Integrated Matching and Evaluation of Large Real-World Ontologies
Isabel F. Cruz

ADVIS Lab
Department of Computer Science
University of Illinois at Chicago

With thanks to: Flavio Palandri Antonelli, Cosmin Stroe, William Sunna, Sujan Bathala, Ulas Keles, and Angela Maduko

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SIGMOD Information Directors
SIGMOD Dallas (1)
Outline

• Background and Motivation
• AgreementMaker
• Efficient Selection of Mappings
• Automatic Quality-driven Combination of Matching Methods
• A Practical Example: OAEI 2009
• Conclusions and Future Work
Objective

Build a system that helps domain experts and developers in the *Ontology Matching* process (real-world ontologies and applications)
Ontology Matching

- Finding correspondences (mappings or agreements) between entities belonging to different ontologies (source and target ontologies)
- $mapping = (source \ entity, target \ entity, relation, similarity)$
- alignment or matching = set of mappings
- mapping cardinality
Ontology Matching Methods
[Shvaiko & Euzenat 2005]

• Concept based
  – String based (e.g., edit distance)
  – Language based (e.g., tokenization)
  – Constraint based (e.g., types, cardinality)
  – Linguistic (e.g., vocabularies like WordNet)

• Structure based
  – Taxonomy and graph based (e.g., relationships among nodes), internal or external
  – Model based (e.g., logic techniques)

• Instance based
Related Work

• Clio [Hérnandez, Miller, Haas 2001]
  – Notable for database-specific constraints
• COMA++ [Aumueller et al. 2005]
  – Schema and ontology matching
• Falcon-AO [Jian et al. 2005]
  – Winner of one of the most challenging tracks of the Ontology Alignment Evaluation Initiative in 2007
• RiMOM [Tang et al. 2006]
  – Powerful ontology matching
Each county (local authority) is divided into parcels and each parcel is given a code that describes its land use.

There are 72 counties and hundreds of cities and towns in the state: each may have their own land use codes.

[Wiegand et al. 2002]
## Land Use Codes

Heterogeneity of attribute names and values.

<table>
<thead>
<tr>
<th>Planning Authority</th>
<th>Attribute</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dane County</td>
<td>Lu_code</td>
<td>41</td>
<td>Railroad, Transit.</td>
</tr>
<tr>
<td>City of Madison</td>
<td>Lu_4_4</td>
<td>4112</td>
<td>Railroad switching and marshaling yards.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4113</td>
<td>Railroad terminal (passenger).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4114</td>
<td>Railroad terminal (freight).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4115</td>
<td>Railroad terminal (passenger and freight).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4116</td>
<td>Railroad equipment and maintenance.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4119</td>
<td>Other railroad transportation, NEC.</td>
</tr>
<tr>
<td>Eau Claire County</td>
<td>Lu1</td>
<td>PWR</td>
<td>Railroad.</td>
</tr>
</tbody>
</table>
Need for Data Integration

• Query: “Find all the land parcels used for rail transportation purposes in the state of Wisconsin.”

• Need to propagate the query to all the local land use databases of the various counties and municipalities

• Query has to be rewritten for each database

• Instead: use a single ontology as mediator
Mapping the adult mouse anatomy ontology (2744 classes) to the NCI thesaurus describing the human anatomy, (3304 classes)

Several types of matching techniques are needed:
- String similarity matching technique
- Domain dictionary (UMLS metathesaurus)
- Others
String Similarity Matcher
Dictionary Based Matching

Joint
- Fibrous Joint
- Synovial Joint
- Symphysis
- Synchondrosis

Synonyms:
- Synovial joint
- Articulatio synoviale
- Junctura synovialis

Joint
- Diarthrosis
- Amphiarthrosis

Synonyms:
- Fibrocartilaginous joint
- Symphysis
- Secondary cartilaginous joint
Geospatial Domain Scenario: Wetlands

Cowardin Wetland Classification System (USA)

South African National Wetland Inventory

[Cruz & Sunna 2009]
Users

<table>
<thead>
<tr>
<th>Name</th>
<th>Measure</th>
<th>Category</th>
<th>Users</th>
<th>Avg</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1.1</td>
<td>familiarity</td>
<td>land use classifications (LUC)</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Q 1.2</td>
<td>frequency</td>
<td>work with LUCs</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Q1.4</td>
<td>yes/no</td>
<td>work with one jurisdiction</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Q1.6</td>
<td>yes/no</td>
<td>work with several jurisdictions</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Q1.7</td>
<td>frequency</td>
<td>using multiple LUCs</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Q1.9</td>
<td>difficulty</td>
<td>understanding relationships</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Q10</td>
<td>yes/no</td>
<td>matching LUCs</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Q1.12</td>
<td>amount</td>
<td>time to perform matching</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Q1.13</td>
<td>amount</td>
<td>accuracy achieved in matching</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Q1.14</td>
<td>difficulty</td>
<td>derivation of facts</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

- However, users want to have control of the matching process
  - Be able to intervene
  - Be able to evaluate
Challenges

• User and application requirements
• Large ontologies (algorithmic), e.g., display of very large ontologies (30K nodes)
• Combination of matching strategies
• Software engineering and semantic engineering
• Evaluation (required by users and by peers), including third-party evaluation
Ontology Alignment Evaluation Initiative (OAEI)

- Annual international competition to evaluate ontology alignment techniques
- Multiple tracks, including:
  - Biomedical track
  - Conference track (15 ontologies)
- “Side effect” of the competition
  - Published ontology sets
    - Ontology set consists of two ontologies and correct mappings as determined by experts
OAEI Competition

• Researchers can participate with only one ontology matching technique (per track)
• Alignment technique must be fully automatic, it cannot be manual or semi-automatic
• Competition provides an API
• User interface not evaluated
• Results measured by
  – Recall, precision, and F-measure (combines recall and precision)
  – Runtime
  – Other
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AgreementMaker
Ontology Matching System

• Motivation
  – Automatic methods are required to match large ontologies
  – Several features of the ontologies have to be considered
  – Users need to trust the mappings and to be directly involved in the loop

• System’s capabilities
  – Wide range of matching methods
  – Capability to smartly combine multiple strategies
  – Multi-purpose user interface to allow evaluation and manual interaction with the matchings
  – Extensible architecture to allow reuse and composition of the matching modules
Matcher’s Abstract Structure

• Template pattern
  – Structure initialization
  – Similarity computation (quadratic number of comparisons)
  – Mapping selection (threshold and cardinality 1-1, 1-N, N-M, n-∗…)

![Diagram](image-url)
Matcher’s Architecture

- Modularization
- Series & parallel composition
Implemented Matchers

- First layer (conceptual)
  - BSM Base Similarity Matcher
  - PSM Parametric String-based Matcher
  - VMM Vector-based Multi-term Matcher
- Second layer (Structural)
  - DSI Descendant’s Similarity Inheritance
  - SSC Sibling’s Similarity Contribution
- Third Layer
  - LWC Linear Weighted Combination
First Layer: Parametric String Matching (PSM)

User

Source Ontology Concept

normalization options

localname

label

comments

isDefinedBy

seeAlso

normalizer

string metric

Target Ontology Concept

normalization options

localname

label

comments

isDefinedBy

seeAlso

normalizer

string comparison

similarity values

User

weights

$$\frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i}$$

weighted average

final similarity
First Layer: Vector-based Multi-term Matcher (VMM)

- Concepts as documents in the vector space model
- Documents as Term Frequency - Inverse Document Frequency vectors
- Cosine Similarity between vectors
Structure-Based Methods: Motivation
Structure Based Methods

- Descendant’s Similarity Inheritance (DSI)
- Sibling’s Similarity Contribution (SSC)
- Both DSI and SSC utilize the results generated by the Base Similarity Method (concept based)
Descendant's Similarity Inheritance (DSI) Method

- Modifies the base similarity between two concepts by considering their ancestors
- Function $DSI\_sim(C, C')$ computed as follows

\[
MCP \cdot base\_sim(C, C') + \frac{2(1 - MCP)}{n(n+1)} \sum_{i=1}^{n} (n+1-i)base\_sim(parent_i(C), parent_i(C'))
\]

where

- $MCP$ is the main contribution percentage (a value of 0.75 was found to work well).
- $parent_i(C)$, $i \geq 0$, is the ancestor $A$ of $C$ such that there is a path of length $i$ (number of edges) between $C$ and $A$. 
DSI Method Example

Source ontology $S$  

Target ontology $T$

\[
DSI\_SIM(C, C') = 0.75 \times BASE\_SIM(C, C') + 0.17 \times BASE\_SIM(B, B') + 0.08 \times BASE\_SIM(A, A')
\]
Sibling’s Similarity Contribution (SSC) Method

- Modifies the base similarity between two concepts by considering the similarity between their siblings
- Function $SSC\_sim(C,C')$ computed as follows

$$MCP \cdot base\_sim(C,C') + \frac{1-MCP}{n} \sum_{i=1}^{n} \max(base\_sim(S_i,S'_1),...,base\_sim(S_i,S'_m))$$

where:
- $MCP$ is the main contribution percentage (a value of 0.75 was found to work well).
- $N$ is the number of siblings of concept $C$
- $M$ is the number of siblings of concept $C'$
SSC Method Example

Source ontology $S$

Target ontology $T$

$SIM(C, C') = 0.75 \times BASE\_SIM(C, C') +$
$\quad + 0.25/2 \times (\text{MAX}(BASE\_SIM(D, D'), BASE\_SIM(D, E'), BASE\_SIM(D, F'))) +$
$\quad + \text{MAX}(BASE\_SIM(E, D'), BASE\_SIM(E, E'), BASE\_SIM(E, F')))
## Ontology Sets

<table>
<thead>
<tr>
<th>Ontology set</th>
<th>Depth</th>
<th>Number of concepts in the source ontology</th>
<th>Number of concepts in the target ontology</th>
<th>Syntax</th>
<th>Relations between concepts and their parents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetlands</td>
<td>5</td>
<td>29</td>
<td>29</td>
<td>XML</td>
<td>PART-OF</td>
</tr>
<tr>
<td>Weapons</td>
<td>6</td>
<td>153</td>
<td>213</td>
<td>N3</td>
<td>IS-A</td>
</tr>
<tr>
<td>People and pets</td>
<td>4</td>
<td>65</td>
<td>93</td>
<td>N3</td>
<td>IS-A</td>
</tr>
<tr>
<td>Computer Networks</td>
<td>5</td>
<td>90</td>
<td>89</td>
<td>N3</td>
<td>IS-A</td>
</tr>
<tr>
<td>Russia</td>
<td>5</td>
<td>86</td>
<td>87</td>
<td>N3</td>
<td>IS-A</td>
</tr>
</tbody>
</table>
Experimental Results
Wetlands

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Precision</th>
<th>Recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base similarity</td>
<td>61.54%</td>
<td>44.44%</td>
</tr>
<tr>
<td>DSI</td>
<td>94.87%</td>
<td>68.52%</td>
</tr>
<tr>
<td>SSC</td>
<td>74.36%</td>
<td>54.70%</td>
</tr>
<tr>
<td>Similarity flooding</td>
<td>92.31%</td>
<td>55.57%</td>
</tr>
</tbody>
</table>

Similarity Flooding: [Melnik, Garcia-Molina, Rahm, 2002]
Experimental Results

• Precision and recall
  – DSI or SSC do at least as well as Base Similarity and Similarity Flooding
  – DSI was most often the winner

• Run time
  – DSI is usually best (Similarity Flooding is first in one case)
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Mappings Selection Module

- **Input:**
  - similarity matrix $SM$
  - threshold value $th \in [0,1]$ (e.g., 0.7)
  - source and target cardinality constraints $sc$-$tc$ (e.g., 1-1, $n$-$m$, $n$-$*$, $*$-$*$)

- **Output:** set of mappings $M$ that
  - maximizes overall similarity of the selected mappings
  - satisfies threshold and cardinality constraints
1-1 Matching Optimization Problem

Even a simple scenario can be tricky!

Greedy approach

Optimal approach

- This is an optimization problem!
  - Namely, the Assignment Problem
- Combinatorial methods have been typically adopted
  - e.g., the Hungarian Method $O(|SM|^3)$ (too slow)
  - not feasible on large ontologies because of memory usage
Our Approach

- Reduce the 1-1 Mappings Selection problem to the Maximum Matching in a Weighted Bipartite Graph

<table>
<thead>
<tr>
<th>Similarity Matrix $SM$</th>
<th>Threshold value $th$</th>
<th>Compute the Weighted Bipartite Graph $G = (S \cup T, E)$</th>
<th>Cut edges with weights lower than the threshold</th>
<th>Run the Shortest Augmenting Path Algorithm (SAP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Concepts $S$</td>
<td>Target Concepts $T$</td>
<td>$w_{ij} = SM[i,j]$</td>
<td>$w_{ij} \geq th$</td>
<td></td>
</tr>
<tr>
<td>$S$</td>
<td>$T$</td>
<td>$a$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>a'</td>
<td>$0.6$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>b'</td>
<td>$0.8$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>c'</td>
<td>$1.0$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>d'</td>
<td>$0.1$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$th = 0.6$

- Worst case $O(n (m + n \log n))$
- Experimentally shown to be better
Maximum Matching vs Hungarian Method

- Significant improvement in execution time
- Efficient memory usage (with 1GB limit of memory the Hungarian won’t work on 3500x3500 matrices)
Maximum Matching vs Hungarian Method

- Performance improves when the threshold value increases
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Quality Evaluation

- Comparison with a gold standard $G$ (if available)
  - Precision $P = \# \text{ correct mappings} / \# \text{ found mappings}$
  - Recall $R = \# \text{ correct mappings} / |G|$
  - F-measure $= \frac{2(P \times R)}{(P + R)}$

- If gold standard $G$ not available we consider quality measures
  - Similarity level
    - Local confidence
  - Alignment level
    - Distance Preservation
    - Order Preservation
Quality Measures of a Matching Method

<table>
<thead>
<tr>
<th></th>
<th>Similarity Level</th>
<th>Selection Level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Local</strong></td>
<td>Quality of each row (or column) of the similarity table</td>
<td>Quality of a mapping</td>
</tr>
<tr>
<td><strong>Global</strong></td>
<td>Quality of the entire similarity table</td>
<td>Quality of the whole set of mappings</td>
</tr>
</tbody>
</table>

[Cruz, Palandri Antonelli, Stroe, 2009]  
[Joslyn et al. 2008]
Global/Selection Level

- Distance Preservation
  - $F$ should not distort the “distance” between concepts
- Order Preservation
  - $F$ should not distort the order of concepts
Local/Similarity Level

• We consider the combination of several methods applied separately
  – Can we do better with a combination of the different methods than with the best of methods?
  – Maybe we can if:
    • We identify unreliable similarity values
    • Give weights associated with perceived confidence
Unreliable Similarity Values
Perceived Confidence

1. The matching method compares features that are not available in the ontologies (e.g., label comparison of non-labeled ontologies) \( \Rightarrow \) all 0 similarity values

2. The matching method compares meaningless features (e.g., string comparison of numeric identifiers) \( \Rightarrow \) random similarity values

3. The matching method compares features that are identical for all concepts (e.g., structural comparison of non-hierarchical ontologies) \( \Rightarrow \) all 1 similarity values

4. Perceived confidence

A pretty confident mapping!
Local Confidence Evaluation

- A local estimation of the reliability of the similarity values
- For each source concept $c$, given the similarity matrix $M$, the set of target concepts $T$, and the target concepts mapped to $c$ $m_M(c)$, then:

$$LC_M(c) = \frac{\sum_{c' \in m_M(c)} sim_M(c, c')}{|m_M(c)|} - \frac{\sum_{c' \in (T - m_M(c))} sim_M(c, c')}{|T - m_M(c)|}$$

<table>
<thead>
<tr>
<th>Selected $S$</th>
<th>NS Not Selected $NS$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0.1 0.2 0.9</td>
</tr>
<tr>
<td>3</td>
<td>0.5 0.4 0.7 0.8</td>
</tr>
<tr>
<td>4</td>
<td>1 1 1 1</td>
</tr>
</tbody>
</table>

$avg(S) - avg(NS) = confidence$

- $0 - 0 = 0$  
- $1 - 0 = 1$  
- $0.9 - 0.1 = 0.8$  
- $0.8 - 0.53 = 0.27$  
- $1 - 1 = 0$
Linear Weighted Combination (LWC)

Similarity Matrices

Weights
- manual
- quality-based

\[ \sum_{i=1}^{n} \frac{w_i x_i}{\sum_{i=1}^{n} w_i} \] weighted average

Max
Min
Average
Weighted avg
Comparison of BSM + DSI, PSM, and VMM

- Real-world ontologies sets provided by I³CON 2004 and OAEI 2008 initiatives
- PSM is the most effective
- VMM finds complex correspondences, but is less effective
Comparison of Combination Strategies

![Bar chart showing F-measure comparison for different strategies across various datasets.](chart.png)

- **best input matcher**
- **LWC-avg**
- **LWC-max**
- **LWC-min**
- **LWC-weight avg**

<table>
<thead>
<tr>
<th></th>
<th>wep</th>
<th>pp</th>
<th>net</th>
<th>rus</th>
<th>101-301</th>
<th>101-302</th>
<th>101-303</th>
<th>101-304</th>
<th>avg</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>best input matcher</strong></td>
<td>98.6%</td>
<td>94.2%</td>
<td>88.9%</td>
<td>79.7%</td>
<td>83.2%</td>
<td>69.2%</td>
<td>83.0%</td>
<td>88.3%</td>
<td>80.6%</td>
</tr>
<tr>
<td><strong>LWC-avg</strong></td>
<td>98.6%</td>
<td>93.2%</td>
<td>75.0%</td>
<td>80.9%</td>
<td>70.8%</td>
<td>69.2%</td>
<td>82.5%</td>
<td>88.5%</td>
<td>82.3%</td>
</tr>
<tr>
<td><strong>LWC-max</strong></td>
<td>98.6%</td>
<td>94.2%</td>
<td>92.9%</td>
<td>58.9%</td>
<td>84.2%</td>
<td>64.3%</td>
<td>65.5%</td>
<td>90.1%</td>
<td>81.1%</td>
</tr>
<tr>
<td><strong>LWC-min</strong></td>
<td>98.6%</td>
<td>93.2%</td>
<td>63.6%</td>
<td>79.7%</td>
<td>35.1%</td>
<td>46.2%</td>
<td>56.8%</td>
<td>81.8%</td>
<td>69.4%</td>
</tr>
<tr>
<td><strong>LWC-weight avg</strong></td>
<td>98.6%</td>
<td>93.3%</td>
<td>90.9%</td>
<td>82.9%</td>
<td>85.7%</td>
<td>69.9%</td>
<td>73.9%</td>
<td>89.2%</td>
<td>86.2%</td>
</tr>
</tbody>
</table>
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A Practical Example: OAEI 2009

- **BSM**: Base Similarity Matcher
- **PSM**: Parametric String-based Matcher (substring + edit-dist)
- **VMM**: Vector-based Multi-term Matcher (TF-IDF + Cosine sim)
- **LWC**: Linear Weighted Combination (local-confidence weighting scheme)
- **DSI**: Descendant’s Similarity Inheritance (structural)
- **WordNet/UMLS**: Dictionaries (lexical)
Anatomy Track Results

- Mapping the adult mouse anatomy ontology (2744 classes) to the NCI thesaurus of the human anatomy (3304 classes)
- AgreementMaker ranked second among ten systems

<table>
<thead>
<tr>
<th>Track</th>
<th>Goal</th>
<th>Rank</th>
<th>Additional Achievements</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>Maximize F-measure</td>
<td>second</td>
<td>First in Recall and Recall+</td>
</tr>
<tr>
<td>#2</td>
<td>Maximize Precision</td>
<td>second</td>
<td>0.05 distance from first, first in F-measure</td>
</tr>
<tr>
<td>#3</td>
<td>Maximize Recall</td>
<td>first</td>
<td>First in Recall+</td>
</tr>
<tr>
<td>#4</td>
<td>Use a Partial Reference</td>
<td>fifth</td>
<td>First in Precision, improved execution time</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System</th>
<th>Runtime</th>
<th>Task #1 Prec.</th>
<th>Task #1 Rec.</th>
<th>Task #1 F</th>
<th>Task #2 Prec.</th>
<th>Task #2 Rec.</th>
<th>Task #2 F</th>
<th>Task #3 Prec.</th>
<th>Task #3 Rec.</th>
<th>Task #3 F</th>
<th>Recall+ #1</th>
<th>Recall+ #3</th>
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</thead>
<tbody>
<tr>
<td>SOBOM</td>
<td>≈ 19 min</td>
<td>0.952</td>
<td>0.777</td>
<td>0.855</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.431</td>
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<tr>
<td>AgrMaker</td>
<td>≈ 23 min</td>
<td>0.865</td>
<td>0.798</td>
<td>0.831</td>
<td>0.967</td>
<td>0.682</td>
<td>0.800</td>
<td>0.511</td>
<td>0.815</td>
<td>0.628</td>
<td>0.489</td>
<td>0.553</td>
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<tr>
<td>RiMOM</td>
<td>≈ 10 min</td>
<td>0.940</td>
<td>0.684</td>
<td>0.792</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.183</td>
<td>-</td>
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<tr>
<td>TaxoMap</td>
<td>≈ 12 min</td>
<td>0.870</td>
<td>0.678</td>
<td>0.762</td>
<td>0.953</td>
<td>0.609</td>
<td>0.743</td>
<td>0.458</td>
<td>0.716</td>
<td>0.559</td>
<td>0.222</td>
<td>0.319</td>
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<tr>
<td>DSSim</td>
<td>≈ 12 min</td>
<td>0.853</td>
<td>0.676</td>
<td>0.754</td>
<td>0.973</td>
<td>0.620</td>
<td>0.757</td>
<td>0.041</td>
<td>0.135</td>
<td>0.063</td>
<td>0.185</td>
<td>0.061</td>
</tr>
<tr>
<td>ASMOV</td>
<td>≈ 5 min</td>
<td>0.746</td>
<td>0.755</td>
<td>0.751</td>
<td>0.821</td>
<td>0.736</td>
<td>0.776</td>
<td>0.725</td>
<td>0.767</td>
<td>0.745</td>
<td>0.419</td>
<td>0.474</td>
</tr>
<tr>
<td>flood</td>
<td>≈ 15 sec / 4 min</td>
<td>0.873</td>
<td>0.653</td>
<td>0.747</td>
<td>0.892</td>
<td>0.712</td>
<td>0.792</td>
<td>0.827</td>
<td>0.763</td>
<td>0.794</td>
<td>0.197</td>
<td>0.484</td>
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<tr>
<td>Lily</td>
<td>≈ 99 min</td>
<td>0.738</td>
<td>0.739</td>
<td>0.739</td>
<td>0.869</td>
<td>0.559</td>
<td>0.681</td>
<td>0.534</td>
<td>0.774</td>
<td>0.632</td>
<td>0.477</td>
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<tr>
<td>Aroma</td>
<td>≈ 1 min</td>
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<td>0.723</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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<td>-</td>
<td>0.368</td>
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<tr>
<td>kosimap</td>
<td>≈ 5 min</td>
<td>0.866</td>
<td>0.619</td>
<td>0.722</td>
<td>0.907</td>
<td>0.446</td>
<td>0.598</td>
<td>0.866</td>
<td>0.619</td>
<td>0.722</td>
<td>0.154</td>
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</table>
Conference Track Results

- Mapping 15 ontologies dealing with conference organization
- AgreementMaker ranked **first** among seven systems for a threshold of 75% and **second** for any threshold

<table>
<thead>
<tr>
<th>matcher</th>
<th>threshold</th>
<th>P</th>
<th>R</th>
<th>F-meas</th>
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</thead>
<tbody>
<tr>
<td>aflod</td>
<td>*</td>
<td>48%</td>
<td>61%</td>
<td>52%</td>
</tr>
<tr>
<td>AgrMaker</td>
<td>0.75</td>
<td>69%</td>
<td>51%</td>
<td>57%</td>
</tr>
<tr>
<td>AMExt</td>
<td>0.75</td>
<td>54%</td>
<td>50%</td>
<td>51%</td>
</tr>
<tr>
<td>aroma</td>
<td>0.53</td>
<td>39%</td>
<td>48%</td>
<td>42%</td>
</tr>
<tr>
<td>ASMOV</td>
<td>0.23</td>
<td>68%</td>
<td>38%</td>
<td>47%</td>
</tr>
<tr>
<td>DSSim</td>
<td>*</td>
<td>15%</td>
<td>51%</td>
<td>22%</td>
</tr>
<tr>
<td>kosimap</td>
<td>0.51</td>
<td>52%</td>
<td>42%</td>
<td>45%</td>
</tr>
</tbody>
</table>
Conclusions

• Ontology matching engineering
• User requirements
  – The system is being used by geospatial domain experts at the University of Wisconsin-Madison
• Effective matching strategies
  – As shown in the OAEI 2009 competition (and other experimental results)
  – New methods can be easily incorporated, tested and improved upon
• Evaluation strategies
  – The system is being used by the Knowledge Systems Group of Pacific Northwest National Laboratory (PNNL) for evaluation of ontology matching methods
Future Work

• Semi-automatic methods, using a feedback loop
  – Question is: given a certain number of iterations, what help do we want to receive from the user?
• Explanation of matchings and semantic composition
• Efficient recomputation of matchings when ontologies evolve
Publications available at:
http://www.cs.uic.edu/bin/view/Cruz/
Publications
with tag AgreementMaker [AM]
THANK YOU

Isabel F. Cruz

ADVIS Lab
Department of Computer Science
University of Illinois at Chicago

With thanks to: Flavio Palandri Antonelli, Cosmin Stroe, William Sunna, Sujan Bathala, Ulas Keles, and Angela Maduko

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Buenos Aires, Argentina, May 17-20, 2010