

**04171 Abstracts Collection**  
**Logic Based Information Agents**  
— **Dagstuhl Seminar** —

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**Abstract.** From 18.04.04 to 23.04.04, the Dagstuhl Seminar 04171 “Logic Based Information Agents” was held in the International Conference and Research Center (IBFI), Schloss Dagstuhl. During the seminar, several participants presented their current research, and ongoing work and open problems were discussed. Abstracts of the presentations given during the seminar as well as abstracts of seminar results and ideas are put together in this paper. The first section describes the seminar topics and goals in general. Links to extended abstracts or full papers are provided, if available.

## 04171 Summary – Logic Based Information Agents

Logic-based methods have a great potential as a toolbox for the development of information technology infrastructure which is able to provide and handle advances services. With the creation of the world wide web, and the advent of the internet as a communication backbone for connecting people, more and more data and information is becoming available; however, our current methods for managing this wealth of information, including searching, integrating, and updating, are still at an early stage. Quite some efforts will be needed to research the foundations of this as well practical methods. This concerns particular methods for well-defined information processing tasks, as well as the design of systems for intelligent information processing. Due to the distributed nature of the web, and the local autonomy of information sites, this requires in particular the design and development of societies of information agents, which need to cooperate for providing information services as desired by the end user.

The Dagstuhl Seminar 04171 (Logic Based Information Agents) brought together researchers and developers who are involved in the research for methods and the design of systems for agent-based information processing, and in particular for searching, fusing, and cleaning distributed data and knowledge, using tools and methods from computational logic.

The seminar consisted of 20 presentations, which can be classified into the following subgroups:

1. Semantic Web and Description Logics;
2. P2P Data Integration;
3. Agent Systems—agent architectures, agent societies, and logical models of agents.

An open discussion was held on Friday morning about different opinions among participants on the following questions:

1. Should P2P data integration approaches care about agent theories?
2. Conversely, is P2P data integration just “simple” agent theory?
3. What is the use of agent theories in the semantic web? Or, vice versa, what can agent theories gain from semantic web methods?
4. What are “missing links” between (1) semantic web, (2) data integration, and (3) agent systems?
5. How could the current state of the art in (1), (2), and (3) be combined into a uniform framework? Is this desired?
6. Have you seen something from (1), (2) or (3) that might be useful in your field of expertise?

It is clear from the discussion that the fields of (1) semantic web, (2) P2P data integration, and (3) agent systems are closely connected. On one hand, the semantic web technology requires involvement and efforts from agent theories, and on the other hand, semantic web provides a ground for both P2P data integration and agent systems, which can be build on top of it. With more complex P2P systems, more agent technologies would be required and helpful, and agent technologies would play more important role.

In summary, the seminar provided a good opportunity for closer cooperation between the researchers from the areas of agent systems, semantic web, and P2P data integration. It helped to get a better understanding of the ways in which logic-based information agent systems may be built in the future, and helped to develop more efficient implementations of such systems.

## **Query Answering in P2P Data Exchange Systems**

*Leo Bertossi (Carleton Univ. - Ottawa, CDN)*

The problem of answering queries posed to a peer who is a member of a peer-to-peer data exchange system is studied. The answers have to be consistent wrt to both the local semantic constraints and the data exchange constraints with other peers; and must also respect certain trust relationships between peers. A semantics for peer consistent answers under exchange constraints and trust relationships is introduced and some techniques for obtaining those answers are presented.

## The agent metaphor for organizations of information agents

*Guido Boella (University of Torino, I)*

We propose the agent metaphor to structure societies of information agents. The agent metaphor allows to consider social entities like organizations as agents who are attributed mental attitudes like beliefs, desires and goals. Moreover, the metaphor allows structuring social entities in components as well as specifying the relations among their mental attitudes.

*Keywords:* Multiagent systems, organizations, normative systems

*Joint work of:* Boella, Guido; van der Torre, Leendert

## Logical Foundations of Peer-to-peer Data Integration

*Diego Calvanese (Free University - Bozen, I)*

In peer-to-peer data integration, each peer exports data in terms of its own schema, and data interoperation is achieved by means of mappings among the peer schemas. Peers are autonomous systems and mappings are dynamically created and changed. One of the challenges in these systems is answering queries posed to one peer taking into account the mappings. Obviously, query answering strongly depends on the semantics of the overall system. In the presentation, we compare the commonly adopted approach of interpreting peer-to-peer systems using a first-order semantics, with an alternative approach based on epistemic logic. We consider several central properties of peer-to-peer systems: modularity, generality, and decidability. We argue that the approach based on epistemic logic is superior with respect to all the above properties. In particular, we show that, in systems in which peers have decidable schemas and conjunctive mappings, but are arbitrarily interconnected, the first-order approach may lead to undecidability of query answering, while the epistemic approach always preserves decidability. This is a fundamental property, since the actual interconnections among peers are not under the control of any actor in the system. We present a distributed algorithm for query answering in peer-to-peer systems that is sound and complete with respect to the epistemic semantics and runs in polynomial time in the size of the data in the various peers of the system.

*Keywords:* Peer-to-peer systems, data integration, query answering

*Joint work of:* Calvanese, Diego; De Giacomo, Giuseppe; Lenzerini, Maurizio; Rosati, Riccardo

## Data Integration using ID-Logic

*Álvaro Cortés-Calabuig (University of Leuven, B)*

ID-Logic is a knowledge representation language that extends classical first-order logic with non-monotone inductive definitions. In this talk I introduce an ID-Logic based framework for database schema integration, that is: an approach to uniformly represent and reason with independent source databases that contain information about a common domain, but may have different schemas. The ID-Logic theories that are obtained are called mediator-based systems. I show that these theories properly capture the common methods for data integration, i.e., Global-as-View and Local-as-View with either exact or partial definitions), and propose an abductive inference technique for query answering.

## Communication Architecture in the DALI Logic Programming Agent-Oriented Language

*Stefania Costantini (University of L'Aquila, I)*

In this paper we describe the communication architecture of the DALI Logic Agent-Oriented language, and its use in the specification of Information Agents.

We have implemented the relevant FIPA compliant primitives, plus others which we believe to be suitable in a logic setting. We have designed a meta-level where: on the one hand the user can specify, via two distinguished primitives tell/told, constraints on communication and/or a communication protocol; on the other hand, meta-rules can be defined for filtering and/or understanding messages via applying ontologies and forms of commonsense and case-based reasoning. We outline the possible integration of DALI with intelligent wrapper generator and information extraction system, so as to allow the specification of intelligent information agents for the extraction, manipulation and presentation of knowledge from web sources.

*Keywords:* Logic Programming, agent-oriented logic languages, communication, intelligent information agents for extracting web knowledge

## The SEWASIE multi-agent system

*Pablo Fillottrani (Free University - Bozen, I)*

The SEWASIE (SEmantic Web and AgentS in Integrated Economies) is an European research project that aims at designing and implementing an advanced search engine enabling intelligent access to heterogeneous data sources on the web. The purpose of this talk is to present the architecture of the agent system that supports the SEWASIE network.

## Compliance Verification of Interaction Protocols Through Abduction

*Marco Gavanelli (Università di Ferrara, I)*

This seminar presents a framework based on Computational Logic (CL) for modelling interaction among agents that form a society in an open environment. The framework is equipped with a declarative and operational semantics expressed in terms of abduction. The operational counterpart of the proposed framework can be used for on-the-fly verification of agent compliance with respect to specified protocols. The seminar summarizes part of the work done during the first two years of the SOCS project, with respect to the task of modelling interaction amongst CL-based agents, named computees.

## Logic Based Ontology Engineering

*Ian Horrocks (Manchester University, GB)*

In this talk I will give a brief introduction to Description Logics (DLs), to the Semantic Web, and to the DL inspired Semantic Web ontology language OWL. I will show how the (description) logic based design of OWL has many benefits, and in particular how it facilitates the provision of support for ontology engineering using OWL. Finally, I will discuss some outstanding research challenges related to OWL and touch on work in progress that addresses some of these issues.

## Semantic characterizations of XPath, some fragments and some extensions.

*Maarten Marx (University of Amsterdam, NL)*

We provide several semantical characterizations of XPath and some of its useful fragments. One of our characterizations consists of a one line specification of the complete XPath grammar. As far as we know, the shortest one given ever. We characterize XPath in terms of its expressive power in first order logic, using the notion of (bi)simulation, and in terms of an important subset of XPath expressions, which we call declarative XPath.

*Keywords:* Semi-structured data, XML, XPath, logic

## DCaseLP: an Integrated Environment for Agent-Oriented Software Engineering

*Viviana Mascardi (University of Genova, I)*

The development of a prototype system of heterogeneous agents can be carried on in different ways. A first -trivial- solution consists in developing all the agents by means of the same implementation language and to execute the obtained program.

If this approach is adopted, during the specification stage it would be natural to select a specification language that can be directly executed or easily translated into code, and to specify all the agents in the MAS using it.

An opposite solution would be to specify each view of the MAS (including the MAS architecture, the interaction protocols among agents, the internal architecture and functioning of each agent) using the most suitable language in order to deal with the MAS's peculiar features, and to verify, execute, or animate the obtained specifications inside an integrated environment. Such an environment should offer the means to select the proper specification language for each view of the MAS, and to check the specifications. This check may be carried out thanks to formal validation and verification methods or by producing an executable code and running the prototype thus obtained.

Despite its greater complexity, the last solution has many advantages over the first, trivial one.

1. By allowing the use of different specification languages for each view of the MAS, it supports the progressive refinement of specifications.
2. By allowing the use of different specification languages for the internal architecture and functioning of each agent, it respects the differences existing among agents.
3. By allowing different implementation languages to be integrated inside the same running prototype, it allows the direct implementation of some of the agents, skipping the specification stage.
4. In case more than one language fits the requirements of an agent/view under specification, it allows the developer to choose the language he/she better knows and likes, leading to more reliable specifications and implementations.

In this talk we will describe DCASELP, an integrated environment aiming at implementing the desiderata above. Currently, DCASELP integrates two specification languages (AUML, DyLOG) and three implementation languages (Jess, Prolog, Java).

DCASELP takes advantage of the tools offered by the underlying JADE platform to run, monitor and debug the MAS prototype. It also provides a methodology to support the developer in all the stages required to engineer a MAS.

*Keywords:* AOSE, heterogeneity, integration of languages, logic-based languages, rule-based languages, formal verification

## OWL versus the Semantic Web

*Peter Patel-Schneider (Bell Labs - Murray Hill, USA)*

OWL is now a W3C-recommended part of the Semantic Web. OWL provides an ontology layer for the Semantic Web, largely in the form of an expressive Description Logic. However, there is a tension between the design needs of a Description Logic and the W3C vision of the Semantic Web that has resulted in some significant compromises in the design of OWL.

Nonetheless, OWL provides significant capabilities, both by itself and as part of a larger logic-based vision of the Semantic Web.

*Keywords:* Semantic Web Ontologies Description Logics

## Interleaving Planning and Action with Side-effect using Global Abduction

*Ken Satoh (NII - Tokyo, J)*

In this talk, we argue a planning method on the fly where planning and action with side-effect take place interleavingly. We consider situation that an agent makes a plan under incomplete information and therefore, the plan is not guaranteed to succeed. During the action with side-effect according to the plan, failure might be detected and if the failure occurs, an agent have to revise his plan. The problem arises, if the previous taken actions have side-effects since the alternative plans made at the first place might have to be revised. I will talk about an example of such problems and give a tentative solution using "global abduction" in logic programming which can pass the side-effect made at one search branch to other branches.

*Keywords:* Agent Cycle, Abduction, Belief Revision

## PROSOCS: A platform for (societies of) computational logic-based agents

*Kostas Stathis (City University - London, GB)*

We present the design of the PROSOCS (PROgramming Societies Of Computees) platform for developing and deploying societies of logic-based agents that we call computees, whose behaviour is dictated by the "KGP" (Knowledge, Goals, Plan) model of agency that we have developed within the EU project SOCS.

The platform supports computees to operate in an open and dynamic environment, by combining computational logic with P2P computing to enable computees to communicate with each other and be discovered dynamically by

other computees in the environment. Complex organisation of computees, called societies, can also be developed using the platform. For this purpose the platform provides tools for ensuring that computees conform to the social rules of specific societies.

*Keywords:* Agent Platforms, Computational Logic, P2P Computing, Agent Deployment

## Specifying Agent Systems (With and Without Coach)

*Frieder Stolzenburg (HS Harz - Wernigerode, D)*

In order to design and implement multiagent systems, the specification method should be as expressive and comprehensive as possible. Specifications of multiagent systems based on UML statecharts plus logical conditions can be verified, by employing model checking techniques. Hence, the proposed specification technique can be used for automated multiagent system implementation and analysis. This methodology is also suitable for information agents.

In a second part of the talk, we will concentrate on a specific problem of agent systems, namely matching of a group of agents. A matching is a (one-to-one) mapping between two sets, satisfying some given constraints. We discuss several different matching criteria, where preference between elements is based on their distance (not on rankings), and state their relationship to well-known criteria. Examples from different domains are given, e.g. robotic soccer.

## The KGP Model for Computational Logic-Based Agents

*Francesca Toni (Imperial College London, GB)*

We propose a formal framework for computational logic based agents that operate in an open and dynamic environment such as the one envisaged by the EU-sponsored Global Computing initiative.

We call such agents "computees" and the model "KGP" (Knowledge, Goals, Plan). The KGP model is a model for the operation of computees that synthesises their reasoning and sensing capabilities. Within this model computees are able to reason about goals and plans and to execute their plans depending on the state of their (perception of) the external environment. The computees are also able to reason about their own cycle of behaviour and make intelligent choices about it. Finally, the computees are able to interact (both actively and passively) with other computees in the same environment. The model is based upon computational logic (a-la-LP), both to model the reasoning capabilities, the reasoning about behaviour and the interaction with other computees.

*Joint work of:* Kakas, Antonis; Mancarella, Paolo; Sadri, Fariba; Stathis, Kostas; Toni, Francesca



## Perspectives of Knowledge Agency

*Emil Weydert (University of Luxemburg, L)*

Logic-based approaches to information agency offer interesting long-term research perspectives, like the modeling and automating of scientific activities, or in a more practical context, of software engineering.

However, to achieve such highly demanding tasks, information agents have to do metareasoning about the knowledge processes in the world, e.g. knowledge producers and providers, their capacities and relationships.

The corresponding theories are of course characterized by uncertainty and dynamics. This requires the use of sufficiently powerful qualitative and quantitative nonmonotonic formalisms allowing the agent to infer the relevant metadata concerning the information quality from the informational inputs, and to act accordingly. Furthermore, this perspective also provides a straightforward implementation of the cognitive projection paradigm, which distinguishes between rich epistemic structures and their projection onto more traditional decision-theoretic models.

## Implementing Answer Set Agents

*Marina de Vos (University of Bath, GB)*

We present systems of answer set agents (ASAS) to model the interactions between decision-makers while evolving to a conclusion. Such a system consists of a number of agents connected by means of unidirectional communication channels. Agents communicate with each other by passing answer sets obtained by updating the information received from connected agents with their own private information. We discuss both the theoretical as the implementation side of our approach.

*Keywords:* Agents, answer set programming

## Coordination or anticipation: the normative stance

*Leon van der Torre (CWI - Amsterdam, NL)*

Castelfranchi observes that agent theory and computer science focus on mechanisms for coordination, such as protocol design, whereas social theories focus on anticipation, for example based on expectations, agent profiles, and trust. In this presentation we discuss the Boella-vdTorre model of normative multiagent systems, which combines logical methods to formalize the system and game-theoretic methods to formalize anticipation.

Based on joint research with Guido Boella, University of Torino

*Keywords:* Coordination, normative systems