Report from Dagstuhl Seminar 12441

Foundations and Challenges of Change and Evolution in Ontologies

Edited by

James Delgrande[1], Thomas Meyer[2], and Ulrike Sattler[3]

1 **Simon Fraser University, Burnaby, CA,** jim@cs.sfu.ca
2 **Meraka Institute & University of KwaZulu-Natal, ZA,** tmeyer@csir.co.za
3 **University of Manchester, GB,** sattler@cs.man.ac.uk

Abstract

This report documents the program and the outcomes of Dagstuhl Seminar 12441 "Foundations and Challenges of Change and Evolution in Ontologies", held from 28 October to 2 November 2012. The aim of the workshop was to bring together researchers working in the areas of logic-based ontologies, belief change, and database systems, along with researchers working in relevant areas in nonmonotonic reasoning, commonsense reasoning, and paraconsistent reasoning. The workshop provided a forum for discussions on the application of existing work in belief change, nonmonotonic reasoning, commonsense reasoning, and databases to logic-based ontologies. Overall the intent was to provide an interdisciplinary (with respect to computer science and mathematics) workshop for addressing both theoretical and computational issues in managing change and evolution in formal ontologies.

Seminar 28. October–02. November, 2012 – www.dagstuhl.de/12441
1998 ACM Subject Classification I.2 Artificial intelligence, I.2.4 Knowledge representation formalisms and methods, I.2.3 Nonmonotonic reasoning and belief revision, F.4.1 Computational logic, H.2.1 Logical design
Keywords and phrases Artificial intelligence, Belief change, Ontologies, Description logics
Digital Object Identifier 10.4230/DagRep.2.10.105
Edited in cooperation with Ivan Varzinczak

1 Executive Summary

James Delgrande
Thomas Meyer
Ulrike Sattler

An ontology in computer science is an explicit, formal specification of the terms of a domain of application, along with the relations among these terms. An ontology provides a (structured) vocabulary which forms the basis for the representation of general knowledge. Ontologies have found extensive application in Artificial Intelligence and the Semantic Web, as well as in areas such as software engineering, bioinformatics, and database systems.

Research in ontologies in Artificial Intelligence has focussed on description logics (DL), where a description logic can be regarded as a (decidable) fragment of first order logic. Historically a DL is divided into two components, a so-called TBox, for expressing concepts and their interrelationships, and an ABox that contains assertions about specific individuals

Found. and Challenges of Change and Evolution in Ontologies, *Dagstuhl Reports*, Vol. 2, Issue 10, pp. 105–116
Editors: James Delgrande, Thomas Meyer, and Ulrike Sattler
DAGSTUHL REPORTS Dagstuhl Reports
Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

and instances. Thus, the TBox characterises a domain of application while the ABox contains information on a specific instance of a domain. A key point in description logics is that, via their limited expressiveness, one obtains "good", ideally tractable, inference algorithms. The number of description logics is large, with several prominent families of logics, and the complexity of description logics has been well studied. Research in ontology languages and related reasoning services, most notably in description logics, has also spurred work into logics that are weaker than classical systems, as well provided a substantial impetus for research into modal logic. Moreover, there has been substantial interaction with the database community.

The success of this work has led to an increasing demand for a variety of reasoning services, both classical and non-classical. Crucially, an ontology will be expected to evolve, either as domain information is corrected and refined, or in response to a change in the underlying domain. In a description logic, such change may come in two different forms: the background knowledge, traditionally stored in the TBox, may require modification, or the ground facts or data, traditionally stored in the ABox, may be modified. In the former case, the process is akin to theory revision, in that the underlying background theory is subject to change. In the latter case, one cannot simply update instances, as is done in a relational database, since any set of instances must accord with the potentially rich structure imposed by the TBox. The result is that one must be able to deal with changing ontologies, as well as related notions from commonsense reasoning, including nonmonotonic reasoning and paraconsistent reasoning.

The issues mentioned are of common interest to the ontology, belief change, and database communities. While there has been some interaction between researchers in these communities, there has not been a comprehensive meeting to address notions of change in ontologies in a broad or comprehensive fashion.

The aim of the workshop was to bring together researchers working in the areas of logic-based ontologies, belief change, and database systems, along with researchers working in relevant areas in nonmonotonic reasoning, commonsense reasoning, and paraconsistent reasoning. Hence the workshop's goal was to facilitate discussions on the application of existing work in belief change, nonmonotonic reasoning, commonsense reasoning, and related areas on the one hand, to logic-based ontologies on the other. There has been extensive input and interest from the database community, which also has in interest in these problems. Overall the intent was to provide an interdisciplinary (with respect to computer science and mathematics) workshop for addressing both theoretical and computational issues in managing change in ontologies. In particular, the workshop has given participants a deeper understanding of the concepts, terminologies, and paradigms used in the three areas involved, and in their latest achievements and challenges. Examples of these were the distinction between data and schema level, the relation between different revision operators and justifications, the role of less expressive description logics, to name a few.

The workshop consisted of a five-day event with the following program: On the first day there were three introductory talks by a representative in each of the areas of belief change and nonmonotonic reasoning, description logics, and databases. The purpose of these introductory talks was to come to a shared understanding (and terminology) of these areas, and provide a glimpse of the state-of-the-art and current research challenges in all three areas. On day 2, three breakout groups were created and participants were assigned to them based on their expertise but also in such a way as to have representatives of the three main areas in each group. The groups were 'Foundations and Techniques', 'Applications', and 'Perspectives and Future Directions', and their purpose was that of fostering discussions on the three fundamental components at the intersection of the above mentioned areas. Day 3 consisted of a report back from each of the groups followed by further discussion. On the fourth day there were presentations on overlapping areas and discussions of problems and issues of mutual interest for the different communities. Day 5 had a wrap-up session with a discussion on the overlap among the different areas, future challenges and next steps in this workshop series.

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3 Overview of Talks

3.1 Ontology Views and Evolution

Franz Baader (TU Dresden, DE)

We consider two different topics related to the overall theme of the seminar: views and evolution. For the purpose of this talk, a view on an ontology is a subset of the ontology. The challenge is to pre-compute consequences of such views without doing this for every subset separately. Two instances of this overall challenge have been addressed in our work on pinpointing [2, 5, 6] and on lattice-based access control [8]. Regarding evolution, we consider the situation where an ontology represents an evolving "world" in an incomplete way. The challenge is to decide whether a certain temporal property, e.g., expressed in the temporal Description Logic $\mathcal{ALC}$-LTL [7], holds in all possible evolutions of the world. We have considered both the case where the evolution is due to a black-box "system" [3] that can only be observed and where it is due to applying actions defined in a Description Logic action theory [1, 4].

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3.2 Facilitating Ontology Refinement through Nonmonotonic DL

Piero Andrea Bonatti (University of Napoli, IT)

Joint work of Bonatti, Piero Andrea; Faella, Marco; Sauro, Luigi
Main reference P.A. Bonatti, M. Faella, L. Sauro, "EL with Default Attributes and Overriding," ISWC 2010: 64–79.
URL http://dx.doi.org/10.1007/978-3-642-17746-0_5

The process of ontology authoring and maintenance requires suitable support at different levels: tools (eg. versioning systems) as well as language extensions (eg. native support to exceptions and overriding). In this talk we argue that suitable nonmonotonic constructs for description logics may contribute to address these needs. We provide a few examples using Circumscription-based DLs, that prove to be promising in terms of expressiveness and scalability.

3.3 Handling Inconsistency of Rules Accessing Ontologies

Thomas Eiter (TU Wien, AT)

Joint work of Eiter, Thomas; Dao-Tran, Minh; Fink, Michael; Krennwallner, Thomas

Rules have been considered in order to increase the expressiveness and usage of ontologies, be it to cater for nonmonotonic inferences or to access ontologies in declarative problem solving. In this talk, we review a taxonomy of different formalisms for rules plus ontologies, and then hex-programs and dl-programs, which are extensions of answer set programming to access external sources of computation and querying ontologies in description logics, respectively. We will present issues regarding inconsistency in answer set programs and these extensions, some approaches to handle them and point out connections to theory change and ontology management, which pose open issues for future research.

3.4 An Approach for Reasoning about Typicality in Description Logics

Laura Giordano (University of Western Piemont – Alessandria, IT)

Joint work of Giordano, Laura; Gliozzi, Valentina; Olivetti, Nicola; Pozzato, Gian Luca
Main reference L. Giordano, V. Gliozzi, N. Olivetti, G.L. Pozzato, "A Non Monotonic Description Logic for Reasoning about Typicality," Artificial Intelligence, in press, 2012.
URL http://dx.doi.org/10.1016/j.artint.2012.10.004

The talk describes an approach for defining non-monotonic extensions of Description Logics, for reasoning about prototypical properties of individuals, based on a typicality operator T plus a minimal model semantics. For any concept C, T(C) singles out the instances of C that are considered as "typical" or "normal". The typicality operator T is essentially characterized by the core properties of nonmonotonic reasoning, axiomatized by preferential logic P. The approach we propose combines the use of the typicality operator with a minimal model semantics, similar in spirit to circumscription. The minimal model mechanism allows to perform useful nonmonotonic inferences by minimizing the "non typicality" of individuals. The presentation shortly describes the non-monotonic extension of ALC (ALC+Tmin), as well as the non-monotonic extension of some low complexity DLs (namely, DL-lite-core and $EL^{\perp}$). For these extensions, tableau calculi for deciding entailment have been developed. The presentation also points out at some complexity results.

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3.5 Nonmonotonic Reasoning – Survey, Perspectives, and Challenges

Gabriele Kern-Isberner (TU Dortmund, DE)

From the idea of giving up monotonicity in logic-based reasoning to comply better with the requirements of everyday life, a plethora of methods have emerged. On the one hand, from the classical logical side, default logics aim at taking the possibility of exceptions explicitly into account, or at loosening the strict link between antecedent and consequent in logical rules. On the other hand, from the probabilistic side, quantitative information was based on qualitative, logic-like structures. In between, semi-quantitative approaches like ranking functions (alternatively, possibilistic theory) and Dempster-Shafer's evidence theory were proposed to (hopefully) bridge the gap between symbolic and fully quantitative theories. Moreover, belief revision theory came into being as "the other side of uncertain reasoning", aiming at catching epistemic changes when new information arrives.

The aim of this talk is to give a survey on some prevalent approaches to nonmonotononic reasoning, distinguishing between those that use rules with default assumptions, and those that are based on defeasible rules, or conditionals. As a powerful semantics for nonmonotonic reasoning that uses both qualitative and quantitative information, we briefly recall Spohn's ranking functions. Moreover, the inference rules of system P are presented as a syntactical guideline, or calculus, for nonmonotonic reasoning. We also illustrate the nonmonotonic fallacies of probabilistic reasoning and propose Bayesian networks and the principle of maximum entropy as approaches providing high quality and efficient probabilistic reasoning. Finally, we mention very briefly the link to belief revision that is established by considering total preorders (more specifically: ranking functions) as a semantics for (iterated) belief revision.

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3.6 The History of the Semantic Web

Peter F. Patel-Schneider (Nuance Communications – Mountain View, US)

This personal account describes the genesis and unfolding of the Semantic Web from its beginning to Anno Semantici Webi 22.

3.7 DL-Lite Ontology Changes

Zhe Wang (University of Oxford, GB)

Joint work of Wang, Zhe; Wang, Kewen; Topor, Rodney
Main reference Z. Wang, K. Wang, R. Topor, "A new approach to DL-Lite knowledge base revision," in Proc. of 24th AAAI Conf. on Artificial Intelligence (AAAI'10), pp. 369–374, 2010.
URL http://www.aaai.org/ocs/index.php/AAAI/AAAI10/paper/view/1786

Changing ontologies in description logics (DLs) in a syntax-independent manner is an important and challenging problem for ontology management. In this talk, we present a framework for adapting classical model-based belief change techniques to DL-Lite. Unlike propositional logic, a DL ontology may have infinitely many models with complex and often infinite structures, which introduce complexity to the definition of model distances, make computation via models impossible, and cause expressibility problems. For this reason, we first present an alternative semantic characterisation for DL-Lite by introducing the concept of features as approximations to classical DL models, and then define specific revision and merging operators for DL-Lite ontologies based on features. We present the desired properties possessed by these operators, as well as algorithms for computing the result of changing in DL-Lite. Remarkably, the complexity of the proposed operations in DL-Lite is on the same level as major belief change operators in propositional logic. Finally, prototype implementations of these operators are briefly presented.

4 Breakout Groups

4.1 Report of the Foundations Group

James P. Delgrande (Simon Fraser University – Burnaby, CA)

URL http://www.cs.sfu.ca/ jim/Foundations.pdf

The Foundations group was made up of a diverse group of 15 people, with areas of research including description logics, belief change, nonmonotonic reasoning, and database systems. Ten topics for discussion were identified, of which four were immediately put on hold. There was lively discussion on the remaining issues – ABox and TBox change, first-order issues, relevance, nonmonotonic subsumption, and the role of views.

There was agreement on some issues, for example that belief change needs to go beyond propositional accounts if it is to be useful for dealing with change in description logics; moreover a semantics and/or methodology is needed for change in description logics.

There was also recognition of common problems, notably relevance. If any overall conclusion can be drawn, it is that the 3 areas (BR, DL, DB) have somewhat different aims and methodologies on the one hand, yet broadly common problems on the other hand. While the communities are on the whole separate, it was worthwhile to get together and, moreover, it would be useful to continue meeting, perhaps focussing on a narrower topic.

4.2 Report of the Applications Group

Ulrike Sattler (University of Manchester, GB)

URL http://www.cair.za.net/node/115/Applications.pptx

In the Applications breakout group, we exchanged our views

1. on current developments,
2. new trends and challenges,
3. novel solution or coping techniques, and
4. general paradigms

in applications of the 3 different areas.

We had lively discussions and exchanged interesting and telling stories, partly concerned with (overcoming) communication difficulties between (end) users and tool developers and the usual chicken-and-egg difficulties of getting hold of suitable test data for tool development and optimisation. We had the impression that the three different communities had quite different quality criteria, paradigms, and evaluation approaches to their tools, and also value them in quite different ways: exchanging these different views and approaches is set to be useful in future collaborations, but also for exchanging and learning from each other.

4.3 Report of the Perspectives Group

Thomas Meyer (Meraka Institute & University of KwaZulu-Natal, ZA)

URL http://www.cair.za.net/sites/default/files/downloads/Perspectives.pdf

The brief of the Perspectives breakout group was to consider the following three aspects of each of the areas of databases, belief revision/nonmonotonic reasoning, and description logic:

1. Exciting developments
2. Pressing issues and open problems
3. Challenging areas

What followed was a vigorous discussion, culminating in a (perhaps surprisingly) fair level of consensus on these three points. More details can be found in the slides summarising the work of this breakout group. All participants agreed that one of the most valuable developments of the breakout session was the opportunity to gain a better understanding of the details, as well as the perceived successes and problems of those areas in which they are not experts. This may well form the basis of increased collaborative efforts between the different areas.

Participants

- Marcelo Arenas
Univ. Catolica de Chile, CL
- Franz Baader
TU Dresden, DE
- Leopoldo Bertossi
Carleton Univ. – Ottawa, CA
- Meghyn Bienvenu
Université Paris Sud, FR
- Alexander Bochman
Holon Inst. of Techn., IL
- Piero Andrea Bonatti
University of Napoli, IT
- Diego Calvanese
Free Univ. Bozen-Bolzano, IT
- David Carral Martínez
Wright State University – Dayton, US
- Giovanni Casini
Meraka Institute – Pretoria, ZA
- James P. Delgrande
Simon Fraser University – Burnaby, CA
- Thomas Eiter
TU Wien, AT
- Eduardo Fermé
Univ. of Madeira – Funchal, PT
- Giorgos Flouris
FORTH – Heraklion, GR
- Laura Giordano
University of Western Piemont – Alessandria, IT
- Birte Glimm
Universität Ulm, DE
- Andreas Herzig
Paul Sabatier University – Toulouse, FR
- Ian Horrocks
University of Oxford, GB
- Aaron M. Hunter
British Columbia Institute of Technology – Burnaby, CA
- Ryutaro Ichise
NII – Tokyo, JP
- Gabriele Kern-Isberner
TU Dortmund, DE
- Marcel Lippmann
TU Dresden, DE
- Carsten Lutz
Universität Bremen, DE
- Robert A. Meersman
Vrije Universiteit Brussel, BE
- Thomas Meyer
CSIR Meraka & University of KwaZulu-Natal, ZA
- Jeff Z. Pan
University of Aberdeen, GB
- Peter F. Patel-Schneider
Nuance Communications – Mountain View, US
- Rafael Penaloza
TU Dresden, DE
- Marcio Moretto Ribeiro
University of Sao Paulo, BR
- Riccardo Rosati
University of Rome "La Sapienza", IT
- Ulrike Sattler
University of Manchester, GB
- Stefan Schlobach
VU – Amsterdam, NL
- Matthias Thimm
Universität Koblenz-Landau, DE
- David Toman
University of Waterloo, CA
- Leon van der Torre
University of Luxembourg, LU
- Ivan José Varzinczak
Meraka Institute – Pretoria, ZA
- Kewen Wang
Griffith Univ. – Brisbane, AU
- Zhe Wang
University of Oxford, GB
- Renata Wassermann
University of Sao Paulo, BR
- Grant Weddell
University of Waterloo, CA
- Emil Weydert
University of Luxembourg, LU
- Frank Wolter
University of Liverpool, GB