Overview of the Research Work done by Sudhir Agarwal at AIFB, University of Karlsruhe

Sudhir Agarwal
agarwal@aifb.uni-karlsruhe.de

1 Available Results and Tools

1.1 Description of Processes

We have developed a formalism for describing distributed multi-agent processes semantically. The formalism is a novel combination of π-calculus [14] and SHIQ(D) description logic [11] with DL-safe rules [15] and allows describing functional properties (schema, data and behaviour) and non-functional properties (QoS attributes and credentials) of processes in a unifying way [2, 4, 7]. In particular, the formalism supports variables to model relationships between inputs and outputs, mobility of processes, multiple communication protocols, typed names, updates and credential based access control. Such process descriptions are directly executable and during the execution actors prove their credentials by showing semantic SPKI certificates [6, 7].

1.2 Constraint Specification

In order to reason about the processes described with the above mentioned formalism, we have developed a constraints specification language based on μ-calculus and SHIQ(D). The language is very expressive while being still decidable and allows specifying constraints over the (un)desired functional and non-functional properties of a process [3, 1, 2]. The main idea behind the constraint specification language is to extend the basic μ-calculus by using description logic queries in place of μ-calculus atomic propositions and typed input and output activities in place of actions.

1.3 Reasoning about Processes

After having developed a language each for decribing processes and for specifiying constraints on the properties of processes, we have developed algorithms for mainly two reasoning tasks, namely simulation and model checking. The simulation algorithm directly compares two process descriptions and checks whether a process can be simulated by the other [9]. A model checking algorithm checks whether a given goal (set of constraints) can be satisfied by a given process description [3, 2]. Simulation of process descriptions can be computed offline and the materialized simulation relationships among process descriptions can be used to accelerate the model checking algorithm [2]. Formally, for given process descriptions P and Q and a formula ϕ in our constraint specification language, if P simulates Q and $Q \models \phi$ then $P \models \phi$. An ealier, less formal version of the matchmaking algorithm had been published in [8]. A short version of model checking process descriptions has been published in [3].

1.4 Implementation

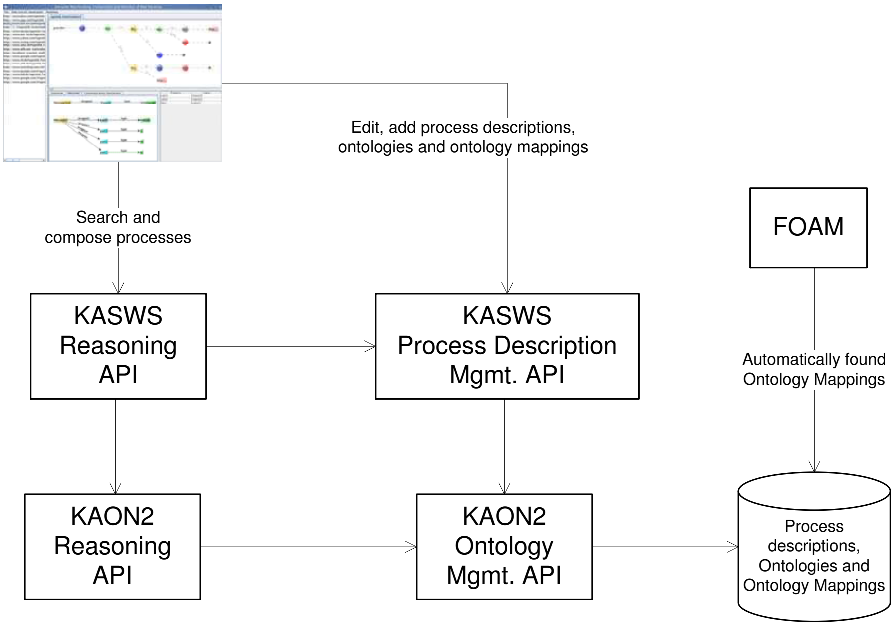

Figure 1: Architecture of Karlsruhe Semantic Web Services Framework

We have implemented an eclipse based tool for modelling the processes graphically (Refer to Figure 1). The graphical user interface allows to model SHIQ(D) ontologies, processes and conncetion between process names and ontogloy elements. Furthermore, it provides support for specifying goals. The above mentioned simulation algorithm and model checking algorithm are implemented as part of the KASWS Reasoning API. The tool allows users to browse the results of a query (goal) graphically. KAON2 (Karlsruhe Ontology Framework) can manage and reason about SHIQ(D) ontologies with DL-safe rules efficiently. So, we have chosen KAON2 to manage the domain ontologies, that are SHIQ(D) ontologies and expressive ontology mappings. We use FOAM (Framework for Ontology Mapping and Alignment) as a bootstrapping tool to extract (possibly faulty) simple mappings between concepts and relationships of the ontologies automatically. For expressive more expressive mappings, we rely on [10]. Furthermore, we have developed SHIQ(D) ontology for our process description language so that we can use KAON2 to manage the process descriptions as well.

2 Planned Extensions

2.1 Composition of Processes

The current matchmaking algorithm is a pure model checking algorithm. It checks for a given goal (set of constraints) and a process description, whether the process description fulfils the goal. It does not construct any process descriptions that may fulfil a given goal.

The first idea is to generalize the model checking algorithm. The new algorithm should also construct new process descriptions from the existing ones such that a composed process description fulfils the given goal. The process description language provides composition operator so that there is no need for developing any new formalism or extend the formalism for describing composite processes. The main challenge here is to develop a sound, complete, decidable and scalable composition algorithm.

The second idea is to go even one step further by considering that there is no repository of process descriptions. Rather, there is just a set of actors with their capabilities (knowledge and actions that they can perform alone or together with other actors). Given such descriptions of actors and a goal, the processes or workflows should be generated (semi) automatically as per demand or on the fly.

We believe that in order to generate processes descriptions that fulfil expressive goals (not just the types of inputs and output parameters) from the existing ones, classical AI planning based composition algorithms may not be sufficient. Rather one needs to extend tableaux proof systems known from modal temporal logics [16].

2.2 Ranking Process Descriptions according to User Preferences

Often, the desired properties of a process defined by a user are not hard but soft. E.g. a user may not completely rule out a process that charges his credit card before the book delivery, rather he might prefer it less than the one that charges his credit card after the delivery of the book. There has already been some work done in our group for specifying user preferences based on fuzzy logic [5] and utility theory [13, 12]. However, in these works preferences are defined only on the non-functional attributes of web services. The problem of specifying preferences on the temporal structure (as in the case of the above credit card example) of a process is still an open and interesting problem.

2.3 Disributed Execution of Processes

Currently, mostly the execution of the processes, even if they are distributed in nature, is centrally controlled. For example, a BPEL engine controls the execution of a process centrally like classical workflow engines. This is not always efficient, since the client needs to coordinate the communication between all the involved actors. A more efficient approach is to execute distributed processes in a distributed manner. In such a distributed execution, the client though initiates the execution, does not need to control the communication among the actors. Rather the involved actors recieve the appropriate data flow information from the client or other actors and send their outputs directly to right actors accordingly.

References

[1] Sudhir Agarwal. A Goal Specification Language for Automated Discovery and Composition of Web Services. In *International Conference on Web Intelligence*, Silicon Valley, USA, Novermber 2007. submitted, currently under review process.

[2] Sudhir Agarwal. *Formal Description of Web Services for Expressive Matchmaking.* PhD thesis, University of Karlsruhe (TH), May 2007.

[3] Sudhir Agarwal. Model Checking Expressive Web Service Descriptions (Short Paper). In *IEEE 5th International Conference on Web Services*, Salt Lake City, Utah, USA, July 2007. IEEE Computer Society.

[4] Sudhir Agarwal. Semantic Description of Behaviour and Trustworthy Credentials of Web Services. In *6th International Semantic Web Conference*, Busan, Korea, November 2007. submitted, currently under review process.

[5] Sudhir Agarwal and Steffen Lamparter. User Preference based Automated Selection of Web Service Compositions. In Kunal Verma; Amit Sheth; Michal Zaremba; Christoph Bussler, editor, *ICSOC Workshop on Dynamic Web Processes*, pages 1–12, Amsterdam, Netherlands, DEC 2005. IBM.

[6] Sudhir Agarwal and Barbara Sprick. Access Control for Semantic Web Services. In Liang-Jie Zhang, editor, *2nd International Conference on Web Services*, pages 770–773, San Diego, California, USA, July 2004. IEEE Computer Society.

[7] Sudhir Agarwal and Barbara Sprick. Specification of Access Control and Certification Policies for Semantic Web Services. In Kurt Bauknecht, Birgit Pröll, and Hannes Werthner, editors, *6th International Conference on Electronic Commerce and Web Technologies*, volume 3590 of *Lecture Notes in Computer Science*, pages 348–357, Copenhagen, Denmark, August 2005. Springer.

[8] Sudhir Agarwal and Rudi Studer. Automatic Matchmaking of Web Services. In Liang-Jie Zhang, editor, *IEEE 4th International Conference on Web Services*, pages 45–54, Chicago, USA, September 2006. IEEE Computer Society.

[9] Sudhir Agarwal and Rudi Studer. Semantic Matchmaking of Web Service Functionalities. *International Journal of Web Services Research (JWSR)[8]*, 2007. Invited submission for special issue on selected papers of ICWS'06. Currently in fast review track.

[10] Peter Haase and Boris Motik. A Mapping System for the Integration of OWL-DL Ontologies. In Axel Hahn, Sven Abels, and Liane Haak, editors, *IHIS 05: Proc.s of the 1st Int. Workshop on Interoperability of Heterogeneous Information Systems*, pages 9–16. ACM Press, November 2005.

[11] Ian Horrocks and Peter F. Patel-Schneider. A Proposal for an OWL Rules Language. In *Proceedings of the Thirteenth International World Wide Web Conference (WWW 2004)*, pages 723–731. ACM, 2004.

[12] Steffen Lamparter, Anupriya Ankolekar, Stephan Grimm, and Rudi Studer. Preference-based selection of highly configurable web services. In *Proc. of the 16th Int. World Wide Web Conference (WWW'07)*, Banff, Canada, MAY 2007.

[13] Steffen Lamparter, Anupriya Ankolekar, Daniel Oberle, Rudi Studer, and Christof Weinhardt. A Policy Framework for Trading Configurable Goods and Services in Open Electronic Markets. In Bruce Spencer, Mark S. Fox, Weichang Du, Donglei Du, and Scott Buffett, editors, *Proceedings of the 8th Int. Conference on Electronic Commerce (ICEC'06)*, pages 162 – 173, Fredericton, New Brunswick, Canada, AUG 2006.

[14] Robin Milner, Joachim Parrow, and David Walker. A Calculus of Mobile Processes, Part I+II. *Journal of Information and Computation*, pages 1–87, September 1992.

[15] Boris Motik, Ulrike Sattler, and Rudi Studer. Query Answering for OWL-DL with Rules. In Sheila A. McIlraith, Dimitris Plexousakis, and Frank van Harmelen, editors, *Proc. of the 3rd. Int. Semantic Web Conference (ISWC 2004)*, volume 3298 of *LNCS*, Hiroshima, Japan, November 2004. Springer.

[16] Barbara Sprick. *Towards Unifying Semantic Contraints and Security Contraints in Distributed Information Systems.* PhD thesis, Chair of Computer Science, 2003.