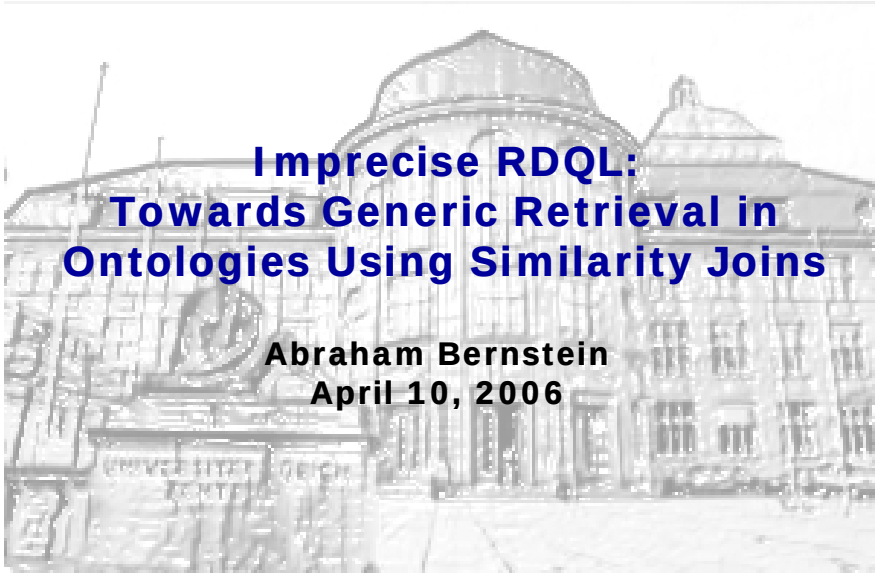
Imprecise RDQL: Towards Generic Retrieval in Ontologies Using Similarity Joins



Imprecise RDQL: Towards Generic Retrieval in Ontologies Using Similarity Joins

Abraham Bernstein
April 10, 2006

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Imprecise RDQL: Towards Generic Retrieval in Ontologies Using Similarity Joins

Agenda

- ***The Problem*:**
  Realistic Querying and the Semantic Web
- ***A Possible Solution*:**
  Similarity Joins
- ***So what is Similarity*:**
  A brief Excursion into Similarity
- ***The Evaluation*:**
  Retrieval Performance in OWL-S
- ***Limitations and Conclusions***

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Surfing the Beach

- Questions:
  - Where to rent a surf board?
  - Which beach service offers best prices?
  - Where to find the biggest waves?

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The Web is a …

- Distributed, interlinked repository of Documents
- Everybody can add and/or remove their documents and links anywhere
- Problems:
  - It is in (many different) natural languages → difficult to process by machines
  - Difficult to query
  - There is no trust, authentication, authorization built into the infrastructure

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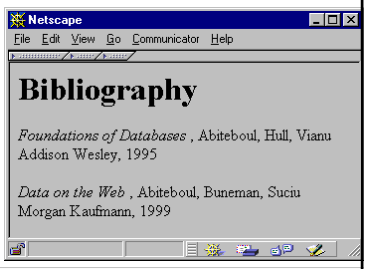
The Semantic Web is a …

- Distributed, interlinked repository of *Knowledge Bases (KBs)*
- Everybody can add and/or remove their KBs and interlink them
- Advantages:
  - It uses standardized concepts from Knowledge Representation (KR)
    → easy to process by machines
  - "Trivial" to query
  - Trust, authentication, authorization built into the infrastructure are achieved by clever use of logic
- Problems:
  - There is no guarantee of consistency between KBs

Example Web vs. Sem. Web

Web

```
<h1> Bibliography </h1>
<p> <i> Foundations of Databases </i>
      Abiteboul, Hull, Vianu
      <br> Addison Wesley, 1995
<p> <i> Data on the Web </i>
      Abiteboul, Buneman, Suciu
      <br> Morgan Kaufmann, 1999
...
```



Sem. Web

- KB 1:
  - penguin(Pingu)
  - ∀ x: penguin(x) ⇒ bird(x)
- KB2:
  - ∀ y: bird(y) ⇒ can_fly(y)
- can_fly(Pingu)?

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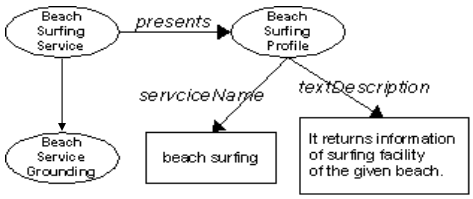
RDQL – RDF Data Query Language

- **Jena – Implementing the Semantic Web Recommendations** [Carroll *et al.* '03]




```
SELECT ?s1,?p1
WHERE (?s1 presents ?p1)
      (?p1 serviceName "beach surfing")
```

?s1	?p1
Beach Surfing Service	Beach Surfing Profile

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iRDQL – Extending RDQL With Similarity Joins

- **3 additional la**
  - **IMPRECISE,**

So how do we define similarity?

```
SELECT ?s1,?p1,
WHERE (?s1 pres
      (?p2 servi
IMPRECISE ?p1,?p2
SIMMEASURE Levenshtein
OPTIONS IGNORECASE false THRESHOLD 0.7
```

Similarity Join

?s1	?p1	?p2	sim
Beach Surfing Service	Beach Surfing Profile	Beach Surfing Profile	1.0
Beach Broker Service	Beach Broker Profile	Beach Surfing Profile	0.85
Abstract Broker Service	Abstract Broker Profile	Beach Surfing Profile	0.7

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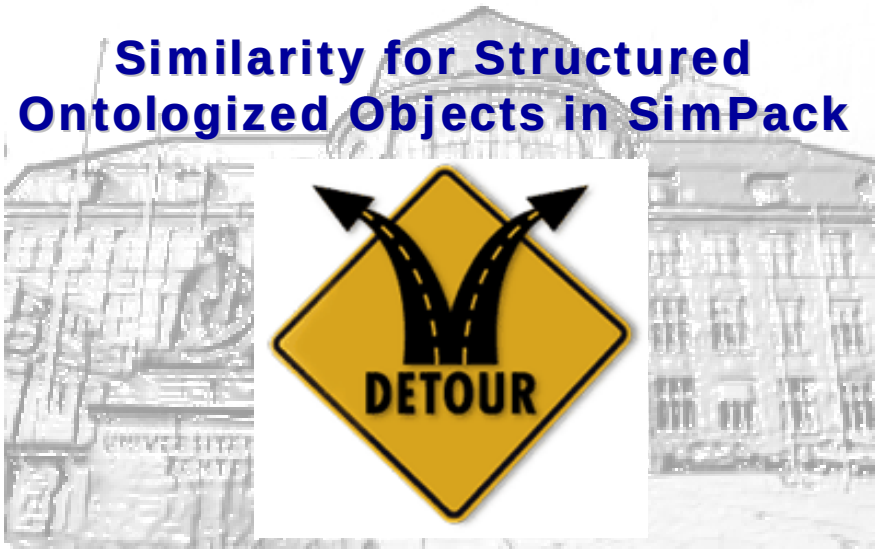
Similarity for Structured Ontologized Objects in SimPack



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SimPack—Current Status

- Generic Java library of similarity measures for the use in ontologies
- Measures from the literature, adapted for ontologies
  - Computer Science, AI, Psychology, Linguistics, ...
- 41 measures in total of all similarity measure categories
- Similarity measure categories
  - feature vectors (8)
    - properties of objects (OWL ObjectProperty, DatatypeProperty, ...)
  - strings or sequences of strings (24)
    - textual description of objects
  - trees and graphs (6)
    - tree/graph comparison
  - information theory (3)
    - amount of information contained in objects

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SimPack—Measures

- **Featur vector-based (8)**
  Cosine, Dice, Jaccard, Overlap, …

Mapping (e.g.)

$$\mathbf{R_x} = \{type, name\} \Rightarrow \mathbf{x'} = \begin{pmatrix} 0 \\ name \\ type \end{pmatrix} \Rightarrow \mathbf{x} = \begin{pmatrix} 0 \\ 1 \\ 1 \end{pmatrix}$$

$$\mathbf{R_y} = \{type, age\} \Rightarrow \mathbf{y'} = \begin{pmatrix} age \\ 0 \\ type \end{pmatrix} \Rightarrow \mathbf{y} = \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}$$

Cosine

$$sim_{cos}(\mathbf{x}, \mathbf{y}) = \frac{\mathbf{x} \cdot \mathbf{y}}{||\mathbf{x}||_2 \cdot ||\mathbf{y}||_2} = \frac{0*1+1*0+1*1}{\sqrt{0^2+1^2+1^2} * \sqrt{1^2+0^2+1^2}} = \frac{1}{2}$$

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SimPack—Measures

- **String-based (24)**
  Levensthein, …

Mapping (extract terms from service file, e.g. from surfing_beach_service.owls)

$\mathbf{x} = [BeachSurfingProfile, hasInput, Beach, label, BEACH, hasOutput, Surfing]$

$\mathbf{y} = [BeachBrokerProfile, hasInput, Beach, label, BEACH, hasOutput, Broker]$

$$sim_{lev}(Rx, Ry) = \frac{xform(\mathbf{x}, \mathbf{y})}{xform\_wc(\mathbf{x}, \mathbf{y})} = \frac{3}{9}$$

Conversion from distance to similarity

$$\frac{1}{1+\frac{3}{9}} = 0.75$$

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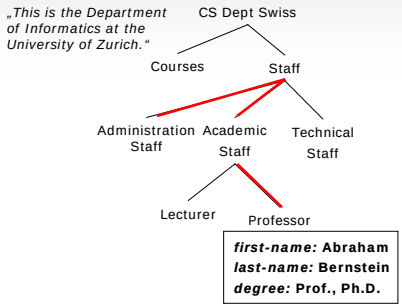
SimPack—Measures

- **Graph-/Tree-based (6)**
  Shortest Path, Tree Edit Distance, …

Shortest path between 'Administration Staff' and 'Professor'



➡ 3

Conversion from distance to similarity

➡ $-1.0 * \log\left(\frac{3}{2.0 * 4}\right)$

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SimPack—Measures

- **Information Theory (3)**
  Resnik, Lin, …

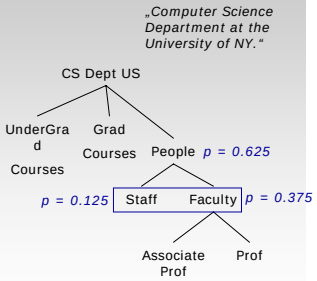
Most Recent Common Ancestor (MRCA) of 'Staff' and 'Faculty' is 'People'

$$sim_{resnik}(R_x, R_y) = -\log_2 P(MRCA(R_x, R_y))$$

➡ $\log_2\left(P(MRCA(Staff, Faculty))\right) = \log_2(0.625)$

$$sim_{lin}(R_x, R_y) = \frac{2\log_2 P(MRCA(R_x, R_y))}{\log_2 P(R_x) + \log_2 P(R_y)}$$

➡ $\frac{2\log_2 P(MRCA(Staff, Faculty))}{\log_2 P(Staff) + \log_2 P(Faculty)} = \frac{2\log_2(0.625)}{\log_2(0.125) + \log_2(0.375)}$



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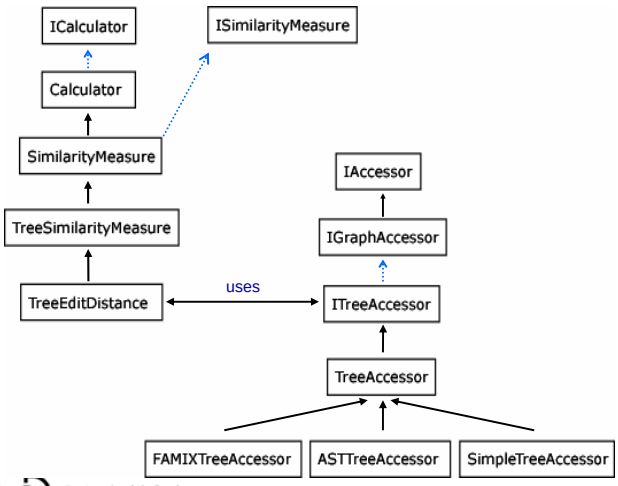
SimPack—Architecture

- **Measures and data accessor**



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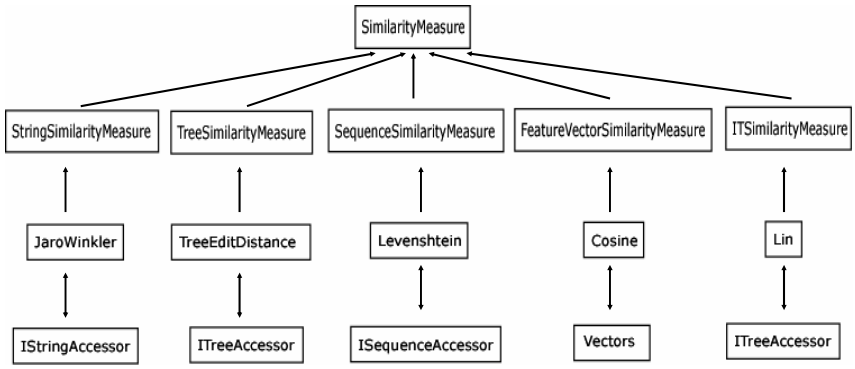
SimPack—Architecture



- **Every measure category uses its own data accessor**
- **To use SimPack, write an appropriate data accessor for your data format**

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iRDQL –Evaluation Approach

- **Quantitative** evaluation using an OWL-S service retrieval test collection **[Klusch '05]**
- OWL-S Service-based **Precision, Recall** and **F-Measure** as performance measures

Precision / Recall / F-Measure:

$$prc = \frac{retrieved\,relevant\,services}{retrieved\,services}$$

$$rec = \frac{retrieved\,relevant\,services}{relevant\,services}$$

$$f = \frac{2 \cdot prc \cdot rec}{prc + rec}$$

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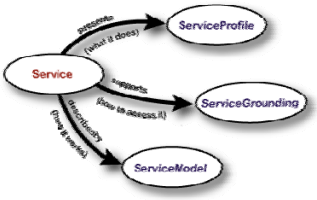
OWL-S Service Retrieval Test Collection

- 406 OWL-S services of 6 different domains
- 9 queries together with its correct answers

Query

```
<?xml version="1.0" encoding="UTF-8"?>
<service:Service rdf:ID="CITY_BROKER_SERVICE">
   <service:presents rdf:resource="#CITY_BROKER_PROFILE"/>
   <service:describedBy rdf:resource="#CITY_BROKER_PROCESS_MODEL"/>
   <service:supports rdf:resource="#CITY_BROKER_GROUNDING"/>
</service:Service>

<profile:Profile rdf:ID="CITY_BROKER_PROFILE">
   <service:isPresentedBy rdf:resource="#CITY_BROKER_SERVICE"/>
   <profile:serviceName xml:lang="en">
      hotel reservation booking service
   </profile:serviceName>
   <profile:textDescription xml:lang="en">
      Provide the best hotel reservation system in a given city.
   </profile:textDescription>
   <profile:hasInput  rdf:resource="#_CITY"/>
   <profile:hasOutput rdf:resource="#_BROKER"/>
   <profile:has_process rdf:resource="CITY_BROKER_PROCESS" />
</profile:Profile>
```



http://www.w3.org/Submission/OWL-S/

Query Relevance Set

```
city_broker_service.owls
city_broker_service2.owls
city_financial_agent_service.owls
city_financial_agent_service1.owls
urbanarea_financial_agent_service.owls
city_organization_service.owls
...
```

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Complete iRDQL Query

```
SELECT ?s, ?p, ?p1, ?m, ?m1

WHERE (?s rdf:type sv:Service)
      (?s sv:supports ?g)
      (?g rdf:type gr:WsdlGrounding)
      (?g sv:supportedBy ?s)
      (?s sv:presents ?p1)
      (?p1 rdf:type pr:Profile)
      (?p1 sv:isPresentedBy ?s)
      (?s sv:describedBy ?m1)
      (?m1 rdf:type px:ProcessModel)
      (?m1 sv:describes ?s)
      (?p rdf:type pr:Profile)
      (?p sv:isPresentedBy ?s1)
      (?s1 rdf:type sv:Service)
      (?p pr:serviceName ?sn)
      (?p pr:textDescription ?sd)
      (?p pr:hasInput ?in1)
      (?p pr:hasOutput ?out1)
      (?in1 px:parameterType ?in1PT)
      (?in1 rdfs:label ?in1L)
      (?out1 px:parameterType ?out1PT)
      (?out1 rdfs:label ?out1L)
      (?m rdf:type px:ProcessModel)
      (?m sv:describes ?s2)
      (?s2 rdf:type sv:Service)
      (?m pr:hasProcess ?x)
      (?x rdf:type px:AtomicProcess)
      (?x px:hasInput ?in2)
      (?x px:hasOutput ?out2)
      (?in2 px:parameterType ?in2PT)
      (?in2 rdfs:label ?in2L)
      (?out2 px:parameterType ?out2PT)
      (?out2 rdfs:label ?out2L)
AND ?sn =~ /beach surfing/i
AND ?sd =~ /It returns information.../i
AND ?in1 =~ /_BEACH/
AND ?out1 =~ /_SURFING/
AND ?in1 eq ?in2
AND ?out1 eq ?out2

USING sv for <Service.owl#>
      pr for <Profile.owl#>
      px for <Process.owl#>
      gr for <Grounding.owl#>

IMPRECISE ?p, ?p1
IMPRECISE ?m, ?m1

SIMMEASURE Levenshtein
OPTIONS IGNORECASE false THRESHOLD 0.7;
```

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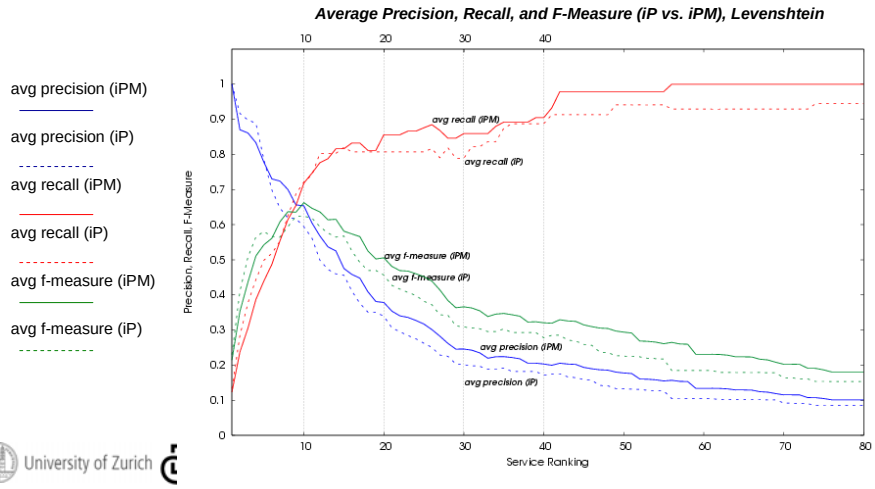
iRDQL – Performance (*iP* vs. *iPM*)

- ***iP***: **IMPRECISE ?p1, ?p2**
- ***iPM***: **IMPRECISE ?p1, ?p2 & IMPRECISE ?m1, ?m2**



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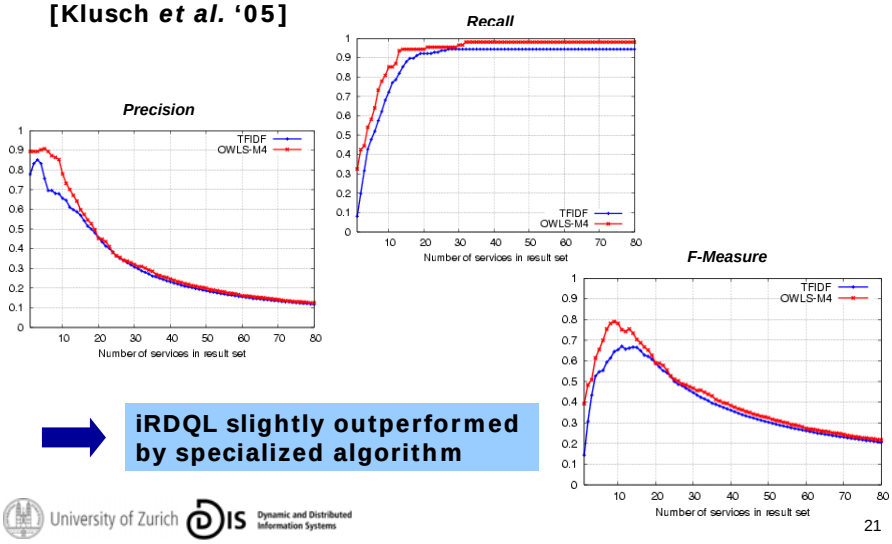
iRDQL – Performance (iRDQL vs. OWLS-M4)

- **OWLS-M4: Matchmaking algorithm of OWLS-MX [Klusch *et al.* '05]**



iRDQL slightly outperformed by specialized algorithm

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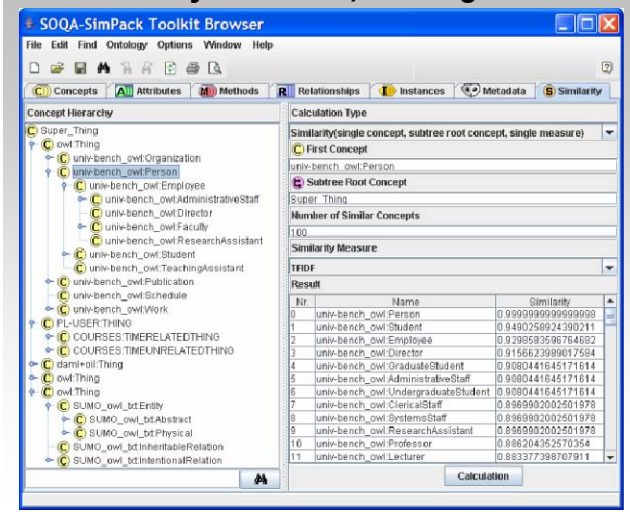
Other things to do with SimPack: SST—SOQA SimPack Toolkit

- **Similarity enabled, Protégé-like ontology browser**



1/ P. Ziegler, C. Kiefer, C. Sturm, A. Bernstein & K. Dittrich, **The SOQA-SimPack Toolkit**, 10th European Conference on Database Technology (EDBT), Munich, Germany. 2006.

2/ P. Ziegler, C. Kiefer, C. Sturm, K. Dittrich, and A. Bernstein. **Generic Similarity Detection in Ontologies with the SOQA-SimPack Toolkit (Demo Paper).** To appear in 2006 ACM SIGMOD International Conference on Management of Data (SIGMOD 2006). Chicago, USA, June 26-29, 2006.

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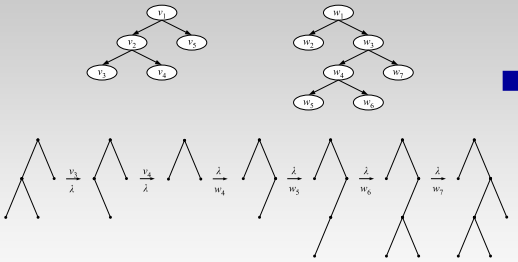
Other things to do with SimPack:
Detecting Similar Java Classes

- **Measures the tree edit distance between source code ASTs**



Edit distance is 6

(2x delete, 4x insert)

Conversion to similarity

$$\frac{(|T_1|+|T_2|)-\#ed}{|T_1|+|T_2|}=\frac{12-6}{12}=\frac{2}{3}$$

Tobias Sager, Abraham Bernstein, Martin Pinzger, Christoph Kiefer. **Detecting Similar Java Classes Using Tree Algorithms**. To appear in MSR '06: Proceedings of the 2006 International Workshop on Mining Software Repositories, China, Shanghai, May 22-23, 2006.

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Other things to do with SimPack:
Detecting Similar Java Classes

- **Visualize a software project's code evolution steps**
- **org.eclipse.compare version 3.0 vs. 3.1**
- Diagonal shows classes that have changed/kept them same between versions
- Horizontal/vertical show similarities between different classes

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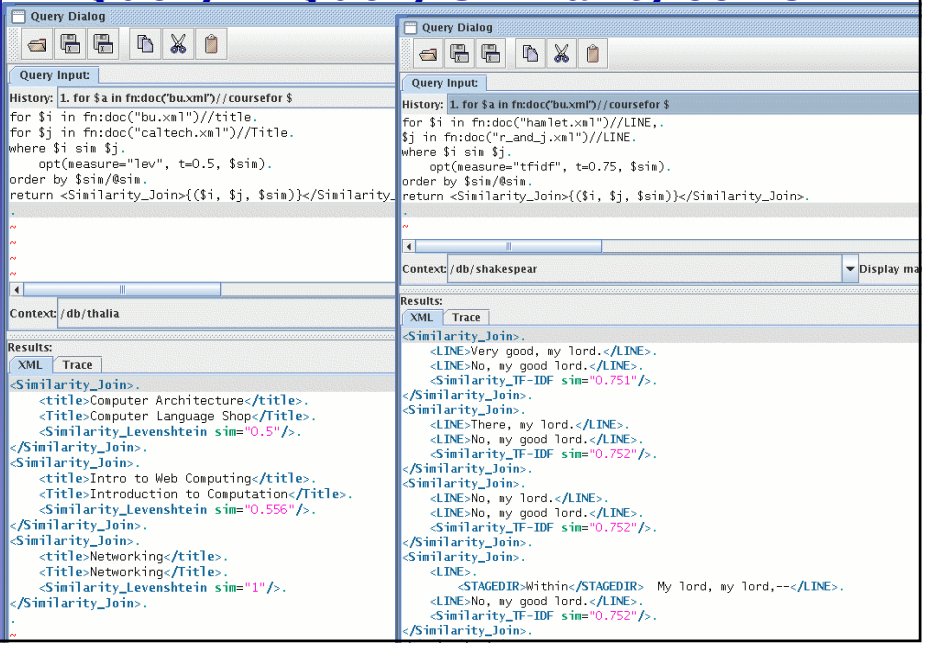
Other things to do with SimPack: iXQuery—XQuery Similarity Joins



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Conclusions and Outlook

- **Similarities are (surprisingly) useful**
- **Combination of RDQL and similarity measures**
- **Generic IR-based approach only slightly outperformed**
- **Inspired by Cohen's work [Cohen '00]**
  - **no flat tables**
  - **aggregated (ontologized) objects**
- **Performance improvements**
- **Switch to SPARQL**

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Thank you…

- **iRDQL makes it possible…**

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