Ontology-Guided Meaning Negotiation in Communities of Practice[1]

Aldo de Moor
STARLab, Vrije Universiteit Brussel, Belgium
ademoor@vub.ac.be

Abstract. Communities of practice require many specialized communication services, including customized workflow management systems, discussion services, and knowledge management systems. Communication ambiguities create a mismatch between these services and community requirements, and are caused by unclear (e.g. incomplete, inconsistent, overlapping) definitions of communication patterns. These are sets of related communicative workflow and norms definitions describing the acceptable and desired communicative interactions within a community. Addressing communication ambiguities requires a process of meaning negotiation, in which community members arrive at the requisite amount of agreement on pattern definitions to continue or improve collaboration. Ontologies are instrumental in facilitating this negotiation process in large-scale online communities. In the DOGMA approach, we are exploring ways to develop ontology-guided meaning negotiation.

Introduction

Communities of practice are important catalysts of research, economic and social processes. Such, at least partially, *virtual* communities are evolving socio-technical systems (Wenger et al., 2002). In these communities, many stakeholders collaborate on joint goals while simultaneously having partially conflicting interests. Examples are regional business networks, SME networks, innovation

[1] Proc. of the Workshop on the Design for Large-Scale Digital Communities at the 2nd International Conference on Communities and Technologies, June 2005, Milano, Italy.
This research was sponsored by the EU Leonardo da Vinci CODRIVE (BE/04/B/F/PP-144.339) project.

platforms, and R&D networks. Communities of practice have a need for a wide range of communication services (Preece, 2000). Examples include customized workflow management systems, discussion services, and knowledge management systems.

At the moment, it is very hard for communities to select and configure appropriate services, since their communicative requirements are difficult to specify using technology-focused web service modelling and specification approaches such as UDDI, BPEL4WS, and WSDL. The reason is that communities are not governed hierarchically, but are complex socio-technical systems regulated by subtle, situated sets of norms (Harvard Law School, 1999; Carotenuto et al., 1999). Such communicative norms work in unexpected ways to generate trust and social support (Ridings et al., 2002; Wellman and Gulia, 1999). To capture such norms in large-scale online communities, systematic support for service selection and configuration is indispensable. Technical modelling approaches for semantic web services do not suffice. Instead, communicative workflow modelling approaches are needed that specify the human and organizational interaction patterns in communities of practice. In this paper, we briefly outline a way of looking at communication in communities of practice, grounded in the Language/Action paradigm. We then sketch the role of ontology-guided meaning negotiation in dealing with the communication ambiguities occurring during collaboration. We conclude by outlining the DOGMA framework in which we are developing an ontology-based support system for meaning negotiation.

Communication in Communities of Practice

Well-designed *communication* is essential for both the coordination of (inter)actions in the community (Malone and Crowston, 1994) and the reaching of true consensus, instead of imposing decisions by force (Froomkin, 2003; Manninen 2002). *Communication patterns* are the key *design* elements that ensure that the systems supporting communities properly embody the communication norms of the community. They can be defined as a set of related communicative workflow and norm definitions describing acceptable and desired communicative interactions within a community. A *communicative workflow* is a sequence of steps to be performed to complete a communicative interaction. A *communication norm* is a set of one or more communicative actions a stakeholder may, must, or may not perform in a communicative workflow. Finally, a communication pattern may also contain *meta-norms*, which are sets of actions an actor may, must, or may not perform in defining or accessing a communication pattern. Over time, communities typically form their own, unique communication patterns that govern their interactions.

Much current state-of-the-art research for workflow modelling and management is grounded in a control flow paradigm, in which the focus is on efficiently moving objects through a system, such as exemplified by Petri-Nets or many business workflow modelling methods (van der Aalst et al., 2003), and embodied in workflow management systems like Lotus Notes/Domino and SAP/R3. However, to model the commitments, interests, responsibilities, and so on that typify workflow processes in evolving stakeholder communities, a communicative workflow paradigm is needed. The Language/Action Perspective (LAP), as originally introduced by Winograd and Flores (1986) provides such a paradigm. In contrast to data-oriented methods such as state transition diagrams or UML interaction diagrams, LAP modelling is based on the notion of communicative action. This means that communication is viewed at the level of social relationships and action, the focus not being on the efficient transmission of data content, but on organizational coordination (Agerfalk, 2004). One classic LAP-based methodology, ActionWorkflow, models communication loops between stakeholders (Medina-Mora et al., 1993). In this model, a customer requests an action from a performer, who promises to act accordingly. After having performed the action, the performer reports back to the customer, who then evaluates the result (Fig.1).

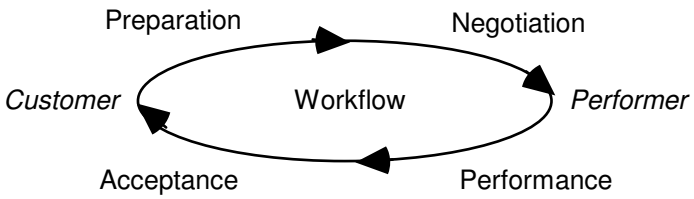

Figure 1. The ActionWorkflow Loop (Medina-Mora et al., 1993)

The Extended Workflow Loop Model (XWL) is an extended version of ActionWorkflow, as it also represents *delegation* of communicative actions. Furthermore, it specifically pays attention to the norms that describe acceptable or desired communicative actions (Weigand and De Moor, 2003). Such norms can be used for instance in a process of legitimacy checking of an actual or proposed communicative workflow (De Moor and Weigand, 2004). Networks of such communication loops are powerful constructs to model the communicative interactions, dependencies and norms that occur in complex, emerging stakeholder communities.

Resolving communication ambiguities

Many of the communication patterns that define communication requirements in communities are implicit, or only defined informally. In communities of practice, many *communication ambiguities* arise, and are caused by unclear (e.g. incomplete, inconsistent, partially overlapping) definitions of communication patterns. This is not necessarily a problem when a small, informal community operates in isolation. However, it becomes a serious drawback when communities grow to become large and distributed. Also, shared meanings need to be clarified when doing large-scale comparisons of patterns across communities, for example when sharing communicative best practices across Europe.

To prevent such ambiguities from leading to disruptions in collaboration, they need to be resolved. Ontologies can play an instrumental role by making *meaning negotiation* more effective and efficient.

Ontology-Guided Meaning Negotiation

Ontologies are essential to be able to represent and reason about shared meanings (Guarino and Giaretta, 1995; Gruber, 1995). Much ontological research on the Semantic Web therefore focuses on developing advanced knowledge representation and reasoning approaches to promote semantic interoperability among applications. However, many open issues remain on the *engineering* process of developing ontology-guided systems that are capable of solving real world problems, such as improving communication and collaboration processes in communities. A necessary condition for communication patterns to be modelled successfully, is that the community members agree on the meaning of the concepts used in the patterns, as well as on their relations. To this purpose, communication and domain ontologies need to be developed that adequately capture the commonalities and differences in meaning. Much advanced work in ontology engineering focusing on the elicitation (Hameed et al., 2002), representation (Gómez-Pérez et al., 2003), alignment, merging (Euzenat et al., 2004) and use of ontologies (Sheth and Meersman, 2002), is relevant here.

A remaining problem with defining and using such ontologies in emerging communities is that there are many sources of meaning and that those meanings shift continuously as well, making knowledge sharing difficult (Edgington et al., 2004). State-of-the art ontology research, therefore, should focus more on developing ontological *meaning negotiation processes*. The problem of whether and how to reach consensus on ontologies in a distributed environment has not been solved, and has so far mainly focused on architectures for consensual knowledge bases (Euzenat, 1995; Decker et al., 1999). Recent work focuses even more on the cooperative construction of domain ontologies (e.g. Aschoff et al., 2004). With meaning negotiation, we refer to developing ontology-guided,

community-oriented processes for agreeing upon and reaching the *appropriate* amount of consensus on terminology and concept definitions. Such processes are necessary in order to allow for the development of effective collaborative services in stakeholder communities with multiple meanings and interests. At the moment it is not clear which ambiguities (e.g. inconsistent definitions) in what types of concept definitions are detrimental to collaboration in communities. For example, different regional communities will have different communicative norms with respect to collaboration quality issues. These can perfectly co-exist as long as communities operate in isolation. The moment communities start to collaborate, however, quality norms may clash. In that case, particular communication norms may have to be redefined and unanimously agreed upon. In our research, we focus on developing the mechanisms to assess the pragmatic *impact* of such semantic differences on a community and on negotiation processes among community stakeholders to effectively and efficiently deal with them.

The DOGMA Approach

Communication ambiguities need to be resolved in an ontology-guided meaning negotiation process, in which stakeholders are guided to reaching agreement on definitions insofar necessary. For example, for a definition of a collaborative workflow, a unanimous agreement of conceptual meaning reached in a consensus-seeking process may be needed. For other types of applications, only terminological agreement may be needed, while all community members can have their own conceptual definitions.

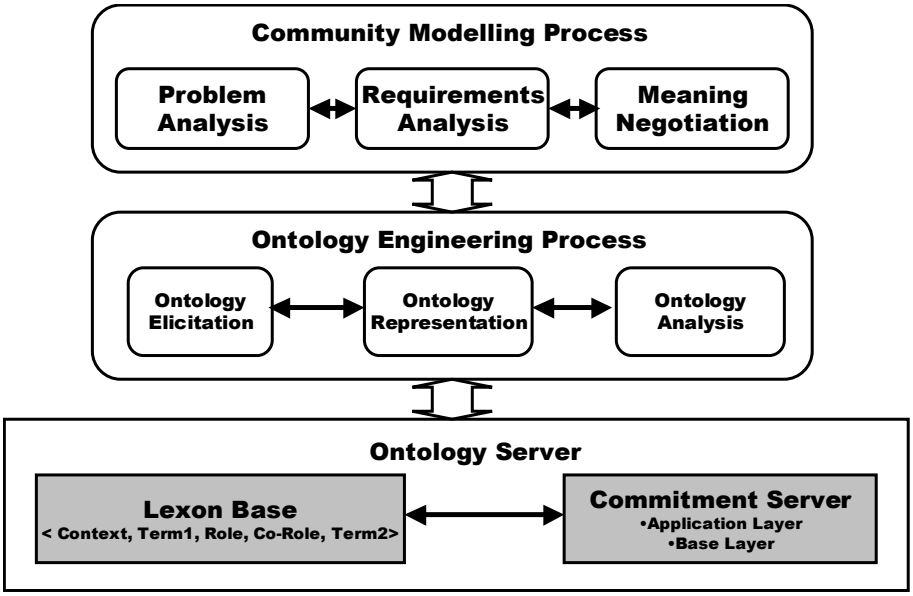

Figure 2. The DOGMA Framework

The DOGMA approach to ontology engineering, developed at VUB STARLab, aims to satisfy real world needs by developing a useful and scalable ontology engineering approach. Its philosophy is based on a double articulation: an ontology consists of an ontology base of lexons, which holds (multiple) intuitive conceptualizations of a domain, and a layer of ontological commitments, where each commitment holds a set of domain rules (Spyns et al. 2002). By having an ontology server consisting of a lexon base and a commitment server, scaleable ontological solutions for complex and overlapping domains can be built. The ontological engineering process focuses on questions of how to elicit, represent, and analyze ontological knowledge. The DOGMA framework is currently being extended with a community modelling process layer (Fig.2). As such, it forms a linking pin between the worlds of ontological engineering and community modelling. The community modelling process supports the process of applying the ontological engineering processes to the community modelling tasks of problem analysis, requirements analysis, and meaning negotiation between members.

The basis for meaning negotiation is an analysis of ontological commitments in which communication patterns are stored in DOGMA Studio, STARLab's distributed and scalable ontology management framework. Ontological commitments provide basic representations of multiple meanings (Spyns et al., 2002). In order to provide communicative requirements specific enough for service specification, commitments may need to be *semantically enriched*, by including context knowledge, such as about roles stakeholders play, quality aspects, and technological infrastructure present in a community. To this purpose, a commitment library management system needs to be developed which will

classify context knowledge so that it can be easily accessed for enrichment purposes.

The *meaning negotiation* process itself will be governed by communication meta-norms, indicating who is entitled to make which changes to ontological definitions. This meta-norm guided ontology specification process is based on the RENISYS method, a conceptual graphs-based approach for the legitimate user-driven specification of community information systems, including their ontologies (De Moor and Jeusfeld, 2001). To define meaning negotiation protocols, we will make use of a Business Negotiation Support Metamodel (BNSM), which provides guidance on negotiation actors, roles, stages, and norms (De Moor and Weigand., 2003). This BNSS will be included as an extension of the current DOGMA Studio system.

Conclusions

Collaborative work in communities is governed by communication patterns. However, in community interactions, many communication ambiguities arise. To prevent these ambiguities from having a disruptive effect on the health and productivity of the community, ontology-guided meaning negotiation is an essential process in clarifying the semantics of communication patterns. We showed how the modeling of communication patterns should be done from a Language/Action perspective and have positioned ontology-guided meaning negotiation as an essential instrument for communication ambiguity resolution. We introduced work being done in the DOGMA framework on operationalizing this process.

Work is only beginning on combining the two very different worlds of community modelling and ontology engineering. Meaning negotiation is the bridge between these two research worlds. Some of the many issues to be addressed are:

- What classifications of communication ambiguities can be conceived? What kinds of meaning agreements are needed to resolve these ambiguities?
- How should meaning negotiation processes be integrated with larger community processes, such as community discussion and collaboration? When exactly should negotiation processes be invoked? Only when breakdowns happen, or pre-emptively? Which stakeholders should be involved in which roles in meaning negotiation processes?
- What exactly is the role of ontologies in the meaning negotiation process? Potential inputs ontologies can provide, include refining communication patterns, providing elements for the discussion agenda, clarifying the context of the negotiation process, and configuring the negotiation process. However, during the negotiation process, ontologies themselves can also be

updated, since new or modified definitions become available. How to organize this ontology update process?

- How best to engineer the ontologies so that they can provide optimal support for the meaning negotiation process? For example, what kinds of ontological analyses are needed? An overview of differences or similarities in commitments made by different stakeholders, could, for instance, help in predicting potential misunderstandings leading to breakdowns in work.

This paper gave a brief outline of the role and possible implementation of the ontology-guided meaning negotiation process. Research on this domain should have profound effects both for theory and practice of improving collaborative work environments for large-scale communities of practice.

Acknowledgments

This research has been done with support of the EU Leonardo da Vinci CODRIVE (BE/04/B/F/PP-144.339) project.

References

Agerfalk, P. (2004). Investigating Actability Dimensions: A Language/Action Perspective on Criteria for Information Systems Evaluation*, Interacting with Computers* 16:957-988.

Aschoff, F.-R, Schmalhofer, F. and van Elst, L. (2004). Knowledge Mediation: a Procedure for the Cooperative Construction of Domain Ontologies. In *Proc. of the ECAI 2004 Workshop on Agent-mediated Knowledge Management*, pp. 29 - 38

Carotenuto, L., Etienne, W., Fontaine, M., Friedman, J., Muller, M., Newberg, H., Simpson, M., Slusher, J. and Stevenson, K. (1999). CommunitySpace: Toward Flexible Support for Voluntary Knowledge Communities. In *Changing Places Workshop, London, April 1999*.

Decker, S., Erdmann, M., Fensel, D. and Studer, R. (1999). Ontobroker: Ontology Based Access to Distributed and Semi-Structured Information. In *Semantic Issues in Multimedia Systems, Proceedings of DS-8*, Kluwer Academic Publisher, pp. 351-369.

de Moor, A. and Jeusfeld, M. (2001). Making Workflow Change Acceptable. *Requirements Engineering*, 6(2):75-96

de Moor, A. and Weigand, H. (2004). Business Negotiation Support: Theory and Practice. *International Negotiation*, 9(1):31-57.

de Moor, A. and Weigand, H. (2004). Legitimacy Checking in Communicative Workflow Design. In S.O. Kimbrough and D.J. Wu (eds.), *Formal Modelling in Electronic Commerce*, Springer : London

Edgington, T., Choi, B., Henson, K., Raghu, T. S. and Vinze, A. (2004). Adopting

Ontology to Facilitate Knowledge Sharing, *Communications of the ACM* 47(11), 85-90.

Euzenat, J. (1995). Building Consensual Knowledge Bases: Context and Architecture. In *Building and Sharing Large Knowledge Bases*, IOP Press, pp. 143-155.

Euzenat, J., Le Bach, T., Barrasa, J., Bouquet, P., De Bo, J., Dieng, R., Ehrig, M., Hauswirth, M., Jarrar, M., Lara, R., Maynard, D., Napoli, A., Stamou, G., Stuckenschmidt, H., Shvaiko, P., Tessaris, S., Van Acker, S., and Zaihrayeu, I. (2004). State of the Art on Ontology Alignment. Knowledge Web Deliverable #D2.2.3, INRIA, Saint Ismier.

Froomkin, M. (2003) Habermas@Discourse.Net: Toward a Critical Theory of Cyberspace, *Harvard Law Review*, 116(3), 749-853.

Gómez-Pérez, A. Fernández-López, M. and Corcho, O., Ontological Engineering, Springer Verlag, 2003.

Guarino N. & Giaretta P. (1995). Ontologies and Knowledge Bases: Towards a Terminological Clarification. In Mars, N. (ed), *Towards Very Large Knowledge Bases: Knowledge Building and Knowledge Sharing*, IOS Press: Amsterdam, 25-32

Gruber T. (1995). Towards Principles for the Design of Ontologies Used for Knowledge Sharing, *International Journal of Human-Computer studies*, 43(5/6): 907 – 928.

Hameed, A., Sleeman, D. and Preece, A. (2002). Detecting Mismatches Among Experts' Ontologies Acquired through Knowledge Elicitation, in *Knowledge-Based Systems*, 15(5-6):265–273.

Harvard Law School (1999). "The Law of Cyberspace. Communities Virtual and Real: Social and Political Dynamics of Law in Cyberspace (student-authored)." *Harvard Law Review* 112(7): 1586-1609.

Malone, T. and Crowston, K. (1994). The Interdisciplinary Study of Coordination. *ACM Computing Surveys*, 26(1): 87-119.

Manninen, T. (2002) Towards Communicative, Collaborative and Constructive Multi-Player Games. In *Proc. of Computer Games and Digital Cultures Conference, June 7-8, Tampere, Finland*, pp. 155-169.

Medina-Mora, R., Winograd, T., Flores, R. and Flores, F. (1993). The ActionWorkflow Approach to Workflow Management Technology, *The Information Society,* 9(4):391-404.

Preece, J. (2000) Online Communities : Designing Usability, Supporting Sociability. John Wiley, Chichester: New York.

Ridings, C. M., Gefen, D. and Arinze, B. (2002). Some Antecedents and Effects of Trust in Virtual Communities, *Journal of Strategic Information Systems* 11, 271-295.

Sheth, A. and Meersman, R. A., eds. (2002), *Proc. of the NSF-EU Workshop on Database and Information Systems Research for Semantic Web and Enterprises, April 3-5, Amicalola Falls and State Park, GA, USA*.

Spyns, P., Meersman, R. and Jarrar, M. (2002). Data modelling versus Ontology engineering. In Sheth, A. and Meersman, R. (eds.), *SIGMOD Record Special Issue* 31(4):12-17

van der Aalst, W. M. P., ter Hofstede, A. H. M., Kiepuszeswki, B. and Barros, A. P. B. (2003). Workflow Patterns, *Distributed and Parallel Databases* 14, 5-51.

Weigand, H. and de Moor, A. (2003). Workflow Analysis with Communication Norms, *Data & Knowledge Engineering,* 47(3):349-369.

Wellman, B. and Gulia, M. (1999) Net Surfers Don't Ride Alone: Virtual Communities as Communities. In M. Smith and P. Kollock (eds.), *Communities in Cyberspace*, Routledge: London.

Wenger, E., McDermott, R. and Snyder, W. (2002) Cultivating Communities of Practice. Harvard Business School Press: Cambridge, MA.

Winograd, T. and Flores, F. (1986). Understanding Computers and Cognition : a New Foundation for Design. Ablex Pub. Corp. : Norwood, N.J.