

LogMap family participation in the OAEI 2016

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Abstract. We present the participation of LogMap and its variants in the OAEI 2016 campaign. The LogMap project started in January 2011 with the objective of developing a scalable and logic-based ontology matching system. This is our seventh participation in the OAEI and the experience has so far been very positive. LogMap is one of the few systems that participates in all OAEI tracks.

1 Presentation of the system

Ontology matching systems typically rely on lexical and structural heuristics and the integration of the input ontologies and the mappings may lead to many undesired logical consequences. In [12] three principles were proposed to minimize the number of potentially unintended consequences, namely: *(i) consistency principle*, the mappings should not lead to unsatisfiable classes in the integrated ontology; *(ii) locality principle*, the mappings should link entities that have similar *neighbourhoods*; *(iii) conservativity principle*, the mappings should not introduce alterations in the classification of the input ontologies. Violations to these principles may hinder the usefulness of ontology mappings. The practical effect of these violations, however, is clearly evident when ontology alignments are involved in complex tasks such as query answering [20].

LogMap [11, 13] is a highly scalable ontology matching system that implements the consistency and locality principles. LogMap also supports (real-time) user interaction during the matching process, which is essential for use cases requiring very accurate mappings. LogMap is one of the few ontology matching system that *(i)* can efficiently match semantically rich ontologies containing tens (and even hundreds) of thousands of classes, *(ii)* incorporates sophisticated reasoning and repair techniques to minimise the number of logical inconsistencies, and *(iii)* provides support for user intervention during the matching process.

LogMap relies on the following elements, which are keys to its favourable scalability behaviour (see [11, 13] for details).

Lexical indexation. An inverted index is used to store the lexical information contained in the input ontologies. This index is the key to efficiently computing an initial set of mappings of manageable size. Similar indexes have been successfully used in information retrieval and search engine technologies [2].

Logic-based module extraction. The practical feasibility of unsatisfiability detection and repair critically depends on the size of the input ontologies. To reduce the size of the problem, we exploit ontology modularisation techniques. Ontology modules with

well-understood semantic properties can be efficiently computed and are typically much smaller than the input ontology (e.g. [5]).

Propositional Horn reasoning. The relevant modules in the input ontologies together with (a subset of) the candidate mappings are encoded in LogMap using a Horn propositional representation. Furthermore, LogMap implements the classic Dowling-Gallier algorithm for propositional Horn satisfiability [6]. Such encoding, although incomplete, allows LogMap to detect unsatisfiable classes soundly and efficiently.

Axiom tracking. LogMap extends Dowling-Gallier’s algorithm to track all mappings that may be involved in the unsatisfiability of a class. This extension is key to implementing a highly scalable repair algorithm.

Local repair. LogMap performs a greedy local repair; that is, it repairs unsatisfiabilities on-the-fly and only looks for the first available repair plan.

Semantic indexation. The Horn propositional representation of the ontology modules and the mappings is efficiently indexed using an interval labelling schema [1] — an optimised data structure for storing directed acyclic graphs (DAGs) that significantly reduces the cost of answering taxonomic queries [4, 21]. In particular, this semantic index allows us to answer many entailment queries as an index lookup operation over the input ontologies and the mappings computed thus far, and hence without the need for reasoning. The semantic index complements the use of the propositional encoding to detect and repair unsatisfiable classes.

1.1 LogMap variants in the 2016 campaign

In the 2016 campaign we have participated with two additional variants:

LogMapLt is a “lightweight” variant of LogMap, which essentially only applies (efficient) string matching techniques.

LogMapBio includes an extension to use BioPortal [8, 9] as a (dynamic) provider of mediating ontologies instead of relying on a few preselected ontologies [3].

This year we did not participate with LogMapC⁴ since in OAEI 2016 there are not alignment tasks suitable for a correct evaluation of LogMapC.⁵ The repair algorithm in LogMapC is more aggressive than in LogMap, which harms its results if the alignment task does not take into account the conservativity principle.

1.2 Adaptations made for the 2016 evaluation

LogMap’s algorithm described in [11, 13, 14] has been adapted with the following new functionalities:

- i* **Extended multilingual support.** We have extended our multilingual module with additional translations.

⁴ LogMapC is a variant of LogMap which, in addition to the consistency and locality principles, also implements the conservativity principle (see details in [22–24]).

⁵ The interested reader please refer to [24, 17] for examples of alignment tasks suitable for LogMapC.

- ii **Extended instance matching support.** We have partially adapted LogMap's instance matching module to cope with the new OAEI 2016 tasks.
- iii **BioPortal module.** We have adapted LogMapBio with respect to the changes in the BioPortal API. Note that LogMapBio only participates in the biomedical tracks. In the other tracks the results are expected to be the same as LogMap.

1.3 Link to the system and parameters file

LogMap is open-source and released under GNU Lesser General Public License 3.0.⁶ LogMap components and source code are available from the LogMap's GitHub page: <https://github.com/ernestojimenezruiz/logmap-matcher/>.

LogMap distributions can be easily customized through a configuration file containing the matching parameters.

LogMap, including support for interactive ontology matching, can also be used directly through an AJAX-based Web interface: <http://krrwebtools.cs.ox.ac.uk/>. This interface has been very well received by the community since it was deployed in 2012. More than 2,500 requests coming from a broad range of users have been processed so far.

1.4 Modular support for mapping repair

Only a very few systems participating in the OAEI competition implement repair techniques. As a result, existing matching systems (even those that typically achieve very high precision scores) compute mappings that lead in many cases to a large number of unsatisfiable classes.

We believe that these systems could significantly improve their output if they were to implement repair techniques similar to those available in LogMap. Therefore, with the goal of providing a useful service to the community, we have made LogMap's ontology repair module (LogMap-Repair) available as a self-contained software component that can be seamlessly integrated in most existing ontology matching systems [16, 7].

2 General comments and conclusions

Please refer to <http://oaei.ontologymatching.org/2016/results/> for the results of the LogMap family in the OAEI 2016 campaign.

2.1 Comments on the results

LogMap has been one of the top systems in the OAEI 2016 and one of the few system that participates in all tracks. Furthermore, it has also been one of the few systems implementing repair techniques and providing (almost) coherent mappings in all tracks.

LogMap's main weakness is that the computation of candidate mappings is based on the similarities between the vocabularies of the input ontologies; hence, in the cases where the ontologies are lexically disparate or do not provide enough lexical information LogMap is at a disadvantage.

⁶ <http://www.gnu.org/licenses/>

2.2 Discussions on the way to improve the proposed system

LogMap is now a stable and mature system that has been made available to the community and has been extensively tested. There are, however, many exciting possibilities for future work. For example we aim at improving the current multilingual features and the current use of external resources like BioPortal. Furthermore, we are applying LogMap in practice in the domain of oil and gas industry within the FP7 Optique⁷ [19, 15, 10, 18]. This practical application presents a very challenging problem.

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References

1. Agrawal, R., Borgida, A., Jagadish, H.V.: Efficient management of transitive relationships in large data and knowledge bases. In: ACM SIGMOD Conf. on Management of Data. pp. 253–262 (1989)
2. Baeza-Yates, R.A., Ribeiro-Neto, B.A.: Modern Information Retrieval. ACM Press / Addison-Wesley (1999)
3. Chen, X., Xia, W., Jiménez-Ruiz, E., Cross, V.: Extending an ontology alignment system with biportal: a preliminary analysis. In: Poster at Int’l Sem. Web Conf. (ISWC) (2014)
4. Christophides, V., Plexousakis, D., Scholl, M., Tourounis, S.: On labeling schemes for the Semantic Web. In: Int’l World Wide Web (WWW) Conf. pp. 544–555 (2003)
5. Cuenca Grau, B., Horrocks, I., Kazakov, Y., Sattler, U.: Modular reuse of ontologies: Theory and practice. *J. Artif. Intell. Res.* 31, 273–318 (2008)
6. Dowling, W.F., Gallier, J.H.: Linear-time algorithms for testing the satisfiability of propositional Horn formulae. *J. Log. Prog.* 1(3), 267–284 (1984)
7. Faria, D., Jiménez-Ruiz, E., Pesquita, C., Santos, E., Couto, F.M.: Towards annotating potential incoherences in biportal mappings. In: 13th Int’l Sem. Web Conf. (ISWC) (2014)
8. Fridman Noy, N., Shah, N.H., Whetzel, P.L., Dai, B., et al.: BioPortal: ontologies and integrated data resources at the click of a mouse. *Nucleic Acids Research* 37, 170–173 (2009)
9. Ghazvinian, A., Noy, N.F., Jonquet, C., Shah, N.H., Musen, M.A.: What four million mappings can tell you about two hundred ontologies. In: Int’l Sem. Web Conf. (ISWC) (2009)
10. Giese, M., Soyulu, A., Vega-Gorgojo, G., Waaler, A., Haase, P., Jimenez-Ruiz, E., Lanti, D., Rezk, M., Xiao, G., Ozcep, O., Rosati, R.: Optique — Zooming In on Big Data Access. *Computer* 48(3), 60–67 (2015)
11. Jiménez-Ruiz, E., Cuenca Grau, B.: LogMap: Logic-based and Scalable Ontology Matching. In: Int’l Sem. Web Conf. (ISWC). pp. 273–288 (2011)
12. Jiménez-Ruiz, E., Cuenca Grau, B., Horrocks, I., Berlanga, R.: Logic-based assessment of the compatibility of UMLS ontology sources. *J. Biomed. Sem.* 2 (2011)

⁷ <http://www.optique-project.eu/>

13. Jiménez-Ruiz, E., Cuenca Grau, B., Zhou, Y., Horrocks, I.: Large-scale interactive ontology matching: Algorithms and implementation. In: *Europ. Conf. on Artif. Intell. (ECAI)* (2012)
14. Jiménez-Ruiz, E., Grau, B.C., Solimando, A., Cross, V.V.: Logmap family results for OAEI 2015. In: *Proceedings of the 10th International Workshop on Ontology Matching collocated with the 14th International Semantic Web Conference (ISWC 2015)*, Bethlehem, PA, USA, October 12, 2015. pp. 171–175 (2015), http://ceur-ws.org/Vol-1545/oaie15_paper10.pdf
15. Jiménez-Ruiz, E., Kharlamov, E., Zheleznyakov, D., Horrocks, I., Pinkel, C., Skjæveland, M.G., Thorstensen, E., Mora, J.: BootOX: Practical Mapping of RDBs to OWL 2. In: *International Semantic Web Conference (ISWC)* (2015), <http://www.cs.ox.ac.uk/isg/tools/BootOX/>
16. Jiménez-Ruiz, E., Meilicke, C., Cuenca Grau, B., Horrocks, I.: Evaluating mapping repair systems with large biomedical ontologies. In: *26th Description Logics Workshop* (2013)
17. Jimenez-Ruiz, E., Payne, T.R., Solimando, A., Tamma, V.: Limiting logical violations in ontology alignment through negotiation. In: *Proceedings of the 15th International Conference on Principles of Knowledge Representation and Reasoning (KR)*. AAAI Press (April 2016)
18. Kharlamov, E., Hovland, D., Jiménez-Ruiz, E., Lanti, D., Lie, H., Pinkel, C., Rezk, M., Skjæveland, M.G., Thorstensen, E., Xiao, G., Zheleznyakov, D., Horrocks, I.: Ontology Based Access to Exploration Data at Statoil. In: *International Semantic Web Conference (ISWC)*. pp. 93–112 (2015)
19. Kharlamov, E., Jiménez-Ruiz, E., Zheleznyakov, D., et al.: Optique: Towards OBDA Systems for Industry. In: *Eur. Sem. Web Conf. (ESWC) Satellite Events*. pp. 125–140 (2013)
20. Meilicke, C.: *Alignment Incoherence in Ontology Matching*. Ph.D. thesis, University of Mannheim (2011)
21. Nebot, V., Berlanga, R.: Efficient retrieval of ontology fragments using an interval labeling scheme. *Inf. Sci.* 179(24), 4151–4173 (2009)
22. Solimando, A., Jiménez-Ruiz, E., Guerrini, G.: Detecting and correcting conservativity principle violations in ontology-to-ontology mappings. In: *Int'l Sem. Web Conf. (ISWC)* (2014)
23. Solimando, A., Jiménez-Ruiz, E., Guerrini, G.: A multi-strategy approach for detecting and correcting conservativity principle violations in ontology alignments. In: *Proc. of the 11th International Workshop on OWL: Experiences and Directions (OWLED)*. pp. 13–24 (2014)
24. Solimando, A., Jimenez-Ruiz, E., Guerrini, G.: Minimizing conservativity violations in ontology alignments: Algorithms and evaluation. *Knowledge and Information Systems* (2016), <https://github.com/asolimando/logmap-conservativity/>