, NY 11794, USA
kifer@cs.stonybrook.edu

Abstract. FLORA-2 is an advanced knowledge representation system that integrates F-logic, HiLog, and Transaction Logic. In this paper we give an overview of the theoretical foundations of the system and of some of the aspects of nonmonotonic reasoning in FLORA-2. These include scoped default negation, behavioral inheritance, and nonmonotonicity that stems from database dynamics.

1 Introduction

FLORA-2 is a knowledge base engine and a complete environment for developing knowledge-intensive applications. It integrates F-logic with other novel formalisms such as HiLog and Transaction Logic. FLORA-2 is freely available on the Internet¹ and is in use by a growing research community. Many of the features of FLORA-2 have been adopted by the recently proposed languages in the Semantic Web Services domain: WSML-Rule² and SWSL-Rules.³

One of the main foundational ingredients of FLORA-2, F-logic [20], extends classical predicate calculus with the concepts of objects, classes, and types, which are adapted from object-oriented programming. In this way, F-logic integrates the paradigms of logic programming and deductive databases with the object-oriented programming paradigm. Most of the applications of F-logic have been in intelligent information systems, but more recently it has been used to represent ontologies and other forms of Semantic Web reasoning [14,12,27,1,11,2,19].

HiLog [8] is an extension of the standard predicate calculus with higher-order syntax. Yet the semantics of HiLog remains first-order and tractable. In FLORA-2, HiLog is the basis for simple and natural querying of term structures and for reification (or objectification) of logical statements, which is an important requirement for a Semantic Web language. Transaction Logic [6] provides the basis for declarative programming of “procedural knowledge” that is often embedded in intelligent agents or Semantic Web services.

In this paper we first survey the main features of FLORA-2 and then discuss three forms of nonmonotonic reasoning provided by the system.

* This work was supported in part by NSF grant CCR-0311512 and by U.S. Army Medical Research Institute under a subcontract through Brookhaven National Lab.

¹ <http://flora.sourceforge.net/>

² <http://www.w3.org/Submission/WSML/>

³ <http://www.daml.org/services/swsl-rules/1.0/>

2 Overview of F-Logic

F-logic extends predicate calculus both syntactically and semantically. It has a monotonic logical entailment relationship, and its proof theory is sound and complete with respect to the semantics. F-logic comes in two flavors: the first-order flavor and the logic programming flavor. The first-order flavor of F-logic can be viewed as a syntactic variant of classical logic [20]. The logic programming flavor uses a subset of the syntax of F-logic, but gives it a different, non-first-order semantics by interpreting the negation operator as negation-as-failure.

The relationship between the first-order variant of F-logic and its logic programming variant is similar to the relationship between predicate calculus and standard logic programming [23]: object-oriented logic programming is built on the rule-based subset of F-logic by adding the appropriate non-monotonic extensions [32,33,24]. These extensions are intended to capture the semantics of negation-as-failure (like in standard logic programming [28]) and the semantics of multiple inheritance with overriding (which is not found in standard logic programming).

F-logic uses first-order variable-free terms to represent *object identity* (abbr., OID); for instance, `John` and `father(Mary)` are possible Ids of objects. Objects can have attributes. For instance,

```
Mary[spouse->John, children->{Alice,Nancy}].
Mary[children->Jack].
```

Such formulas are called F-logic *molecules*. The first formula says that object `Mary` has an attribute `spouse` whose value is the OID `John`. It also says that the attribute `children` is set-valued and its value is a set that *contains* two OIDs: `Alice` and `Nancy`. We emphasize “contains” because sets do not need to be specified all at once. For instance, the second formula above says that `Mary` has an additional child, `Jack`.

In earlier versions of F-logic, set-valued attributes were denoted with `->>` instead of `->`. However, subsequently the syntax was modernized and simplified. Instead of using different arrows, cardinality constraints (to be explained shortly) were introduced to indicate that an attribute is single-valued.

While some attributes of an object are specified explicitly, as facts, other attributes can be defined using deductive rules. For instance, we can derive `John[children->{Alice,Nancy,Jack}]` using the following deductive rule:

```
?X[children->{?C}] :- ?Y[spouse->?X, children->{?C}].
```

In the new and simplified syntax, alphanumeric symbols prefixed with the `?`-sign denote variables and unprefix alphanumeric symbols denote constants (i.e., OIDs). The earlier versions of FLORA-2 used Prolog conventions where variables were capitalized alphanumeric symbols.

F-logic objects can also have *methods*, which are functions that take arguments. For instance,

```
John[grade(cs305,fall2004) -> 100, courses(fall2004) -> {cs305,cs306}].
```


says that **John** has a method, **grade**, whose value on the arguments **cs305** (a course identifier) and **fall2004** (a semester designation) is 100; it also has a set-valued method **courses**, whose value on the argument **fall2004** is a set of OIDs that contains course identifiers **cs305** and **cs306**. Like attributes, methods can be defined using deductive rules.

The F-logic syntax for *class membership* is **John:student** and for *subclass relationship* it is **student::person**. Classes are treated as objects and it is possible for the same object to play the role of a class in one formula and of an object in another. For instance, in the formula **student:class**, the symbol **student** plays the role of an object, while in **student::person** it appears in the role of a class.

F-logic also provides means for specifying schema information through *signature* formulas. For instance, **person[spouse {0:1}=>person, name {0:1}=>string, child=> person]** is a signature formula that says that class **person** has three attributes: single-valued attributes **spouse** and **name** (single-valuedness is indicated by the cardinality constraint 0:1) and a set-valued attribute **child**. It further says that the first attribute returns objects of type **person**, the second of type **string**, and the last returns sets of objects such that each object in the set is of type **person**.

3 HiLog and Meta-information

F-logic provides simple and natural means for exploring the structure of object data. Both the schema information associated with classes and the structure of individual objects can be queried by simply putting variables in the appropriate syntactic positions. For instance, to find the set-valued methods that are defined in the *schema* of class **student** and return objects of type **person**, one can ask the following query:

```
?- student[?M=>person].
```

The next query is about the type of the results of the attribute **name** in class **student**. This query also returns all the superclasses of class **student**.

```
?- student::?C and student[name=>?T].
```

The above are schema-level meta-queries: they involve the subclass relationship and the type information. One can also pose meta-queries that involve object data (rather than schema). The following queries return the methods that have a known value for the object **John**:

```
?- John[?Meth->?SomeValue].
```

However, the meta-query facilities of F-logic are not complete. For instance, there is no way in such queries to separate method names from their arguments. Thus, if we had a fact of the form

```
John[age(2005) -> 20].
```