The Semantic Web: From Teaching To Research

Prof.(Dr.) Yuh-Jong Hu

2005/11/21

hu@cs.nccu.edu.tw
`http://www.cs.nccu.edu.tw/˜jong`
Emerging Network Technology(ENT) Lab.
`http://ent.cs.nccu.edu.tw/forum`
Department of Computer Science
National Chengchi University, Taipei, Taiwan

Talk Outline

- *Teaching*
  - *Teaching Sources*
  - *The World Wide Web*
  - *The Semantic Web*
  - *Current Status and Progress*
  - *Well-Known Layer Cake In Depth*
  - *The Ontology Language*
  - *Querying the Ontology*
  - *The Rule Language*
  - *The Semantic Web Services*

- *Research*
  - *Research Sources*
  - *Trusted Semantic Web Management*
  - *Combining Ontology and Policy*
  - *The Semantic Web Services*
  - *Semantic Overlay P2P Network*
- *References*

Teaching

Go To Talk Outline

Teaching Sources

Go To Talk Outline

Teaching Sources

- *Why No Textbook?*

- *Sources*
  - *Papers from recent key conferences and journals*
  - *A Semantic Web Primer (undergraduate level), MIT Press, 2004*
  - *Handbook on Ontologies, Springer-Verlag, 2004*
  - *Information Sharing on the Semantic Web, Springer-Verlags, 2005*

The World Wide Web (WWW)

Go To Talk Outline

The World Wide Web (WWW)

- Information sharing space between readers and writers

- Separation of context and content (or form and content)

- On the current WWW (WWW 2.0), how the data, document, information, knowledge, etc, are:

  - indexed (or named)
  - searched
  - referred (or dereference)
  - retrieved
  - processed
  - integrated
  - inferred (or reasoned)

The Semantic Web

Go To Talk Outline

The Semantic Web (conti.)

”The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation.”

–Tim Berners-Lee, James Hendler, Ora Lassila,

–The Semantic Web, Scientific American, May 2001

The Semantic Web (conti.)

- A new form of Web content that is meaningful to computers will unleash a revolution of new possibilities.

- The Semantic Web will enable machines to comprehend semantic documents and data, not human speech and writings.

- The explicit representation of the semantics of data, accompanied with domain theories (that is, ontologies), will enable a Web that provides a qualitatively new level of service.

–Tim Berners-Lee, James Hendler, and Ora Lassila

–The Semantic Web, Scientific American, May 2001

Agents and the Semantic Web

The real power of the Semantic Web will be realized when people create many programs that collect Web content from diverse sources, process the information and exchange the results with other programs. The effectiveness of such software agents will increase exponentially as more machine-readable Web content and automated services (including other agents) become available. · · ·

–Tim Berners-Lee, James Hendler, Ora Lassila,

–The Semantic Web, Scientific American, May 2001

Ontology = Taxonomies + Axioms

- *An ontology is a formal, explicit specifications of a shared conceptualization[Grub:93]:*
  - *Formal refers to the fact that the ontology should be machine understandable.*
  - *Explicit means that the type of concepts used and the constraints on their use are explicitly defined.*
  - *Shared reflects the notion that an ontology captures consensual knowledge, that is, it is not restricted to some individual, but accepted by a group.*
  - *Conceptualization refers to an abstract model of some phenomenon in the world which identifies the relevant concepts of that phenomenon.*

The Semantic Web

- ☛ *Are there any incentives to introduce the Semantic Web?*

- ☛ *On the Semantic Web, how the data, document, information, knowledge, etc, are (for both human and agent):*

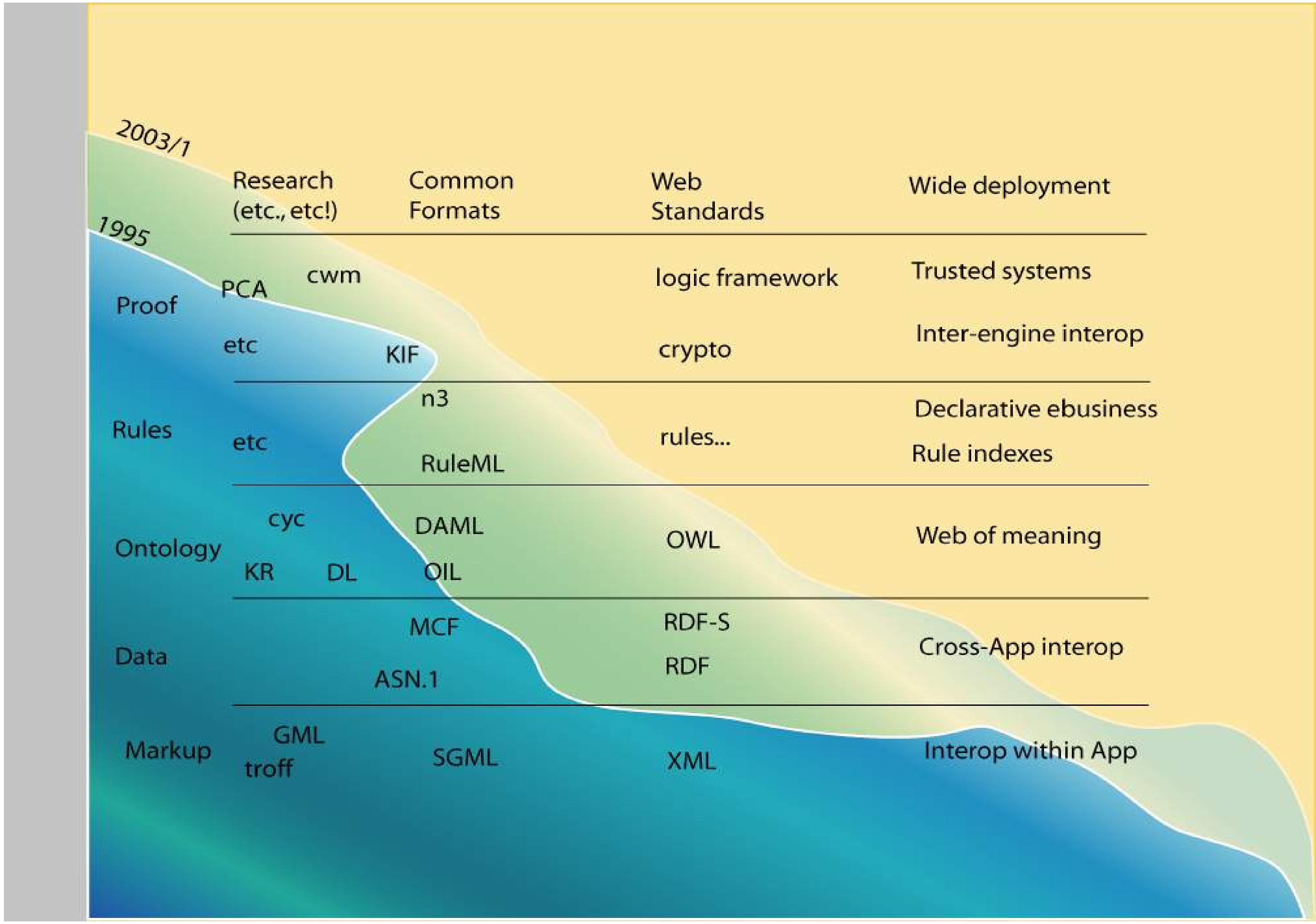
  - ✔ *indexed (or named)*
  - ✔ *searched*
  - ✔ *referred (or dereference)*
  - ✔ *retrieved*
  - ✔ *processed*
  - ✔ *integrated*
  - ✔ *inferred (or reasoned)*

Current Status and Progress

Go To Talk Outline

W3C Current Status and Progress

The Semantic Web Wave



The Client/Server on the Semantic Web

- ☛ What the client (or browser) will be?
  - ✔ Amaya
  - ✔ Haystack
  - ✔ Protege (+OWL+SWRL Editor)
  - ✔ Piggy Bank

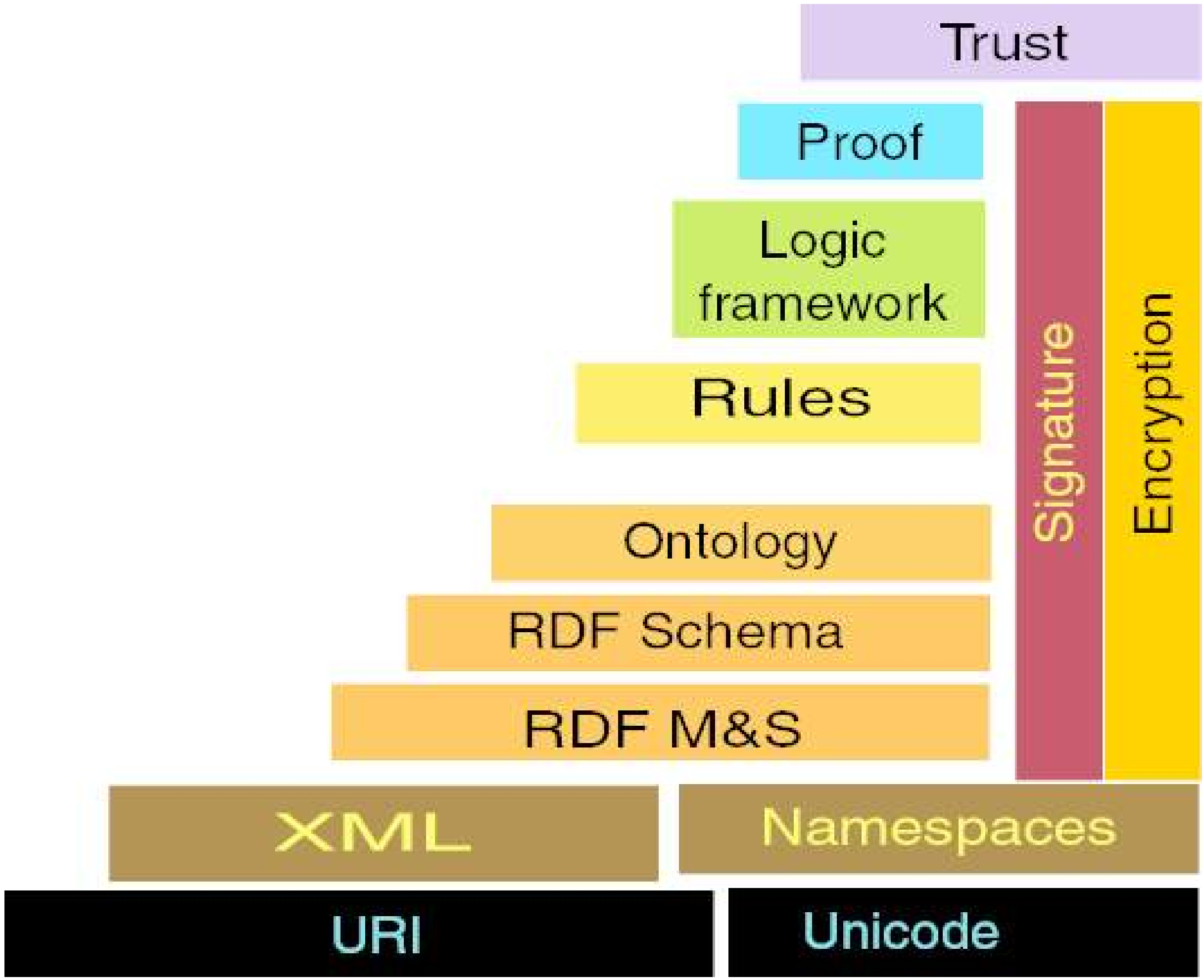
- ☛ What the web server will be?
  - ✔ Jena2 (+JESS)
  - ✔ Joseki
  - ✔ KANO (The KArlsruhe ONtology)

see WWW2004 Semantic Web Roundup

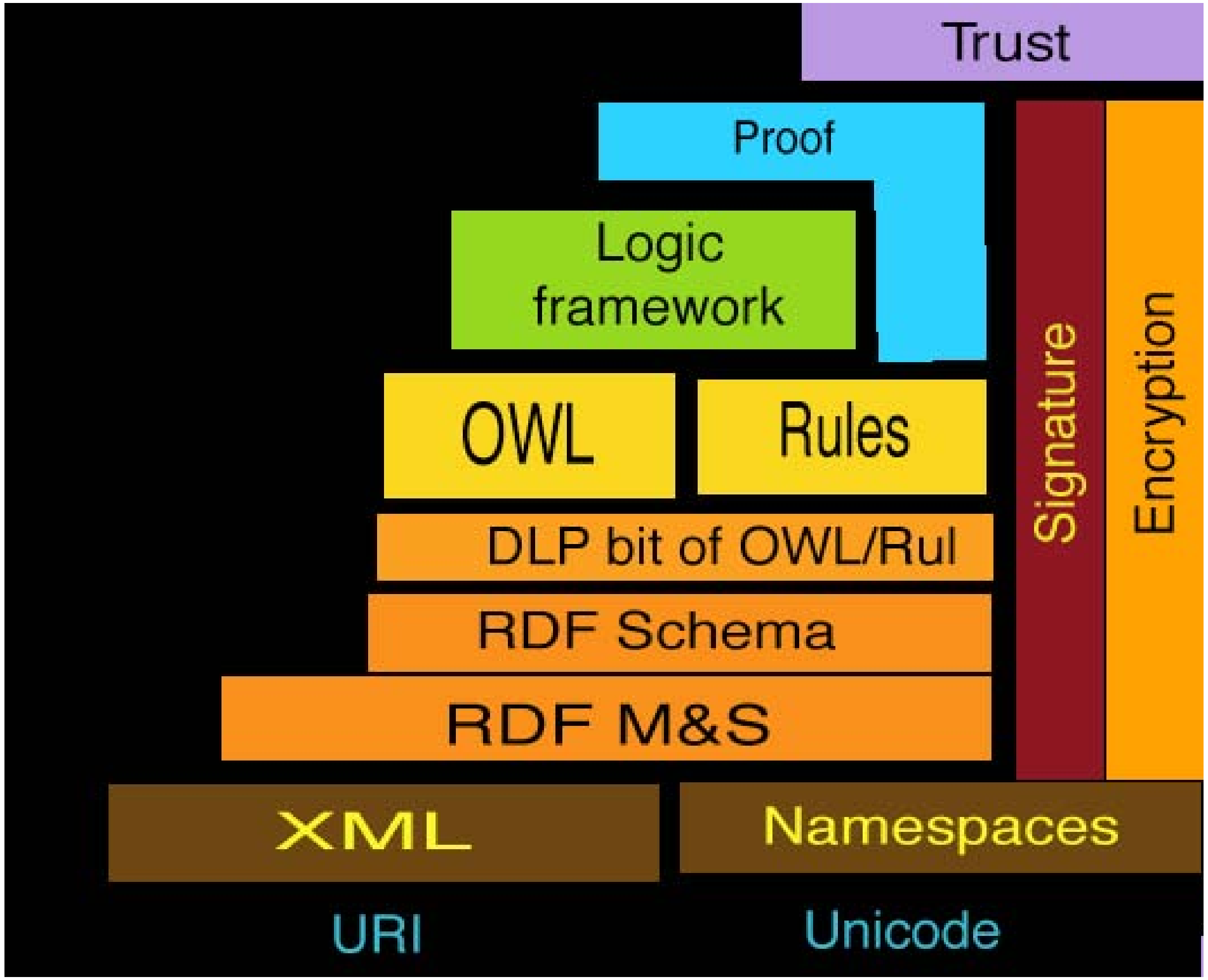
Well-Known Layer Cake In Depth

Go To Talk Outline

Well-Known Layer Cake (Before 2004) [Tim Berners-Lee]



Well-Known Layer Cake (2005 Version) *[Tim Berners-Lee]*



The Ontology Language

Go To Talk Outline

The Ontology Language[Horr:03a]

- *XML/XML Schema* ⟸ *Not an ontology language*
- *RDF/RDF-Schema* ⟸ *ontology language*
- *DAML/OIL* ⟸ *ontology language*
- *OWL (Web Ontology Language)* ⟸ *DAML+OIL [Horr:03a] [* ⟸ *ontology language*

The Ontology Language[Horr:03a] (conti.)

- OWL Ontology Language
  - OWL Lite
  - OWL DL (Description Logic)
  - OWL Full (OWL DL + RDF(S)) $\supset$ RDF(S)
- Why ontology language's semantics are justifiable?
  - RDF(S) uses RDF Model Theory (MT)
  - OWL uses OWL Semantics

RDF and RDFS (RDF(S)) (Example) [Pan:03]

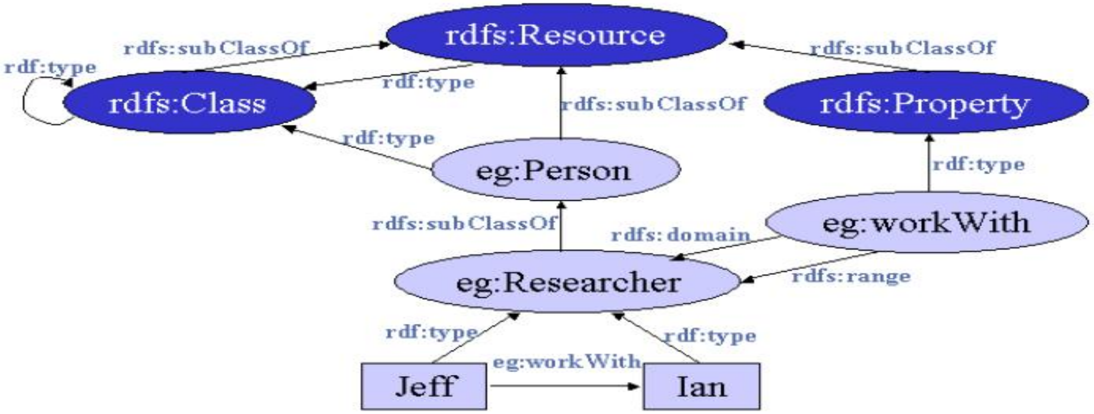


Fig. 1. An Example of Dual Roles in RDFS

Model Theory for RDF(S) Semantics[Pan:03]

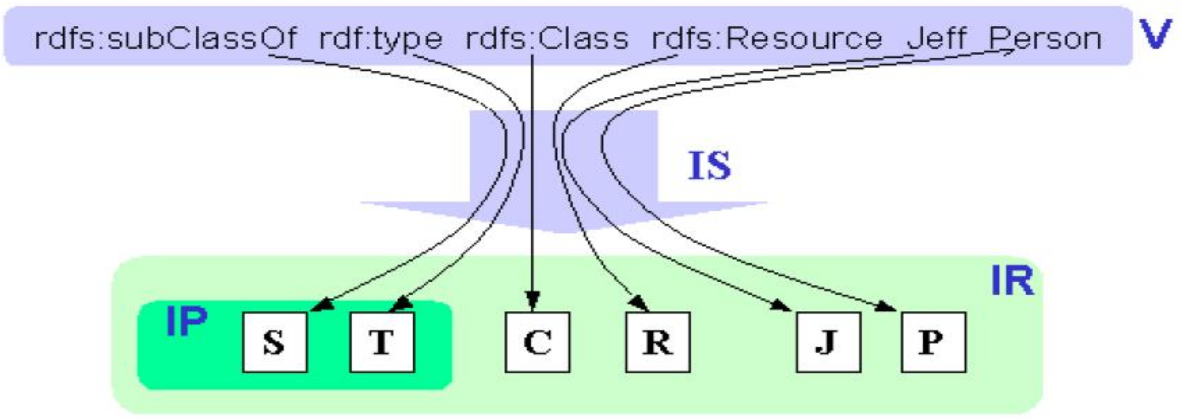


Fig. 6. Resources in RDF MT

Model Theory for RDF(S) Semantics[Pan:03]

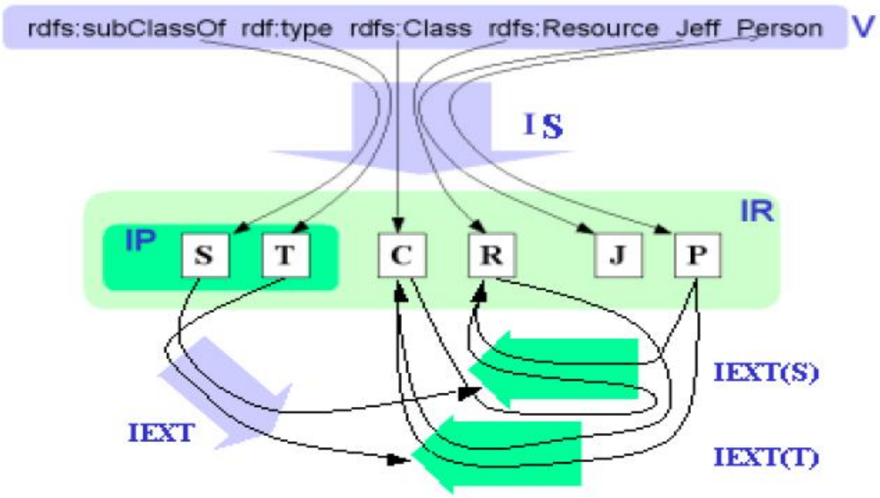


Fig. 7. Interpretation of RDF MT

Ontologies in RDF(S) (Example) [Staa:01]

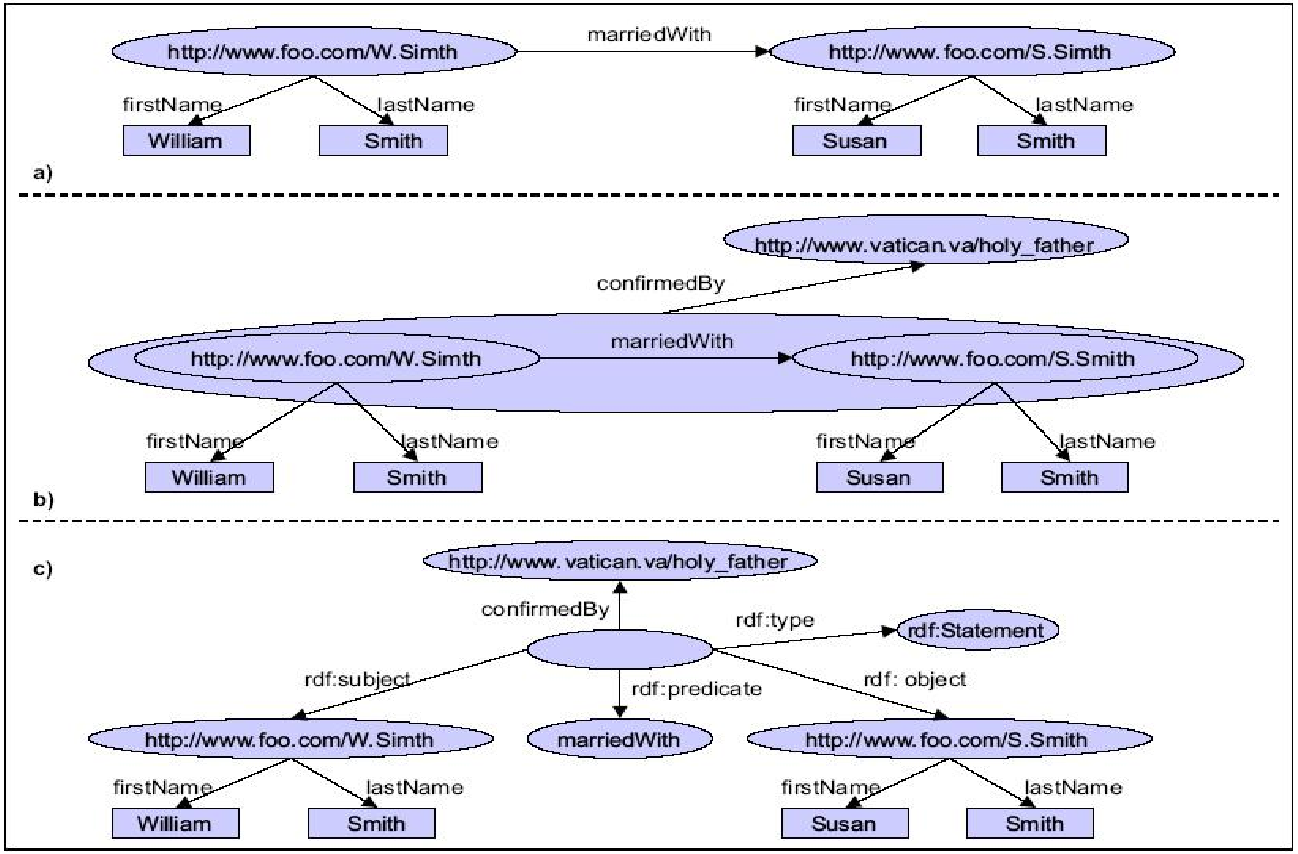


Figure 1: An example RDF data model.

Ontologies in RDF(S) (Example)[Staa:01]

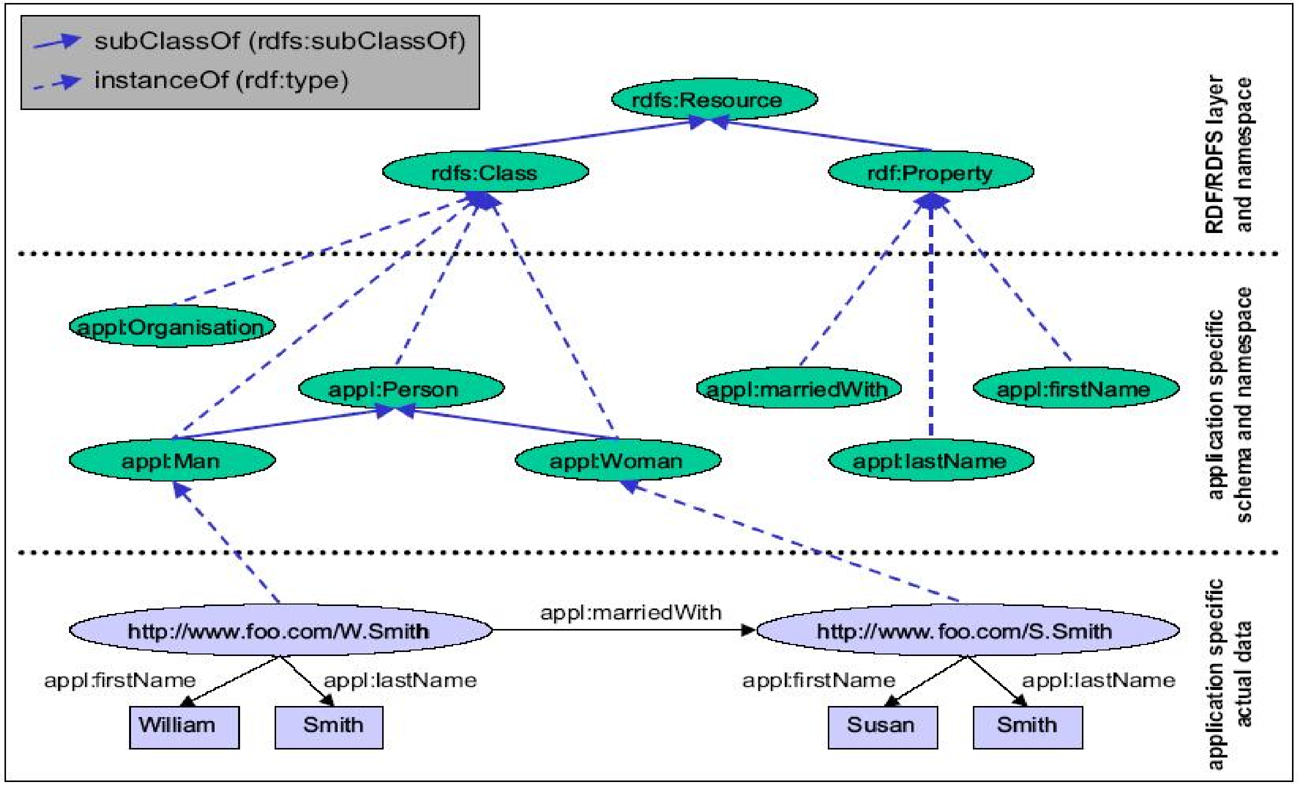


Figure 2: An example RDF schema and its embedding in RDF(S).

Ontologies in RDF(S) (Example)[Staa:01]

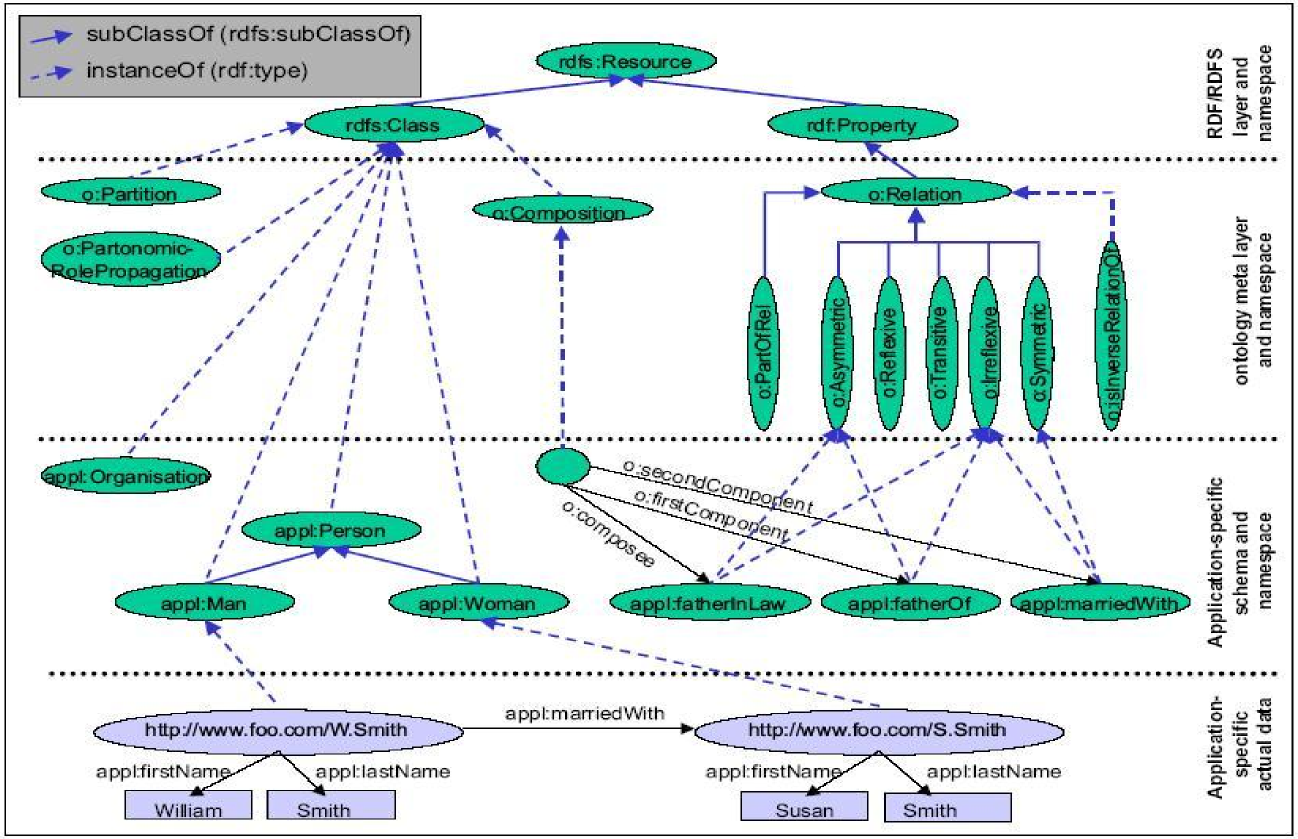


Figure 3: An excerpt of the example object model and an instantiation of classes, properties, and axioms in RDF(S)

Expressive Power of the RDF(S)[Pan:03]

- RDF(S) includes the followings:
  - Anyone can say anything about anything.
  - RDFS has a non-standard and non-fixed layer metamodeling architecture, which makes some elements in the model appear to have multiple roles.
  - Properties can be defined between any two resources.
  - Any resource can be an instance of any resource (including itself).

Limitations of the RDF(S)[Anto:03]

- RDF(S) excludes the followings:
  - Local scope of properties
  - Disjointness of classes
  - Boolean combinations of classes
  - Cardinality restrictions
  - Special characteristics of properties, such as transitive, unique, inverse, etc

RDF(S) vs. OWL [Horr:03a]

- The major extension of OWL over RDFS is the ability in OWL to provide restrictions on how properties behave that are local to a class:

  - ✔ Define classes with property is restricted so that all the values for the property in instances of class must belong to a certain class (or datatype);

  - ✔ At least one (or certain) value(s) must come from a certain class (or datatype);

  - ✔ At least or at most a certain number of distinct values.

RDF(S) vs. OWL (Example)[Horr:03a]

- Example using RDFS:
  - declare classes like Country, Person, Student, and Canadian;
  - state that Student is a subclass of Person;
  - state that Canada and England are both instances of the class Country;
  - declare Nationality as a property relating the classes Person (its domain) and Country (its range);
  - state that age is a property; with Person as its domain and integer as its range;
  - state that Peter is an instance of the class Canadian, and that his age has value 48.

RDF(S) vs. OWL (Example)[Horr:03a]

- OWL we can additionally have:
  - state that Country and Person are disjoint classes;
  - state that Canada and England are distinct individuals;
  - state HasCitizen as the inverse property of Nationality;
  - state that the class Stateless is defined precisely as those members of the class Person that have no values for the property Nationality;
  - state that the class MultipleNationals is defined precisely as those members of the class Person that have at least 2 values for the property Nationality;
  - state that the class Canadian is defined precisely as those members of the class Person that have Canada as a value of the property Nationality;
  - state that age is a functional property.

Query The Ontology

Go To Talk Outline

Ontology Query Language

- XQuery ⟸ Not an ontology query language

- RDF(S) ontology query languages
  - ✔ SPARQL (including SPARQL Protocol) ⟸ (W3C Standard)
  - ✔ RQL, SeRQL, RDQL
  - ✔ Triple, N3, Versa

- OWL-QL (D-QL) ⟸ OWL ontology query language

Usecases for RDF Query Language [Haas:04]

- *Usecases for the querying of RDF data:*
  - ✔ *Graph Matching:path expressions, optional path expressions*
  - ✔ *Relational Algebraic Operations: selection, projection, cartesian product set union, set difference*
  - ✔ *Aggregation and Grouping*
  - ✔ *Recursion*
  - ✔ *Reification*
  - ✔ *Collections and Containers*
  - ✔ *Namespaces*
  - ✔ *Language*
  - ✔ *Literals and Datatypes*
  - ✔ *Entailment*

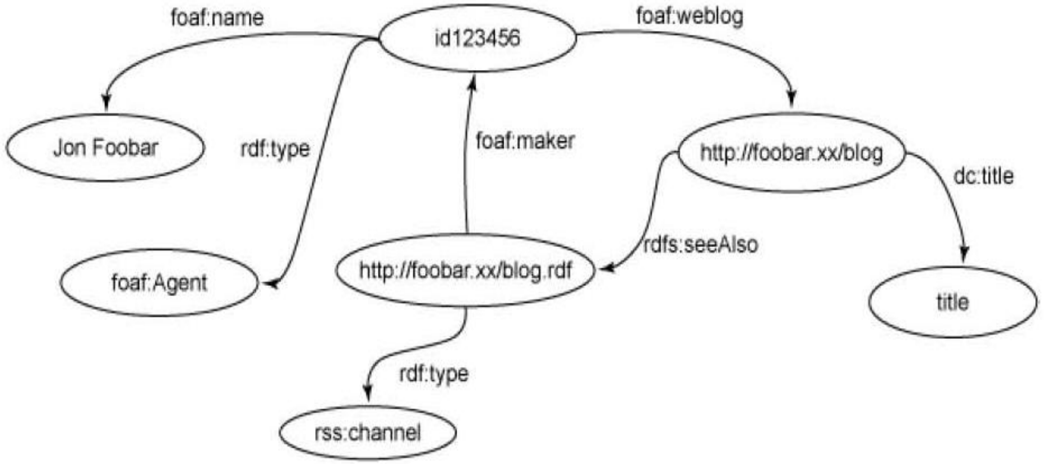
學期群組計畫：

一個以音樂分類數位內容為主的本體論查詢系統

在網際網路速度以及效能不斷提昇的今天，我們不論用主從架構的 WWW 或對等式架構的 P2P 網路資訊系統都很容易的去查詢我們要的數位內容資訊。現有的查詢系統不外是利用現有的網路伺服器再配合關連式資料庫管理系統來完成。我們為了要確認語意網系統的可行性，本學期的學期計畫將要求設計並實作一個以音樂分類為主的數位內容本體論查詢系統。在概念上各位首先要去瞭解音樂的分類機制以及相關的屬性為何為何？例如以曲風分類 (Music Style)則我們有： 藍調 (Blues)、古典(Classical)、鄉村 (Country)、民俗(Folk)、流行(Pop)、拉丁(Latin)、搖滾(Rock)等分類。另外我們也可以利用年代(Period)來分類，如此一來我們將會有： 16 世紀，17 世紀、 18 世紀、19 世紀、 20 世紀、現代化音樂的分別。如果以區域來劃分則我們有： 中國、日本、台灣、美國、英國、印度等國家的音樂。因此音樂的分類可以是一個多面向的分類方式。至於每一首音樂將會有原創者(Creator)、表演者(Performer)、演出時間(Time)等屬性，而音樂本身因為數位化之後也將會有一些屬性，如編碼格式(MP3, WMA)、檔案大小、傳送速率(bps)、檔案名稱等。因此同學們以某一種音樂的分類(Taxonomy)機制建立一個音樂查詢系統的本體論架構，並在此分類機制之下訂出每一個分類(Class)的屬性為何？以及該如何來將這些屬性繼承到子分類的結構中。在此分類架構中每一個末端將會是 2-3 首的具體的音樂曲目它們同時具有完整的屬性。

在此本音樂分類本體論系統的建置上請用 RDF(S) （內含有 RDF, RDF-Schema）本體論語言來表示和設計其藍圖(Schema)，並用 W3C 協會所建議的 SPARQL 查詢語言及相關的協定(Protocol)來進行主從架構的查詢。我們的課程助教將會建置一個網站提供建置本系統所要的開發工具，如 ARQ (http://jena.hpl.hp.com/~afs/ARQ/), Jena-2, Protégé 和伺服器平台 本系統的設計書將要求各位在期中考試週(11/17)交出並列入評分項目。學期末考試週（1/12）則進行實際系統的線上測試和評分。本計畫的分組人數為 1-3 人。分數的高低將以整體系統的完整性、正確性、和效能為基準，各分組人員的多寡也將列入考慮。

SPARQL Query Language for RDF [McCa:05]



SPARQL Query Language for RDF [McCa:05]

Listing 4. Executing a simple query using Jena's API

```
// Open the bloggers RDF graph from the filesystem
InputStream in = new FileInputStream(new File("bloggers.rdf"));

// Create an empty in-memory model and populate it from the graph
Model model = ModelFactory.createMemModelMaker().createModel();
model.read(in,null); // null base URI, since model URIs are absolute
in.close();

// Create a new query
String queryString =
        "PREFIX foaf: <http://xmlns.com/foaf/0.1/> " +
        "SELECT ?url " +
        "WHERE {" +
        "       ?contributor foaf:name \"Jon Foobar\" . " +
        "       ?contributor foaf:weblog ?url . " +
        "       }";

Query query = QueryFactory.create(queryString);

// Execute the query and obtain results
QueryExecution qe = QueryExecutionFactory.create(query, model);
ResultSet results = qe.execSelect();

// Output query results
ResultSetFormatter.out(System.out, results, query);

// Important - free up resources used running the query
qe.close();
```

SPARQL Query Language for RDF [McCa:05]

Listing 5. A small FOAF graph describing four people

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .

_:a foaf:name         "Jon Foobar" ;
    foaf:mbox         <mailto:jon@foobar.xx> ;
    foaf:depiction    <http://foobar.xx/2005/04/jon.jpg> .

_:b foaf:name         "A. N. O'Ther" ;
    foaf:mbox         <mailto:a.n.other@example.net> ;
    foaf:depiction    <http://example.net/photos/an-2005.jpg>

_:c foaf:name         "Liz Somebody" ;
    foaf:mbox_sha1sum "3f01fa9929df769aff173f57dec2fe0c2290ae

_:d foaf:name         "M Benn" ;
    foaf:depiction    <http://mbe.nn/pics/me.jpeg> .
```

SPARQL Query Language for RDF [McCa:05]

Listing 10. A query to find people described in two named FOAF graphs

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT ?name
FROM NAMED <jon-foaf.rdf>
FROM NAMED <liz-foaf.rdf>
WHERE {
  GRAPH <jon-foaf.rdf> {
    ?x rdf:type foaf:Person .
    ?x foaf:name ?name .
  } .
  GRAPH <liz-foaf.rdf> {
    ?y rdf:type foaf:Person .
    ?y foaf:name ?name .
  } .
}
```

SPARQL Query Language for RDF [McCa:05]

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT ?name ?graph_uri
FROM NAMED <jon-foaf.rdf>
FROM NAMED <liz-foaf.rdf>
WHERE {
    GRAPH ?graph_uri {
      ?x rdf:type foaf:Person .
      ?x foaf:name ?name .
    }
}

--------------------------------------------------------
| name                    | graph_uri                  |
========================================================
| "Liz Somebody"          | <file://.../jon-foaf.rdf>  |
| "A. N. O'Ther"          | <file://.../jon-foaf.rdf>  |
| "Jon Foobar"            | <file://.../liz-foaf.rdf>  |
| "A. N. O'Ther"          | <file://.../liz-foaf.rdf>  |
--------------------------------------------------------
```

SPARQL Query Language for RDF [McCa:05]

RDF Dataset Source: PlanetRDF

Listing 12. Getting a personalized live PlanetRDF feed

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX rss:  <http://purl.org/rss/1.0/>
PREFIX dc:   <http://purl.org/dc/elements/1.1/>

SELECT ?title ?known_name ?link

FROM <http://planetrdf.com/index.rdf>
FROM NAMED <phil-foaf.rdf>

WHERE {
        GRAPH <phil-foaf.rdf> {
          ?me foaf:name "Phil McCarthy" .
          ?me foaf:knows ?known_person .
          ?known_person foaf:name ?known_name .
        } .

        ?item dc:creator ?known_name .
        ?item rss:title ?title .
        ?item rss:link ?link .
        ?item dc:date ?date.
      }

ORDER BY DESC[?date] LIMIT 10
```

The Rule Language

Go To Talk Outline

The Rule Language (Standardization)

- ☛ Ontology Language for Ontology vs. (or complementary) Rule Language for Policy

- ☛ Description Logic Programs (DLP)

- ☛ Rule Language Standardization
  - ✔ Rule Markup Language (RuleML); pioneer researcher: Benjamin Grosof
  - ✔ Semantic Web Rule Language (SWRL)
  - ✔ TRIPLE
  - ✔ Semantic Web Service Language (SWSL)-Rules(or -FOL)
  - ✔ Web Service Modelling Language (WSML)-Rule(or -DL)
  - ✔ Notation 3 (N3)

Description Logic Programs (DLP) *[Gros:03]*

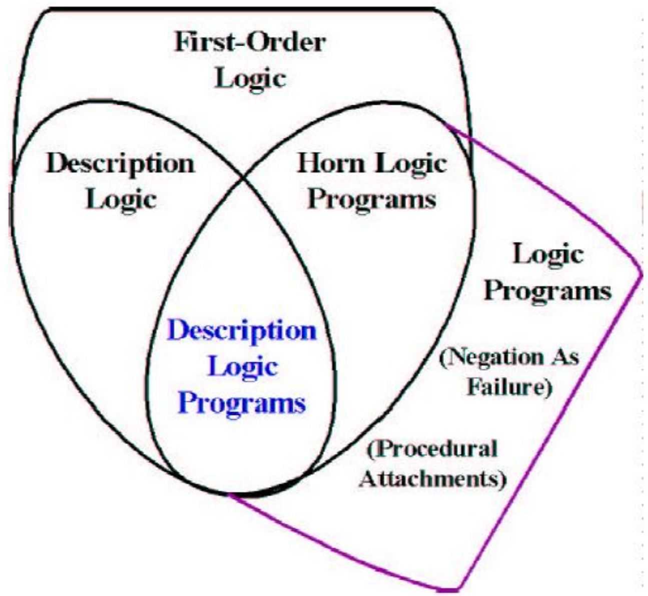


Figure 1: Expressive overlap of DL with LP.

The Semantic Web Services

Go To Talk Outline

The Semantic Web Services [Syca:03]

A Semantic Web service is a Web service whose description is in a language that has well-defined semantics. It is unambiguously computer interpretable, and facilitates maximal automation and dynamism in Web service discovery, selection, composition, negotiation, invocation, monitoring, management, recovery and compensation.

The Semantic Web Services (conti.)

- Semantic Web Service (SWS) overlay (or embed) Services Oriented Architecture (SOA)

- What (Where) are the incentives to apply semantic on the existing web services, such as WSDL, UDDI, BPEL4WS, etc?

- Where do we put the semantics (ontologies)to enhance the web services[Siva:03]?

  - Description Layer (WSDL): services grounding semantics
  - Publish and Discovery Layer (UDDI): capabilities matching semantics
  - Flow Layer (BPEF4WS): execution semantics

The Semantic Web Services (conti.) *[Syca:03]*

- *The current Web services infrastructure focuses on syntactic interoperability, such as SOAP, WSDL, UDDI, WSCI, and BPEL4WS.*
- *Semantic interoperability is crucial for Web services.*
- *The semantic Web and Web services are synergistic: the Semantic Web transforms the Web into a repository of computer readable data, while Web services provide the tools for the automatic use of that data.*

Research

Go To Talk Outline

Research Sources

Go To Talk Outline

General Research Sources

☛ Conferences

- ✔ *World Wide Web (WWW)*
- ✔ *International Semantic Web Conference (ISWC)*
- ✔ *European Semantic Web Conference (ESWC)*
- ✔ *Web Intelligence (WI)*
- ✔ *Asia Pacific Web Conference (APWeb)*

General Research Sources (conti.)

- *Journals*
  - *Journal of Web Semantics: Science, Services and Agents on the World Wide Web*
  - *International Journal on Semantic Web and Information Systems*
  - *International Journal of Metadata, Semantics and Ontologies*
  - *Knowledge and Information Systems*
  - *IEEE Transactions on Knowledge and Data Engineering*

- *Other: AIS Special Interest Group on Semantic Web and Information Systems (SIGMIS)*

Trusted Semantic Web Management

Go To Talk Outline

Trusted Semantic Web Management: Research Issues

- *iTrust Conference for Social Network's Trust, Recommendation, Reputation:*
  - *iTrust2005*
  - *iTrust2004*
  - *iTrust2003*

Trusted Semantic Web Management: Research Issues (conti.)

- *Research Sources and Papers:*
  - *Semantic Web Trust and Security Resource Guide*
  - *TriQL.P - Trust Architecture*
  - *The Semantic Web Trust Layer*
  - *Framework for Security and Trust Standard*
  - *Creating a Policy-Aware Web: Discretionary, Rule-based Access for the World Wide Web, Web and Information Security, Idea Group.*
  - *Trust Network-Based Filtering of Aggregated Claims, ISWC04, IJMSO05.*
  - *Named Graphs, Provenance and Trust, WWW05.*
  - *Ontology-Based Policy Specification and Management, ESWC05.*
  - *Trust Strategies for the Semantic Web, ISWC04.*
  - *Trust Management for the Semantic Web, ISWC03.*

Trusted Semantic Web Management: Research Issues (conti.)

- *Issues Consideration:*
  - *Social Network vs. Certification Theory*
  - *Trust Justification based on Evidences*
  - *Trust for Information Provenance and Dissemination*
  - *Context Trust vs. Content Trust*
  - *Ontology and Policy for Trust Management*
- *Current Study:* *Trusted Semantic Blog (or Forum)*

Combining Ontology and Policy

Go To Talk Outline

Combining Ontology and Policy: Research Issues

- ☞ *Issues Consideration:*
  - ✔ *Ontology Language for Ontology vs. Rule Language for Policy*
  - ✔ *Possible Applicable Domains Investigation, such as Semantic Web Services, DRM*
- ☞ *Current Study:*
  - ✔ *Digital Rights Management (DRM) for P2P Content Distribution Network*
  - ✔ *Semantic Some Rights Representation and Delegation for Creative Commons (CC) Information Sharing*

The Semantic Web Services

Go To Talk Outline

The Semantic Web Services: Research Issues

- Standard Infrastructure, Ontology, Language, and Applications

- Research Sources fro Two Main Camps:

  - ✔ USA for SWSF: SWSF, SWSL(SWSL-FOL, SWSL-Rules), SWSO((SWSO-FOL(FLOWS), SWSO-Rules(ROWS))

  - ✔ EU for WSMF: WSMF, WSMO, WSML (WSML-DL, WSML-Rule), WSMX

  - ✔ Other:OWL-S $\Longleftarrow$ DAML-S

The Semantic Web Services: Research Issues (conti.)

- *Issues Consideration:*
  - *What Incentives for Semantics? (Semi)-Automatic Services Description, Requesting, Discovery, Matching, Engagement, and Execution*
  - *Semantics Overlay vs. Semantics Embedded over SOA*
  - *Research focus on All-in-One, Single Issue, or Applications*
- *Current Study:* *Trusted Semantic Web Services Selection*

Semantic Overlay P2P Network

Go To Talk Outline

Semantic Overlay P2P Network: Research Issues

☛ *Research Sources and Papers:*

- ✔ *Semantic Web and P2P (SWAP)*
- ✔ *RDFPeers: A Scalable Distributed RDF Repository based on A Structured Peer-to-Peer Network, WWW04*
- ✔ *Super-Peer-Based Routing and Clustering Strategies for RDF-Based Peer-to-Peer Networks, WWW03*
- ✔ *Semantic Overlay Networks for P2P Systems, Stanford Univ.*
- ✔ *A Metadata Model for Semantics-Based Peer-to-Peer Systems, SemPGRID03*
- ✔ *Design Issues and Challenges: for RDF- and Schema-Based Peer-to-Peer Systems,*

  SIGMOD Record, Vol. 32, No. 3, Sep. 2003

Semantic Overlay P2P Network: Research Issues (conti.)

- *Issues Consideration:*
  - ✔ *P2P Topology Selection? Unstructured, Structured (DHT)*
  - ✔ *URI and Protocols over P2P Network? HTTP, JXTA, AJAX*
  - ✔ *Semantic Schema Overlay Issues? What, How, and Where for indices binding*
  - ✔ *The Incentives of Semantic Overlay?*
  - ✔ *Experiment for Field Trial Testbed? PlanetLab*
- *Current Study: RDF(S)-Based Music Recommendation Systems for Super Peer P2P Networks*

References

- [Anto:03]

  Antoniou, G. and F. van Harmelen, Web Ontology Language:OWL. Handbook on Ontologies, S. Staab and R. Studer (eds.), Springer Series on Handbooks in Information Systems, 2003, pp. 67-92.

- [Aras:01]

  Arasu, a., et al., Searching the Web. ACM Transactions on Internet Technology, Vol. 1, No. 1, Aug. 2001, pp. 2-43.

- [Bern:01]

  Berners-Lee, Tim, James Hendler, and Ora Lassila, The Semantic Web, Scientific American, May 2001, http://www.sciam.com

- [Boot:03]

  Booth, D., et al., Web services architecture. http://www.w3.org/TR/2003/WD-ws-arch-20030514/, 14 May 2003. W3C Working Draft.

- [Broe:01]

  Broekstra, J., et al., Enabling Knowledge Representation on the Web by Extending RDF Schema. Electronic Transactions on Artificial Intelligence (ETAI), http://www.ida.liu.se/ext/epa/cis/2001/010/tcover.html.

- [Cai:04]

  Cai, M. and M. Frank, RDFPeers: A Scalable Distributed RDF Repository based on A Structured Peer-to-Peer Network, WWW2004.

Go To Talk Outline

- [Cham:02]

  Chamberlin, D., XQuery: An XML Query Language. IBM Systems Journal, Vol. 41, No. 4, 2002.

- [Clar:04]

  Clark, G. Kendall, SPARQL Protocol for RDF, `http://www.mindswap.org/2005/sparql/protocol/`

- [Clar:05]

  Clark, G. Kendall, SPARQL Protocol for RDF, W3C Working Draft 27, May 2005, `http://www.w3.org/TR/rdf-sparql-protocol/`.

- [Corc:02]

  Corcho, O.; Gomez-Perez, A. Ontology languages for the Semantic Web, IEEE Intelligent Systems and their Applications, Vol. 17 No4. February 2002. Pags: 54-60.

- [Eric:05]

  Eric P. and A. Seaborne, SPARQL Query Language for RDF, W3C Working Draft 21, July 2005, http://www.w3.org/TR/rdf-sparql-query/.

- [Fike:03a]

  Fikes, R., P. Hayes, and I. Horrocks, DQL - A Query Language for the Semantic Web. WWW 2003, May 20-24, 2003, Budapest, Hungary.

- [Fike:03b]

  Fikes, R., P. Hayes, and I. Horrocks, OWL-QL - A Language for Deductive Query Answering on the Semantic Web, Journal of Web Semantics, 2(2004) 19-29.

Go To Talk Outline

- [Fiel:02]

  Fielding, T. Roy and Richard N. Taylor, Principled Design of the Modern Web Architecture, ACM Transactions on Internet Technology, Vol. 2, No. 2, May 2002, pp. 115-150.

- [Grau:04]

  Grau, C. B., A Possible Simplification of the Semantic Web Architecture. WWW2004, May 17-22, 2004, New York.

- [Gros:03]

  Grosof, N. B., et al., Description Logic Programs: Combining Logic Programs with Description Logic. WWW2003, May 20-24, 2003, Budapest, Hungary.

- [Grub:93]

  Gruber, T. R., A Translation Approach to Portable Ontology Specifications. Knowledge Acquisition, 5(2), 1993.

- [Haas:04]

  Haase, P. et. al., A Comparison of RDF Query Languages, ISWC 2004.

- [Haye:04]

  Hayes, P., RDF Semantics, W3C Recommendation 10 February 2004.
  http://www.w3.org/TR/rdf-mt/.

- [Horr:02]

  Horrocks, I. and S. Tessaris, Querying the Semantic Web: A Formal Approach. ISWC2002, LNCS 2342, pp. 177-191, 2002.

Go To Talk Outline

- [Horr:03a]

  Horrocks, I., P. F. Patel-Schneider, and F. van Harmelen, From SHIQ and RDF to OWL: The Making of a Web Ontology Language. Journal of Web Semantics, 1(1). 7-26, 2003.

- [Horr:03b]

  Horrocks, I., SWRL: A Semantic Web Rule Language Combining OWL and RuleML, Version 0.6 of 30 April, 2004, http://www.daml.org/2004/04/swrl/rules-all.html.

- [Horr:04]

  Horrocks, I. and P. F. Patel-Schneider, A Proposal for an OWL Rules Language. WWW2004, May 17-22, 2004, New York, NY USA.

- [Karv:03]

  Karvounarakis, G, et al., Querying the Semantic Web with RQL. Computer Network: The International Journal of Computer and Telecomm. Networking, Vol. 42, Issue 5, Aug. 2003, 617-640.

- [Klei:01]

  Klein, M., et al., The Relation between Ontologies and XML Schemas. Electronic Transactions on Artificial Intelligence (ETAI), http://www.ida.liu.se/ext/epa/cis/2001/004/tcover.html.

- [Mcbr:04]

  McBride, B., The Resource Description Framework (RDF) and its Vocabulary Description Language RDFS. Handbook on Ontologies, Springer-Verlag, 2004, pp. 51-65,

Go To Talk Outline

- [McCa:05]

  McCarthy, Phil, Search RDF data with SPARQL: SPARQL and the Jena Toolkit open up the semantic Web, May 2005, IBM developerWorks, `http://www-128.ibm.com/developerworks/xml/library/j-sparql/`.

- [Nejd:03a]

  Nejdl, W., W. Siberski, and M. Sintek, Design Issues and Challenges for RDF- and Schema-Based Peer-to-Peer Systems. ACM SIGMOD Record, Vol. 32, No. 3, Sep. 2003.

- [Nejd:03b]

  Nejdl, W., et al., Super-Peer-Based Routing and Clustering Strategies for RDF-Based Peer-to-Peer Networks. WWW2003, May 20-24, 2003, Budapest, Hungary.

- [Ober:04]

  Oberle, D., et al., An extensible ontology software environment. Handbook on Ontologies, S. Staab and R. Studer (eds.), Springer Series on Handbooks in Information Systems, 2004, pp. 299-320.

- [Ober:05]

  Oberle, D. et al., Supporting application development in the Semantic Web. ACM Transaction on Internet Technology, 2005.

- [Pan:03]

  Pan, Z. J. and I. Horrocks, RDF(FA) and RDF MT: Two Semantics for RDFS. ISWC 2003.

Go To Talk Outline

- [Pate:02]

  Patel-Schnedier, P. F. and D. Fensel, Layering the Semantic Web: Problems and Directions. ISWC 2002.

- [Ruleml:04]

  The Rule Markup Initiative, `http://www.ruleml.org/`.

- [Siva:03]

  Sivashanmugam, K., et al., Metadata and Semantics for Web Services and Processes. Book Chapter, Datenbanken und Information systems, Festschrift zum 60. Geburtstag von Gunter Schlageter, Publication Hagen, October, 2003-09-26.

- [Siva:03a]

  Sivashanmugam, K., et al., Framework for Semantic Web Process Composition Technical Report 03-008, LSDIS Lab., Dept. of Computer Science, UGA, June 2003.

- [Staa:01]

  Staab, S., M. Erdmann, and A. Maedche, Ontologies in RDF(S). Electronic Transactions on Artificial Intelligence (ETAI), `http://www.ida.liu.se/ext/epa/cis/2001/009/tcover.html`.

- [Syca:03]

  Sycara, K., et al., Automated Discovery, Interaction and Composition of Semantic Web Services. Journal of Web Semantics, 1(1), 2003.

- [Triple:02]

  Sintek, M. and S. Decker, TRIPLE - A Query, Inference, and Transformation Language for the Semantic Web. ISWC 2002, Sardinia, Italy.

Go To Talk Outline