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A Survey on Ontology Mapping

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Abstract

Ontology is increasingly seen as a key factor for enabling interoperability across heterogeneous systems and semantic web applications. Ontology mapping is required for combining distributed and heterogeneous ontologies. Developing such ontology mapping has been a core issue of recent ontology research. This paper presents ontology mapping categories, describes the characteristics of each category, compares these characteristics, and surveys tools, systems, and related work based on each category of ontology mapping. We believe this paper provides readers with a comprehensive understanding of ontology mapping and points to various research topics about the specific roles of ontology mapping.

Introduction

"An ontology is defined as a formal, explicit specification of a shared conceptualization." [27] Tasks on distributed and heterogeneous systems demand support from more than one ontology. Multiple ontologies need to be accessed from different systems. The distributed nature of ontology development has led to dissimilar ontologies for the same or overlapping domains. Thus, various parties with different ontologies do not fully understand each other. To solve these problems, it is necessary to use ontology mapping geared for interoperability. This article aims to present the broad scope of ontology mapping, mapping categories, their characteristics, and a comprehensive overview of ontology mapping tools, systems, and related work.

We classify ontology mapping into the following three categories: 1) mapping between an integrated global ontology and local ontologies [3, 4, 1, 7], 2) mapping between local ontologies [6, 1, 8, 9, 12, 13, 14], and 3) mapping on ontology merging and alignment.[15, 16, 17, 18, 19, 20]

The first category of ontology mapping supports ontology integration by describing the relationship between an integrated global ontology and local ontologies. The second category enables interoperability for highly dynamic and distributed environments as mediation between distributed data in such environments. The third category is used as a part of ontology merging or alignment as an ontology reuse process.

In this paper, we survey the tools, systems, and related work about ontology mapping based on these three ontology mapping categories. A comparison of tools or systems about ontology mapping is made based on specific evaluation criteria[10], which are input requirements, level of user interaction, type of output, content of output, and the following five dimensions: structural, lexical, domain, instance-based knowledge, and type of result.[8] Through a comparative analysis of ontology mapping categories, we aim to provide readers with a comprehensive understanding of ontology mapping and point to various research topics about the specific roles of ontology mapping.

The paper is organized as follows. The meanings of ontology mapping[4, 3, 7, 15, 25], ontology integration, merging, and alignment [2, 24] are outlined in Section 2. In Section 3, characteristics and application domains of three different categories of ontology mapping are discussed. The tools, systems, frameworks, and related work of ontology mapping are surveyed based on the three different ontology mapping categories. Then the overall comparison of tools or systems about ontology mapping is presented. In Section 4, a conclusion and presentation of future work are detailed.

2. Terminology: ontology mapping, ontology integration, merging, and alignment

In this section, we set the scope of ontology mapping and ontology mapping tools, and outline meanings of ontology mapping, integration, merging, and alignment. We aim to give a wide view of ontology mapping including ontology integration, merging, and alignment because this concept of ontology mapping is broad in scope[5] and ontology mapping is required in the process of ontology integration, merging, and alignment. Furthermore, one closely related research topic with ontology mapping is schema matching, which has been one major area of database research.[3, 36, 37, 38] However, this is beyond our scope in this paper. We also refer to tools for ontology integration, merging, and alignment as ontology mapping tools in this paper. We discuss the meanings of ontology mapping based on the three different ontology mapping categories.

Ontology merging, integration, and alignment

Ontology merging, integration, and alignment can be considered as an ontology reuse process.[2,24]

Ontology merging is the process of generating a single, coherent ontology from two or more existing and different ontologies related to the same subject.[26] A merged single coherent ontology includes information from all source ontologies but is more or less unchanged. The original ontologies have similar or overlapping domains but they are unique and not revisions of the same ontology.[24]

Ontology alignment is the task of creating links between two original ontologies. Ontology alignment is made if the sources become consistent with each other but are kept separate.[15] Ontology alignment is made when they usually have complementary domains.

Ontology integration is the process of generating a single ontology in one subject from two or more existing and different ontologies in different subjects.[26] The different subjects of the different ontologies may be related. Some change is expected in a single integrated ontology. [26]

Ontology mapping

Ontology mapping between an integrated global ontology and local ontologies.[4, 3, 7] In this case, ontology mapping is used to map a concept found in one ontology into a view, or a query over other ontologies (e.g. over the global ontology in the local-centric approach, or over the local ontologies in the global-centric approach).

Ontology mapping between local ontologies.[25] In this case, ontology mapping is the process that transforms the source ontology entities into the target ontology entities based on semantic relation. The source and target are semantically related at a conceptual level.

Ontology mapping in ontology merge and alignment.[15] In this case, ontology mapping establishes correspondence among source (local) ontologies to be merged or aligned, and determines the set of overlapping concepts, synonyms, or unique concepts to those sources.[15] This mapping identifies similarities and conflicts between the various source (local) ontologies to be merged or aligned.[5]

3. Categories of Ontology Mapping

In this section, ontology mapping based on the following three categories will be examined: 1) ontology mapping between an integrated global ontology and local ontologies, 2) ontology mapping between local ontologies, and 3) ontology mapping in ontology merging and alignment.

One of the crucial differences among the three ontology mapping categories is how mapping among ontologies is constructed and maintained. Each category of ontology mapping has different characteristics (strengths and drawbacks). Ontology mapping plays an important role in different application domains[5] and is the foundation of several applications.[14]

3.1 Ontology mapping between an integrated global ontology and local ontologies

This category supports ontology integration processes. Methodological aspects of ontology integration relate to how this mapping is defined.[1] This mapping specifies how concepts in global and local ontologies map to each other, how they can be expressed based on queries[7], and how they are typically modeled as views or queries (over the mediated schema in the local-as-view approach, or over the source schemas in the global-as-view approach).[7]

3.1.1 Strengths and drawbacks

The strengths of this mapping can also be the drawbacks of mapping between local ontologies and vice versa. In this mapping, it is easier to define mapping and find mapping rules than in mapping between local ontologies because an integrated global ontology provides a shared vocabulary and all local ontologies are related to a global ontology. It can be difficult to compare different local ontologies because no direct mappings exist between local ontologies. This mapping lacks maintainability and scalability because the change of local ontologies or the addition and removal of local ontologies could easily affect other mappings to a global ontology. This mapping requires an integrated global ontology. But there exists a practical impossibility of maintaining it in a highly dynamic environment.[8] This mapping cannot be made among different ontologies which have mutually inconsistent information over the same domain or over a similar view of domain because a global ontology cannot be created.

3.1.2 Application domains

This mapping supports the integration of ontologies for the Semantic Web, enterprise knowledge management, and data or information integration. In the Semantic Web, an integrated global ontology extracts information from the local ones and provides a unified view through which users can query different local ontologies.[7] When managing multiple ontologies for enterprise knowledge management, different local ontologies (data sources) can be combined into an integrated global ontology for a query.[1] In an information integration system, a mediated schema is constructed for user queries. Mappings are used to describe the relationship between the mediated schema (i.e., an integrated global ontology) and local schemas.[1,7,3,4] Ontology is more complicated and expressive in semantics than schema and has some differences but shares many features.[34, 35, 5] Schema can still be viewed as an ontology with restricted relationship types.[9] Therefore, the mediated schema can be considered as a global ontology.[3]

3.1.3 Tools, systems, and related work

An integrated global ontology (the logical mediated schema) is created as a view.[4,7,3] Mappings are used to describe the relationship between the mediated schema and local schemas.

LSD[3] (Learning Source Description): LSD semi-automatically creates semantic mappings with a multi-strategy learning approach. This approach employs multiple learner modules with base learners and the meta-learner where each module exploits a different type of information in the source schemas or data. LSD uses the following base learners: 1) The Name Learner: it matches an XML element using its tag name, 2) The Content Learner: it matches an XML element using its data value and works well on textual elements, 3) Naïve Bayes Learner: it examines the data value of the instance, and doesn't work for short or numeric fields, and 4) The XML Learner: it handles the hierarchical structure of input instances. Multi-strategy learning has two phases: training and matching. In the training phase, a small set of data sources has been manually mapped to the mediated schema and is utilized to train the base learners and the meta learner. In the matching phase, the trained learners predict mappings for new sources and match the schema of the new input source to the mediated schema. LSD also examines domain integrity constraints, user feedback, and nested structures in XML data for improving matching accuracy. LSD proposes semantic mappings with a high degree of accuracy by using the multi-strategy learning approach.

MOMIS[4] (Mediator Environment for Multiple Information Sources): MOMIS creates a global virtual view (GVV) of information sources, independent of their location or their data's heterogeneity. MOMIS builds an ontology through five phases as follows:

1) Local source schema extraction by wrappers
2) Local source annotation with the WordNet
3) Common thesaurus generation: relationships of inter-schema and intra-schema knowledge about classes and attributes of the source schemas
4) GVV generation: A global schema and mappings between the global attributes of the global schema and source schema by using the common thesaurus and the local schemas are generated.
5) GVV annotation is generated by exploiting annotated local schemas and mappings between local schemas and a global schema.

MOMIS generates mappings between global attributes of the global schema and source schemas. For each global class in the global virtual view (GVV), a mapping table (MT) stores all generated mappings. MOMIS builds an ontology that more precisely represents domains and provides an easily understandable meaning to content, a way to extend previously created conceptualization by inserting a new source.

A Framework for OIS[7] (Ontology Integration System): Mappings between an integrated global ontology and local ontologies are expressed as queries and ontology as Description Logic. Two approaches for mappings are proposed as follows: 1) concepts of the global ontology are mapped into queries over the local ontologies (global-centric approach), and 2) concepts of the local ontologies are mapped to queries over the global ontology (local-centric approach).

3.2 Ontology mapping between local ontologies

This category provides interoperability for highly dynamic, open, and distributed environments and can be used for mediation between distributed data in such environments.[12] This mapping is more appropriate and flexible for scaling up to the Web than mappings between an integrated global ontology and local ontologies.[12]

3.2.1 Strengths and drawbacks

This mapping enables ontologies to be contextualized because it keeps its content local.[6] It can provide interoperability between local ontologies when different local ontologies cannot be integrated or merged because of mutual inconsistency of their information.[6,1] It is useful for highly dynamic, open, and distributed environments[6] and also avoids the complexity and overheads of integrating multiple sources.[1] Compared to mapping between an integrated ontology and local ontologies, this category mapping has more maintainability and scalability because the changes (adding, updating, or removing) of local ontology could be done locally without regard to other mappings. Finding mappings between local ontologies may not be easier than between an integrated ontology and local ontologies because of the lack of common vocabularies.

3.2.2 Application domains

The primary application domains of this mapping are the Web or the Semantic Web because of their de-centralized nature. When there is no central mediated global ontology and coordination has to be made using ontologies, then mappings between local ontologies are necessary for agents to interoperate.[14] In distributed knowledge management systems, when building an integrated view is not required or multiple ontologies cannot be integrated or merged because of mutual inconsistency of the information sources, this category of mapping is required between local ontologies.[1,6]

3.2.3 Tools, systems, and related work

Context OWL[6] (Contextualizing Ontologies): OWL syntax and semantics are extended. Ontologies cannot be integrated or merged as a single ontology if two ontologies contain mutually inconsistent concepts. However, those two ontologies can be mapped using bridge rules which are the basic notion about the definition of context mappings.[6] A mapping between two ontologies is a set of bridge rules using $\supseteq$, $\subseteq$, $\equiv$, $*$ (related), and $\perp$ (unrelated).

CTXMATCH[8]: CTXMATCH is an algorithm for discovering semantic mappings across hierarchical classifications (HCs) using logical deduction. CTXMATCH takes two inputs H, and H1 in HCs, and for each pair of concepts $k \in H$, $k1 \in H1$ (a node with relevant knowledge including meaning in Hierarchical classifications), returns their semantic relation ($\supseteq$, $\subseteq$, $\equiv$, $*$, and $\perp$). For example, k is more general than k1 ($k \supseteq k1$), k is less general than k1 ($k \subseteq k1$), k is equivalent to k1 ($k \equiv k1$), k is compatible with k1 ($k * k1$), and k is incompatible with k1 ($k \perp k1$).

The contribution of the CTXMTCH is that mappings can be assigned a clearly defined model-theoretic semantics and that structural, lexical, and domain knowledge are considered.

GLUE[9]: GLUE semi-automatically creates ontology mapping using machine learning techniques. GLUE consists of Distribution Estimator, Similarity Estimator, and Relaxation Labeler. GLUE finds the most similar concepts between two ontologies and calculates the joint probability distribution of the concept using a multi-strategy learning approach for similarity measurement. GLUE gives a choice to users for several practical similarity measures. GLUE has a total of three learners: Content Learner, Name Learner, and Meta Learner. Content and Name Learners are two base learners, while Meta Learner combines the two base learners' prediction. The Content Learner exploits the frequencies of words in content of an instance (concatenation of attributes of an instance) and uses the Naïve Bayes' theorem. The Name Learner uses the full name of the input instance. The Meta-Learner combines the predictions of base learners and assigns weights to base learners based on how much it trusts that learner's predictions. In GLUE, Relaxation Labeling takes a similarity matrix and reaches for the mapping (best label assignment between nodes (concepts)). This mapping configuration is the output of GLUE.

MAFRA[12] (Ontology **MA**apping **FRA**mework for distributed ontologies in the Semantic Web): MAFRA provides a distributed mapping process that consists of five horizontal and four vertical modules.[12] Five horizontal modules are as follows:

1) Lift & Normalization: It deals with language and lexical heterogeneity between source and target ontology.
2) Similarity Discovery: It finds out and establishes similarities between source ontology entities and target ontology entities.
3) Semantic Bridging: It defines mapping for transforming source instances into the most similar target instances.
4) Execution: It transforms instances from the source ontology into target ontology according to the semantic bridges.
5) Post-processing: It takes the result of the execution module to check and improve the quality of the transformation results.

Four vertical modules are as follows:

1) Evolution: It maintains semantic bridges in synchrony with the changes in the source and target ontologies.
2) Cooperative Consensus Building: It is responsible for establishing a consensus on semantic bridges between two parties in the mapping process.
3) Domain Constraints and Background Knowledge: It improves similarity measure and semantic bridge by using WordNet or domain-specific thesauri.
4) Graphical User Interface (GUI): Human intervention for better mapping.

MAFRA maps between entities in two different ontologies using a semantic bridge, which consists of concept and property bridges. The concept bridge translates source instances into target ones. The property bridge transforms source instance properties into target instance properties.

LOM[21] (Lexicon-based Ontology Mapping): LOM finds the morphism between vocabularies in order to reduce human labor in ontology mapping using four methods: whole term, word constituent, synset, and type matching. LOM does not guarantee accuracy or correctness in mappings and has limitations in dealing with abstract symbols or codes in chemistry, mathematics, or medicine.

QOM[22] (Quick Ontology Mapping): QOM is a efficient method for identifying mappings between two ontologies because it has lower run-time complexity. In order to lower run-time complexity

QOM uses a dynamic programming approach.[33] A dynamic programming approach has data structures which investigate the candidate mappings, classify the candidate mappings into promising and less promising pairs, and discard some of them entirely to gain efficiency. It allows for the ad-hoc mapping of large-size, light-weight ontologies.

ONION[13] (**ON**tology composit**ION** system): ONION resolves terminological heterogeneity in ontologies and produces articulation rules for mappings. The linguistic matcher identifies all possible pairs of terms in ontologies and assigns a similarity score to each pair. If the similarity score is above the threshold, then the match is accepted and an articulation rule is generated. After the matches generated by a linguistic matcher are available, a structure-based matcher looks for further matches. An inference-based matcher generates matches based on rules available with ontologies or any seed rules provided by experts. Multiple iterations are required for generating semantic matches between ontologies. A human expert chooses, deletes, or modifies suggested matches using a GUI tool. A linguistic matcher fails when semantics should be considered.

OKMS[1] (Ontology-based knowledge management system): OKMS is an ontology-based knowledge management system. In OKMS, mapping is used for combining distributed and heterogeneous ontologies. When two different departments deal with the same business objects, their ontologies for their systems do not match because they approach the domain from different perspective. When they want to include information from other departments in their knowledge management system, the information must be transformed (i.e., reclassified). This can be accomplished through a mapping between local ontologies. The five-step ontology-mapping process[12] is used in the OKMS. The five-step ontology mapping process is as follows: 1) Lift and normalization: If source information is not ontology-based, it will be transformed to the ontology level by a wrapper. 2) Similarity extraction: The similarity extraction phase creates a similarity matrix, which represents the similarities between concepts and instances in ontologies being mapped. 3) Semantic mapping: This step produces the mappings that define how to transform source-ontology instances into target-ontology instances. 4) Execution: Execute mappings. 5) Post-processing: It improves the results of the execution phase.

OMEN[31] (Ontology Mapping Enhancer): OMEN is a probabilistic ontology mapping tool which enhances the quality of existing ontology mappings using a Bayesian Net. The Bayesian Net uses a set of meta-rules that represent how much each ontology mapping affects other related mappings based on ontology structure and the semantics of ontology relations. Existing mappings between two concepts can be used for inferring other mappings between related concepts.

P2P ontology mapping[32]: This work[32] proposes the framework which allows agents to interact with other agents efficiently based on the dynamic mapping of only the portion of ontologies relevant to the interaction. The framework executes three steps: 1) Generates the hypotheses. 2) Filters the hypotheses. 3) Selects the best hypothesis.

3.3 Ontology mapping (matching) in ontology merging and alignment

This category allows a single coherent merged ontology to be created through an ontology merging process. It also creates links between local ontologies while they remain separate during the ontology alignment process. Mappings do not exist between a single coherent merged ontology and local ontologies, but rather between local ontologies to be merged or aligned. Defining a mapping between local ontologies to be merged or aligned is the first step in the ontology merging or alignment process. This mapping identifies similarities and conflicts between local ontologies to be merged or aligned.

3.3.1 Strength and drawbacks

This mapping applies to ontologies over the same or overlapping domain. Finding mapping is a part of other applications such as ontology merging or alignment. This might be fairly obvious and more interesting in a large ontology.[14,11]

3.3.2 Application domains

The growing usage of ontologies or the distributed nature of ontology development has led to a large number of ontologies which have the same or overlapping domains.[15,17] These should be merged or aligned to be reused.[15] Many applications such as standard search, e-commerce, government intelligence, medicine, etc., have large-scale ontologies and require the reuse of ontology merging processes.[11]

3.3.3 Tools, systems, and related work

SMART[18]: SMART is a semi-automatic ontology merging and alignment tool. It looks for linguistically similar class names through class-name matches, creates a list of initial linguistic similarity (synonym, shared substring, common suffix, and common prefix) based on class-name similarity, studies the structures of relation in merged concepts, and matches slot names and slot value types. It makes suggestions for users, checks for conflicts, and provides solutions to these conflicts.

PROMPT[15]: PROMPT is a semi-automatic ontology merging and alignment tool. It begins with the linguistic-similarity matches for the initial comparison, but generates a list of suggestions for the user based on linguistic and structural knowledge and then points the user to possible effects of these changes.

OntoMorph[16]: OntoMorph provides a powerful rule language for specifying mappings, and facilitates ontology merging and the rapid generation of knowledge-base translators. It combines two powerful mechanisms for knowledge-base transformations such as syntactic rewriting and semantic rewriting. Syntactic rewriting is done through pattern-directed rewrite rules for sentence-level transformation based on pattern matching. Semantic rewriting is done through semantic models and logical inference.

HICAL[19] (Hierarchical Concept Alignment system): HICAL provides concept hierarchy management for ontology merging/alignment (one concept hierarchy is aligned with another concept in another concept hierarchy), uses a machine-learning method for aligning multiple concept hierarchies, and exploits the data instances in the overlap between the two taxonomies to infer mappings. It uses hierarchies for categorization and syntactical information, not similarity between words, so that it is capable of categorizing different words under the same concept.

Anchor-PROMPT[20]: Anchor-PROMPT takes a set of anchors (pairs of related terms) from the source ontologies and traverses the paths between the anchors in the source ontologies. It compares the terms along these paths to identify similar terms and generates a set of new pairs of semantically similar terms.

CMS[23] (CROSI Mapping System): CMS is an ontology alignment system. It is a structure matching system on the rich semantics of the OWL constructs. Its modular architecture allows the system to consult external linguistic resources and consists of feature generation, feature selection, multi-strategy similarity aggregator, and similarity evaluator.

FCA-Merge[17]: FCA-Merge is a method for ontology merging based on Ganter and Wille's formal concept analysis[28], lattice exploration, and instances of ontologies to be merged. The overall process of ontology merging consists of three steps: 1) instance extraction and generation of the formal context for each ontology, 2) the computation of the pruned concept lattice by algorithm TITANIC[29], and 3) the non-automatic generation of the merged ontology with human interaction based on the concept lattice.

CHIMAERA[30]: CHIMAERA is an interactive ontology merging tool based on the Ontolingual ontology editor. It makes users affect merging process at any point during merge process, analyzes ontologies to be merged, and if linguistic matches are found, the merge is processed automatically, otherwise, further action can be made by the use. It uses subclass and super class relationship.

3.4 A Comparison of ontology mapping tools or systems

A specific unified framework does not exist for comparison of ontology mapping tools[2], nor may direct comparison of ontology mapping tools be possible.[10] But a set of evaluation criteria to compare ontology mapping tools is proposed[10] and some of systems about ontology mapping are compared.[8] See Table 1 for a summary of ontology mapping tools.

4. Conclusion

This paper has presented a broad scope of ontology mapping, mapping categories and characteristics, and surveyed ontology mapping tools, systems, and related work based on ontology mapping categories as follows: a mapping between an integrated global ontology and local ontologies, a mapping between local ontologies, and a mapping on ontology merging and alignment. The different roles of these three ontology mapping categories were also identified. Techniques for a mapping between local ontologies have not been widely used for a mapping between a global ontology and local ontologies for two reasons. First, mapping between a global ontology and local ontlgies is done in the process of ontology integration or when a global ontology exists.[3, 4, 7] Second, some techniques for a mapping between local ontlgies are aimed at distributed ontologies on the Semantic Web, ontologies which have mutually inconsistent concepts or requirements of a more dynamic or flexible form of mapping.[1, 6, 8, 9, 12, 22, 32]

Further research is needed to improve methods of constructing an integrated global ontology, utilizing the mapping techniques for local ontologies in order to map between an integrated global ontology and local ontologies. In addition, research about the usage or roles of ontology mapping in different application domains should be performed. Research aimed at developing sufficiently applicable mapping techniques between local ontologies for the same or overlapping domain will improve ontology merge and alignment processes. In order to find an accurate ontology mapping, accurate similarity measurements between source ontology entities and target ontology entities should be considered. Techniques for complex ontology mappings between ontologies and discovering more constraints in ontologies should be also investigated.

	MOMIS	LSD	CTXMATCH	GLUE	MAFRA	LOM	ONION	PROMPT	FCA-Merge
Input	Data model	Source schemas & their instances	Concepts in concept hierarchy	Two taxonomies with their data instances in ontologies	Two ontologies	Two lists of terms from two ontologies	Terms in two ontologies	Two input ontologies	Two input ontologies and a set of documents of concepts in ontologies
Output	An integrated global ontology (GVV)	pairs of related terms between a global and local schema	Semantic relation between concepts	A set of pairs of similar concepts	Mappings of two ontologies by the Semantic bridge ontology	A list of matched pairs of terms with score ranking similarity	Sets of Articulation rules between two ontologies	A merged ontology	A merged ontology
User interaction	The designer involves in schema annotation & sets a threshold for integration clusters for generating a GVV	The user provides mappings for training source & feedback on the proposed mappings.	No (CTXMATCH is an algorithm.)	User-defined mappings for training data , similarity measure, setting up the learner weight, and analyzing system's match suggestion	The domain expert interface with the similarity and semantic bridging modules and it has graphical user interface	It requires human validation at the end of the process.	A human expert chooses or deletes or modifies suggested matches using a GUI tools	The user accepts, Rejects , or adjusts system's suggestions.	Generating a merged ontology requires human interaction of the domain expert with background knowledge
Mapping strategy or algorithm	Name equality: Synonyms hyponyms Matching of clustering	Multi-strategy Learning approach : (machine Learning technique)	Logical deduction	Multi-strategy learning approach : (machine learning technique)	Semantic bridge	Lexical similarity whole term, word constituent, synset, and type matching	Linguistic matcher, Structure-, inference-based heuristics	Heuristic-based analyzer	Linguistic analysis & TITANIC algorithm for computation for pruned concept lattice
Structured knowledge	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes
Instance-based knowledge	No	Yes	No	Yes	Yes	No	No	No	Yes
Lexical knowledge	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
domain knowledge	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes

Table 1 A summary of ontology mapping tools

5. References

1. Alexander Maedche, Boris Motik, Ljiljana Stojanovic, Rudi Studer, and Raphael Volz, "*Ontologies for Enterprise Knowledge Management*", IEEE Intelligent Systems, 2003.

2. Yannis Kalfoglou, Marco Schorelmmer, "*Ontology Mapping: The State of the Art*", The Knowledge Engineering Review, Vol. 18:1, 1-31, 2003.

3. AnHai Doan, Pedro Domingos, Alon Halevy, "*Learning to Match the Schemas of Data Sources: A Multistrategy Approach*", Machine Learning, 50 (3): 279-301, March 2003.

4. Domenico Beneventano, Sonia Bergamaschi, Francesco Guerra, Maurizio, "*Synthesizing an Integrated Ontology*", IEEE Internet Computing, September • October 2003.

5. Xiaomeng Su, "*Semantic Enrichment for Ontology Mapping*" PhD thesis Dept. of Computer and Information Science, Norwegian University of Science and Technology.

6. Paolo Bouquet, Fausto Giunchiglia, Frank van Harmelen, Luciano Serafini, Heiner Stuckenschmidt, "*C-OWL: Contextualizing Ontologies*", ISWC 2003, LNCS 2870, pp.164-179, 2003.

7. Calvanese, D, De Giacomo, G and Lenzerini, M, 2001a, "*A Framework for Ontology Integration*" Proceedings of the 1st International Semantic Web Working Symposium (SWWS) 303–317.

8. Paolo Bouquet, Luciano Serafini, Stefano Zanobini, "*Semantic Coordination: A New Approach and an Application*", ISWC 2003, LNCS 2870, pp.130-145, 2003.

9. AnHai Doan, Jayant Madhavan, Pedro Domingos, Alon Halevy, "*Learning to Map between Ontologies on the Semantic Web*", VLDB Journal, Special Issue on the Semantic Web, 2003.

10. N. F. Noy and M.A. Musen, "*Evaluating Ontology*

Mapping Tool: Requirement and Experience", Proceedings of the Workshop on Evaluation of Ontology Tools at EKAW'02 (EOEN2002), Siguenza, Spain, 2002.
11. Deborah L. McGuinness, Richard Fikes, James Rice, Steve Wilder, "*An Environment for Merging and Testing Large Ontologies"*, Proceedings of the Seventh International Conference on Principles of Knowledge Representation and Reasoning (KR200), Breckenridge, CO, April 12-15, 2000.
12. Nuno Silva, Joao Rocha, *"MAFRA – An Ontology Mapping FRAmework for the Semantic Web"*, Proceedings of the 6th International Conference on Business information Systems; UCCS, Colorado Springs, CO, May 2003.
13. Mitra, P and Wiederhold, G, "*Resolving Terminological Heterogeneity in Ontologies*", Proceedings of the ECAI'02 workshop on Ontologies and Semantic Interoperability, 2002.
14. Madhavan, J, Bernstein, PA, Domingos, P and Halevy, A, , "*Representing and reasoning about mappings between domain models*", Proceedings of the 18th National Conference on Artificial Intelligence (AAAI'02*)*, 2002.
15. N. Noy and M. Musen, "*PROMPT: Algorithm and Tool for Automated Ontology Merging and Alignment.*" Proceedings of the National Conference on Artificial Intelligence (AAAI), 2000.
16. H. Chalupsky. "*Ontomorph: A Translation System for Symbolic Knowledge*", Principles of Knowledge Representation and Reasoning, 2000.
17. Gerd Stumme, Alexander Maedche, *"FCA-Merge: Bottom-Up Merging of Ontologies"*, In proceeding of the International Joint Conference on Artificial Intelligence IJCA101, Seattle, USA, 2001.
18. Natalya Fridman Noy and Mark A. Musen, *"Smart: Automated Support for Oontology Merging and Alignment"*, Proceedings of the Twelfth Banff Workshop on Knowledge Acquistion, Modeling, and Management, Banff Algeberta, 1999.
19. R. Ichise, H. Takeda, and S. Honiden. "*Rule Induction for Concept Hierarchy Alignment*", Proceedings of the Workshop on Ontology Learning at the 17th International Joint Conference on Artificial Intelligence (IJCAI), 2001.
20. N. Noy and M. Musen, "*Anchor-PROMPT: Using Non-Local Context for Semantic Matching*", Proceedings of the Workshop on Ontologies and Information Sharing at the International Joint Conference on Artificial Intelligence (IJCAI), 2001.
21. John Li, *"LOM: A Lexicon-based Ontology Mapping Tool"*, Proceedings of the Performance Metrics for Intelligent Systems (PerMIS. '04), 2004.
22. Marc Ehrig, Steffen Staab, *"QOM – Quick Ontology Mapping"*, GI Jahrestagung (1), 2004.
23. Yannis Kalfoglou, Bo Hu, *"CROSI Mapping System (CMS) Results of the 2005 Ontology Alignment Contest"*, K-CAP Integrating Ontologies Workshop 2005, Banff, Alberta, Canada, 2005.
24. Helena Sofia Pinto, Joao P. Martins, *"A Methodology for Ontology Integration*", Proceedings of the International Conference on Knowledge Capture, Technical papers, ACM Press, pp. 131-138, 2001.
25. Nuno Silva and Joao Rocha, *"Ontology Mapping for Interoperability in Semantic Web"*, Proceedings of the IADIS International Conference WWW/Internet 2003 (ICWI'2003). Algarve, Portugal; November 2003.
26. H. Sofia Pinto, A. Gomez-Perez, J. P. Martins, *"Some Issues on Ontology Integration"*, In Proc. of IJCAI99's Workshop on Ontologies and Problem Solving Methods: Lessons Learned and Future Trends, 1999.
27. Studer R, Benjamins VR, Fensel D, *"Knowledge Engineering: Principles and Methods"*, IEEE Transactions on Data and Knowledge Engineering, 25(1-2): 161- 199, 1998.
28. Ganter B., Wille R., *"Formal Concept Analysis: Mathematical Foundaations Springer"*, 1999.
29. G. Stumme, R. Taouil, Y. Bastide, N. Pasquiter, L. Lakhal, "Fast computation of concept lattices using data mining techniques", Proc. KRDB '00, http: //sunsite.informatik.rwth-aachen.de/Publications/CEUR-WS 129-139, 2000.
30. D. McGuinness, R. Fikes, J. Rice, and S. Wilder, "*The Chimaera Ontology Environment*", In Proceedings of the 17th National Conference on Artificial Intelligence (AAAI), 2000.
31. Prasenjit Mitra, Natasha F. Noy, Anju Jaiswals, "*OMEN: A Probabilistic Ontology Mapping Tool"*, International Semantic Web Conference 2005: 537-547.
32. Paolo Besana, Dave Robertson, and Michael Rovatsos, *"Exploiting interaction contexts in P2P ontology mapping"*, P2PKM2005.
33. Boddy, M., *"Anytime problem solving using dynamic programming"*, In proceedings of the Ninth National Conference on Artificial Intelligence, Anaheim, California, Shaker Verlag (1991) 738-743.
34. D. Fensel, "*Ontologies: Silver Bullet for knowledge management and Electronic Commerce"*, Springer_Verlag, 2001.
35. Natalya F. Noy, Michel Klein, "*Ontology Evolution: Not the same as Schema Evolution"*, In: Knowledge and Information Systems, 6(4): 428-440, July, 2004.
36. C. Batini and M. Lenzerni. "*A comparative analysis of methodologies for database schema integration"*, ACM Computer Surveys, 18(4), 1986.
37. AnHai Doan, Alon Y. Halevy, "*Semantic Integration Research in the Database Community: A Brief Survey"*, AI Magazine, Volume 26, Mar. 2005.
38. Madhavan J., Bernstein P., Doan A., and Halevy A., "*Corpus based schema matching"*, In proc. of The 18th IEEE Int. Conf. on Data Engineering, 2005.