RDF Standard and Technologies

Tutorial for NETTAB 2007

2007-06-12

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Primer's Primer

```
<html>
<head>
<title>NETTAB2007</title>
</head>
<body>
This year, <a
href="http://...">NETTAB</
a> provides an RDF
Tutorial by <a
href="http://...">Heiko
Stoermer</a> from the <a
href="http://...">Universi
ty of Trento</a>.
</body>
</html>
```

Query:

"Which talks will NETTAB feature in 2007?"

Search-Engine answer: ???

Primer's Primer

```
NETTAB2007
      hasYear 2007
      hasURL http://...

HeikoStoermer
      givesTalk TutorialRDF
      hasURL http://...

TutorialRDF
      isA Tutorial
      location NETTAB2007

Tutorial isA Talk
```

Query:

"Which talks will NETTAB feature in 2007?"

Possible RDF-Answer:

RDFTutorial, given by HeikoStoermer

Tutorial Overview - Theory

- Introduction to the Semantic Web Vision
- Introduction to RDF
  - What is RDF (not)
  - Main RDF Ingredients
  - Composing, creating, storing and viewing RDF
- Advanced RDF
  - Defining RDF Vocabularies
  - Querying RDF
- Discussion Pro/Con RDF

Tutorial Overview - Practice

- Creating a model with IsaViz
- PHP + RDF with RAP
- A word on Java
- Further resources and readings
  - general
  - developer tools
  - advanced topics

The Semantic Web I

- The Web today: Documents for humans.
- Problem: hard (impossible) to machine-process on a semantic level.
- Evidence: keyword-based search engines.
- Example: search for „red wine" does not return „Teroldego" ☹

The Semantic Web II

- Vision: Make the information in the Web machine-processable, for intelligent services, better user interaction and autonomous agents
- Examples:
  - search engines which know that Teroldego is a type of red wine ☺
  - automatic (re-) classification/ordering of documents
  - faceted navigation and browsing
  - applications that are able to combine remote services dynamically to achieve tasks

The Semantic Web III

- Realization idea: Semantic annotation of objects + query and reasoning mechanisms
- Requirement:
  - machine-processable languages for annotation and representation
  - reasoning tools
  - a naming mechanism
- Related areas: Logics, Knowledge Representation, Automated Reasoning
- (very little/no Statistics)

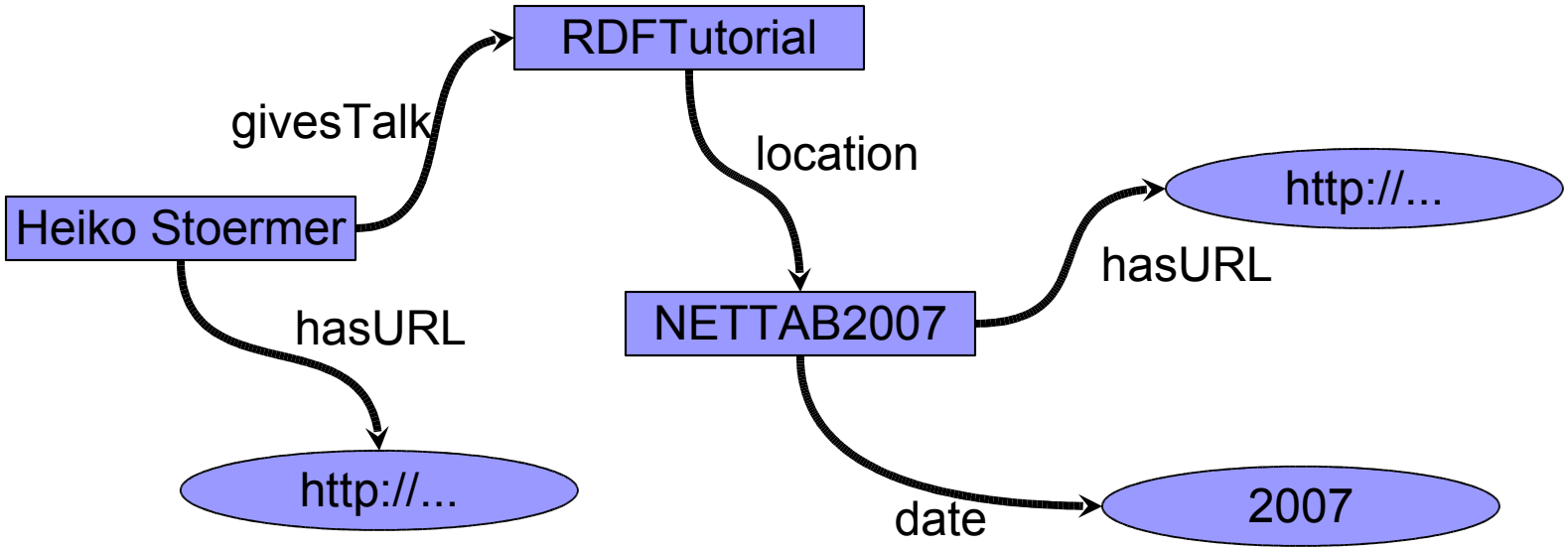
Semantic Web IV

- Current approach: abstract representation of the world (classes, relations) + statements about real-world objects that conform to this abstract representation.

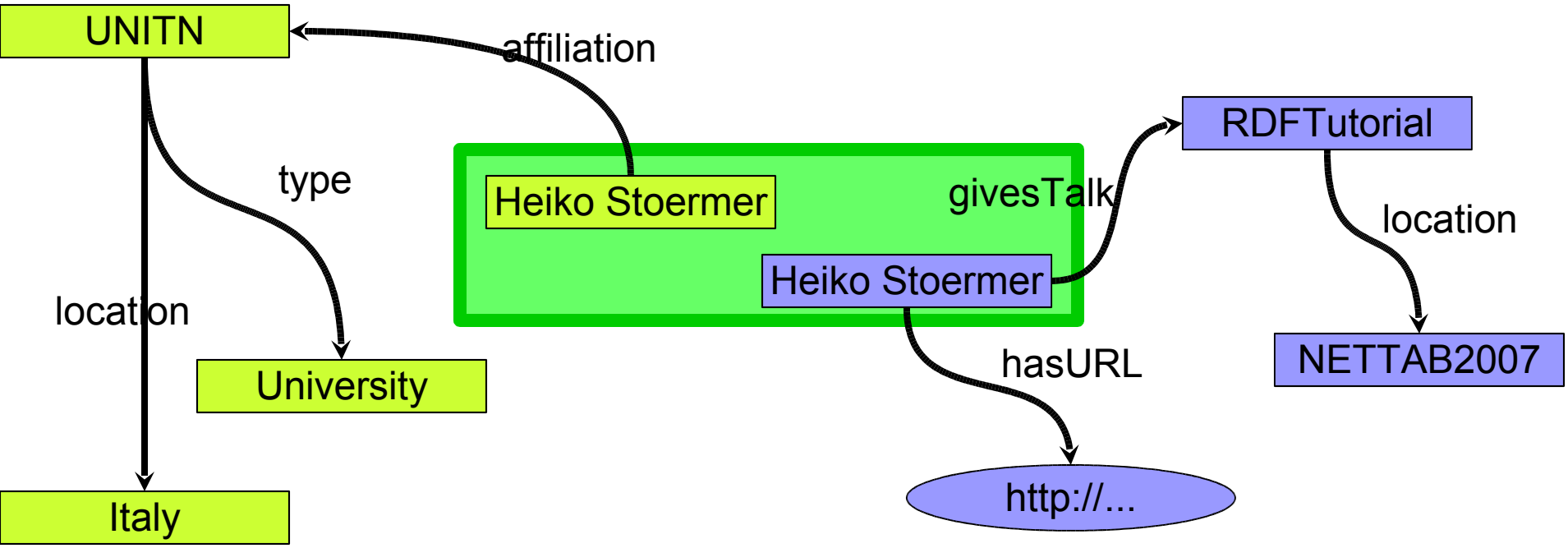
Core Language: RDF

Think Graphs!

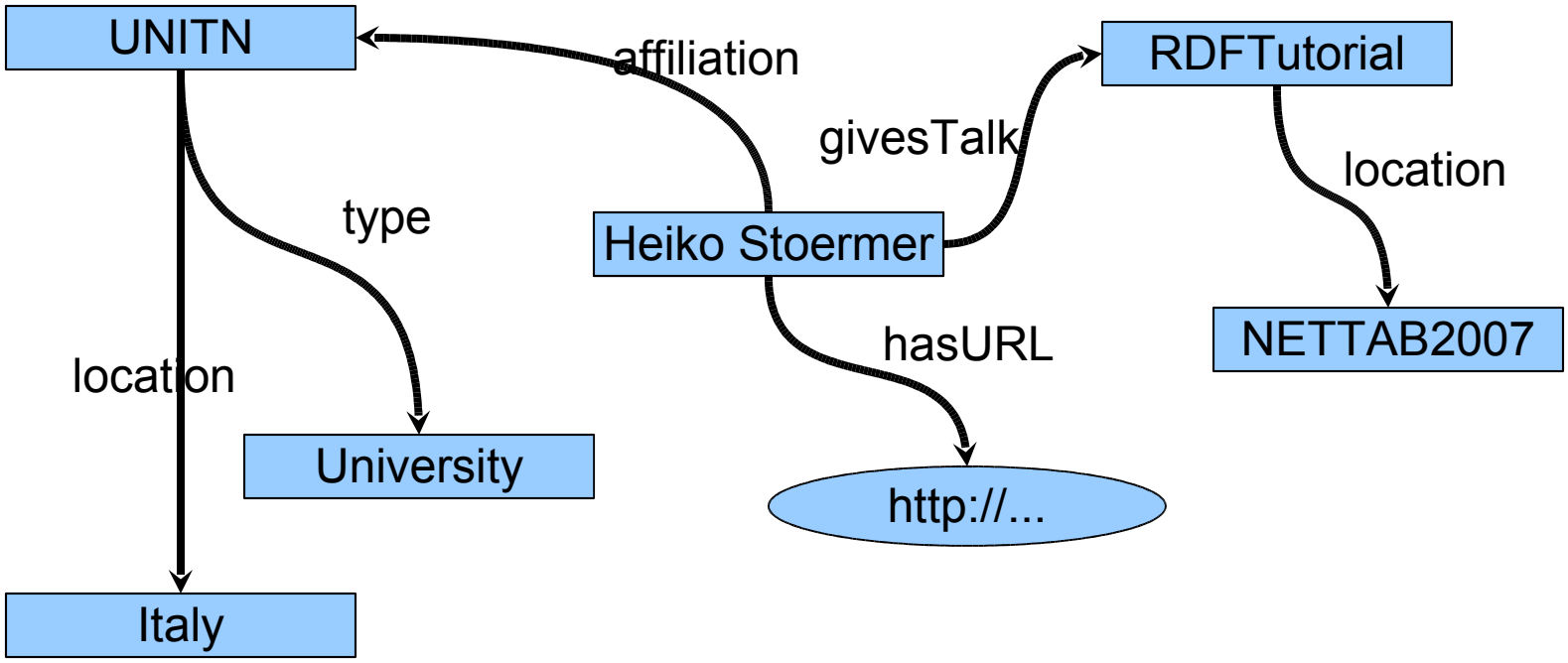
- RDF is much about graphs and less about syntax



RDF Vision: Distribute, Integrate



RDF Vision: Distribute, Integrate



What is RDF?

- An abstract formalism
- A graph data model (directed)
  - terms used: "graph" or "model"
- A set of binary statements ("triples")
  - Subject Predicate Object
- A representation of a part of the world

What is RDF not?

- A relational database
- A (database) management system
- A query language
- A file
- A new version of HTML or XML
- Something to say negative things with...

RDF Elements

- Resources R
- Properties P
- Literal Values L
- Assertions "R P L" or "R P R"
- Namespaces

(Almost) Everything is a Resource

- RDF stores statements about "resources":
  - Tangible things of the real world
  - Electronic objects
  - Abstract ideas such as classes/topics/...
- Resources are identified by URIs
  - URIs are rigid designators in a global domain.

Properties create Statements

- Resource Property Resource:
  - NETTAB location Pisa
  - Heiko givesTalk RDFTutorial
- Resource Property Literal
  - Heiko fullName "Heiko Stoermer"
  - NETTAB date "2007"
- ~~Literal Property Resource~~
  - ~~"2007" dateOf NETTAB~~

Literal Values are Data

- Untyped literals are just strings
- Typed literals borrow from XML Schema Datatypes:
  - string
  - date
  - float
  - ...

Assertions span the Graph

- Assertion = Triple = Statement
- A graph can be empty
- A graph cannot contain only resources
- A set of assertions creates a graph
- A graph can be a lettuce:

```
Heiko type Researcher
Paolo type Professor
```

My Language is mine!

- RDF knows Namespaces
- Used to separate vocabularies (see RDFS later today)
- A namespace is defined by a URI
- There syntactic methods to define abbreviations for these URIs and a default namespace for a graph.

Composing RDF

- With a text editor (textual serialization in a file)
- With a graphical "drawing" tool
  - IsaViz Demo
- Programmatically (in-memory), see examples later today

RDF is XML

```
<?xml version="1.0"?>
<rdf:RDF
    xmlns:gss="http://www.w3.org/2001/11/IsaViz/graphstylesheets#"
    xmlns:nettab="http://www.nettab.org/tutorial-ns#"
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#">
  <rdf:Description rdf:ID="NETTAB2007">
    <nettab:date rdf:datatype="http://www.w3.org/2001/XMLSchema#date"
    >2007-06-12</nettab:date>
  </rdf:Description>
  <rdf:Description rdf:ID="hst">
    <nettab:name>Heiko Stoermer</nettab:name>
    <nettab:givesTalk>
      <rdf:Description rdf:about="http://www.know-who.net/talks/nettab.ppt">
        <nettab:name>RDF Tutorial</nettab:name>
        <nettab:location rdf:resource="#NETTAB2007"/>
      </rdf:Description>
    </nettab:givesTalk>
  </rdf:Description>
</rdf:RDF>
```

RDF is not XML

```
@prefix :        <#> .

:NETTAB2007
      <http://www.nettab.org/tutorial-ns#date>
               "2007-06-12"^^<http://www.w3.org/2001/XMLSchema#date> .

:hst  <http://www.nettab.org/tutorial-ns#givesTalk>
               <http://www.know-who.net/talks/nettab.ppt> ;
      <http://www.nettab.org/tutorial-ns#name>
               "Heiko Stoermer" .

<http://www.know-who.net/talks/nettab.ppt>
      <http://www.nettab.org/tutorial-ns#location>
               :NETTAB2007 ;
      <http://www.nettab.org/tutorial-ns#name>
               "RDF Tutorial" .
```

Storing RDF

- RDF graphs can be serialized as files (see example later) and stored in the file system
- For more DBMS-like applications, there are RDF repositories that provide
  - Query functionality
  - Access control
  - Distribution
- Example:
  - Sesame
  - 3-Store
  - JENA
  - RDF-API for PHP

Viewing RDF

- RDF Gravity
- IsaViz
- dot
- Jambalaya
- W3C RDF Validator

Advanced RDF'ing

- Schemas
- Query languages

No life without schemas...

- RDF Schema (RDFS) is a vocabulary to create vocabularies...
  - Comparable to XML Schema or XML DTD
  - Used to standardize which „tags" the creator of a graph is allowed to use for annotating resources
- Introduces notions such as "Class" and "Subclass„
- Helps define which relations a resource of a certain type may have

Main RDFS Namespace Elements

- X rdf:type rdfs:class
  - denotes that resource X is a class
- R rdf:type rdf:Property
  - denotes that resource R is a property
- R rdfs:domain X
  - denotes that the subject of R must be an X
- R rdfs:range Y
  - denotes that the object of R must be a Y

RDFS 2

```
<?xml version="1.0"?>
<rdf:RDF
    xmlns:gss="http://www.w3.org/2001/11/IsaViz/graphstylesheets#"
    xmlns:nettab="http://www.nettab.org/tutorial-ns#"
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#">

<rdfs:class rdf:ID="person" />
<rdfs:class rdf:ID="talk" />
<rdfs:class rdf:ID="event" />

<rdf:Property rdf:ID="givesTalk">
    <rdfs:domain rdf:resource="#person" />
    <rdfs:range rdf:resource="#talk" />
</rdf:Property>

<rdf:Property rdf:ID="location">
    <rdfs:domain rdf:resource="#talk" />
    <rdfs:domain rdf:resource="#event" />
</rdf:Property>

</rdf:RDF>
```

RDFS 3

- Compatibility check of a graph to a schema is NOT automatically performed upon parsing
- This is a consistency check which is performed by an RDFS reasoner on demand
- RDF triples that are inconsistent can be added to a graph (e.g. programmatically) and are not detected unless a consistency check is performed
- to answer queries which involve properties from a superclass, the query engine must have reasoning capabilities
- more details are left for the OWL tutorial later today

Querying RDF

- Several query languages exist to retrieve resulting triples from RDF
  - RDQL
  - SERQL
  - SPARQL (upcoming W3C Standard)
- These languages use triple patterns as input and return matching triples as results
- Example today: SPARQL

SPARQL Example

```
PREFIX nettab
  <http://www.nettab.org/tutorial-ns#>
SELECT ?x ?y ?z
WHERE { ?x nettab:givesTalk ?z }
```

Matching triple:

Subject:	http://www.nettab.org/tutorial-ns#hst
Predicate:	http://www.nettab.org/tutorial-ns#givesTalk
Object:	http://www.know-who.net/talks/nettab.ppt

SPARQL Features

- Can deliver triples in serialized form
  - XML output
  - RDF graph
- Knows value filters (e.g. 'age >= 24')
- Knows "optionals" to return information in case it is available
- Optionals and filters can be combined
- Knows other constructs as from SQL (order, distinct, offset, limit...)

RDF Discussion

- Strengths and weaknesses
- Further developments
- Semantic Web shortcomings
- State of the Art

RDF Pros

- Potential universal data format with enhanced capabilities:
  - reasoning on subclass relations and properties
  - query results can be serialized easily (as opposed to SQL results)
  - RDF+OKKAM provides information integration for free

RDF Cons

- Limited Semantics
- Maturity
- Context
- Addressing

Limited Semantics

- Subclass relations are „built in", i.e. directly understood by an RDF reasoner
- Other important relations have no semantics to a reasoner, their names are only symbols that are (hopefully!) meaningful to a human who writes a query, e.g.:
  - part-of
  - causal relations (cause -> effect)
- This is not RDF's „fault", it is inherent to the underlying KR mechanisms

Maturity: RDF is young... and old!

- RDF is only a few years old
- related technologies such as SPARQL are not even fully standardized yet
- repositories promote „successes" to store billions of triples; but how long does it take to answer reasoning queries?
- research (and funding) has mostly ended

⇒ transition phase between research and product development

⇒ too much has been invested already, RDF will probably not disappear.

Knowledge is Contextual

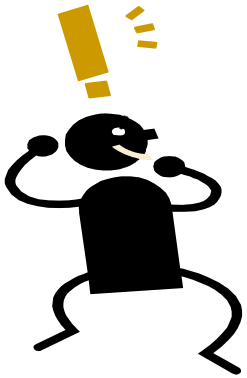
1. KR theory says: statements depend on situations, viewpoints, opinions, etc.
2. the Semantic Web envisions all RDF statements that exist as one big knowledge base

- 1) and 2) can be incompatible

Knowledge is Contextual II

„Prodi prime_minister Gov_Italy“ + **in 2006**

„human“ consistency check OK



Expression in RDF

„human“ consistency check OK

„Berlusconi prime_minister Gov_Italy“+ **in 2004**

Knowledge is Contextual III

- RDF knows only triples, not n-tuples
- The sentence
  „Prodi is Prime Minister of Italy in 2006“
  cannot be directly modelled.

→ Preliminary solution approaches exist, but are in research prototype state.

Addressing is Crucial

- Especially in Bioinformatics, RDF is seen as a future standard for information integration:
  - Integrating data from different sources
  - Integrating and clustering information around resources
  - Example: medical records of different hospitals for the same person

Your Resources are Lost

- The „global graph" vision of the Semantic Web has an identity and reference problem:
  - whoever creates an RDF graph is free to create the identifiers for the described resources
  - there is no mechanism to ensure that in your graph (s) and my graph(s) e.g. the NETTAB conference gets described using the same identifier
  - so even if we described the same objects, we would never find out about it

The OKKAM Vision

- An architecture and infrastructure in development to address the identity and reference problem
- Strategy:
  - issuing globally unique identifiers for resources
  - enabling you to find my resources, so we can finally talk about the same objects and integrate our information correctly
- More information:

www.okkam.org

Practical Part

- IsaViz demo
- PHP RDF API Quickstart

PHP API: Load & Display

```php
<?php
ob_start();
define("RDFAPI_INCLUDE_DIR", "C:/Programme/LAMP/Apache/Apache2
                              /htdocs/rap095/rdfapi-php/api/");
include(RDFAPI_INCLUDE_DIR . "RdfAPI.php");


// Filename of an RDF document
$base="ex1_simple.xml.rdf";

// Create a new MemModel
$model = ModelFactory::getDefaultModel();

// Load and parse document
$model->load($base);

// Visualize model
$model->writeAsHtmlTable();
?>
```

PHP API: SPARQL Query

```
// Load and parse document
$model->load( $base );

// create querystring
 $querystring = '
PREFIX nettab <http://www.nettab.org/tutorial-ns#>
SELECT ?x ?y
WHERE { ?x nettab:givesTalk ?y }';

// execute query and display resulting triples with HTML default renderer
echo $base->sparqlQuery( $querystring, 'HTML' );
?>
```

PHP API: SPARQL Result

?x	?y
hst	http://www.know-who.net/talks/nettab.ppt

A word on Java

- Major toolkit: JENA Toolkit
  - jena.sourceforge.net
  - Production-strength
  - tested
  - large user base
- Usage more complex
- Visualization more complex
- Includes storage plugin architecture
- Includes reasoning and query answering support
- Includes support for OWL

Not covered in this talk...

- Blank nodes
- Reification
- RDF Collections
- Named Graphs in SPARQL
- and a lot more...

Resources - General

- W3C RDF page
  http://www.w3.org/RDF/
- Dave Beckett's Resource Description Framework (RDF) Resource Guide
  http://planetrdf.com/guide/

Resources - Developer

- Developers Guide to Semantic Web Toolkits for different Programming Languages (Bizer & Westphal)
  http://www.wiwiss.fu-berlin.de/suhl/bizer/toolkits/
- Jena Semantic Web Framework:
  http://jena.sourceforge.net/
- RAP Toolkit for PHP
  http://www.wiwiss.fu-berlin.de/suhl/bizer/rdfapi

Resources – SPARQL

- http://www.w3.org/2004/Talks/17Dec-sparql/
- http://www.ibm.com/developerworks/xml/library/j-sparql/
- http://www.w3.org/TR/rdf-sparql-query/ (Working draft!)

Resources – Repositories

- Jena and RAP toolkits
- http://esw.w3.org/topic/LargeTripleStores
- Sesame: http://www.openrdf.org/
- 3store: http://threestore.sourceforge.net/

Further Reading

- RDF and Topic Maps:
  http://www.w3.org/TR/rdftm-survey/
- RDF and Context:
  http://okkam.dit.unitn.it:8088/RDFContextManager/publications
- OKKAM and ISO11179 (added by request):
  http://www.okkam.org/ -> Wiki -> OkkamRelatedWork

Thank you!