Semantic Web Services

Introduction

Dr Anna Fensel

What is the course about?

- New, emerging sciences: web science, service science
- Service based technologies: Web services, Web2.0/Restful services
- Semantic Web services: vision, approaches, usage

Course Organization

- Course is organized as follows:
  - Lecture every Monday 16:15-19:00
  - Tutorial every Monday 10:15-12:00
- The lecturers are:
  - Anna Fensel (anna.fensel@sti2.at)
  - and Dieter Fensel
- The tutors are:
  - Srdjan Komazec (srdjan.komazec@sti2.at)
  - and Anna Fensel

Course material

- Web site:
  - http://www.sti-innsbruck.at/teaching/course-schedule/ss2012/details/?title=semantic-web-services
- Slides are available online
- Mailing list:
  https://lists.sti2.at/mailman/listinfo/sws20112

Examination

- Written test at the end of the course, no literature use
- Exam grade:

score	grade
86-100	1
74-85.9	2
62-73.9	3
50-61.9	4
0-49.9	5

- Tutorial and Exam have separate grades since these is not an integrated course

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Where are we?

#	Title
1	**Introduction**
2	Web Science
3	Service Science
4	Web services
5	Web2.0 services
6	Semantic Web
7	Web Service Modeling Ontology (WSMO)
8	Web Service Modeling Language (WSML)
9	Web Service Execution Environment (WSMX)
10	OWL-S and other
11	Light-weight Annotations
12	Applications
13	Mobile Services

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Outline

- Motivation
- Semantic Web
- Web Services
- Semantic Web Services
- Summary
- References

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MOTIVATION

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Motivation

The Future Internet: Service Web 3.0 Video

http://www.sti-innsbruck.at/results/movies/serviceweb30-the-future-internet/

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Motivation

http://www.sti-innsbruck.at/results/movies/dip-promotion-movie

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SEMANTIC WEB

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The traditional Web

More than a 2 billion users
more than 50 billion pages

Static

WWW

URI, HTML, HTTP

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Serious Problems in
- information finding,
- information extracting,
- information representing,
- information interpreting and
- and information maintaining.

Static

WWW
URI, HTML, HTTP

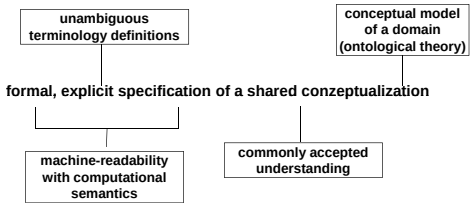
Semantic Web
RDF, RDF(S), OWL

- *"An extension of the current Web in which information is given well-defined meaning, better enabling computers and people to work in cooperation."*
  - Sir Tim Berners-Lee et al., Scientific American, 2001: tinyurl.com/i59p
- *"…allowing the Web to reach its full potential…"* with far-reaching consequences
- *"The next generation of the Web"*

- The next generation of the WWW
- Information has machine-processable and machine-understandable semantics
- Not a separate Web but an augmentation of the current one
- Ontologies as basic building block

- Web Data Annotation
  - connecting (syntactic) Web objects, like text chunks, images, … to their semantic notion (e.g., this image is about Innsbruck, Dieter Fensel is a professor)
- Data Linking on the Web (Web of Data)
  - global networking of knowledge through URI, RDF, and SPARQL (e.g., connecting my calendar with my rss feeds, my pictures, ...)
- Data Integration over the Web
  - Seamless integration of data based on different conceptual models (e.g., integrating data coming from my two favorite book sellers)

Semantic Web - Ontologies



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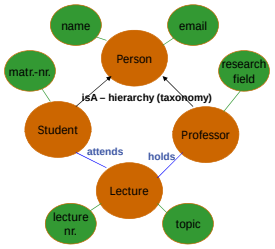
Semantic Web - Ontologies

Concept
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

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Semantic Web - Ontologies

To make the Semantic Web working we need:

- **Ontology Languages**:
  - expressivity
  - reasoning support
  - web compliance
- **Ontology Reasoning**:
  - large scale knowledge handling
  - fault-tolerant
  - stable & scalable inference machines
- **Ontology Management Techniques**:
  - editing and browsing
  - storage and retrieval
  - versioning and evolution Support
- **Ontology Integration Techniques**:
  - ontology mapping, alignment, merging
  - semantic interoperability determination
- and … **Applications**

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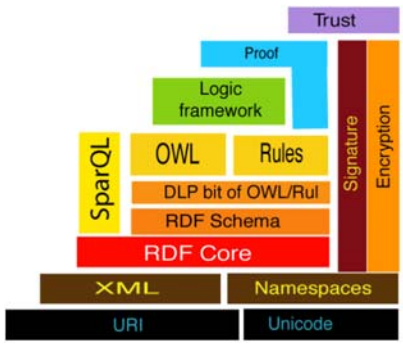
"Semantic Web Language Layer Cake"



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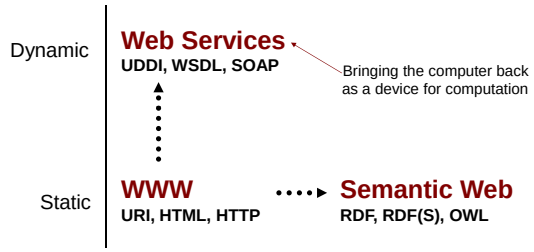
WEB SERVICES



1) "Loosely coupled, reusable software components that encapsulate discrete functionality and are distributed and programmatically accessible over standard Internet protocols", *The Stencil Group*

2) Web service applications are encapsulated, loosely coupled Web "components" that can bind dynamically to each other, *F. Curbera*

3) "Web Services are a new breed of 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 request to complicated business processes", *The IBM Web Services tutorial*

Common to all definitions:

- Components providing functionality
- Distributed
- Accessible over the Web

- Loosely coupled, reusable components
- Encapsulate discrete functionality
- Distributed
- Programmatically accessible over standard internet protocols
- Add new level of functionality on top of the current web

Web Service vs. Service

- Service
  - A provision of value in some domain (not necessarily monetary, independent of how service provider and requestor interact)
- Web Service
  - Computational entity accessible over the Internet (using Web Service Standards & Protocols), provides access to (concrete) services for the clients.

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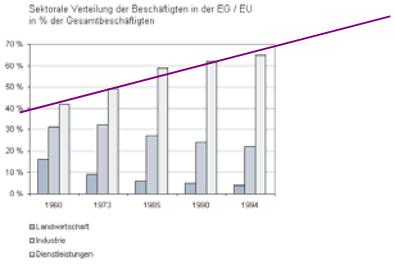
The Service Society

80% of jobs can be found in the service sector



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Service Dimensions

- From “Others“ to 80% of business activity
- The productivity of production and provisioning of services is therefore of high importance for the overall productivity of a developed economy
- Like in the primary and secondary sector also here information and communication technologies will be very important
- The usage of modern ICT in the service area is called internet of services

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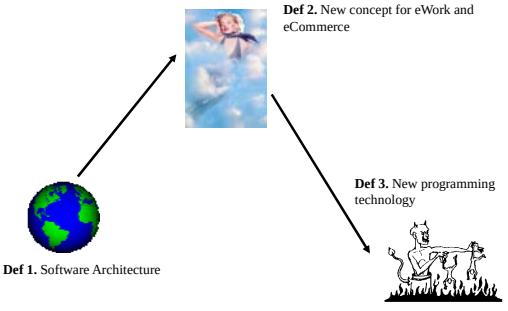
Definitions



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Definitions

Def 1. Software architecture

- 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.

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Definitions

Def 2. Web Services as a new Concept for eWork and eCommerce

- Business services can be completely decentralized and distributed over the Internet and accessed by a wide variety of communications devices.
- The internet will become a global common platform where organizations and individuals communicate among each other to carry out various commercial activities and to provide value-added services.
- The dynamic enterprise and dynamic value chains become achievable and may be even mandatory for competitive advantage.

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Definitions

Def 3. Web Services as a programming technology

Web Services are Remote Procedure Calls (RPC) over HTTP

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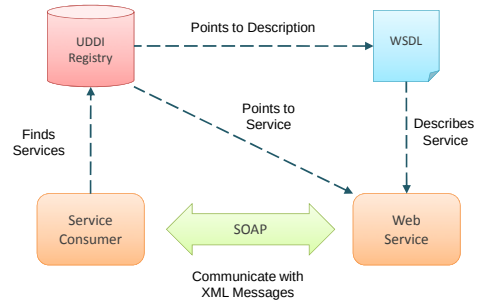
Web Services



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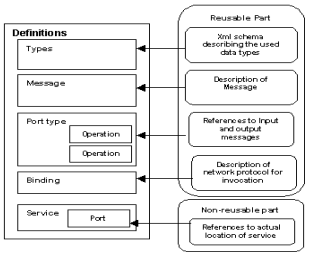
WSDL

- Web Service Description Language

describes interface for consuming a Web Service:
- Interface: operations (in- & output)
- Access (protocol binding)
- Endpoint (location of service)



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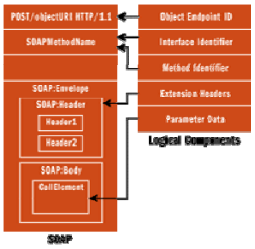
SOAP

- Simple Object Access Protocol
- W3C Recommendation

XML data transport:
- sender / receiver
- protocol binding
- communication aspects
- content



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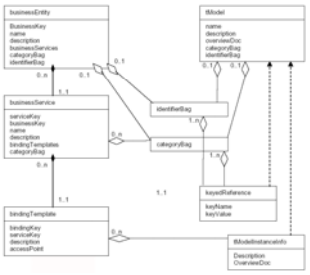
UDDI

- Universal Description, Discovery, and Integration Protocol
- OASIS driven standardization effort

Registry for Web Services:
- provider
- service information
- technical access



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Restful services

- Another way of realizing services, other then SOAP/WSDL/UDDI approach
- Follows the Web principles (REST principles)

- Services expose their data and functionality through resources indentified by URI
- Services are Web pages that are meant to be consumed by an *autonomous* program
- Uniform interfaces for interaction: GET, PUT, DELETE, POST
- HTTP as the application protocol

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People as a Service
Amazon - Mechanical Turk

"People as a service"

- **Amazon Mechanical Turk**
  - An API to Human Processing Power
  - The Computer Calls People
  - An Internet Scale Workforce
  - Game-Changing Economics

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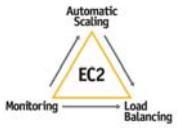
Infrastructure as a Service
Amazon – S3 & EC2

"Infrastructure as a service"

- **Amazon Simple Storage Service (S3)**
  - Write and read objects up to 5GB
  - 15 cents GB / month to store
  - 20 cents GB / month to transfer
- **Amazon Elastic Compute Cloud (EC2)**
  - allows customers to rent computers on which to run their own computer applications
  - virtual server technology
  - 10 cents / hour



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Data as a Service
Google – Unified Cloud Computing

- An attempt to create an open and standardized cloud interface for the unification of various cloud API's
- Key drivers of the unified cloud interface is to create an api about other API's
- Use of the resource description framework (***RDF***) to describe a semantic cloud data model (taxonomy & ontology)

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SEMANTIC WEB SERVICES

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Semantic Web Services

Bringing the web to its full potential

Dynamic	**Web Services** **UDDI, WSDL, SOAP**	**Semantic Web Services**
Static	**WWW** **URI, HTML, HTTP**	**Semantic Web** **RDF, RDF(S), OWL**

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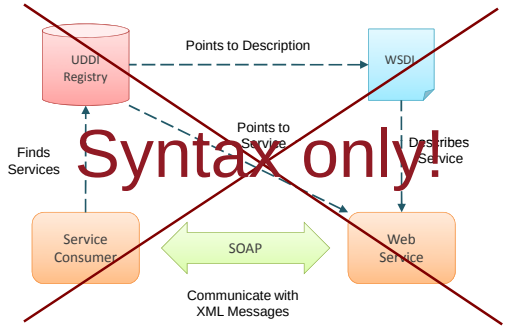
Deficiencies of WS Technology



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Deficiencies of WS Technology

- current technologies allow usage of Web Services
- but:
  - only syntactical information descriptions
  - syntactic support for discovery, composition and execution
  - ***=> Web Service usability, usage, and integration needs to be inspected manually***
  - no semantically marked up content / services
  - no support for the Semantic Web

=> current Web Service Technology Stack failed to realize the promise of Web Services

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So what is needed?

- **Mechanized support** is needed for
  - Annotating/designing services and the data they use
  - Finding and comparing service providers
  - Negotiating and contracting services
  - Composing, enacting, and monitoring services
  - Dealing with numerous and heterogeneous data formats, protocols and processes, i.e. mediation

=> Conceptual Models, Formal Languages, Execution Environments

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Semantic Web Technology

- allow machine supported data interpretation
- ontologies as data model

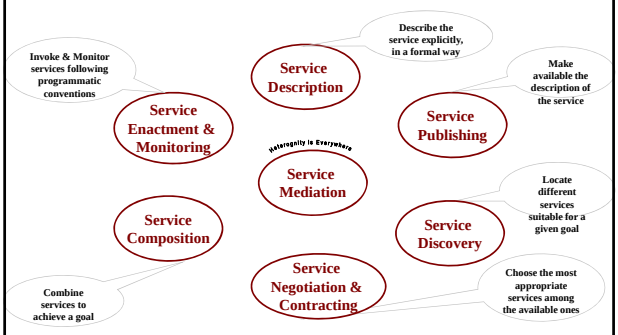
+

Web Service Technology

automated discovery, selection, composition, and web-based execution of services

=> Semantic Web Services as integrated solution for realizing the vision of the next generation of the Web

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



- Semantic Web Services are a layer on top of existing Web service technologies and do not aim to replace them
- Provide a formal description of services, while still being compliant with existing and emerging technologies
- Distinguish between a Web service (computational entity) and a service (value provided by invocation)
- Make Web services easier to:
  - Find
  - Compare
  - Compose
  - Invoke

Semantic Web Services benefits

- Brings the benefits of Semantics to the executable part of the Web
  - Ontologies as data model
  - Unambiguous definition of service functionality and external interface
- Reduce human effort in integrating services in SOA
  - Many tasks in the process of using Web services can be automated
- Improve dynamism
  - New services available for use as they appear
  - Service Producers and Consumers don't need to know of each others existence
- Improve stability
  - Service interfaces are not tightly integrated so even less impact from changes
  - Services can be easily replaced if they are no longer available
  - Failover possibilities are limited only by the number of available services

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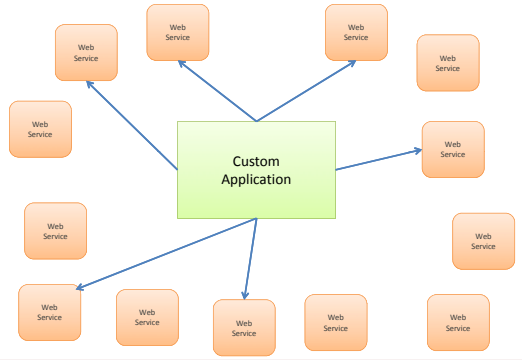
Service Oriented Architecture



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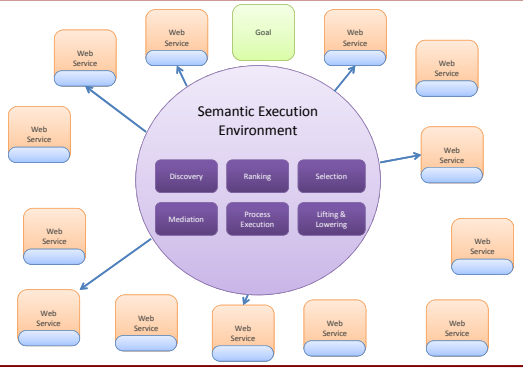
Semantically Enabled SOA (SESA)



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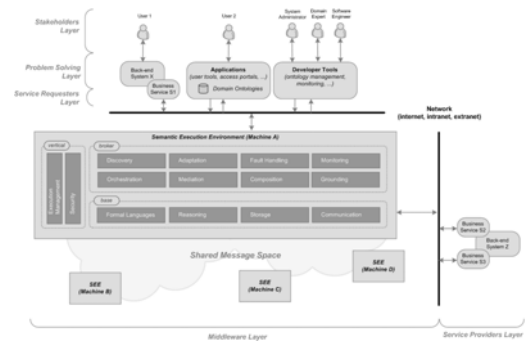
SESA Architecture



Fensel, D.; Kerrigan, M.; Zaremba, M. (Eds): *Implementing Semantic Web Services: The SESA Framework. Springer 2008.*

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SESA functionality

- Middleware for Semantic Web Services
  - Allows service providers to focus on their business,
- Environment for goal based discovery and invocation
  - Run-time binding of service requesters and providers,
- Provide a flexible Service Oriented Architecture
  - Add, update, remove components at run-time as needed,
- Keep open-source to encourage participation
  - Developers are free to use in their own code, and
- Define formal execution semantics
  - Unambiguous model of system behavior.

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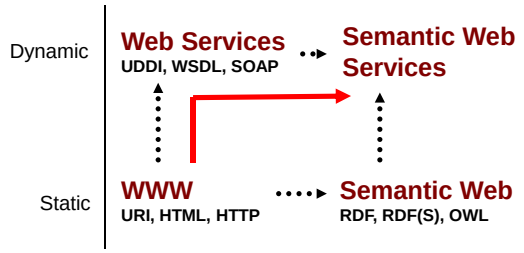
Realizing Semantic Web Services Vision



- Take the WSDL/SOAP web service stack as a starting point and add semantic annotations.

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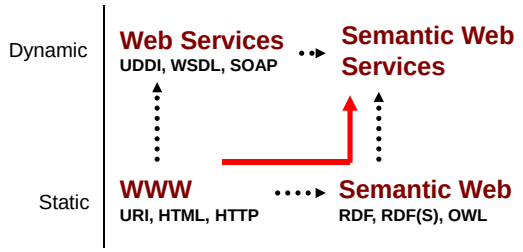
Realizing Semantic Web Services Vision



- Alternative way to realize Semantic Web Services vision is to focus on further developing the Semantic Web.

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Semantic Spaces - Motivation

- **Are WSDL/SOAP web services really web services? - No!**
- Web services require tight coupling of the applications they integrate.
  - Applications communicate via message exchange requiring strong coupling in terms of reference and time.
- The Web is strongly based on the opposite principles. Information is published in a persistent and widely accessible manner.
  - Any other application can access this information at any point in time without having to request the publishing process to directly refer to it as a receiver of its information.
- Web services can use the Web as a transport media, however **that is all they have in common with the Web.**

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Semantic Spaces - Motivation

- Distributed systems dominated by **messaging**
  - Web services / SOAP
  - CORBA / RPC / RMI / MOM
  - Agents
- Web architecture different
  - **Persistent publication** as the main principle
  - Uniform interface
  - Uniform addressing
- Web clearly scales to a large size

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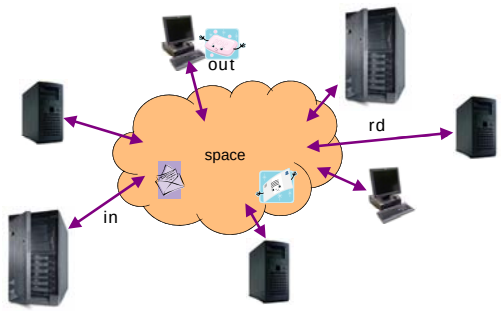
Semantic Spaces - Space-based Communication



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Semantic Spaces

- **Persistent publication** of semantic data
- Retrieval by **semantic matching**
- **Mediation** of data between heterogeneous services
- Semantics-aware **distribution** of data
- **Coordination** of concurrent access situations
- Appropriate **security and trust** mechanisms
- Use of **Web service protocol stack** and **Semantic Web** technologies

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LOD Cloud March 2009

Linked Data, http://linkeddata.org/ (last accessed on 18.03.2009)

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Data Linking on the Web

- **Linked Open Data statistics:**
  - **data sets: 121**
  - **total number of triples: 13.112.409.691**
  - **total number of links between data sets: 142.605.717**
- Statistics available at (last accessed on 04.02.2010):
  - http://esw.w3.org/topic/TaskForces/CommunityProjects/LinkingOpenData/DataSets/Statistics
  - http://esw.w3.org/topic/TaskForces/CommunityProjects/LinkingOpenData/DataSets/LinkStatistics

Data linking on the Web principles

- Use URIs as names for things
  - anything, not just documents
  - you are not your homepage
  - information resources and non-information resources
- Use HTTP URIs
  - globally unique names, distributed ownership
  - allows people to look up those names
- Provide useful information in RDF
  - when someone looks up a URI
- Include RDF links to other URIs
  - to enable discovery of related information

DBpedia

- DBpedia is a community effort to:
  - Extract structured information from Wikipedia
  - Make the information available on the Web under an open license
  - Interlink the DBpedia dataset with other open datasets on the Web
- DBpedia is one of the central interlinking-hubs of the emerging Web of Data

Content on this slide adapted from Anja Jentzsch and Chris Bizer

The DBpedia Dataset

- 91 languages
- Data about 2.9 million “things”. Includes for example:
  - 282.000 persons
  - 339.000 places
  - 119.00 organizations
  - 130.000 species
  - 88.000 music albums
  - 44.000 films
  - 19.000 books
- Altogether 479 million pieces of information (RDF triples)
  - 807.000 links to images
  - 3.840.000 links to external web pages
  - 4.878.100 data links into external RDF datasets

Content on this slide adapted from Anja Jentzsch and Chris Bizer

LinkedCT

- LinkedCT is the Linked Data version of ClinicalTrials.org containing data about clinical trials.
- Total number of triples:
  6,998,851
- Number of Trials:
  61,920
- RDF links to other data sources:
  177,975
- Links to other datasets:
  - DBpedia and YAGO(from intervention and conditions)
  - GeoNames (from locations)
  - Bio2RDF.org's PubMed (from references)

Content on this slide adapted from Chris Bizer

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SUMMARY

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Why Semantic Web Services ?

- To overcome limitations of traditional Web-Services Technology by integrating it with Semantic Technology;
- To enable automatic and personalized service discovery;
- To enable automatic service invocation and execution monitoring;
- To enable automatic service integration;
- To enable semantic mediation of Web-Services.

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Summary

- Two new sciences are currently emerging: Web science and Service Science.
- Core pillar of these sciences are:
  - Semantic Web
    - the next generation of the Web in which information has machine-processable and machine-understandable semantics.
  - Semantic Web Services
    - overcome limitations of traditional Web-Services Technology using Semantic Technology to enable automatic service discovery, ranking, selection, composition, etc.

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REFERENCES

References

- Mandatory reading:
  - D. Fensel, M. Kerrigan, and M. Zaremba (eds.). Implementing Semantic Web Services - The SESA Framework, Springer, 2008. ISBN: 978-3-540-77019-0
  - D. Fensel, C. Bussler. The Web Service Modeling Framework WSMF, Electronic Commerce Research and Applications, 1(2): 113-137, 2002
  - D. Fensel: Triple-space computing: Semantic Web Services based on persistent publication of information. In Proc. of the IFIP Int'l Conf. on Intelligence in Communication Systems (INTELLCOMM 2004), Bangkok, Thailand, November 23-26, 2004.
- Further reading:
  - L. Richardson, and S. Ruby. Web services for the real world, O'Reilly, 2007. ISBN 10: 0-596-52926-0
  - SOAP: http://w3.org/TR/soap12
  - WSDL: http://w3.org/TR/wsdl20
  - UDDI: http://uddi.xml.org/
  - http://dbpedia.org/About

References

- Wikipedia links:
  - http://en.wikipedia.org/wiki/Semantic_Web_Services
  - http://en.wikipedia.org/wiki/Service_(systems_architecture)
  - http://en.wikipedia.org/wiki/Webservice
  - http://en.wikipedia.org/wiki/Service-oriented_architecture
  - http://en.wikipedia.org/wiki/Web_Services_Description_Language
  - http://en.wikipedia.org/wiki/SOAP
  - http://en.wikipedia.org/wiki/Universal_Description_Discovery_and_Integration
  - http://en.wikipedia.org/wiki/Cloud_computing
  - http://en.wikipedia.org/wiki/Amazon_Elastic_Compute_Cloud
  - http://en.wikipedia.org/wiki/Amazon_Mechanical_Turk

Next Lecture

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Questions?