The Knowledge Engineering Review, Vol. 23:1, 1–6. © 2008, Cambridge University Press
doi:10.1017/S0269888907001294 Printed in the United Kingdom

Guest editorial preface: special issue on contexts and ontologies

PAVEL SHVAIKO

Department of Information and Communication Technology (DIT) University of Trento I-38050, Povo, Trento, Italy; e-mail: pavel@dit.unitn.it

This special issue includes a selection of extended papers from C&O-2006, the second International Workshop on Contexts and Ontologies, Theory, Practice and Applications[1] collocated with the seventeenth European Conference on Artificial Intelligence (ECAI) which took place in August 2006 in Riva del Garda, Italy.

During the last decade, there has been a line of successful series of workshops and conferences on the development and application of contexts[2] and ontologies[3]. Early workshops were focused mostly on identifying what contexts and ontologies are, and how they can be formalized and exploited. In more recent years with the emergence of distributed systems (for example, peer-to-peer systems, semantic Web (Staab & Stuckenschmidt, 2006)) the focus of workshops shifted towards issues of practical applications, such as semantic integration and coordination among information sources, where both contexts and ontologies were applied as promising solutions. However, few, if any, of these meetings have focused on combining the themes of ontologies and contexts and discussed them as complementary disciplines.

The goal of the C&O workshop series is to bring people from the context and ontology communities together to discuss the approaches they use for information integration. These workshops promote the cross-fertilization and exchange of ideas, for example, what are the commonalities and differences in the methods, which of the methods from one community can be successfully adopted by the other community and vice versa. C&O-2005 (Shvaiko et al., 2005) revealed multiple perspectives on combinations of contexts and ontologies. One perspective (originating from the work in Bouquet et al. (2004)) views an ontology as an explicit encoding of a domain model that may be shared and reused, while a context may be viewed as an explicit encoding of a domain model that is expected to be local and may contain one party's subjective view of the domain. C&O-2006 (Shvaiko et al., 2006) further explored this perspective as well as other perspectives and made more progress in leveraging increased communication between the context and ontology communities. The workshop was open to technical areas of interest between contexts and ontologies with anticipated focus on:

- approaches to semantic heterogeneity that utilize multiple contexts and ontologies;
- analysis and understanding of technical problems related to combination of contexts and ontologies from theoretical, practical and application perspectives.

Before proceeding to the introduction for the articles of this special issue, let us briefly overview the major lines of work done in various domains that consider ontologies, contexts and their combinations as the key instruments used to tackle the semantic heterogeneity problem in information integration tasks.

[1] http://www.c-and-o.net/

[2] See, for example, the International and Interdisciplinary Conferences on Modeling and Using Context (CONTEXT): http://context-web.org/context-conferences/

[3] See, for example, the International Conferences on Formal Ontology in Information Systems (FOIS): http://www.formalontology.org/ and the International Semantic Web Conferences (ISWC): http://iswc.semanticweb.org/

https://doi.org/10.1017/S0269888907001294 Published online by Cambridge University Press

Ontologies. An ontology is often defined as an explicit specification of a conceptualization (Gruber, 1993). This view has been further refined in Guarino (1998) and Guarino and Welty (2004), specifically, an ontology is a logical theory accounting for the intended meaning of a formal vocabulary, that is, its ontological commitment to a particular conceptualization of the world. The intended models of a logical language using such a vocabulary are constrained by its ontological commitment. An ontology indirectly reflects this commitment (and the underlying conceptualization) by approximating these intended models. Along these lines in some later works, such as Jarrar et al. (2003) and Parent et al. (2006), ontology is viewed as a generic knowledge about a domain and its association to a commitment specializes the ontology for a given application within the domain. Ontologies are expressed in an ontology language, for example, in OWL (Smith et al., 2004). There are a number of tools (see, e.g. Staab & Studer, 2004; Serafini et al., 2005; Sirin et al., 2007) providing (reasoning) services that help knowledge engineers and users in creating and using ontologies.

Contexts. According to (McCarthy, 1993), contexts are first class objects and the basic relation is *ist*, such that *ist*(p, c) asserts that the proposition p is true in context c. In CYC (Guha, 1995; Lenat, 1995), which is a knowledge base covering most common sense domains, a context or "micro-theory" is viewed as a set of assertions, representing a particular set of surrounding circumstances, relevant facts, if-then rules, and background assumptions[4]. Following the work in (Giunchiglia, 1993), the notion of context is used as a means for formalizing the locality of reasoning. This idea has been further developed in Giunchiglia and Ghidini (1998) by providing a foundation for contextual reasoning based on the formalization of two key principles: (1) locality, that is, reasoning uses only part of what is potentially available (e.g. what is known, the available inference procedures). The part being used while reasoning is called context (of reasoning). And, (2) compatibility, that is, there is compatibility among the kinds of reasoning performed in different contexts. Finally, the work in Benerecetti et al. (2000) identified three fundamental dimensions along which a context dependent representation may vary: (1) partiality, namely with the portion of the world which is taken into account; (2) approximation, namely with the level of detail at which a portion of the world is represented; and (3) perspective, namely with the point of view from which the world is observed.

Contexts and ontologies. There have been proposed several frameworks for combining contexts and ontologies as well as these have been used in various applications. Recalling the work in (Bouquet, 2004) mentioned before, ontologies are shared models of some domain that encode a view which is common to a set of different parties. In turn, contexts are local (where local is intended here to imply not shared) models that encode a party's view of a domain. Then, a contextual ontology is an ontology plus context mappings. The key idea is to share as much as possible (OWL import construct) and keep the contents local whenever sharing does not work (C-OWL context mappings) (Giunchiglia, 2008). In Segev and Gal (2007), ontologies are viewed as the result of a manual effort to model a domain, while contexts are automatically generated models. The uncertainty, which usually exists in automatic context extraction, is managed through the definition of distance among contexts and a ranking of ontology concepts with respect to a given context. Following Spaccapietra (2006), ontologies define the semantics of concepts, while contexts define which of the many semantics of a concept holds due to the "environment" surrounding the use of the concept. This work focuses on making data context-aware and contextualization of data is viewed as ontology modularization, where a module is a set of knowledge relevant for a given context.

The work in Chalmers (2004) discusses the origins of context-aware systems and ubiquitous computing. A design methodology for small databases to be hosted by mobile devices and used in context-aware applications is given in Bolchini et al. (2007). In such settings, context is often defined as any information that can be used to characterize the situation of entities (i.e. whether a person, place or object) that are considered relevant to the interaction between a user and an

[4] Cyc: `http://www.cyc.com/cycdoc/course/what-is-a-context.html`

https://doi.org/10.1017/S0269888907001294 Published online by Cambridge University Press

application, including the user and the application themselves. Context is typically the location, identity and state of people, groups and computational and physical objects (Dey et al., 2001). Some other works, such as those in Coutaz et al. (2005) and Henricksen et al. (2005), have further proposed more sophisticated and general context models to be used in pervasive computing settings. In turn, ontologies here are often used as an explicit representation of contextual facts, such that devices can share and reason about contexts, see, for example.

Matching data and conceptual models of information sources is a plausible solution to the semantic heterogeneity problem in many metadata intensive applications. Heterogeneity can be reduced in two steps: (1) match data and conceptual models to determine alignment (i.e. set of correspondences between entities of those models) and (2) process the alignment according to an application needs (for instance, data translation) (Euzenat & Shvaiko, 2007). When two ontologies (in a loose sense of the term, thus including database schemas, classifications, etc.) have to be matched, often intermediate resources can be used for that purpose in order to define the common context or background knowledge (Giunchiglia et al., 2006) for them. The intuition is that a background ontology with a comprehensive coverage of the domain of interest of the ontologies to be matched helps in the disambiguation of multiple possible meanings of terms, see, for example, Aleksovski and Klein (2006) and Zhang and Bodenreider (2007). Also, an earlier work in Kashyap and Sheth (1996) uses context as the key component in capturing the semantics related to a database object definition as well as its relationships to other objects in a multidatabase environment. In turn, the contexts are obtained from domain-specific ontologies.

Let us note that the discussion above was only meant to set the scene for the articles of this special issue as well as to provide several entry points to the topic, though it is far from being exhaustive. A final observation is that the above mentioned works as well as the discussions and the invited talks (by Fausto Giunchiglia, Chris Welty, Frank van Harmelen and Selene Makarios) made at C&O-2005 and C&O-2006 events suggest that ontologies need contexts, contexts need ontologies and the main themes of convergence among them include the information interoperability and reuse.

Contents of this issue

Based on C&O-2005, three extended papers were accepted for a special issue of the *Journal on Data Semantics* Spaccapietra et al. (2007a,b). In turn, the selection from C&O-2006 resulted in five extended papers being accepted for this special issue of *The Knowledge Engineering Review* after two rounds of reviews.

The first paper, 'Situational reasoning for task-oriented mobile service recommendation' by Marko Luther, Yusuke Fukazawa, Matthias Wagner and Shoji Kurakake presents an approach that combines ontological and contextual knowledge to guide mobile users towards best-fitting services. In particular, a task navigation system has been used and extended by exploiting a situation reasoning engine to apply classification-based inference to context elements, gathered from multiple sources represented by means of OWL DL ontologies. The task navigator enables the delivery of situation-aware recommendations in a proactive way and the experiments conducted indicate its adequate usability.

The second paper, 'Dynamic context management for pervasive applications' by Jérôme Euzenat, Jérôme Pierson and Fano Ramparany, as its title indicates, discusses an approach for dynamic context management in pervasive applications. In particular, it provides a distributed component architecture where a context manager relies on the semantic Web technologies in order to identify and characterize available resources. The components in the environment maintain their own contexts by means of RDF and OWL ontologies, and may communicate this context information to other components by means of SPARQL. In turn, the heterogeneity of independently developed context models (which are represented using different ontologies) is handled by using ontology matching. The approach allows introduction of new components and

https://doi.org/10.1017/S0269888907001294 Published online by Cambridge University Press

applications dynamically, featuring their smooth integration into the environment. The proposed context management system has been implemented and an experiment in the hotel room scenario has been provided.

The third paper, 'Semantically routing queries in peer-based systems: the H-Link approach' by Silvana Castano and Stefano Montanelli provides a new mechanism, called H-Link, for routing queries in peer-to-peer networks, where each peer provides its own context represented by means of a peer ontology specified in OWL. The semantically close peers are discovered and selected to be the recipients of a given query instead of broadcasting the query to all peers in the system. Also, there is no assumption that the correspondences among peers are known in advance. Instead, these links between peers with similar contexts are established via an affinity-based ontology matching, specifically by using the H-Match system and trading quality of matching for its efficiency in view of scalability reasons. The approach has been implemented and evaluated using several simulation experiments.

The fourth paper, 'Personalized information retrieval based on context and ontological knowledge' by Phivos Mylonas, David Vallet, Pablo Castells, Miriam Fernandez and Yannis Avrithis provides methods for automatic extraction of persistent user preferences as well as ad-hoc user interests, which are combined in order to improve the accuracy of personalization in information retrieval. Specifically, ontologies are used to represent a domain of discourse as a common ground for encoding content meaning and user interests. In turn, the notion of context is used at profiling and retrieval stages and by relying on a fragment of a domain ontology it is exploited to help focusing or extending the system interpretation of user interests to a specific area. Fuzzy representations are used as an instrument to handle the uncertainty and imprecision involved in the automatic interpretation of user preferences and user context. The proposed approach has been implemented and evaluated.

The fifth paper, 'A context-sensitive framework for lexical ontologies' by Tony Veale and Yanfen Hao presents an automatic Web-based approach to acquiring the diagnostic properties of concepts, for example, that espresso is strong and black, in order to augment the lexical ontologies, such as WordNet, by tagging the concepts with these properties. This allows defining functional forms for WordNet senses, such that they can better be understood in different contexts of how these concepts are actually used, thereby facilitating the design of context-sensitive ontologies. An empirical evaluation of the approach has been provided.

Finally, it is worth noting that at the time of writing this special issue preface, the third workshop on the topic called Contexts and Ontologies: Representation and Reasoning (C&O:RR) and collocated with the sixth International and Interdisciplinary Conference on Modeling and Using Context (CONTEXT) took place in August 2007 in Roskilde, Denmark (Bouquet et al., 2007).

Acknowledgements

We appreciate support from the Knowledge Web[5] European Network of Excellence (IST-2004-507482) and the OpenKnowledge[6] European STREP (FP6-027253). We would like to express our utmost gratitude to the special issue referees, who invested a lot of time and energy in contributing detailed reviews and feedback on the submitted articles:

- Patrick Brézillon, University Paris, France
- Harry Chen, Image Matters, USA
- Jérôme Euzenat, INRIA Rhône-Alpes, France
- Aldo Gangemi, CNR-ISTC, Italy
- Fausto Giunchiglia, University of Trento, Italy

[5] http://www.knowledgeweb.semanticweb.org
[6] http://openk.org

https://doi.org/10.1017/S0269888907001294 Published online by Cambridge University Press

- Peter Haase, University of Karlsruhe, Germany
- Jingshan Huang, University of South Carolina, USA
- Mustafa Jarrar, Vrije Universiteit Brussel, Belgium
- Vipul Kashyap, Clinical Informatics R&D, Partners HealthCare System, USA
- Alain Léger, France Telecom R&D, France
- Leo Obrst, The MITRE Corporation, USA
- Dimitris Plexousakis, University of Crete, Greece
- Fano Ramparany, France Telecom R&D, France
- Chantal Reynaud, University of Paris-Sud, France
- Karen Robinson (Henricksen), NICTA, Australia
- Aviv Segev, Technion, Israel
- Elena Simperl, University of Innsbruck, Austria
- Umberto Straccia, ISTI-C.N.R., Italy
- Mikalai Yatskevich, University of Trento, Italy

References

Aleksovski, Z., Klein, M., ten Kate, W. and van Harmelen, F. 2006 Matching unstructured vocabularies using a background ontology. In *Proceedings of the International Conference on Knowledge Engineering and Knowledge Management (EKAW)*, pp. 182–197.

Benerecetti, M., Bouquet, P. and Ghidini, C. 2000 Contextual reasoning distilled. *Journal of Experimental and Theoretical Artificial Intelligence* **12**(3), 279–305.

Bolchini, C., Schreiber, F. A. and Tanca, L. 2007 A methodology for a very small data base design. *Information Systems* **32**, 61–82.

Bouquet, P., Euzenat, J., Ghidini, C., McGuinness, D.L., de Paiva, V., Serafini, L., Shvaiko, P. and Wache, H. (eds.) 2007 *Proceedings of the 3rd CONTEXT Workshop on Contexts and Ontologies: Representation and Reasoning (C&O:RR-2007)*:. Available at `http://ftp.informatik.rwth-aachen.de/publications/CEUR-WS/Vol-298/proc.pdf`.

Bouquet, P., Giunchiglia, F., van Harmelen, F., Serafini, L. and Stuckenschmidt, H. 2004 Contextualizing ontologies. *Journal of Web Semantics* **1**(1), 325–343.

Chalmers, M. 2004 A historical view of context. *Computer Supported Cooperative Work* **13**(3), 223–247.

Chen, H., Finin, T. and Joshi, A. 2003 An ontology for context-aware pervasive computing environments. *Knowledge Engineering Review* **18**(3), 197–207.

Coutaz, J., Crowley, J., Dobson, S. and Garlan, D. 2005 Context is key. *Communications of the ACM* **48**(3), 49–53.

Dey, A. K., Abowd, G. D. and Salber, D. 2001 A conceptual framework and a toolkit for supporting the rapid prototyping of context-aware applications. *Human-Computer Interaction* **16**(2–4), 97–166.

Euzenat, J. and Shvaiko, P. 2007 *Ontology matching*. Heidelberg: Springer.

Giunchiglia, F. and Ghidini, C. 1998 Local models semantics, or contextual reasoning = locality + compatibility. In *Proceedings of the International Conference on the Principles of Knowledge Representation and Reasoning (KR)*, pp. 282–291.

Giunchiglia, F. 1993 Contextual reasoning. *Epistemologia* **16**, 345–364.

Giunchiglia, F., Shvaiko, P. and Yatskevich, M. 2006 Discovering missing background knowledge in ontology matching. In *Proceedings of the European Conference on Artificial Intelligence (ECAI)*, pp. 382–386.

Giunchiglia, F., van Harmelen, F., Serafini, L. and Stuckenschmidt, H. 2008 Distributed *Ontologies on the Semantic Web—The C-OWL Approach*. Springer, to appear.

Gruber, T. R. 1993 A translation approach to portable ontology specifications. *Knowledge Acquisition* **5**(2), 199–220.

Guarino, N. and Welty, C. A. 2004 An overview of OntoClean. In Staab, S. and Studer, R. (eds.), *Handbook on Ontologies, International Handbooks on Information Systems*, pp. 151–172. Heidelberg: Springer.

Guarino, N. 1998 Formal ontology in information systems. In *Proceedings of the International Conference on Formal Ontology in Information Systems (FOIS)*, pp. 3–15.

Guha, R. 1995 *Contexts: A Formalization and Some Applications*. PhD thesis, Stanford University.

Henricksen, K., Indulska, J., McFadden, T. and Balasubramaniam, S. 2005 Middleware for distributed context-aware systems. In *Proceedings of the International Symposium on Distributed Objects and Applications (DOA)*, pp. 846–863.

Jarrar, M., Demey, J. and Meersman, R. 2003 On using conceptual data modeling for ontology engineering. *Journal on Data Semantics* **I**, 185–207.

Kashyap, V. and Sheth, A. 1996 Semantic and schematic similarities between database objects: a context-based approach. *The VLDB Journal* **5**(4), 276–304.

https://doi.org/10.1017/S0269888907001294 Published online by Cambridge University Press

Lenat, D. B. 1995 CYC: A large-scale investment in knowledge infrastructure. *Communications of the ACM* **38**(11), 33–38.

McCarthy, J. 1993 Notes on formalizing contexts. In *Proceedings of the International Joint Conference on Artificial Intelligence (IJCAI)*, pp. 555–560.

Parent, C., Spaccapietra, S. and Zimányi, E. 2006 *Conceptual Modeling for Traditional and Spatio-Temporal Applications: The MADS Approach*. Heidelberg: Springer.

Segev, A. and Gal, A. 2007 Putting things in context: A topological approach to mapping contexts to ontologies, *Journal on Data Semantics* **IX**, 113–140.

Serafini, L., Borgida, A. and Tamilin, A. 2005 Aspects of distributed and modular ontology reasoning. In *Proceedings of the International Joint Conference on Artificial Intelligence (IJCAI)*, pp. 570–575.

Shvaiko, P., Euzenat, J., Léger, A., McGuinness, D. L. and Wache, H. (eds.) 2005 *Proceedings of the 1st AAAI Workshop on Contexts and Ontologies: Theory, Practice and Applications (C&O-2005)*. Menlo Park, CA, USA: AAAI Press.

Shvaiko, P., Euzenat, J., Léger, A., McGuinness, D. L. and Wache, H. (eds.) 2006 *Proceedings of the 2nd ECAI Workshop on Contexts and Ontologies: Theory, Practice and Applications (C&O-2006)*. Available at `http://ftp.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-120/`.

Sirin, E., Parsia, B., Cuenca Grau, B., Kalyanpur, A. and Katz, Y. 2007 Pellet: a practical OWL-DL reasoner, *Journal of Web Semantics* **5**, 51–53.

Smith, M., Welty, C. and McGuinness, D. (eds.) 2004 *OWL web ontology language guide*. Recommendation, W3C.

Spaccapietra, S. 2006 What would you like to drink? Invited talk at the ECAI Workshop on Context Representation and Reasoning (CRR-2006), http://lbdwww.epfl.ch/~stefano/Context06.ppt.

Spaccapietra, S., Atenzi, P., Fages, F., Macid, M.-S., Kifer, M., Mylopoulos, J., Pernici, B., Shvaiko, P., Trujillo, J. and Zaihrayeu, I. (eds.) 2007a *Journal of Semantics VIII*. Lecture Notes in Computer Science **4380**. Heidelberg: Springer.

Spaccapietra, S., Atenzi, P., Fages, F., Macid, M.-S., Kifer, M., Mylopoulos, J., Pernici, B., Shvaiko, P., Trujillo, J. and Zaihrayeu, I. (eds.) 2007b *Journal on Data Semantics IX*. Lecture Notes in Computer Science **4601**. Heidelberg: Springer.

Staab, S. and Stuckenschmidt, H. (eds.) 2006 *Semantic Web and Peer-to-Peer*. Heidelberg: Springer.

Staab, S. and Studer, R. 2004 *Handbook of Ontologies. International Handbooks on Information Systems*. Heidelberg: Springer.

Strang, T., Linnhoff-Popien, C. and Frank, K. 2003 CoOL: a context ontology language to enable contextual interoperability. In *Proceedings of the IFIP WG 6.1 International Conference on Distributed Applications and Interoperable Systems (DAIS)*, pp. 236–247.

Zhang, S. and Bodenreider, O. 2007 Experience in aligning anatomical ontologies. *International Journal on Semantic Web and Information Systems* **3**(2), 1–26.

https://doi.org/10.1017/S0269888907001294 Published online by Cambridge University Press