

Chapter XV

An Integrated Formal Approach to Semantic Work Environments Design

Hai H. Wang

University of Southampton, UK

Jin Song Dong

National University of Singapore, Singapore

Jing Sun

The University of Auckland, New Zealand

Terry R. Payne

University of Southampton, UK

Nicholas Gibbins

University of Southampton, UK

Yuan Fang Li

National University of Singapore, Singapore

Jeff Pan

University of Aberdeen, UK

INTRODUCTION

The Semantic Web (Berners-Lee, Hendler, & Lassila, 2001) has become increasingly significant as it proposes an evolution of the current World Wide Web from a web of documents to a distributed and decentralised, global knowledge-base. Based on the notion of interlinked resources grounded within formally defined ontologies, it promises to be an enabling technology for the automation of many Web-based tasks, by facilitating a shared understanding of a domain through inference over shared knowledge models. Semantic Work Environment (SWE) applications use Semantic Web techniques to support the work of the user by collecting knowledge about the current needs

in a specific activity, and providing both inferred and augmented knowledge that can then be integrated into current work. Web Services have emerged as distributed, heterogeneous software components that provide machine access to the services otherwise offered on the Web through Web pages. Built upon defacto Web standards for syntax, communication protocols, and markup languages such as XML, Web services provide a near ubiquitous mechanism for communication between applications and agents. In addition, such services can be composed to provide additional functionality, thus facilitating the rapid construction of new services. However, the dynamic use of services is limited by the need to agree a-priori upon data models and interface definitions. By

coupling Web service technology with Semantic Web technology, *Semantic Web Services* can partially relax these constraints, both in the dynamic use of services, and in the data models shared by such services. Several examples of such services have been developed, for example, the ITTALKS services (Cost, Finin, & Joshi, 2002), which are considered in this chapter.

The use of reasoning over shared domain models and the description of services and capabilities using Semantic Web Service descriptions are essential in supporting communication and collaboration between agents. Agents may agree on the same vocabulary and domain for communication, but different agents may not necessarily refer to the same concept in the same way. The Semantic Web is by definition highly distributed, and is built upon the assumption that different parties may have a different conceptualisation or representation for the same concept. Agreement on the concepts and the terms used to reference them, their relationships with other concepts, and the underlying axiomatisation of a domain model is addressed by formally defining shared ontologies. These ontologies represent different domains, and, through inference, can identify the equivalence of two concepts that may have different representations. The OWL Web Ontology Language (Dean et al., 2004) is a W3C recommendation for representing ontologies based on Description Logics, and provides a basis for providing both terminologies (i.e., vocabularies, relationships, axioms, and rules) and knowledge bases. Whilst providing the mechanisms for defining domain ontologies, representational ontologies (Heijst, Schreiber, & Wielinga, 1997) are necessary for defining the structure of services themselves, and several such ontologies have been proposed (Ankolekar et al., 2002; Roman et al., 2005). These ontologies define at a meta-level what the service does, how to use it, what are its outputs and effects, and so forth, and thus can facilitate the run-time use of services (including discovery and execution) and consequently problem solving

without necessitating human intervention at that point. OWL-S (Ankolekar et al., 2002) is one such ontology (defined in OWL-DL) that describes Web Services, including models for service orchestration (through the process model) and mappings to Web Service definitions.

Services found in Semantic Work Environments (SWE) can be defined using Semantic Web Service ontologies, and grounded within a specific domain by using the relevant, shared domain ontologies. The services may have intricate data states, complex process behaviours, and concurrent interactions. The design of such systems requires precise and powerful modelling techniques to capture not only the ontology domain properties but also the services' process behaviours and functionalities. It is therefore desirable to have a powerful formal notation that captures these notions, in addition to the declarative ontological representations of the domains and the services themselves, to precisely design Semantic Work Environments.

Timed Communicating Object-Z (TCOZ) (Mahony & Dong, 2000) is a Formal Specification language which builds on the strengths of Object-Z (Duke & Rose, 2000; Smith, 2000) in modelling complex data and state with the advantage of Timed CSP (Schneider & Davies, 1995) in modelling real-time concurrency.

The following characteristics of many SWE applications make TCOZ a good candidate to design such a system:

- A complex SWE applications system often has both intricate data state and process control aspects. An integrated formal modeling language, like TCOZ, has the capability to model such systems.
- A service-providing agent may offer several kinds of different services concurrently. TCOZ can support this through its multi-threaded capabilities.
- A complex SWE system is often composed from many individual services. These other

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