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Rule Technologies

Research, Tools, and Applications

10th International Symposium, RuleML 2016
Stony Brook, NY, USA, July 6–9, 2016
Proceedings

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Preface

The annual International Web Rule Symposium (RuleML) is an international conference on research, applications, languages, and standards for rule technologies. It has evolved from an annual series of international workshops since 2002, international conferences in 2005 and 2006, and international symposia since 2007. RuleML 2016 was the 10th symposium of this series, co-located in New York State with the 25th International Joint Conference on Artificial Intelligence (July 9–15, 2016) and the Joint Multi-Conference on Human-Level Artificial Intelligence 2016 (July 16–19, 2016).

RuleML is a leading conference aiming to build bridges between academia and industry in the field of rules and its applications, especially as part of the semantic technology stack. It is devoted to rule-based programming and rule-based systems including production rule systems, logic programming rule engines, and business rule engines and business rule management systems, Semantic Web rule languages and rule standards (e.g., RuleML, SWRL, RIF, PRR, SBVR, DMN, CL, Prolog), rule-based event processing languages (EPLs) and technologies, and research on inference rules, transformation rules, decision rules, and ECA rules.

This annual symposium is the flagship event of RuleML. The RuleML Initiative (http://ruleml.org) is a non-profit umbrella organization with a Steering Committee, an advisory board, taskforces, and technical groups, whose participants from academia, industry, and government work on rule technology and its applications. Its aim is to promote the study, research, and use of rules in heterogeneous distributed environments such as the Web. RuleML maintains effective links with other major international societies and acts as intermediary between various "specialized" rule vendors, applications, industrial and academic research groups, as well as standardization efforts from, e.g., W3C, OMG, OASIS, and ISO. One of its major contributions is the unifying RuleML system of families of rule languages, serialized in XML and spanning across all industrially relevant kinds of Web rules.

The technical program of RuleML 2016 included presentations of novel rule-based technologies, such as Semantic Web rule languages and standards, rule engines, formal and operational semantics, rule-based systems, as well as new emerging topics relevant to rules. Besides the regular research track, RuleML 2016 included six special research tracks: Smart Contracts, Blockchain, and Rules; Constraint Handling Rules; Event-Driven Architectures and Active Database Systems; Legal Rules and Reasoning; Rule- and Ontology-Based Data Access and Transformation; Rule Induction and Learning. These tracks reflect the significant role of rules in several research and application areas, which include: blockchains and smart contract, ontology-based data access, active databases and rules, legal rules, constraint handling rule, and rule induction and learning.

After a successful industry track at RuleML 2015, RuleML 2016 again included such a track, describing practical applications of rules, and aspects of the state of the art of rule-based business cases.

The highlights of this year's RuleML Symposium included the following invited presentations:

Two keynote talks:

- Richard Waldinger, from Artificial Intelligence Center, SRI International, USA, presenting "Natural Language Access to Data: It Needs Reasoning"
- Bruce Silver from Bruce Silver Associates, presenting "DMN as a Decision Modeling Language"

Two tutorials:

- "Programming in Picat" by Neng-Fa Zhou, City University of New York
- "Practical Knowledge Representation and Reasoning in Ergo" by Michael Kifer, Theresa Swift and Benjamin Grosof (Coherent Knowledge Systems)

A RuleML standards talk:

- "The RuleML Knowledge-Interoperation Hub" by Harold Boley, Faculty of Computer Science, University of New Brunswick

In addition, the program included the 10th International Rule Challenge, dedicated to practical experiences with rule-based applications, the 6th RuleML Doctoral Consortium, which focused on PhD research in the area of rules, and finally, the DecisionCAMP 2016.

The contributions in this volume include a set of invited papers and research track papers. Invited presentations include two full papers and three abstracts for the keynotes, tutorials, and standards talk. Research papers include a selection of 20 papers, which were presented during the technical program of RuleML 2016. The research papers were selected from 36 submissions through a peer-review process. Each paper was reviewed by at least three members of the Program Committee.

RuleML 2016, like its predecessors, offered a high-quality technical and applications program, which was the result of the joint effort of the members of the RuleML 2016 Program Committee.

Special thanks are due to the Track Chairs, the excellent Program Committee, and the additional reviewers for their hard work in reviewing the submitted papers. Their criticisms and very useful comments and suggestions were instrumental in achieving a high-quality publication. We also thank the symposium authors for submitting high-quality papers, responding to the reviewers' comments, and abiding by our production schedule. We further wish to thank the invited speakers for contributing their inspiring presentations. RuleML 2016 was financially supported by industrial companies and scientific journals and was technically supported by several professional societies. We wish to thank our sponsors, whose financial support helped us to offer this event, and whose technical support allowed us to attract high-quality submissions. Last, but not least, we would like to thank the development team of the EasyChair conference

management system and our publisher, Springer, for their support in the preparation of this volume and the publication of the proceedings.

May 2016

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Invited Papers Abstracts

Natural Language Access to Data: It Needs Reasoning

Richard Waldinger

Artificial Intelligence Center, SRI International

Researchers have been working on natural language access to data for decades. We argue that to do a good job, we must have knowledge of the subject domain and the ability to reason with that knowledge. We are interested in queries for which the answer does not exist explicitly in any one data source but must be deduced or computed from information provided by many sources. Furthermore, we consider queries which are not be expressed in a single question but are distributed over a sequence of questions, each one refining or elaborating on earlier ones. We have adopted a deductive approach to this problem, in which the query is translated into a logical form, which is submitted as a conjecture to a theorem prover; answers are extracted from proofs. A proof is conducted over an axiomatic theory of the subject domain; symbols in the theory are linked to tables in appropriate databases, which may be consulted as the proof is underway. Reasoning is necessary to link the query to the relevant databases, to compose answers from information provided by those databases, and to resolve ambiguities in the English query. We illustrate the approach with the SAP Quest system, which answers questions in a business enterprise domain.

DMN as a Decision Modeling Language

Bruce Silver

Bruce Silver Associates

Decision Model and Notation (DMN) is a relatively new decision modeling standard maintained by the Object Management Group. Based on a formal metamodel, it combines a business-oriented graphical notation with precise rule-based decision logic semantics. As such, DMN tools allow non-technical users to define, validate, and maintain executable decision logic themselves, as opposed to the traditional error-prone approach of writing business requirements for programmers. In the notation, the dependencies of a complex decision on other supporting decisions and input data are represented graphically by a Decision Requirements Diagram (DRD). The decision logic of each decision node in the DRD is defined by a variety of tabular formats called boxed expressions, and DMN also specifies a new expression language, FEEL, used in the boxed expressions. In combination, the DRD, boxed expressions, and FEEL constitute a powerful decision modeling language standard. In fact, the XML serialization of a DMN model captures all the essential semantic details of the notation, so that it can be validated for completeness and consistency, and supplied with input data values directly executed on a suitable engine.

This keynote talk reviews the structure and key features of DMN 1.1 as a decision modeling language.

Programming in Picat

Neng-Fa Zhou

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Abstract. Picat (picat-lang.org) is a logic-based multi-paradigm programming language that integrates logic programming, functional programming, constraint programming, and scripting. Picat takes many features from other languages, including logic variables, unification, backtracking, pattern-matching rules, functions, list/array comprehensions, loops, assignments, tabling for dynamic programming and planning, and constraint solving with CP (constraint programming), SAT (satisfiability), and MIP (mixed integer programming). These features make Picat more convenient than Prolog for scripting and modeling, and more suitable than functional languages (such as Haskell and F#) and scripting languages (such as Python and Ruby) for symbolic computations. This article provides a quick introduction to Picat using examples from Google Code Jam (GCJ).

Practical Knowledge Representation and Reasoning in Ergo

Michael Kifer, Theresa Swift, and Benjamin N. Grosof

Coherent Knowledge Systems, LLC

This tutorial covers the latest progress in Ergo[1], a cutting-edge practical knowledge representation and reasoning system. Ergo is the most complete and highly optimized implementation of Rulelog, an expressive yet scalable extension of Datalog and logic programs. Some of the salient (and often unique) features of Ergo include:

- *frame-based* object syntax [5]
- *higher-order* statements [3, 12]
- support for *general quantification and general formulas* [4]
- *dynamically* evolving knowledge [2]
- *hypothetical* reasoning
- *modularity*
- argumentation-based *defeasible reasoning* [10, 11]
- *user-defined functions*, which provide a limited form of functional programming
- *ErgoText*, which relates controlled natural language phrases (sprinkled with variables and other syntactic elements) to logic sentences
- *explanations* that are fully detailed, interactively navigable, and presented in natural language – understandable by those who are not expert in logic or programming [1]
- flexible probabilistic reasoning, including distribution semantics [9], evidential probability [6], and tight integration with inductive machine learning

Ergo also has connectors for fast loading of data, SQL and SPARQL querying, graph databases, Java and C interfaces, and more. Probabilistic uncertainty and machine learning capabilities are under development. In case studies, Ergo enables cost-effective, agile development of knowledge bases for automated decisions/analytics support in finance, defense, e-commerce, health, and in domains that utilize complex knowledge such as terminology mappings, policies, regulations, contracts, and science.

Much of this tutorial will be dedicated to Ergos development environment, *Ergo Studio*, especially to its unique advanced support for debugging knowledge. For instance, execution of Ergo queries can be paused and the state of the evaluation examined. Information that can be gleaned at that point includes the various statistics as well as indication of whether the query may be inefficient or even that it might not terminate. Ergos *Terminyzer* [7, 8] is a tool that performs a more detailed analysis and can point to the specific parts of the knowledge base that are likely to cause objectionable behavior. The user can also set up various *tripwires*, which would trigger

[1] Ergo is a product of Coherent Knowledge (`coherentknowledge.com`). It is available free of charge to selected academic researchers.

various actions if certain conditions are met. Last, but not least, Ergo can be asked to explain the answers it returns as well as the answers it does not return. These explanations can use either logical expressions or English sentences (through ErgoText).

In conclusion, we will also briefly discuss key frontiers for research, including probabilistic, machine learning, natural language, and multi-processor inferencing.

This tutorial requires prerequisite knowledge of neither Ergo nor Rulelog. However, familiarity with logic rules, semantic technology, and logic programming is very desirable.

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The RuleML Knowledge-Interoperation Hub

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Abstract. The RuleML knowledge-interoperation hub provides for syntactic/semantic representation and internal/external transformation of formal knowledge. The representation system permits the configuration of textbook and enriched Relax NG syntax as well as the association of syntax with semantics. The transformation tool suite includes serialized formatters (normalizers and compactifiers), polarized parsers and generators (the RuleML↔POSL tool and the RuleML→PSOA/PS generator and PSOA/PS→AST parser), as well as importers and exporters (the importer from Dexlog to Naf Datalog RuleML and the exporter from FOL RuleML languages to TPTP). An N3-PSOA-Flora knowledge-interoperation use case is introduced for illustration.

Contents