Lecture

Semantic Web & Ontology

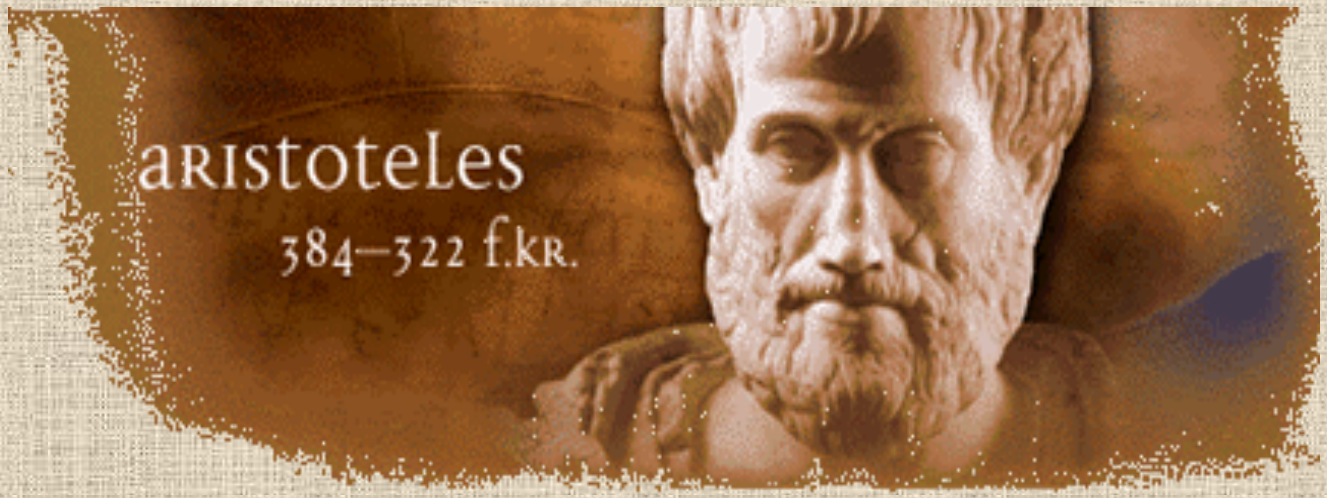
Content

- Introduction
- Ontology
- Semantic Web
- Web sevices
- Related topics
- Seminar topics
- Homework

Introduction

- Course objectives
- Methodology
- Assessment
  - Teamwork
  - Rubric
- Suggestions

Ontology



Ontology…

- Long history coming from Philosophy - Aristoteles
  - *" The metaphysical study of the nature of being and existence"*
- Pick up by the Artificial Intelligence
  - ***"a shared and common understanding of some domain that can be communicated between people and application systems" - Gruber***

What is Ontology……

- ***an ontology is a formal, explicit specification of a shared conceptualization - Gruber***
  - 'Conceptualization' refers to an abstract model of phenomena in the world by having identified the relevant concepts of those phenomena.
  - 'Explicit' means that the type of concepts used, and the constraints on their use are explicitly defined.
  - 'Formal' refers to the fact that the ontology should be machine readable.
  - 'Shared' reflects that ontology should capture consensual knowledge accepted by the communities

Main components of an Ontology

- Five kinds of components:
  - classes:
    - concepts of the domain or tasks, which are usually organized in taxonomies
    - in univ-ontology: student and professor are two classes
  - relations:
    - a type of interaction between concepts of the domain
    - such as: subclass-of, is-a

Main components of an Ontology (Cont.)

- Five kinds of components:
  - functions:
    - a special case of relations in which the n-the element of the relationship is unique for the n-1 preceding elements
    - Such as: Price-of-a-used-car can define the calculation of the price of the second-hand car on the car-model, manufacturing data and kilometres
  - axioms
    - model sentences that are always true
    - such as: if the student attends both A and B course, then he or she must be a second year student
  - instances
    - to represent specific elements
    - such as: Student called Peter is the instance of Student class

Kinds of ontologies

- Knowledge Representation ontologies
  - capture the representation primitives used to formalize knowledge in KR paradigm
  - such as: Frame-Ontology
- General/Common ontologies
  - vocabulary related to things, events, time, space, etc.
  - such as: meter and inch exchange table
- Meta-ontologies
  - reusable across domains
  - such as: mereology ontology (Borst, 97)

Kinds of ontologies

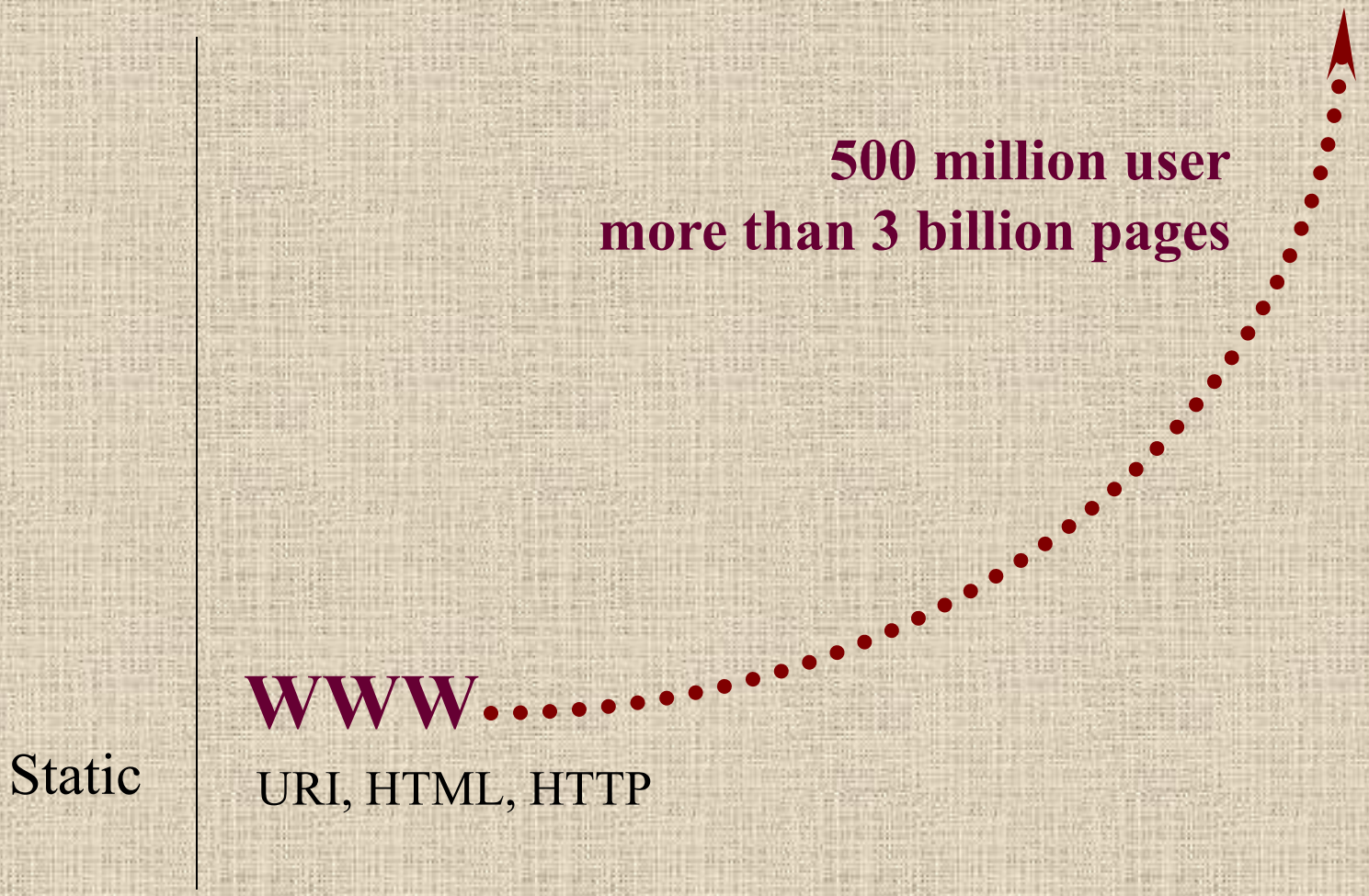
- Domain ontologies
  - vocabularies about the concepts in a domain
  - such as: the theory or elementary principles governing the domain
- Task ontologies
  - a systematic vocabulary of the terms used to solve problems associated with tasks that may or may not from the same domain
  - such as: scheduling task ontology
- Domain-task ontology
  - task ontology reusable in a given domain
  - such as: scheduling task ontology for flight schedule
- Application ontology
  - necessary knowledge for modeling a particular domain
  - such as: ????

Ontology Applications

- Knowledge Management
- Enterprise Application Integration
- e-Commerce

More goes to next Lecture

Current Web


500 million user
more than 3 billion pages
WWW
URI, HTML, HTTP
Static

The vision

- The World Wide Web is a big and impressive success story, both in terms
  - of the amount of available information and
  - the growth rate of human users
- It starts to penetrate most areas of our daily life and business.
- This success is based on its simplicity

the restrictivenss of HTTP and HTML allowed software developers, information providers and users to make easy access of the new media helping it to reach a critical mass

The Vision

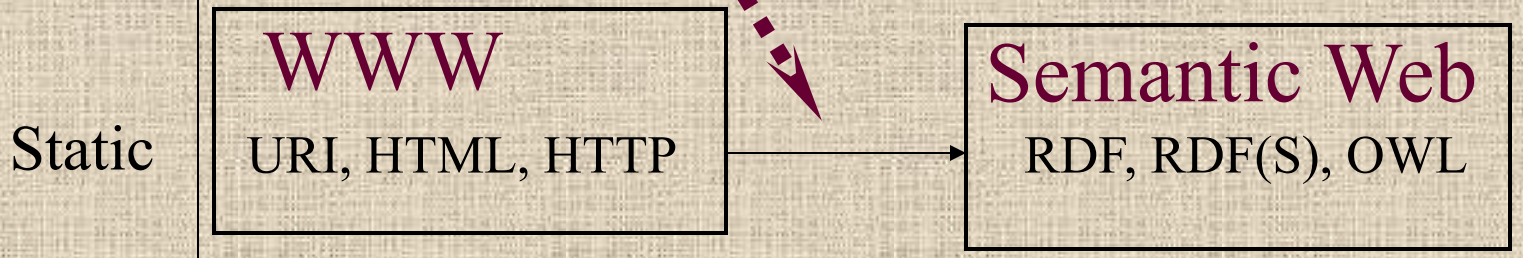
- However this simplicity may hamper the further development of the Web

What we see currently is the very first version of the web and the next version will probably even more bigger and much powerful compared to what we have now.

Semantic Web

Serious Problems in information

•finding
•extracting
•representing
•interpreting
•and maintaining



Semantic Web Technology

- Tim Berners-Lee has a vision of a Semantic Web which
  - has machine-understandable semantics of information, and
  - millions of small specialized reasoning services that provide support in automated task achievement based on the accessible information

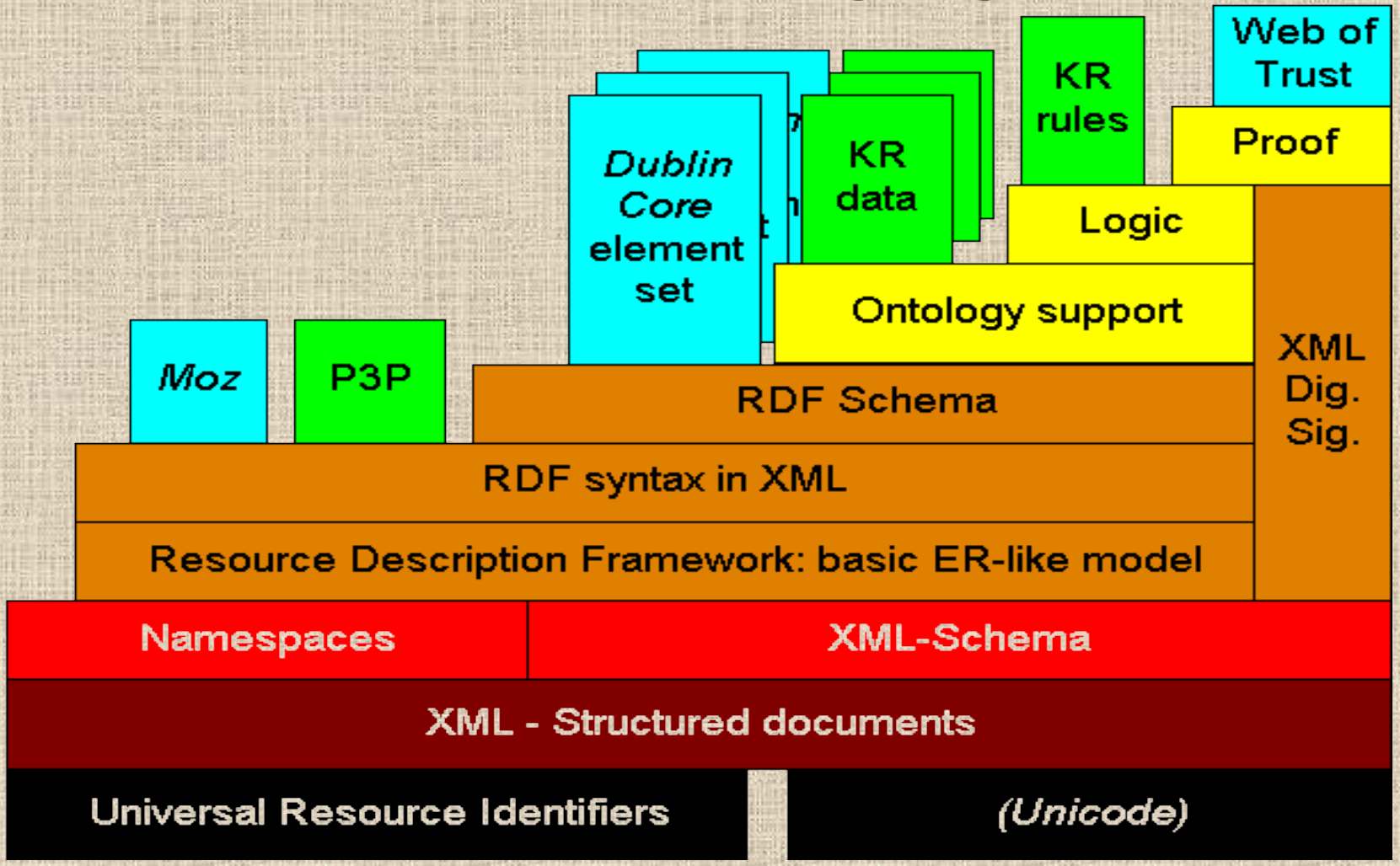
The Semantic Web

- The semantic Web is essentially based on ontologies
  - ontologies are ***formal*** and ***consensual*** specifications of conceptualizations…
  - providing a ***shared and common*** understanding of a domain that can be communicated across people and application systems

Semantic Web Technology

- Ontologies glue together two essential aspects that help to bring the web to its full potential:
  - ontology define a formal semantics for information allowing information processing by a computer
  - ontologies define a real-world semantics allowing to link machine processable content with meaning for humans based on consensual terminology

Semantic Web - Language tower



XML

- Tags define the semantics of the data

  <name>Dieter Fensel</name>

- XML provides arbitrary tress (graphs) as data structures

```
<person>
    <name>Dieter Fensel</name>
    <phone>6084751</phone>
</person>
```

- XML allows the definition of application-specific tags

http://www.w3.org/XML/

XML Schema

- DTDs allow to define a grammar and meaningful tag for documents
- XML schema provides similar service and add:
  - XML schemas definition are itself XML documents
  - XML schemas provide a rich set of datatypes that can be used to define the values of elementary tags
  - XML schemas provide much richer means for defining nested tags (such as tags with subtags)
  - XML schemas provide the namespace mechanism to combine XML documents with heterogeneous vocabulary

RDF

- XML provides semantic information as a by-product of defining the structure of the document
- XML prescribes a tree structure for documents and the different leaves of the tree have a well-defined tag and context the information can be understood with.

- That is, structure and semantics of documents are interwoven

RDF

- The Resource Decription Framework RDF provides a means for adding semantics to a document without making any assumptions about the structure of the document and it provides pre-defined modeling primitives for expressing semantics of data

RDF Schema

RDFs provides a simple and basic modeling language for ontologies

- concepts
- properties
- is-a hierarchy and
- simple domain and range restrictions

be expressed in RDFs

Advanced ontology modeling need more, however, can be realized as a layer on top of RDFs

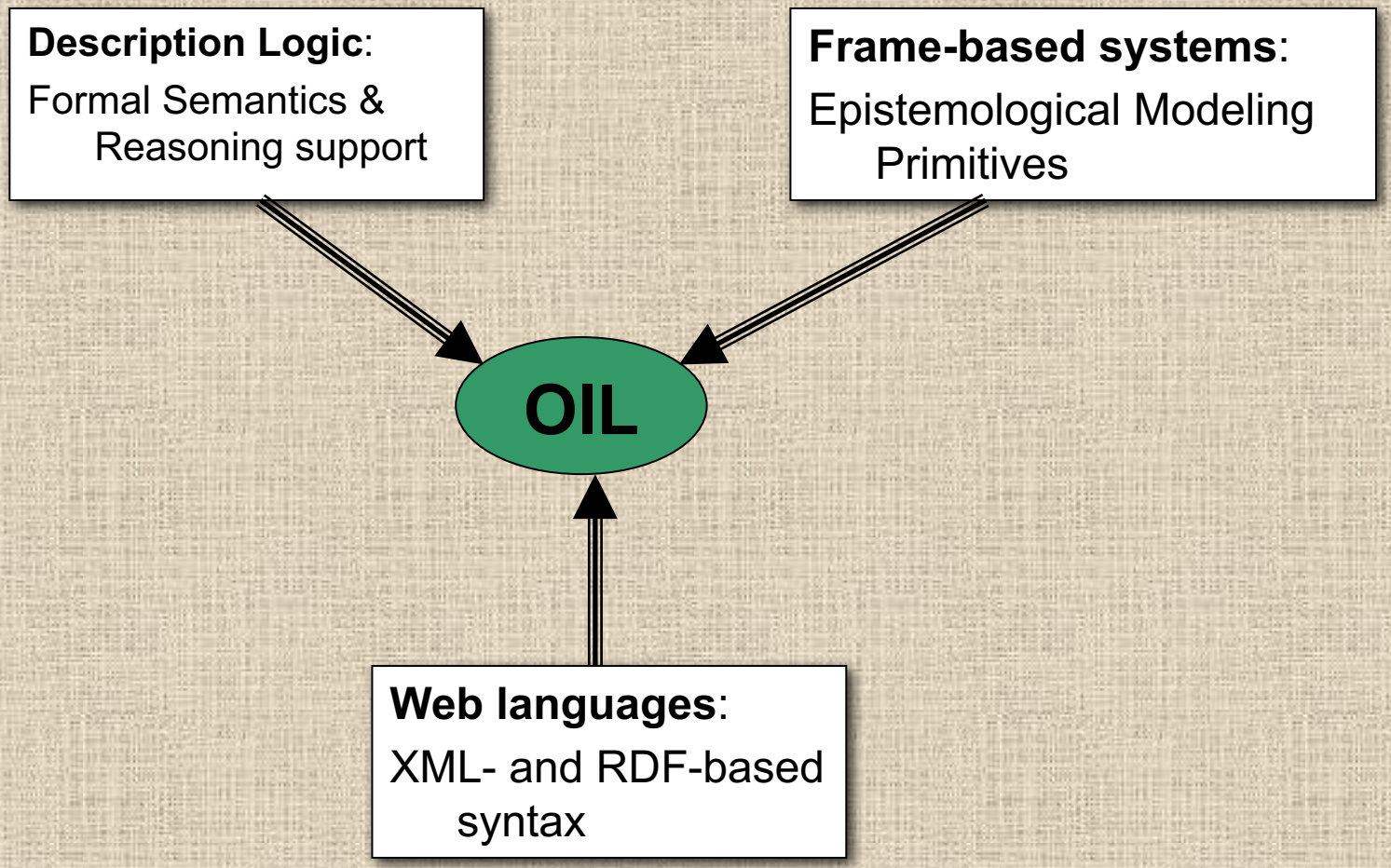
OIL

- OIL adds a simple Description Logic to RDF Schema
- It allows to define axioms that logically describe classes, properties and their hierarchies
- OIL enables to define necessary and sufficient conditions that define class membership of instances

OIL

- OIL
  - Developed in the Ontoknowledge project www.ontoknowledge.org
  - Core language contains consensus primitives, extensions add aditional expresiveness
  - Layered architecture:
    - Applications are not forced to work with a language more complex and expresive than required
    - Applications that can only process a low level of complexity are able to catch the aspects of the ontology
    - Applications aware of higher level of complexity can still understand a simpler ontology language

- OIL


Description Logic:
Formal Semantics & Reasoning support
Frame-based systems:
Epistemological Modeling Primitives
OIL
Web languages:
XML- and RDF-based syntax

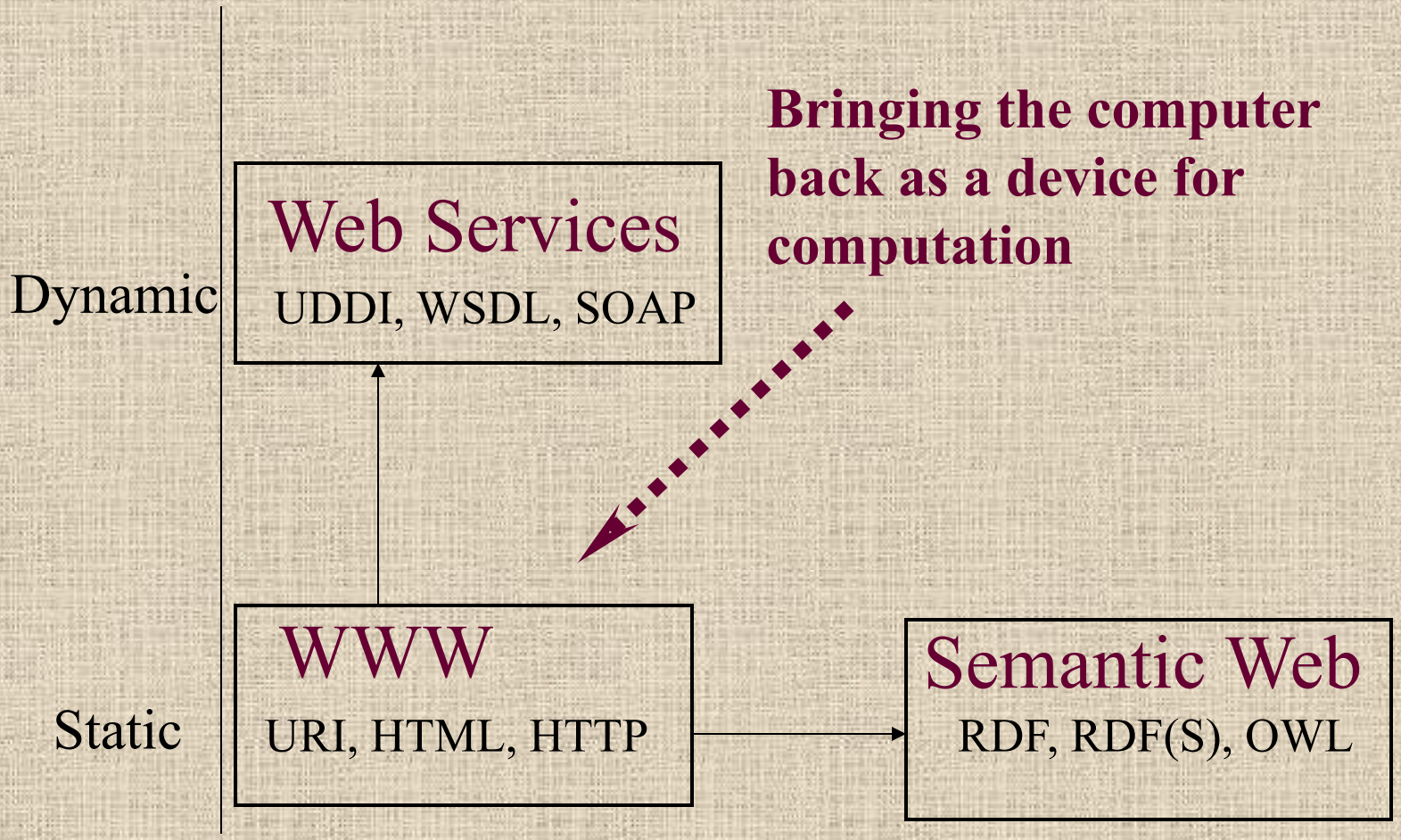
DAML+OIL

- DAML+OIL
  - Semantic markup language
  - Joint efford of the American and European communities
  - DAML+OIL = DAM-ONT + OIL
  - Designed to describe the structure of a domain in terms of classes and objects
  - Supports full range of datatypes in XML

OWL

- OWL
  - Under development of W3C Web Ontology Working Group
  - DAML+OIL based
  - Offers:
    - More accurate web searches
    - Intelligent agents
    - Knowledge management
  - Abstract syntax that provides:
    - Higher level way of writing ontologies
    - Clear statement of semantics
    - Compound axioms resembling frames
- OWL-lite
  - OWL sublanguage
  - OWL-lite = RDFs + 0/1 cardinality
  - Suites well to express light weight ontologies
  - Limited expresiveness power
    - Some fields require a full-fledged semantic web modeling language

Web Service


Dynamic
Web Services
UDDI, WSDL, SOAP
Bringing the computer back as a device for computation
Static
WWW
URI, HTML, HTTP
Semantic Web
RDF, RDF(S), OWL

Web Services

"Web services are a new breed of Web application. They are self-contained, self-describing, modular applications that can be published, located, and invoked across the Web. Web services perform functions, which can be anything from simple requests to complicated business processes. …

Once a Web service is deployed, other applications (and other Web services) can discover and invoke the deployed service."

IBM web service tutorial

Web Services

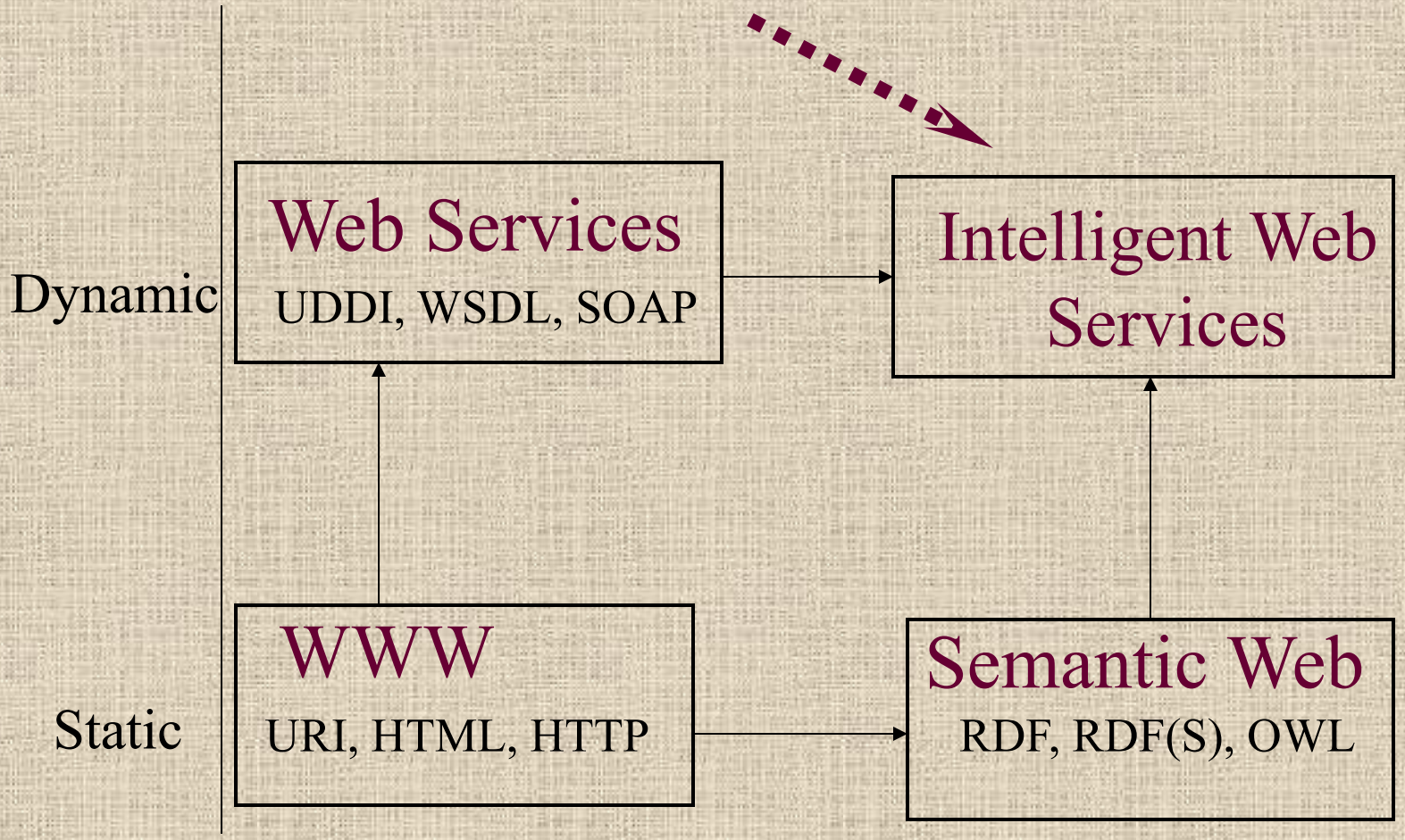
- Web Services connect computers and devices with each other using the Internet to exchange data and combine data in new ways.
- The key to Web Services is on-the-fly software creation through the use of loosely coupled, reusable software components.
- Software can be delivered and paid for as fluid streams of services as opposed to packaged products.

Web Services

- **UDDI** provides a mechanism for clients to find web services. A UDDI registry is similar to a CORBA trader, or it can be thought of as a DNS service for business applications.
- **WSDL** defines services as collections of network endpoints or *ports*. A port is defined by associating a network address with a binding; a collection of ports define a service.
- **SOAP** is a message layout specification that defines a uniform way of passing XML-encoded data. In also defines a way to bind to HTTP as the underlying communication protocol. SOAP is basically a technology to allow for "RPC *over the web*".

Semantic Web Service

Bringing the web to its full potential



Semantic Web Services

"Semantic differences, remain the primary roadblock to smooth application integration, one which Web Services alone won't overcome. Until someone finds a way for applications to understand each other, the effect of Web services technology will be fairly limited. When I pass customer data across [the Web] in a certain format using a Web Services interface, the receiving program has to know what that format is. You have to agree on what the business objects look like. And no one has come up with a feasible way to work that out yet -- not Oracle, and not its competitors..."

--- Oracle Chairman and CEO Larry Ellison

Semantic Web Services

- UDDI, WSDL, and SOAP are important steps into the direction of a web populated by services.
- However, they only address part of the overall stack that needs to be available in order to achieve the above vision eventually.
- There are many layer requires to achieve automatic web service discovery, selection, mediation and composition into complex services.

Semantic Web Services

- Semantic Web Services combine Semantic Web and Web Service Technology.
- Automatization of Web Service Discovery, Combination, and Invocation makes the technology scalable.
- This combination is a pre-requisite to make web service technology scalable and mature.
- This technology is a pre-requisite to enable fully open, flexible, and dynamic eWork and eCommerce a reality.

Semantic Web Services

- Mechanized support is needed in finding and comparing vendors and their offers. Machine processable semantics of information allows to mechanize these tasks.
- Mechanized support is needed in dealing with numerous and heterogeneous data formats. Ontology technology is required to define such standards better and to map between them.
- Mechanized support is needed in dealing with numerous and heterogeneous business logics. Mediation is needed to compensate these differences, allowing partners to cooperate properly.

Short Summary

- The semantic web is based on **machine-processable** semantics of data.
- Its backbone technology are **Ontologies**.
- It is based on new web languages such as XML, RDF, and OWL, and tools that make use of these languages.

Short Summary

- ***Ontologies*** are key enabling technology for the semantic web.
- They interweave human understanding of symbols with their machine processability.
- In a nutshell, Ontologies are ***formal*** and ***consensual*** specifications of conceptualizations that provide a shared and common understanding of a domain

Related Topics

- L1: **Introduction (Semantic Web and Ontologies)**
- L2: **Applications: KM, EAI, and eCommerce**
- L3: **Information Retrieval & Information Extraction**
- L4: **Logic (Propositional Logic and First-order logic)**
- L5: **Logic (First-order Logic and extensions)**
- L6: **XML and XML Schema**
- L7: **RDF and RDF Schema**
- L8: **Description Logic**

Related Topics

- L9: **Frame Logic**
- L10: **OWL and XML/RDF relationship**
- L11: **Ontobroker**
- L12: **Ontoknowledge**
- L13: **Dynamic Logic & Transaction Logic**
- L14: **UDDI, SOAP and WSDL**
- L15: **BPEL4WS and WSMF**
- L16: **Exam feedback etc.**

Seminar Topics

- Topic provided by each member of Next Generation Web
- The main focuses are:
  - Ontology
  - Semantic Web
  - Web Services
  - Information Retrieval and Information Extraction
  - Applications

Homework

- Creating your own University Ontology
- helpful readings and tools
  - download and play with Protégé
  - Ontology Development 101: A Guide to Creating Your First Ontology
  - Ontoweb deliverable 1.1