4th International Semantic Service Selection Contest

– Performance Evaluation of Semantic Service Matchmakers –

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S3 Contest 2010: Entries

Track 1 OWL-S Service Matchmakers

1. iSeM 1.0 (DFKI, Germany)
2. OWLS-MX3 (DFKI, Germany)
3. SeMa^2 (TU Berlin, Germany)
4. OWLS-iMatcher (U Zurich, Switzerland)
5. SPARQLent (HP, Italy)
6. OWLS-SLR (lite) (Aristotle U of Thessaloniki, Greece)
7. XSSD (Beihang U, China)
8. EMMA (U Seville, Spain)

Source: Klusch

S3 Contest 2010: Entries

Track 2 SAWSDL Service Matchmakers

1. LOG4SWS.KOM (TU Darmstadt, Germany)
2. COV4SWS.KOM (TU Darmstadt, Germany)
3. iSeM 1.0 (DFKI, Germany)
4. SAWSDL-MX1 (DFKI, Germany)
5. URBE (Politecnico di Milano, Italy)
6. SAWSDL-iMatcher (U Zurich, Switzerland)

S3 Contest 2010: Evaluation Framework

- **Service retrieval test collections**
  - Track1: **OWLS-TC 4.0**
    - 1083 services, 42 requests w/ binary & graded relevance sets, 38 ontologies
    - Groundings in WSDL 1.1
    - 160 services and 18 requests w/ preconditions + effects *each* in SWRL *and* PDDL 2
    - @semwebcentral: 11026 downloads (Top 10, Nov 17 2010)
  - Track2: **SAWSDL-TC 3.0**
    - 1080 services, 42 requests w/ binary & graded relevance sets, 38 ontologies
    - @semwebcentral: 387 downloads (Nov 17 2010)
  - Development: DFKI (initial), U Jena, TU Darmstadt, Beihang U, U Thessaloniki, a.o.
- **Evaluation tool: SME² v2.1.1**
  - Publicly available @semwebcentral.org since 2008, Developed @ DFKI
  - Standard retrieval performance measures: Macro-averaged recall/precision, Average precision, Q, nDCG (averaged cumulative gain); Average query response time (Elapsed time per query execution)

Source: Klusch

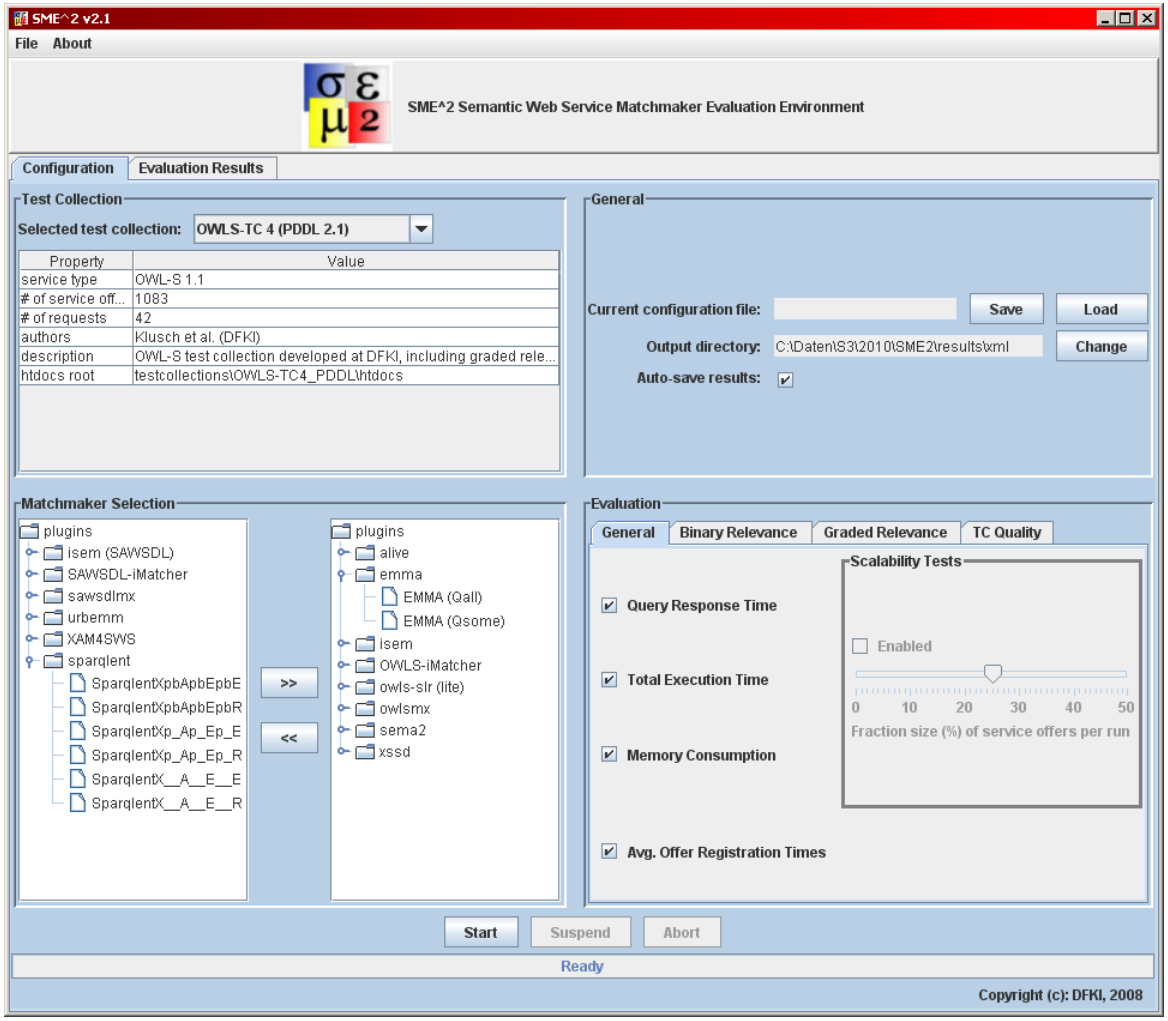
Evaluation Tool SME² v2.1.1

Performance measures

- Macro-averaged recall/precision
- Average precision
- Q, nDCG [Graded relevance]
- Average query response time
- http-request analysis
- Precision@k, R-Precision (v2.2)

Easy-to-Use

- Load test collections +
  Select matchmaker plugin(s) +
  Configure evaluation
- Tailor your personal (printable) evaluation result reports



Source: Klusch

Evaluation Tool SME² v2.1.1

Development

- Plug-in architecture
- Implemented in Java
- XML-based matchmaker plugin & TC configuration
- Embedded Jetty web server

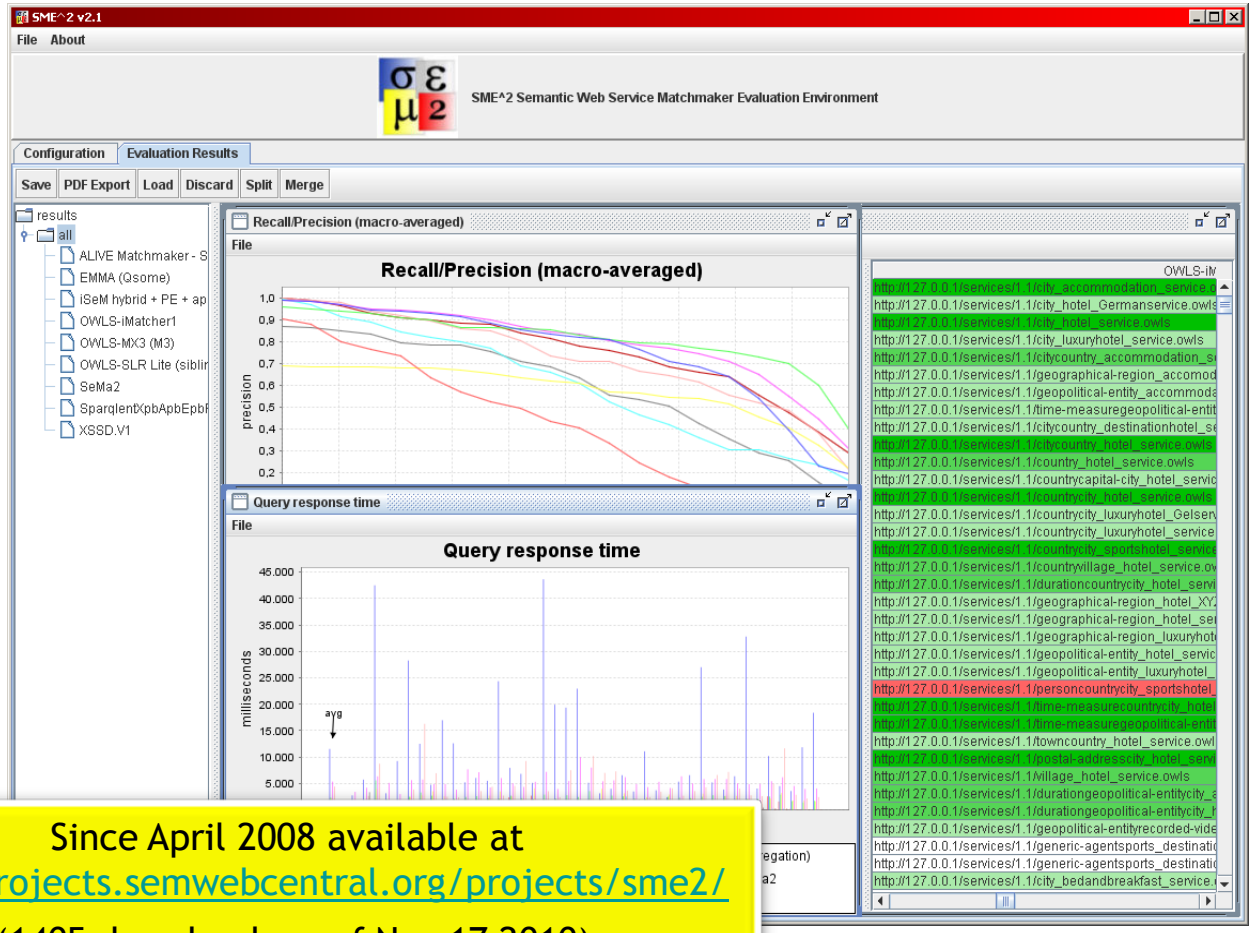
Developed @ DFKI:

Minko Dudev

Patrick Kapahnke

Josef Misutka

Martin Vasileski



Since April 2008 available at
http://projects.semwebcentral.org/projects/sme2/
(1405 downloads as of Nov 17 2010)

Release of new version 2.2 in December 2010

Track 1: OWL-S Matchmakers in Brief

- **SeMa²**
  - Selection: *Hybrid; Signature (I/O), Specification (P/E)*
    - Logic-based match: Logical I/O concept subsumption relation as numeric score
    - Non-logic-based match: String matching of I/O concept names (via string.equal(), string.contains(), AND-integrated with logic-based)
    - Ranking: Linear weighted aggregation of logical *and* string matching scores
  - Dev: Nils Masuch (TU Berlin, Germany)
- **OWLS-SLR lite**
  - Selection: *Hybrid; Signature (I/O), Non-functional parameters*
    - Logic-based match: Logical I/O concept subsumption relations as basis for …
    - Non-logic-based match: … Ontology-based structural match (edge distance, upward co-topic distance)
    - Ranking: Structural similarity
  - Dev: Georgios Meditskos, Nick Bassiliades (U Thessaloniki, Greece)

Track 1: OWL-S Matchmakers in Brief

- **OWLS-MX3**
  - Selection: *Hybrid, adaptive; Signature (I/O)*
    - Logic-based match Logical I/O concept subsumption
    - Non-logic-based match: Text similarity of unfolded service signatures, Ontology-based structural match – Separated filters
    - Adaptive (offline): SVM relevance classifier [TS = 10% OWLS-TC3] for aggregation of (non-)logic-based matching degrees with subsequent ranking
  - Dev: Matthias Klusch, Patrick Kapahnke (DFKI, Germany)
- **OWLS-iMatcher**
  - Selection: *Syntactic; Signature (I/O)*
    - Non-logic-based: Vector-based text similarities of unfolded service signatures
    - Ranking: Text similarity
  - Dev: Christoph Kiefer, Avi Bernstein (U Zurich, Switzerland)

Source: Klusch

Track 1: OWL-S Matchmakers in Brief

- **SPARQLent**
  - Selection: *Logic-Based*; *Signature (I/O)*, *Specification (P/E)*
    - Logic-based match: P/E described in SPARQL, I/O concepts represented as additional constraints; I/O concept match via RDF entailment rules for RDF-encoded OWL
    - Ranking: ?
  - Dev: Marco Luca Sbodio (Hewlett-Packard EIC, Italy)

Source: Klusch

Track 1: OWL-S Matchmakers in Brief

- **XSSD**
  - Selection: *Hybrid; Signature (I/O), Service description tag*
    - Logic-based match: Logical I/O concept subsumption
    - Non-logic-based match: Text similarity match of service description tags
    - Ranking: Logic-based degree followed by text similarity-based ranking
  - Dev: Jing Li, Dongjie Chu (U Beihang, China)

- **EMMA**
  - Selection: *Logic-based semantic pre-filtering; Signature (I/O)*
    - Logic-based pre-filtering: SPARQL query in Jena RDF store using inference rules
    - Hybrid match: Based on pre-filtering using OWLS-MX3 (or other OWL-S MM plugins)
    - Ranking: Ranking procedure of internal OWLS-MX3 plugin
  - Dev: José María García, David Ruiz, Antonio Ruiz-Cortés (U Seville, Spain)

Track 1: OWL-S Matchmakers in Brief

- **iSeM 1.0**
  - Selection: *Hybrid; Signature (I/O), Specification (P/E), Service description tag*
    - Logic-based match Logical I/O concept subsumption and information-theoretic valuation of approximated concept subsumption
    - Non-logic-based match: Text similarity of unfolded service signatures and service description tag, Ontology-based structural match – Separated filters
    - Adaptive (offline): SVM relevance classifier with coherence-based weighting scheme [TS = 5% OWLS-TC4] for aggregation of matching degrees with subsequent ranking
  - Dev: Patrick Kapahnke, Matthias Klusch (DFKI, Germany)

Source: Klusch

Performance Evaluation: AP (Binary)

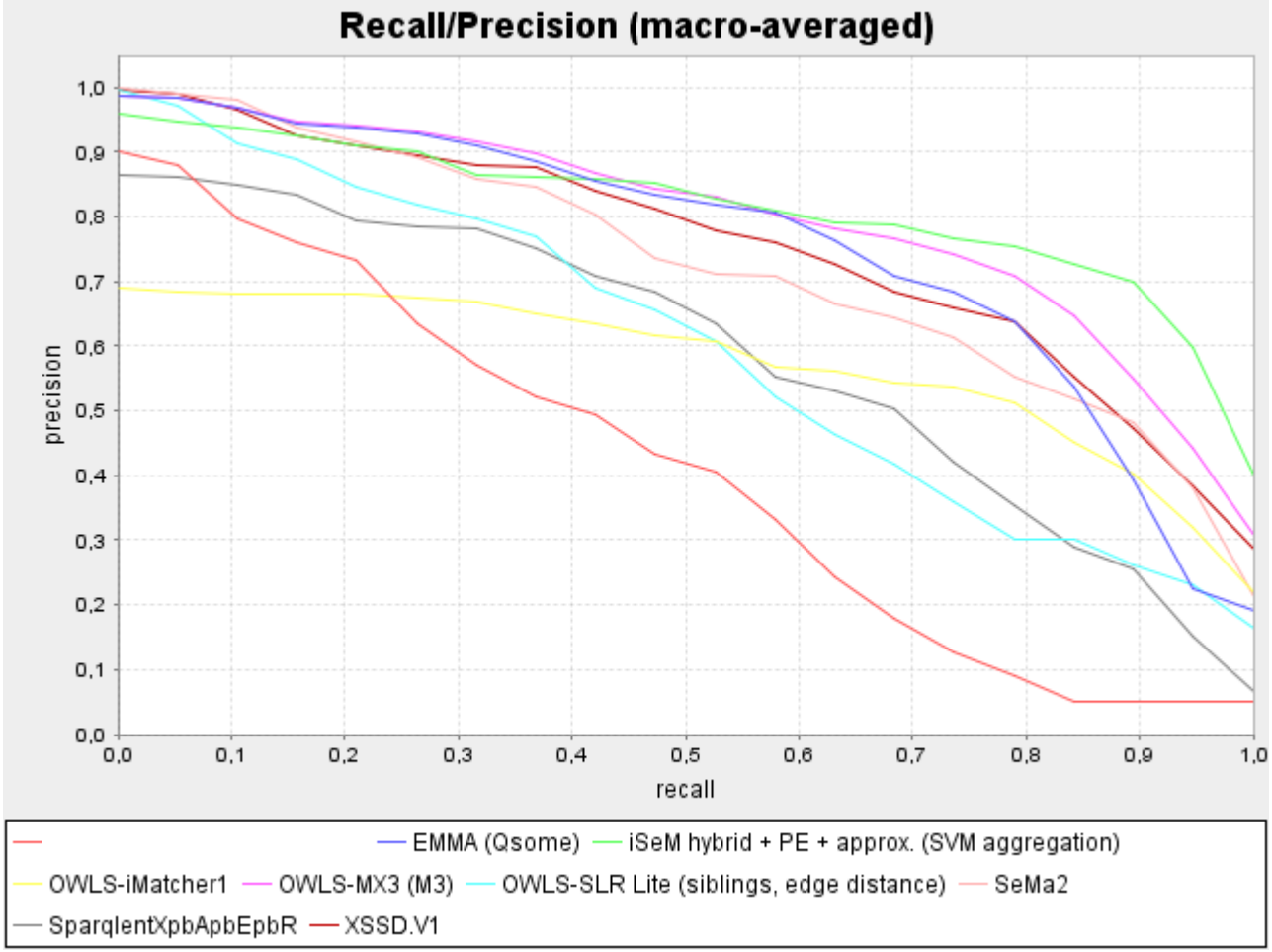
Average Precision for Binary Relevance:

1.	**iSeM 1.0**	**.922**
2.	OWLS-MX3	.831
3.	EMMA	.803
4.	XSSD	.795
5.	SeMa^2	.741
6.	OWLS-iMatcher	.672
7.	SPARQLent	.612
8.	OWLS-SLR (lite)	.609

Please note: **For entries providing more than one variant, the variant with best AP was chosen.**
Detailed results *for all variants* can be found in the Appendix.

Performance Evaluation: MARP (Binary)

Macro-Averaged Recall/Precision for Binary Relevance:



Source: Klusch

Lesson Learned: Specification Matching

SeMa²

- Structural comparison of SWRL rules + query containment (Abox)

SPARQLent

- SPARQL ASK [where] query containment (Abox)

iSeM 1.0

- Approximated logical implication checking using □-Subsumption between P/E in PDDL transformed to Prolog

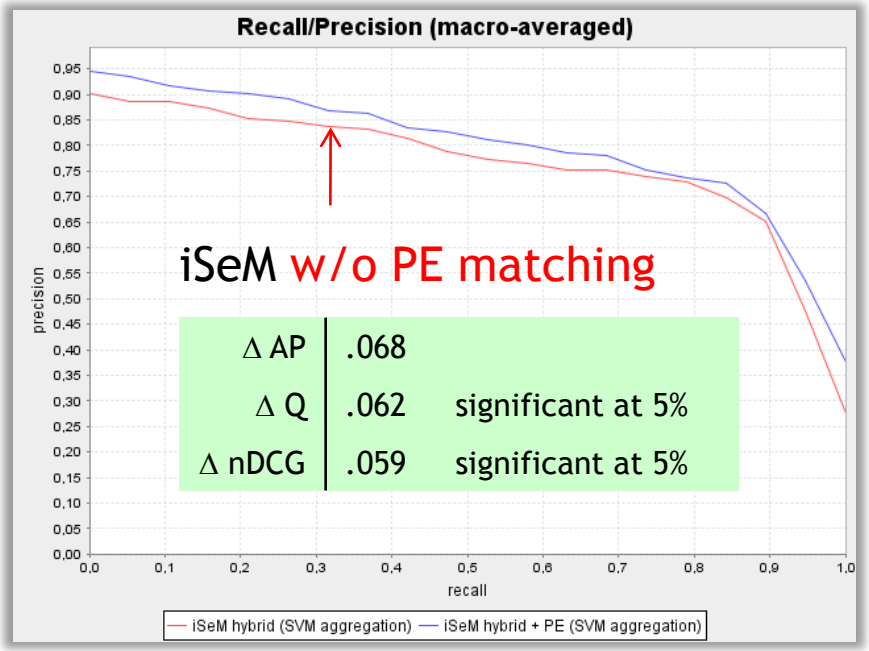
Problems

- No ABox in OWLS-TC4
- Technical differences of SWRL syntax in OWL-S spec vs SWRL spec
- No P/E described as SPARQL ASK [where] constraints

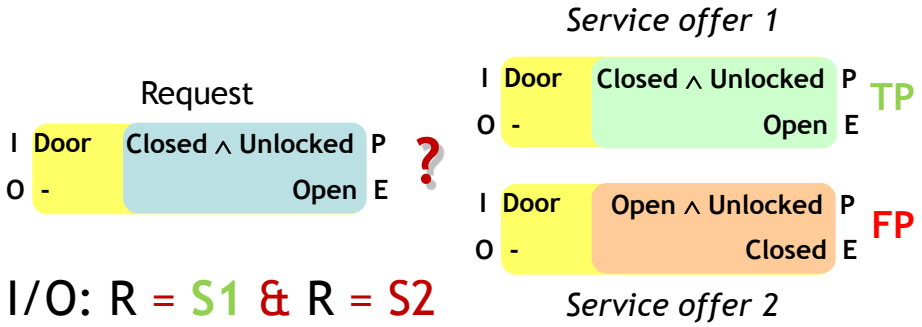
= *iSeM only IOPE matchmaker used in S3 2010.*

Source: Klusch

Lesson Learned: Specification Matching



I/O matching pitfall example:



I/O: R = S1 & R = S2

Rank:	1	2	3	4	
iSeM 1.0	TP	TP	FP	-	IOPE
OWLS-SLR	TP	FP	TP	FP	IO
SeMa2	TP	FP	FP	TP	IO(PE)
XSSD	TP	FP	TP	FP	IO

Problems

- Only 15% of OWLS-TC4 services have P/E: Low increase of precision w/ PE match
- „Solution“ of I/O pitfalls by „luck of random choice“ (S1 or S2) w/o PE matching
- Need: More services with complex P/E

Source: Klusch

Performance Evaluation: Response Time

AQRT - Average Query Response Time (in seconds):

	total	w/o HTTP response time	Vs. fastest variant [AQRT; diff AP]: diff rank AQRT
1. XSSD	0.125	0.124	
2. OWLS-SLR lite	0.46	0.446	[0.169; - .023]: +1
3. SPARQLent	0.576	0.569	[0.201; - .423]: +2
4. OWLS-iMatcher	2.152	2.121	
5. iSeM 1.0	2.34	2.332	[1.828; - .097]: +1
6. SeMa^2	4.419	4.405	
7. OWLS-MX3	5.369	4.997	
8. EMMA	11.543*	11.089*	

* Caused by repeated plugin restart (see next slide)

Source: Klusch

Lesson Learned: Evaluation of Pre-Filtering

EMMA

- SPARQL-based pre-filtering of service offers for SME^2 plug-in of matchmakers

Idea

Fast pre-filtering techniques on top of heavy-weight matchmakers *to reduce AQRT while maintaining „good“ precision*.

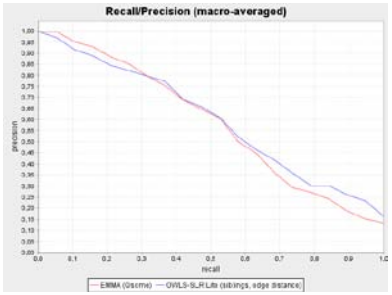
Problem: „to reduce AQRT“

This kind of evaluation *not fully* possible with SME2 2.1.1 (but forthcoming SME2 2.2)

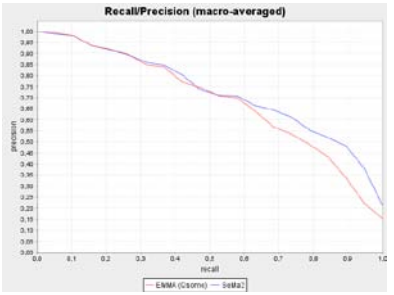
- Registration followed by querying phase:

  Requires registration of EMMA‘s pre-filtering results (= service subsets) *for each query by means of plugin restart*.

EMMA + OWLS-SLR (lite)



EMMA + SeMa^2



	AP	Q	nDCG
OWLS-SLR	.609	.57	.723
+ EMMA	**.623**	**.588**	**.74**
OWLS-MX3	.831	.834	.899
+ EMMA	.803	.815	.885
OWLS-iMatcher	.672	.671	.719
+ EMMA	.66	.666	**.723**
SeMa^2	.741	.73	.83
+ EMMA	.731	.728	.83

Significance at 5%: positive / negative

HTTP-Request Analysis

HTTP-Request Analysis of Query Phase

using SME2 with embedded Jetty Web server

		Avgerage time (ms)	#http-requests min-max	#http-requests average
1.	**XSSD**	1	1-1	**1**
2.	OWLS-SLR (lite)	14	1-13	**1**
3.	SPARQLent	7	3-106	30
4.	OWLS-iMatcher	31	1-1	**1**
5.	iSeM 1.0	7*	2-8	**3**
6.	SeMa^2	14	1-1	**1**
7.	OWLS-MX3	372	1054 - 1085	1058
8.	EMMA	454	390 – 2709	834

* HTTP-requests to *external* DIG API of approximative DL reasoner *not* included

Lesson Learned: Caching Strategies

Different caching strategies used by different matchmakers [exp. observation]

- Complete ontologies cached during service registration

  Reduced #requests: Only queries but no ontologies

  XSSD, OWLS-iMatcher, SeMa^2

- Caching of self-contained (unfolded) concept definitions

  Reduced #requests: *Some* queries require additional concept loading & classification

  iSeM 1.0, OWLS-MX3

  But: Services reloaded per query due to bug.

- Unknown strategy

  OWLS-SLR lite, SPARQLent

- No caching

  EMMA No caching for its SME^2 plug-ins possible

Performance Evaluation: Precision (Graded)

Precision for Graded Relevance:

	nDCG		Q
1.	OWLS-MX3	1.	OWLS-MX3
2.	EMMA	2.	iSeM 1.0
3.	XSSD	3.	EMMA
4.	iSeM 1.0	4.	XSSD
5.	SeMa^2	5.	SeMa^2
6.	SPARQLent	6.	OWLS-iMatcher
7.	OWLS-SLR (lite)	7.	SPARQLent
8.	OWLS-iMatcher	8.	OWLS-SLR (lite)

nDCG	Q
.899	.834
.885	.821
.881	.815
.841	.788
.83	.73
.728	.671
.723	.576
.719	.57

Source: Klusch

Track 2: SAWSDL Matchmakers in Brief

- **URBE**
  - Selection: *Non-logic-based; Signature (I/O)*
    - Non-logic-based match: Bipartite graph-matching of service operations; Ontology-based structural I/O concept similarity (worst-case path length in given reference ontology); Text similarity (WordNet) for property-class and XSD data type matching
    - Ranking: Weighted aggregation of structural and text matching scores
  - Dev: Pierluigi Plebani (Politecnico di Milano, Italy)

- **SAWSDL-MX1**
  - Selection: *Hybrid; Signature (I/O)*
    - Logic-based match: Logical I/O concept subsumption
    - Non-logic-based match: Text similarity of unfolded concept definitions
    - Ranking: Logic-based sorted by text similarities
  - Dev: Patrick Kapahnke, Matthias Klusch (DFKI, Germany)

Source: Klusch

Track 2: SAWSDL Matchmakers in Brief

- **COV4SWS.KOM**
  - Selection: *Non-logic-based; Signature (I/O), Element names*
    - Non-logic-based match: Ontology-based semantic relatedness (Resnik, Lin); WordNet distance (fallback strategy for missing modelReference)
    - Adaptive (offline): Aggregated results using Ordinary Least Squares (OLS)
    - Ranking: Linear weighted average similarity of matched operations
  - Dev: Stefan Schulte, Ulrich Lampe (TU Darmstadt, Germany)
- **LOG4SWS.KOM**
  - Selection: *Hybrid; Signature (I/O), Element names*
    - Logic-based match: Logical I/O concept subsumption relation as numeric score
    - Non-logic-based match: Ontology-based structural I/O concept similarity (path length); WordNet distance (fallback strategy for missing modelReference)
    - Adaptive (offline)/Ranking: cf. COV4SWS.KOM
  - Dev: Stefan Schulte, Ulrich Lampe (TU Darmstadt, Germany)

Track 2: SAWSDL Matchmakers in Brief

- **SAWSDL-iMatcher**
  - Selection: *Non-logic-based; Signature (I/O)*
    - Non-logic-based: Vector-based text similarities of unfolded service signatures
    - Ranking: Text similarity
  - Dev: Dengping Wei, Avi Bernstein (U Zurich, Switzerland)
- **iSeM 1.0 for SAWSDL**
  - Selection: *Hybrid; Signature (I/O), Service name*
    - Match: cf. iSeM Track 1; but no P/E, service name instead of description tag
    - Adaptive (offline): cf. iSeM Track 1; [TS = 5% SAWSDL-TC3]
  - Dev: Patrick Kapahnke, Matthias Klusch (DFKI, Germany)

Performance Evaluation: AP (Binary)

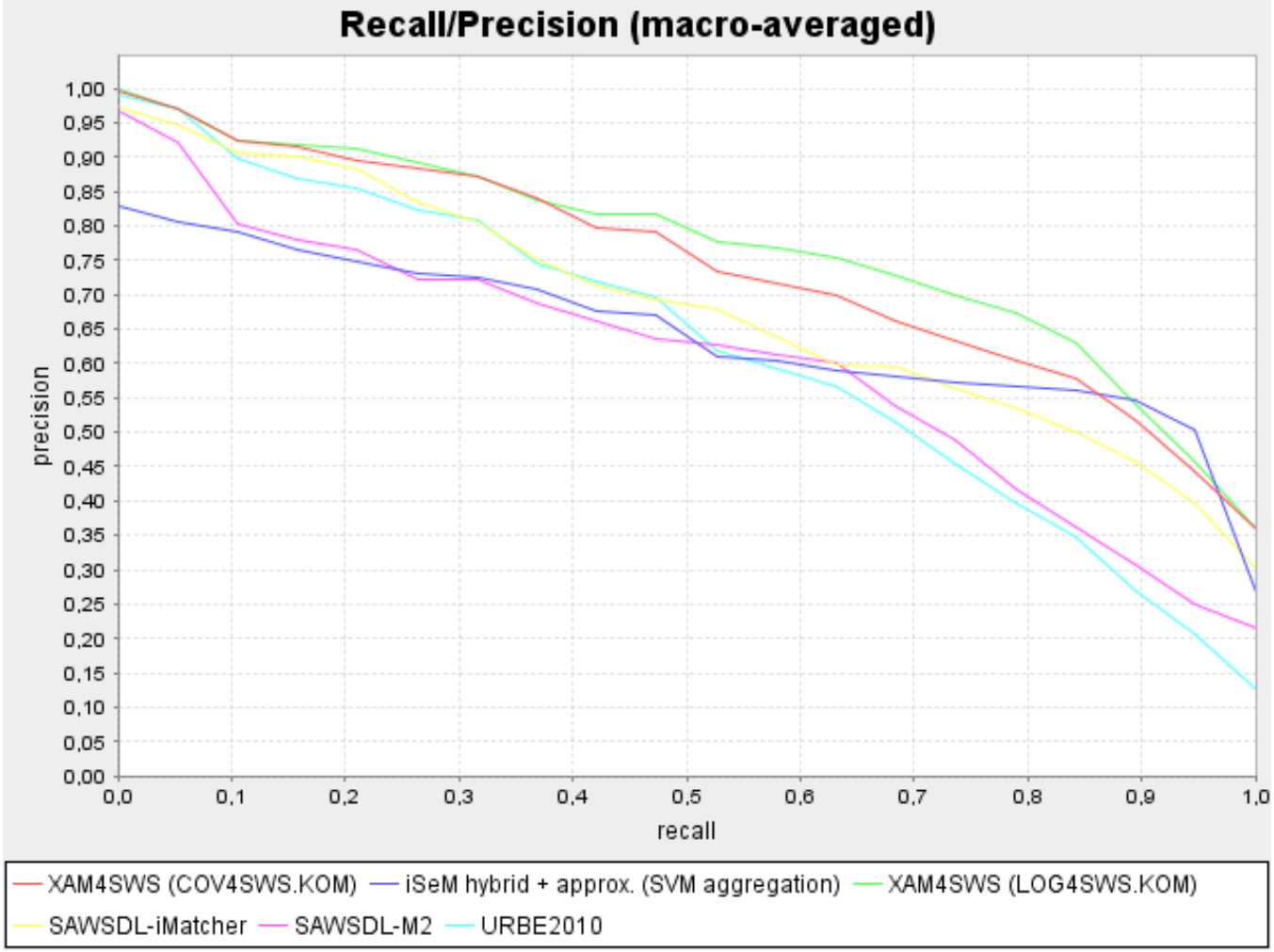
Average Precision for Binary Relevance:

1.	**iSeM 1.0**	**.842**
2.	LOG4SWS.KOM	.837
3.	COV4SWS.KOM	.823
4.	SAWSDL-iMatcher	.764
5.	URBE	.749
6.	SAWSDL-MX1	.747

Source: Klusch

Performance Evaluation: MARP (Binary)

Macro-Averaged Recall/Precision for Binary Relevance:



Source: Klusch

Performance Evaluation: Response Time

AQRT - Average Query Response Time (in seconds):

		total	w/o HTTP response time	Vs. fastest variant [AQRT; diff AP]: diff rank AQRT
1.	LOG4SWS.KOM	0.241	0.241	
2.	COV4SWS.KOM	0.301	0.301	
3.	SAWSDL-iMatcher	1.787	1.787	
4.	SAWSDL-MX1	3.859	3.853	
5.	iSeM 1.0	10.662	10.655	[1.584; - .018]: +2
6.	URBE	40.01	39.941	

HTTP-Request Analysis

HTTP-Request Analysis of Query Phase

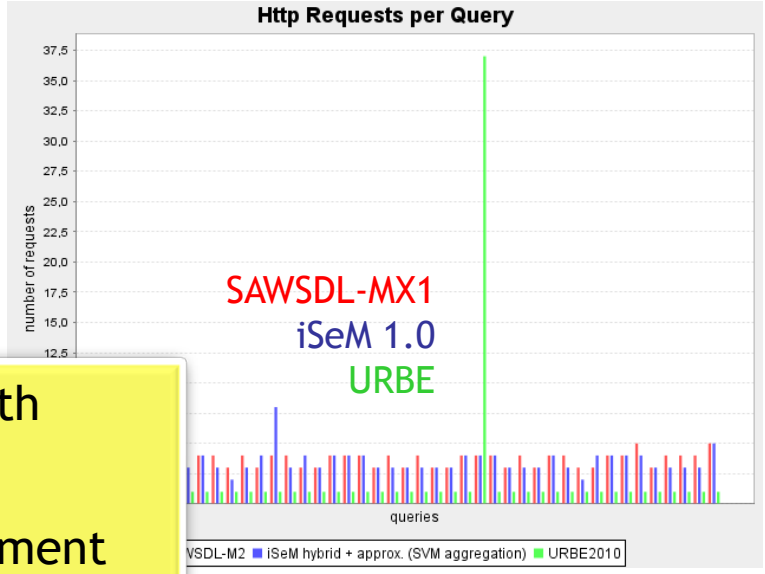
using SME2 with embedded Jetty Web server

		Avgerage time (ms)	#http-requests min-max	#http-requests average
1.	LOG4SWS.KOM	0	0-2	0
2.	COV4SWS.KOM	0	0-0	0
3.	SAWSDL-iMatcher	0	0-0	0
4.	SAWSDL-MX1	6	3-5	3
5.	iSeM 1.0	7	2-8	3
6.	URBE	69	1-37	1

Source: Klusch

Lesson Learned: Caching Strategies (2)

- Complete ontologies cached before service registration
  - LOG4SWS.KOM, COV4SWS.KOM:
    Ontologies loaded and classified after plug-in initialization → global ontology assumed
  - SAWSDL-iMatcher:
    Everything seems to be cached „out of the box“
- Caching of unfolded concepts
  - SAWSDL-MX1, iSeM 1.0
- Unknown strategy
  - URBE



SME² **2.2** (December 2010) with
Extended plug-in interface
for more detailed AQRT measurement

Source: Klusch

Performance Evaluation: Precision (Graded)

Precision for Graded Relevance:

	nDCG		Q	
1.	LOG4SWS.KOM	.896	1.	LOG4SWS.KOM	.851
2.	COV4SWS.KOM	.884	2.	COV4SWS.KOM	.825
3.	SAWSDL-iMatcher	.855	3.	SAWSDL-iMatcher	.784
4.	URBE	.85	4.	URBE	.777
5.	SAWSDL-MX1	.839	5.	SAWSDL-MX1	.767
6.	iSeM 1.0	.803	6.	iSeM 1.0	.762

Source: Klusch

Track 3: Cross-Evaluation

- **Principle**
  - **Specific Domain Test Collection**: Jena Geography Dataset JGD
    - 201 geoservices, 10 queries, graded relevance judgements
  - Semantic annotation of JGD services **in different formats provided by participants: Variants of the same JGD collection.**
  - Cross-evaluation: Comparative performance evaluation of entries over each JGD collection variant with graded relevance-based performance measures Q, nDCG and AQRT using the SME^2 tool.
  - Initial cross-evaluation in 2009 organized by Ulrich Küster
- **No new entries in 2010 = No new results. See S3 in 2009.**
- Submissions welcome at any time. Contact: Birgitta.Koenig-Ries@uni-jena.de

Outlook on 5th Contest S3 in 2011

- New entries were indicated to be in preparation for 2011
- Open call for location of final presentation/discussion of S3 2011 results
- New release of test collections: OWLS-TC**5** and SAWSDL-TC**4**

  But what about WSML-TC?

- New release of evaluation tool SME^2 version 2.2 (December 2010)
  - ✓ Extended matchmaker plugin interface for even more detailed evaluation configuration
  - ✓ More performance measures: Precision@k, R-Precision
  - ✓ More matchmaker plugins included
  - ✓ Improved usability: Error handling, more configuration details

  Contact: Patrick Kapahnke (DFKI) patrick.kapahnke@dfki.de

… Thanks for your attention !

Any QUESTIONS?

… ***Next year with your brand new ultra mega beat‘em all matchmaker !?*** ☺

Source: Klusch

Appendix: Complete Results for Track 1

		AP
1.	iSeM all	.922
2.	iSeM no approx.	.893
3.	OWLS-MX3	.831
4.	iSeM no approx., no PE	.825
5.	EMMA Qsome	.803
6.	XSSD	.795
7.	SeMa2	.741
8.	OWLS-iMatcher	.672
9.	SPARQLent XpbApbEpbR	.612
10.	EMMA Qall	.61
11.	OWLS-slr (lite) siblings, edge distance	.609
12.	OWLS-slr (lite) siblings, cotopic distance	.586
13.	SPARQLent XpbApbEpbE	.495
	SPARQLent Xp_Ap_Ep_R	.495
14.	OWLS-slr (lite) edge distance	.428
15.	SPARQLent Xp_Ap_Ep_E	.391
16.	SPARQLent X__A__E__R	.262
17.	SPARQLent X__A__E__E	.189

		Q
1.	OWLS-MX3	.834
2.	iSeM all	.821
3.	EMMA Qsome	.815
4.	iSeM no approx.	.811
5.	XSSD	.788
6.	iSeM no approx., no PE	.749
7.	SeMa2	.73
8.	OWLS-iMatcher	.671
9.	EMMA Qall	.67
10.	SPARQLent XpbApbEpbR	.576
11.	OWLS-slr (lite) siblings, edge distance	.57
12.	OWLS-slr (lite) siblings, cotopic distance	.553
13.	SPARQLent XpbApbEpbE	.462
	SPARQLent Xp_Ap_Ep_R	.462
14.	OWLS-slr (lite) edge distance	.402
15.	ALIVE Composite 2	.399
16.	SPARQLent Xp_Ap_Ep_E	.363
17.	SPARQLent X__A__E__R	.24
18.	SPARQLent X__A__E__E	.172

Appendix: Complete Results for Track 1

		nDCG
1.	OWLS-MX3	.899
2.	EMMA Qsome	.885
3.	XSSD	.881
4.	iSeM no approx.	.844
5.	iSeM all	.841
6.	SeMa2	.83
7.	EMMA Qall	.802
8.	iSeM no approx., no PE	.785
9.	SPARQLent XpbApbEpbR	.728
10.	OWLS-slr (lite) siblings, edge distance	.723
11.	OWLS-iMatcher	.719
12.	OWLS-slr (lite) siblings, cotopic distance	.712
13.	SPARQLent Xp_Ap_Ep_R	.639
14.	SPARQLent XpbApbEpbE	.625
19.	OWLS-slr (lite) edge distance	.591
20.	SPARQLent Xp_Ap_Ep_E	.556
21.	SPARQLent X__A__E__R	.452
22.	SPARQLent X__A__E__E	.366

		AQRT-http (ms)
1.	XSSD	124
2.	OWLS-slr (lite) siblings, cotopic distance	169
3.	SPARQLent X__A__E__E	196
4.	SPARQLent X__A__E__R	277
8.	SPARQLent Xp_Ap_Ep_E	317
9.	ALIVE Composite 2	339
10.	OWLS-slr (lite) edge distance	379
11.	SPARQLent XpbApbEpbE	400
12.	OWLS-slr (lite) siblings, edge distance	446
13.	SPARQLent Xp_Ap_Ep_R	456
14.	SPARQLent XpbApbEpbR	569
15.	iSeM no approx., no PE	1828
16.	iSeM no approx.	1915
17.	OWLS-iMatcher	2121
18.	iSeM all	2332
19.	SeMa2	4405
20.	OWLS-MX3	4997
21.	EMMA Qsome	11089
22.	EMMA Qall	31814

Appendix: Complete Results for Track 2

		AP
1.	iSeM w. approx.	.842
2.	LOG4SWS.KOM	.837
3.	iSeM no approx.	.824
4.	COV4SWS.KOM	.823
5.	SAWSDL-iMatcher	.764
6.	URBE	.749
7.	SAWSDL-MX1	.747

		Q
1.	LOG4SWS.KOM	.851
2.	COV4SWS.KOM	.825
3.	iSeM no approx.	.799
4.	SAWSDL-iMatcher	.784
5.	URBE	.777
6.	SAWSDL-MX1	.767
7.	iSeM w. approx.	.762

		nDCG
1.	LOG4SWS.KOM	.896
2.	COV4SWS.KOM	.884
3.	SAWSDL-iMatcher	.855
4.	URBE	.85
5.	iSeM no approx.	.84
6.	SAWSDL-MX1	.839
7.	iSeM w. approx.	.803

		AQRT-http (ms)
1.	LOG4SWS.KOM	241
2.	COV4SWS.KOM	301
3.	iSeM no approx.	1584
4.	SAWSDL-iMatcher	1787
5.	SAWSDL-MX1	3853
6.	iSeM w. approx.	10655
7.	URBE	39941

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