3. Risch T., Josifovski V., and Katchaounov T. Functional data integration in a distributed mediator system. In Functional Approach to Data Management – Modeling, Analyzing and Integrating Heterogeneous Data, P. Gray, L. Kerschberg, P. King, A. Poulovassilis (eds.). Springer, Berlin, 2003.
4. Wilkinson K., Lyngbaek P., and Hasan W. The iris architecture and implementation, IEEE Trans. Knowl. Data Eng., 2(1):63–75, 1990.

Overlay Network

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Definition

An *overlay network* is a communication network constructed on top of an another communication network. The nodes of the overlay network are interconnected with logical connections, which form an *overlay topology*. Two overlay nodes may be connected with a logical connection despite being several hops apart in the underlying network. Overlay networks may define their own *overlay address space* which is used for efficient message routing in the overlay topology.

Key Points

When a distributed application is deployed in a computer network, the individual nodes on which the application is running need to be able to discover and communicate with one another. A solution to this problem is the overlay network. The overlay network interconnects all the application nodes and provides the basic communication primitives such as flooding, random walks or point-to-point overlay message routing and multicast.

Overlay networks are typically deployed on top of the Internet and by far the most common usage is in peer-to-peer systems. For example, Gnutella, an early peer-to-peer file sharing system connects all the peers in an overlay network, each peer shares its files, and files are searched for using query flooding in the overlay network.

Overlay network topologies can be divided into two broad classes: unstructured and structured. Unstructured overlay networks do not construct a globally consistent topology, instead peers choose their neighbor sets independently and in a largely ad-hoc way. In unstructured overlay networks nodes reach the other nodes by message flooding or random walks. Structured overlays define an address space and each of the overlay nodes has a unique address. The addresses are used to construct an overlay topology that enables efficient and scalable messages passing between the overlay nodes. In most of the modern structured overlays the expected number of routing hops scales as $O(log\ N)$ with the network size. Distributed Hash Tables are a specific case of structured overlay networks. Apart from structured and unstructured there also exist hybrid overlays.

Overlay networks are designed to be robust to *churn*, i.e., arrivals and departures of the overlay network nodes to and from the network. As overlay network nodes loose their overlay topology connections, new connections have to be added in their place. In structured overlay networks the additional challenge is to maintain the overlay topology such that the overlay routing remains efficient, i.e., the routing paths are kept short.

Cross-references

▶ Distributed Hash Table
▶ Peer to Peer Overlay Networks: Structure, Routing and Maintenance
▶ Peer-to-Peer System

OWL: Web Ontology Language

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Synonyms

Web ontology language

Definition

The Web Ontology Language OWL is a language for defining ontologies on the Web. An OWL Ontology describes a domain in terms of classes, properties and individuals and may include rich descriptions of the characteristics of those objects. OWL ontologies can be used to describe the properties of Web resources. Where earlier representation languages have been used to develop tools and ontologies for specific user-communities in areas such as sciences, health and e-commerce, they were not necessarily designed to be compatible with the

World Wide Web, or more specifically the Semantic Web, as is the case with OWL.

Features of OWL are a collection of expressive operators for concept description including boolean operators (intersection, union and complement), plus explicit quantifiers for properties and relationships; the ability to specify characteristics of properties, such as transitivity or domains and ranges; a well defined semantics facilitating the use of inference and automated reasoning; the use of URIs for naming concepts and ontologies; a mechanism for importing external ontologies; and compatability with the architecture of the World Wide Web, in particular other representation languages such as RDF and RDF Schema.

OWL consists of a suite of World Wide Web Consortium (W3C) Recommendations – six documents published in February 2004 describe Use Cases and Requirements, an Overview of the language, a Guide, Reference, OWL Semantics and a collection of Test Cases [3].

Key Points

Ontology languages allow the representation of ontologies. An ontology "defines a set of representational primitives with which to model a domain of knowledge or discourse" (see Ontology). The definition of an ontology can encompass a wide range of artefacts, from simple word lists, through taxonomies, thesauri and rich logic-based models and there are a corresponding range of languages for their representation.

Standardization of representation languages is a cornerstone of the Semantic Web effort. A standard representation facilitates interoperation – in particular, well-defined, unambiguous *semantics* ensure that applications can agree on the meaning of expressions. OWL is intended to provide that standard representation.

OWL builds on RDF and RDF Schema and adds more vocabulary for describing properties and classes. The design of the language was influenced by a number of factors. Description Logics, Frame-based modeling paradigms, and Web languages RDF and RDF Schema were key inputs, as was earlier work on languages such as OIL and DAML+OIL.

Knowledge Representation in a Web setting introduces particular requirements such as the distribution across many systems; scalability to Web size; compatibility with Web standards for accessibility and internationalization; and openness and extensibility. OWL uses URIs for naming and extends the description framework for the Web provided by RDF to address some of the issues above.

OWL defines three sublanguages: OWL Lite, OWL DL and OWL Full. OWL Full is essentially RDF extended with additional vocabulary, with no restrictions on the way in which that vocabulary is used. OWL DL places restrictions on the way in which the vocabulary can be used in order to define a language for which a number of key reasoning tasks (for example concept satisfiability or subsumption) are decidable. OWL Lite further restricts the expressivity allowed – for example, explicit union or complement are disallowed in OWL Lite. OWL DL and OWL Lite have a model theoretic semantics that corresponds to a Description Logic (DL) [1] and thus facilitate the use of DL reasoners to provide reasoning support for the language [2].

The design of representation languages often involves trade-offs, and there are limitations on what can be expressed using OWL, in particular in OWL-DL. These limitations have been selected primarily to ensure that these language subsets are well-behaved computationally, with decidable procedures for concept satisfiability. For example, OWL does not provide support for general purpose rules, which are seen as an important paradigm in knowledge representation, for example in expert systems or deductive databases. Extensions to OWL are being proposed to cover, among others, rules, query, additional expressivity, metamodeling and fuzzy reasoning.

Cross-references

► Description Logics
► Ontology
► RDF
► RDF Schema
► Semantic Web

Recommended Reading

1. Baader F., Calvanese D., McGuinness D.L., Nardi D., and Patel-Schneider P.F. (eds.). The Description Logic Handbook: Theory, Implementation, and Applications. Cambridge University Press, Cambridge, UK, 2003.
2. Horrocks I., Patel-Schneider P.F., and van Harmelen F. From *SHIQ* and RDF to OWL: the making of a web ontology language. J. Web Semant., 1(1):7–26, 2003.
3. World Wide Web Consortium. Web Ontology Language (OWL). W3C Recommendation. Available at: http://www.w3.org/2004/OWL/.