Semantically Annotated Multi-Protocol Adapter Nodes: A New Approach to Implementing Network-Based Information Systems Using Ontologies

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Abstract

Network-based information systems are an important class of distributed systems that serve large and diverse user communities with information and essential network services. Centrally defined standards for interoperation and information exchange ensure that any required functionality is provided but do so at the expense of flexibility and ease of system evolution. This thesis presents a novel approach to implementing network-based information systems in a knowledge-representation-based format using an ontological description of the service. Our approach allows us to provide flexible distributed systems that can conform to global standards while still allowing local developments and protocol extensions.

We can share data between systems if we provide an explicit specification of the relationship between the knowledge in the system and the structure and nature of the values shared between systems. Existing distributed systems may share data based on the values and structures of that data but we go beyond syntax-based value exchange to introduce a semantically-based exchange of knowledge. The explicit statement of the semantics and syntax of the system in a machine-interpretable form provides the automated integration of different systems through the use of *adapter nodes*. Adapter nodes are members of more than one system and seamlessly transport data between the systems.

We develop a multi-tier software architecture that characterises the values held inside the system depending on an ontological classification of their structure and context to allow the definition of values in terms of the knowledge that they represent. Initially, received values are viewed as data, with no structural information. Structural and type information, and the context of the value can now be associated with it through the use of ontologies, leading to a value-form referred to as knowledge: a value that is structurally and contextually rich. This is demonstrated through an implementation process employing RDF, OWL and SPARQL to develop an ontological description of a network-based information system. The implementation provides evidence for the benefits and costs of representing a system in such a manner, including a complexity-based analysis of system performance.

The implementation demonstrates the ability of such a representation to separate global standards-based requirements from local user requirements. This allows the addition of

behaviour, specific to local needs, to otherwise global systems in a way that does not compromise the global standards.

Our contribution is in providing a means for network-based information systems to retain the benefits of their global interaction while still allowing local customisation to meet the user expectations. This thesis presents a novel use of ontologically-based representation and tools to demonstrate the benefits of the multi-tier software architecture with a separation of the contents of the system into data, information and knowledge. Our approach increases the ease of interoperation for large-scale distributed systems and facilitates the development of systems that can adapt to local requirements while retaining their wider interoperability. Further, our approach provides a strong contextual framework to ground concepts in the system and also supports the amalgamation of data from many sources to provide rich and extensible network-based information system.

Declaration

This work contains no material that has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Signed:

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