INFS 3204/7204
Service-Oriented Architecture

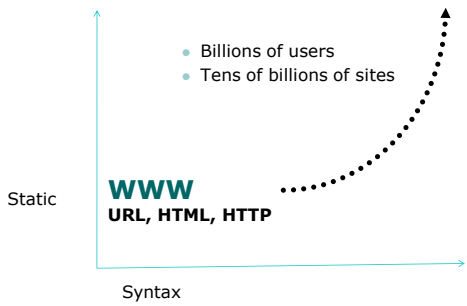
Dr Heng Tao SHEN
ITEE, UQ
Semester 2, 2009.

M9: Semantic Web Service

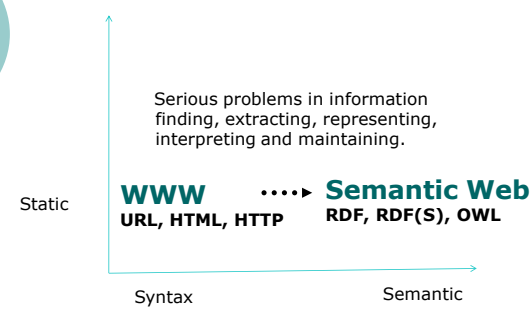
M9 Topics

- Semantic Web Service:
  - The vision
  - Semantic Web
    - RDF
    - Ontology
  - Semantic WS

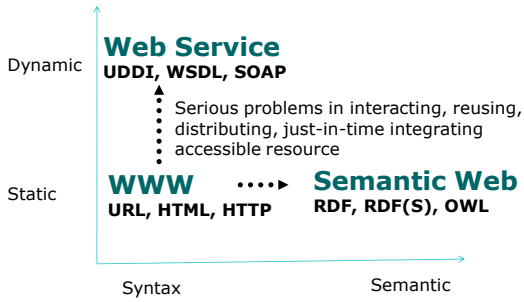
The Vision



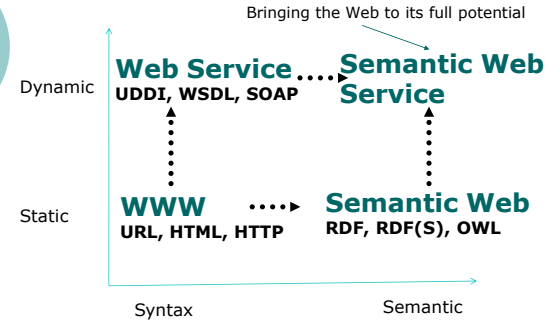
The Vision



The Vision



The Vision



The Semantic Web

- An idea of building the next generation Internet, where we will not just surf the web, but work the web
  - Conversation between people and machines
  - Conversation among people (Web 2.0)
- Decentralise DATA and centralise METADATA
- Build on top of XML with RDF and ontologies
- Not a well defined entity itself, many interpretations

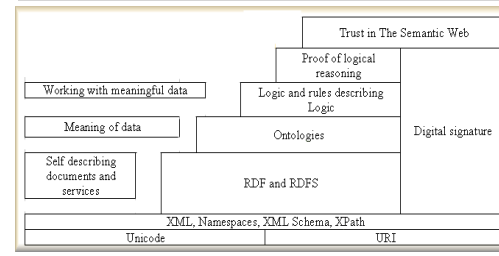
Definitions

- Semantic Web: a metadata based infrastructure for reasoning the Web
- Metadata: a set of statements
- Statements can be modeled with:
  - Resources: an element, a URI, a literal, ...
  - Properties: relations between two resources
  - Statements**:** "triplets" of two resources bound by a property
- Not a separate Web but an augmentation of the current one
- Ontologies as basic building block

Semantics

- "Semantic" means a resource or content description
  - includes the information about the resource that can be processed by computers
- The semantics of something is the **meaning** of it
  - Human brains are really good at this, but computers are not!
- How to better understand the semantic of Web information?
  - Semantic Web: building a new form of Web content that is meaningful to computers

Semantic Web Architecture



•Top 4 levels are unclear
•The higher the level, the less concrete the concepts are

RDF (Resource Description Framework)

- Defines a way of expressing meaning of the Web that machine can understand
- Consists a family of (dynamic) W3C specifications
  - The specifications
  - The RDF data model
  - RDF schema and validation
  - XML and pictorial RDF syntax

RDF Vision

Once the web has been sufficiently "populated" with rich metadata, what can we expect? First, searching on the web will become easier as search engines have more information available, and thus searching can be more focused. Doors will also be opened for automated software agents to roam the web, looking for information for us or transacting business on our behalf. The web of today, the vast unstructured mass of information, may in the future be transformed into something more manageable - and thus something far more useful.

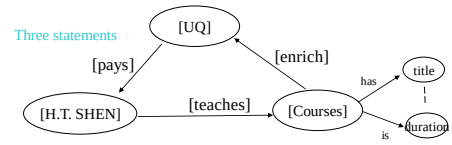
Ora Lassila
Editor of the RDF Model and Syntax Specification

RDF

- Resource
  - A resource is anything that has an identity
- Description
  - A bucket of one or more statements
- Framework
  - Rules that will allow humans and machines to make and understand an infinite number of statements whose subjects and objects are resources

RDF Data Model

- The RDF data model is a graph
  - Can be represented in XML
  - An RDF statement is a triple (subject, predicate, object)
    - All are resources, uniquely identified by URIs (but not necessary network retrievable)



RDF Schema

- Semantic networks for the Web
- A vocabulary for vocabularies
  - A list of words, a typing system
    - Subject validity (which predicates go with which subjects)
    - Object validity (which predicates go with which objects)
    - E.g., [Mary] reads [books] (not [books] reads [Mary])
  - Validation
    - A key concern for information owner

RDF: A Simple Example

H.T. Shen is the author of the resource http://www.itee.uq.edu.au/~infs3204/intro.xml

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:s="http://description.org/schema/">
  <rdf:Description about="http://www.itee.uq.edu.au/~infs3204/intro.xml">
      <s:Author> H.T. Shen </s:Author>
  </rdf:Description>
</rdf:RDF>
```

RDF is a standard syntax to represent (edge-labelled) directed graphs in XML

From XML to RDF

- XML gives 'meanings' to documents?
  - DTD is just a 'content model'
  - We need a 'meaning model"

```
<person name="H.T. Shen">
  <teaches course="SOA" />
</person>
```

```
<course name="SOA">
  <lecturer name="H.T. Shen" />
</course>
```


RDF or XML?

- It depends...
  - XML's model is a tree
    - a strong hierarchy
    - applications may rely on hierarchy position (e.g., *li* in HTML)
    - relatively simple syntax and structure
    - not easy to combine trees
  - RDF's model is a graph
    - a loose collections of relations
    - applications may do "database"-like search
    - not easy to recover hierarchy
    - easy to combine relations in one big collection

Ontology

- In philosophy
  - A study of being
  - A formal account of what exists
- For the Web
  - Taxonomy + inference rules
    - Taxonomy: a system that classifies things that exist (in the form of a tree)

Ontology

- Defines the terms and relationships used to describe and represent an area of knowledge
- The goal is to develop a Web Ontologies Language (OWL) to define
  - the terminology used in a specific context
  - possible constraints on properties
  - the logical characteristics of properties
  - the equivalence of terms across ontologies
  - But, it is HARD…

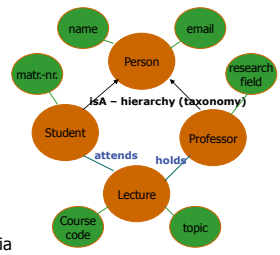
Ontology: an example of university community

Concept/term
conceptual entity of the domain

Property
attribute describing a concept

Relation
relationship between concepts or properties

Axiom
Coherency description between Concepts / Properties / Relations via logical expressions



holds(Professor, Lecture) =>
Lecture.topic = Professor.researchField

Logic

- RDF provides statements of using subject/object/predicate model, then first order logic can be used to enhance these statements with richer syntax and more semantic power, with the UoD(Universe of Discourse)

Predicate logic: constants, functions, relations, variables, Boolean values, $\wedge$ $\vee$ $\neg$ $\rightarrow$ $\equiv$ $\forall$ $\exists$, term, atom, sentence, well-formed formula

First-order predicate logic is a predicate logic in which predicates take only individuals as arguments and quantifiers only bind individual variables. Higher-order predicate logic is a predicate logic in which predicates take other predicates as arguments and quantifiers bind predicate variables. For example, second-order predicates take first-order predicates as arguments.

Proof

- The logic layer provides a language for describing truth or falsity of statements (in a UoD)
- The proof layer gives the steps in the reasoning
  - E.g., why `book(Chinese)` is true?
- Related disciplines
  - Formal methods for software verification
  - Automated theorem proving

Web Service

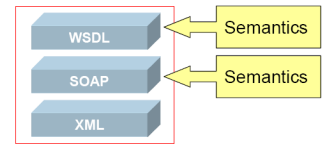
- WS approaches the Semantic Web (SW) from the other end of the spectrum
  - Rather than classify everything, it focuses on standardising XML-based interactions between computers
- Traditional WS usage limitations
  - Syntactical information descriptions
  - Syntactic support for discovery, composition and execution
  - Manual inspection for Web Service usability and integration
  - No semantically marked up content / services, i.e., no support for the Semantic Web

Semantic WS

- Semantic Web+Web Service
- Goal:
  - Add semantics to WS to automate:
    - Specification
    - Discovery
      - Find me a pizza delivery service in my area
    - Composition
      - Make the travel arrangement for the next trip
    - Execution
      - Buy me "Batman 3" at Amazon

Semantic WS Specification

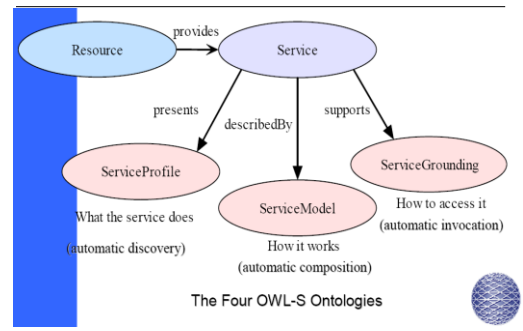
- Associate ontology concepts to WS description



OWL-S

- OWL-based Web service ontology
- Enables Web Service providers to
  - Describe the properties and capabilities of their web services
  - In machine-processable form
- Facilitates automatic Web service
  - Discovery, execution, composition, interoperation

OWL-S Ontology for WS



OWL-S Semantic WS

Service	The superclass
ServiceProfile	Used by a *Requesting* Agent to determine whether the service meets its needs.
ServiceModel	Describes what happens when the service is carried out
ServiceGrounding	Specifies how an agent can access a service i.e., "grounded" using ***WSDL***

Semantic WS

- Defines exhaustive description frameworks for describing Web Services and related aspects **(Web Service Description Ontologies)**
- Supports ontologies as underlying data model to allow machine supported data interpretation **(Semantic Web aspect)**
- Defines semantically driven technologies for automation of the Web Service usage process **(Web Service aspect)**

Semantic WS usage process

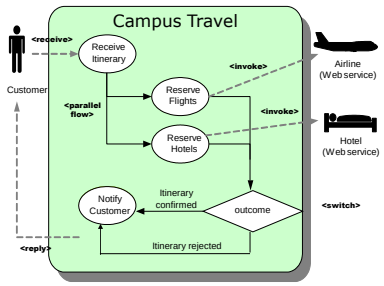
- **Publication**: Make available the description of the capability of a service
- **Discovery**: Locate different services suitable for a given task
- **Selection**: Choose the most appropriate services among the available ones
- **Composition**: Combine services to achieve a goal
- **Mediation**: Solve mismatches (data, protocol, process) among the combined
- **Execution**: Invoke services following programmatic conventions

Semantic WS execution support

- **Monitoring**: Control the execution process
- **Compensation**: Provide transactional support and undo or mitigate unwanted effects
- **Replacement**: Facilitate the substitution of services by equivalent ones
- **Auditing**: Verify that service execution occurred in the expected way

Semantic WS: a travel agent example

Goal: book hotel and flight for the trip to Melbourne Cup 2008



Service discovery

Semantic WS discovery

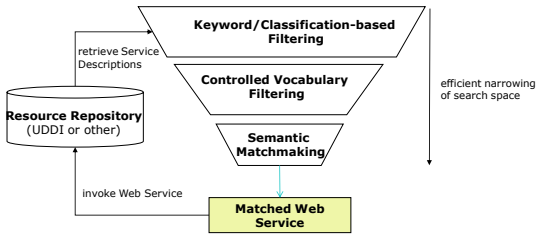
Find appropriate Web Service for automatically resolving a goal as the objective of a requester

- Aims:
  - high precision discovery
  - maximal automation
- Requirements:
  - infrastructure that allows storage and retrieval
  - description of Web services functionality
  - description of requests or goals
  - algorithms for matching requesters for capabilities with the corresponding providers

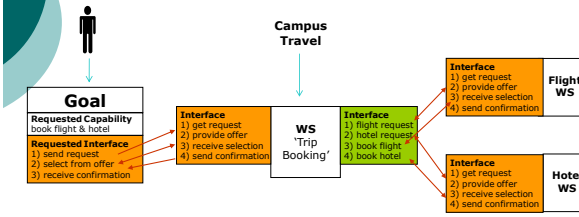
Discovery techniques

- Different techniques available
  - Key Word Matching
    - match natural language key words in resource descriptions
  - Controlled Vocabulary
    - ontology-based key word matching
  - **Semantic Matchmaking**
    - What Semantic Web Services aim at
    - Exact, partial, intersection, contain, non-match, etc.

Discovery architecture



Choreography Discovery



Choreography Discovery as a central reasoning task in Service Interfaces:
Melbourne Cup 2008 -> date, airline, venue

Summary

- This week:
  - Semantic Web Service:
    - The vision
    - Semantic Web
    - Semantic Web + Web Service
- Next week:
  - **Project Demo**

References

- Semantic Web Services Tutorial
  - Michael Stollberg and Armin Haller, ICWS 2005.
- Microsoft FoodMovers example
  - http://msdn.microsoft.com/library/default.asp?url=/library/en-us/dnvsent/html/FoodMovers1.asp
- Service-Oriented Architecture Explained
  - http://www.ondotnet.com/pub/a/general/print_code.html
- Semantic Web Service
  - http://www.swsi.org
- OWL-S
  - http://www.daml.org/services