Towards a Methodology for Selection of Suitable Matching Approaches - A Case Study

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Abstract. The natural solution to fully explore the potentials hidden in existing matching approaches is a strategy based on the reuse of available matchers. However, building semantic applications based on the reuse of existing approaches is still a tedious process, this is due to fact that reusing available alignment methodologies within new application contexts is currently not being discussed deeply. In this paper we propose a methodology that takes into consideration the given application requirements as well as explores existing ontology matching approaches for the purpose of selection the suitable matchers among them. We apply this methodology to real world case studies, discuss the results achieved by our approach and compare them with the matcher ranking obtained during real processing.

1 Introduction

The technological foundations of the Semantic Web are maturing and the Semantic Web is in a phase in which consensus regarding its potential is being discussed. It is also currently evolving from a pure research topic to real world applications. This trend is underscored by the wide range of international projects with major industry involvement and by the increasing interest of small and medium size enterprizes requesting consultancy in this domain. However, Semantic Web-based applications at industrial scale have to be supported by elaborated methodologies, technologies, tools, case studies and documentation, due to the well-known difficulties associated with the realization of the Semantic Web vision, especially building, using, and maintaining such Semantic Web-based applications.
While it is generally accepted that reuse and reusability of existing ontological sources are very important issues for a cost-effective and high-quality ontology engineering, the reuse of semantic-based approaches like semantic matching, mapping and alignment have not yet been analyzed satisfactory within the Semantic Web realm. This situation is a consequence of the process in which the ontology engineers recognized the potentials of the "reuse strategy" and proposed, utilized and tested a wide range of different methodologies [12] for

building ontologies from existing sources [10, 16, 15, 19, 20]. In contrast, the ontology matching, mapping and alignment field still does not take into extensive account the alternative solution, which is to reuse existing approaches during the development of semantic-based applications.
Our experiences collected during the development of ontology-based applications [2, 8, 14] confirm previous findings in the literature that building such applications is still a tedious process, due to the lack of proved and tested support tools and that reusing existing methods within new application contexts is currently not deeply discussed. Since much time and effort have been spent for the development of new ontology alignment and matching algorithms, the collection of such algorithms is still growing. In our research we have exploited potentials hidden in the existing methods and investigated the possibility of reusing the impressive body of matching algorithms. In this paper we suggest a methodology for managing the existing approaches, on the one hand, and selection of the suitable among them, taking into account the given application requirements, on the other hand. In other words the methodology explores existing ontology matching approaches for the purpose of detecting what kind of approach can be applied to what kind of matching issue, to what type of ontologies and to what sort of application. To conduct a usability check of the proposed methodology we have evaluated it in the context of the *Ontology Alignment Evaluation Initiative (OAEI) 2006 Campaign*[3], which aims to establish a consensus for evaluation of the increasing number of methods for schema matching and ontology integration.
The remainder of the paper is organized as follows: Section 2 outlines our methodology including a developed characteristic of matching approaches and explains how a decision making process has been adopted to the approach selection. In Section 3 we describe the application of our selection methodology to two test cases defined by the OAEI 2006 Campaign and compare our results with those achieved by contestants in the contest. Section 4 gives a brief overview of the relevant approaches and finally section 5 briefly discusses the results achieved and sketches the work still to be done.

2 Matcher Selection Methodology

As long as decisions rely on single criterion that serve as the basis for comparison of alternatives or the scales of the different criteria are consistent and numeric measures accurately capture expected performance, summary statistics or, in some cases, just acting on the human instinct may be sufficient for the decision making process. However, when the decision depends on multiple criteria and scales are not consistent the process becomes very complicated, and the involvement of qualitative as well as quantitative methodologies or tools is indispensable. Consequently, in such cases a multi criteria decision making process is required, otherwise known as a *Multi Criteria Decision Analysis (MCDA)*, which is a procedure that aims to support decision makers whose problems are

[3] `http://oaei.ontologymatching.org/2006/`

concerned with numerous and conflicting criteria. Such methods developed for better model decision scenarios vary in their mathematical rigor, validity and design[9]. One of such methods is a systematic approach developed to structure the expectancy, intuition, and heuristic based decision making into a well-defined methodology on the basis of sound mathematical principles called *Analytic Hierarchy Process (AHP)* [1]. It helps to set priorities and to take the best decision when both qualitative and quantitative aspects of a decision need to be considered[17], i.e. AHP provides a mathematically rigorous application and proven process for prioritization and decision-making. By reducing complex decisions to a series of pair-wise comparisons and then synthesizing the results, decision-makers arrive at the best decision based on a clear rationale. It is generally accepted that AHP constitutes one of the best options to aid multi-criteria decision making, since it does not use the normalized groups of separate numbers which destroy the lineal relationship among them[7]. It compares the relative importance that each criterion has with respect to the others, while enabling the relative weight of the criteria to be calculated. Finally it standardizes the weights so that the measures for the existing alternatives may be obtained.
The AHP-method consists of the following steps:

1. *definition of a problem or project objectives*;
2. *building a decision hierarchy*: AHP provides a means to break down the problem into a hierarchy of subproblems (hierarchy built on the goal, criteria, sub-criteria and alternatives), which can be more easily comprehended and subjectively evaluated[1];
3. *data collection*: data is collected from domain experts corresponding to the hierarchical structure in the pairwise comparison of the alternatives on a qualitative scale; this step assesses the characteristics of each alternative;
4. *building a pairwise comparison*: for each level of criteria (sub-criteria and criteria) pairwise comparisons between sibling nodes[4] is to be built and organized into a square matrix[5];
5. *calculation of a final result*: the ratings of each alternative (cf. step 3) is multiplied by the weight of the sub-criteria (cf. step 4) and aggregated to obtain local ratings with respect to each criterion.

The local ratings are then multiplied by the weight of the criteria (cf. step 4) and aggregated to global ratings. The final value is used to make a decision about the problem defined at the beginning of the process.
A Web-enabled matching framework requires a highly flexible selection and composition of available matching services in order to take full advantage of the broad spectrum of ontologies across the network. Since the decision regarding the suitability of different matchers also depends on numerous criteria and the final result needs to be delivered in the prioritization and rational decision-making process, we have decided to apply the AHP approach to the "matching issue". In the following we will briefly go thought the AHP steps to provide an insight into the way the AHP can support the matcher selection.

[4] It is an exhaustive comparison taking into account all possibilities
[5] For details see[17]

2.1 Definition of a "matching problem"

From our point of view the obvious solution to make full use (and to limit the disadvantages) of existing matching approaches is a strategy based on the reuse of available matchers[6]. The most important step in the process of realizing the aim of a "reuse strategy" is the selection of the "appropriate" matchers. In other words the main goal of the proposed AHP-based methodology is to *determine matching approaches currently relevant and suitable w.r.t the given application requirements.*

2.2 Building of a decision hierarchy regarding matcher suitability

To find an answer to the issue defined in the previous section we have applied the common structure of the AHP hierarchy, which includes goal, criteria, subcriteria and solution alternatives(cf. Fig.1), to the matching issue. Following this structure we have already defined the goal: "which matcher is suitable" and isolated the common matcher alternatives[7]. The missing link is now to break down the "matching problem"[8] into a hierarchy of different criteria. Strictly speaking, we now need to find relevant factors that have an impact on the selection of adequate matching approach.

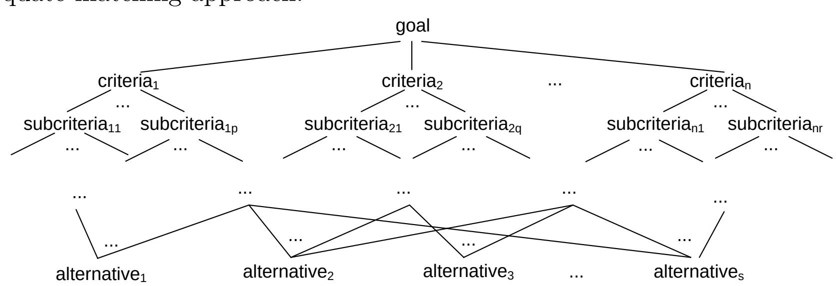


Fig. 1. AHP hierarchy structure

To this end we have identified six main properties (or dimensions) as relevant to the matcher selection process: (i)*input characteristic* takes into account the ontologies to be matched; (ii)*approach characteristic* describes the matching algorithms themselves; (iii)*output characteristic* defines the desired result of the matching execution; (iv)*usage characteristic* takes into account the different situations where the approaches have been used; (v)*documentation characteristic* points out the existence and type of the documentation; and (vi)*cost characteristics* addresses the costs which must be paid for the usage of the algorithm. These dimensions form the superficial collection of matcher attributes and correspond to the first level of criteria in Fig.1. Furthermore the dimensions are

[6] Matcher reuse means here the reuse of matching approach(es) and not the reuse of match results as described in [4, 21]

[7] Matching approaches which took part at the OAEI 2006 Campaign

[8] Matching problem means in this context the problem of the selection of a suitable (w.r.t the given application requirements) approach

defined by sets of factors (cf. sub-criteria in Fig.1) which are in turn described by attributes and all these properties form the *multilevel characteristic of matching approaches*. Since the decision concerning the suitability of a single matcher depends on the multilevel characteristic defined, the compilation of a set of properties is a significant step towards the realization of our methodology. The initial characteristic called *a-priori characteristic*, whose detailed description can be found in [13], has already been evaluated by conducting interviews with domain experts. During the interviews, the participants expressed their concerns w.r.t. the matcher-related issues. Their experiences regarding development and application of matching algorithms were recorded and changes within the characteristic were proposed. Having the multilevel characteristic in combination with the defined goal and matcher alternative, the AHP-tree for the matcher selection can be build (cf. Fig. 2).

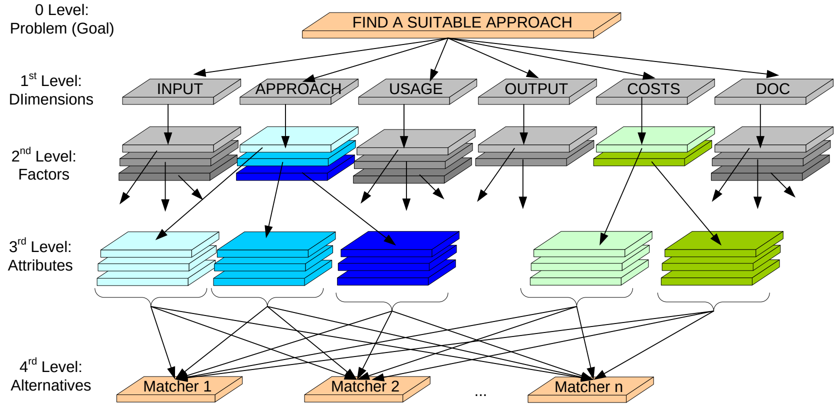


Fig. 2. AHP hierarchy structure applied to problem of matcher selection

2.3 Collection of matcher data

As mentioned in the previous section we have already isolated the matcher alternatives which will be considered within the selection process. In order to collect data on the different approaches and to be able to conduct the pairwise comparisons we firstly need the relevant information about the particular alternatives. For this reason we have developed (following the a-posteriori hierarchical structure of the multilevel characteristic for matching approaches) an online questionnaire[9] (to be fill out by the experts in the matching domain) that allows the addition and rating (by usage of a predefined scale) of new matcher alternatives. When a new matching approach is added via the questionnaire into the collection of the alternatives, all available alternatives in the system are automatically weighted against the new approach.

Given two matcher alternatives m_1, m_2 and criteria c as well as the user defined weighings for the single approach $w(c)_{m_1}$ and $w(c)_{m_2}$ the weighings for the pairwise comparisons (between alternatives m_1, m_2) $w(c)_{m_1,m_2}$ and $w(c)_{m_2,m_1}$ are

[9] `http://matching.ag-nbi.de`

calculated as follows:
$(i)\ w(c)_{m_1,m_2} = w(c)_{m_1} - w(c)_{m_2}$;
$(ii) w(c)_{m_2,m_1} = w(c)_{m_2} - w(c)_{m_1}$

2.4 Weighing of requirements

In the next step of the AHP methodology the requirements concerning the potential matching approaches in the context of the task or application specification must be compared and weighed. This means that for each level of properties defined within the multilevel characteristic of matching approaches, a pairwise comparison between the sibling nodes (comparison of attributes against attributes, factors against factors and dimensions against dimensions) is to be built. To allow the users to compare and weight their requirements we have developed a tool which supports the processing of the AHP method[10]. The users of the AHP tool must define the requirements of their application concerning their specification of the potential suitable matching approach by weighing of the properties in the pairwise comparison on the scale from 0 to 8 (cf. Tab 1).

Importance	Definition	Explanation
0	equal importance	two criteria (c_1 & c_2) have the same importance
2	moderate importance	c_1 is weakly more relevant than c_2
4	strong importance	c_1 is strongly more relevant than c_2
6	very strong (demonstrated) importance	c_1 is very strongly more relevant than c_2
8	absolute importance	c_1 is absolutely more relevant than c_2
1,3,5,7	intermediate between values (for compromise between the values mentioned above)	to interpolate a compromise judgment because there is not good word to describe it

Table 1. AHP scale

Following the AHP scale Figure 3 illustrates the weighings of the attributes within the factor *formality level*: the weighing means that *formal ontologies* are absolutely more relevant for a given application than *informal* or *semiformal* ontologies.

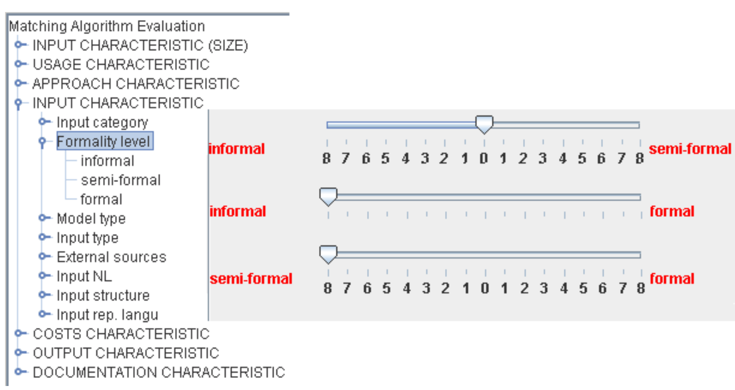


Fig. 3. AHP tool (extract): weighed attributes

[10] Our AHP tool is based on the Java-based AHP tool (JAHP); `http://www2.lifl.fr/~morge/software/JAHP.html`

2.5 Determining suitable matchers

In the last step of the AHP approach the final result needs to be calculated, i.e. the alternative matching approaches have to be ranked regarding their suitability w.r.t to the application requirements defined before. The decision regarding the determination of the relevant matching approaches is based on the ranking $r(goal)$ of a matcher alternative m. The ranking reflects the global importance of the approach according to the alternative weightings described in Section 2.3 and criteria ($crit$) weightings briefly stated in Section 2.4 and is calculated as followed:

$$c_{crit} = \{n|n \text{ child of } crit\}$$

$$r(crit) = \begin{cases} |\text{getWeight}(m, crit)|, & \text{if crit is at lowest hierarchy level} \\ \sum\limits_{n \in c_{crit}} r(n) \cdot |\text{getWeight}(m, n)|, & \text{otherwise} \end{cases}$$

The higher a matcher alterative m is weighted for various criteria, with each criteria weighted with respect to the users requirements, the higher the priority of the particular approach in the entire ranking. Following this weighting process the AHP tool supports the creation of a ranking of the alternatives that depends upon the multilevel characteristic of matching approaches, weightings of these characteristics as well as weightings of the alternatives that show the priority of each alternative for the goal defined.

3 Applying the AHP Approach

The first step of the evaluation dedicated to the global relevance of the a-priori multilevel characteristic of matching approaches was conducted during the questioning of domain experts (cf. Sec. 2.2). The remaining aspects of the characteristic are directly related to the usage of the methodology in real-world situations and to the accuracy of its predictions. Therefore case studies are to be applied in a second step of the evaluation on the a-posteriori model resulting from the adaptation of the preliminary one.

To be able to significantly evaluate our AHP-based approach against the real world matching case studies, we need statements regarding the “real” suitability of different matchers, which consequently means that our case studies should satisfy (at least the first five of) the following requirements:(i) different matchers are to be tested on the same input sources; (ii) matching results or the ranking of the matchers regarding their suitability for the particular sources must be available; (iii) matching results must be approved; (iv) sources, which have been matched, must be specified; (v) some information regarding the desired matcher must be given; (vi) information is required to specify if some additional sources e.g. dictionary should be used; (vii) certain details w.r.t required matcher usage (like the approach will be used for sources integration) are needed; (viii) information about needed matcher output must be specified e.g. matcher cardinality; (ix) information concerning the matcher documentation, e.g. the availability of examples, as well as (x) specification of the importance of the matcher costs e.g.

costs of the matcher licence should be available. In general it is true that, the more information available regarding the case studies, then the better the prediction of our methodology can be tested. Taking into account the requirements mentioned above we have found such use cases in the context of the *Ontology Alignment Evaluation Initiative (OAEI)* [11], which is a coordinated international initiative whose aim is to establish a consensus for evaluation of available methods for semantic matching and ontology integration. A series of evaluation campaigns has been conducted since 2004[12] to assess strengths and weaknesses of existing alignment/matching systems, to compare the performance of different techniques, to improve evaluation techniques as well as to help improve the ontology alignment/matching approaches. During the campaigns the participants sampled their matchers on the test cases provided by the contest organizers, which at the end rank matchers based on their suitability for a particular case. Since the goal of our methodology has been already defined in the previous section and the decision hierarchy regarding matcher suitability has been built (cf. Sec. 2.1, 2.2 respectively), the missing link in the process of matcher selection is, on the one hand, the information about the matcher approaches (cf. Sec. 2.3) and, on the other hand, the weighing of requirements (cf. Sec. 2.4). In order to collect information about the matching approaches presented in the OAEI contests, we asked the corresponding matcher developers to fill out our questionnaire[13].
In the following sections we briefly describe how we have applied our methodology to two case studies from the OAEI 2006 Campaign, and in particular, how we have specified the requirements regarding the suitable matchers using the a-posteriori multilevel characteristic of matching approaches and the AHP scale. Furthermore, we discuss the corresponding matcher raking delivered by the AHP-based approach and compare them with the results obtained during the OAEI 2006 Campaign.

3.1 Medical Ontologies

One of the test cases during the OAEI 2006 Campaign was the anatomy real world case[14] covering the domain of human anatomy and consisting of two ontologies: the Foundational Model of Anatomy[15] and the OpenGalen Anatomy Model[16]. To define the requirements of the application that may be built, we have analyzed the available information regarding the two given ontologies along with the restrictions regarding the suitable matching approaches. In order to compare the application requirements, we first need to "translate" each part of

[11] `http://oaei.ontologymatching.org`
[12] OAEI 2004 Campaign: `http://oaei.ontologymatching.org/2004/Contest/`
OAEI 2005 Campaign: `http://oaei.ontologymatching.org/2005/`
OAEI 2006 Campaign: `http://oaei.ontologymatching.org/2006/`
[13] We would like to thank all developers who have filled out our questionnaire
[14] `http://oaei.ontologymatching.org/2006/anatomy/`
[15] `http://sig.biostr.washington.edu/projects/fm/AboutFM.html`
[16] `http://www.opengalen.org/`

the requirement description into the corresponding terms from the developed multilevel characteristic of matching approaches.

Description from text	**Multilevel characteristic of matching approaches notation**
General information	
ontologies	input characteristic: input category: ontology
large ontologies	input characteristic: input size: **large** input characteristic: input size: **extra large**
very large models	input characteristic: input size: **large** input characteristic: input size: **extra large**
owl models	input characteristic: input category: ontology input characteristic :input formality level: formal ontology
extensive class hierarchies	input characteristic: input structure: tree structure input characteristic: input size: number of concepts: **large** input characteristic: input size: number of concepts: **extra large**
thousands of classes	input characteristic: input category: input size: **extra large** input characteristic: input size: input size: **large** input characteristic: input size: number of concepts: **large** input characteristic: input size: number of concepts: **extra large**
different views on the domain	input characteristic: input model type: domain ontology
complex relationships	input characteristic: input structure: heterogeneous relations
number of different relations	input characteristic: input structure: heterogeneous relations input characteristic: input size: number of relations: small input characteristic: input size: number of relations: medium
classes . . . (**large ontologies**)	input characteristic: input category: number of concepts: **large** input characteristic: input size: number of concepts: **extra large**
relations	input characteristic: input size: number of relations: small input characteristic: input size: number of relation: medium
alignment between two ontologies	input characteristic: input size: number of ontologies: two
any information in the two models can be used	input characteristic: external sources: domain specific resources
it is allowed to use background knowledge	input characteristic: external sources: domain specific resources
limited use of axioms	input characteristic: input size: number of axioms: small
background knowledge, that has not specifically been created for the alignment tasks	(NO) input characteristic: external sources: previous matching decision (NO) input characteristic: external sources: training matches (NO) input characteristic: external sources: miss-match information (NO) input characteristic: external sources: matching rules
other medical terminologies	input characteristic: external sources: domain specific resources
medical dictionaries	input characteristic: external sources: dictionary
document sets	input characteristic: external sources: domain specific resources
Foundational Model of Anatomy	
owl ontology	input characteristic: input category: ontology input characteristic: input formality level: formal ontology
class hierarchy	input characteristic: input structure: tree structure
relations between classes	input characteristic: input size: number of relations: medium
free text documentation	input characteristic: input size: domain specific resources
synonyms	input characteristic: external sources: domain specific resources
names in different languages	input characteristic: input natural language (nl): many languages input characteristic: input natural language (nl): nl-independent
OpenGalen Anatomy Model	
owl ontology	input characteristic: input category: ontology input characteristic: input formality level: formal ontology
big concept hierarchy	input characteristic: input size: number of concepts: **large** input characteristic: input size: number of concepts: **extra large**
relations between concepts	input characteristic: input category: number of relations: small input characteristic: input size: number of relations: medium

Table 2. Translation of requirements into notation of the AHP-methodology

In Table 2 we have outlined the "translation" of the requirements regarding the input sources (the given anatomy ontologies) of the potential matching approach: if we found e.g. **"owl models"** in the description of the anatomy sources we annotated it as `input characteristic:input category:ontology` and `input characteristic:input formality level:formal ontology`. In other words, the input sources are `ontologies`, and in the strict sense, they are `formal ontologies`. In the case of a term **"thousands of classes"** we translated it into (i)`input characteristic:input size:extra large`, (ii)`input characteristic:input size: large`, (iii)`input characteristic:input size: number of concepts: large`, and (iv)`input characteristic:input category:number of concepts: extra large`, which means that the potential matcher must deal with *large* (up to 1000 primitives) and *extra large sources* (over 1000 primitives) containing *large* (up to 1000 concepts) or *extra large* number of concepts (over 1000 concepts).

After we have isolated the requirements and annotated them using the multilevel characteristics we need to specify the importance of each feature using the AHP scale for pairwise comparisons between sibling nodes. Following requirements regarding the suitable matcher from multilevel notation of the anatomy case study, it becomes obvious that one of the essential features is the size (large or extra large) of the sources to be matched. This is reflected in a very high rating of the characteristics related to the size of incoming sources. Therefore this means that the suitable matchers *must* be capable of dealing with inputs of such magnitude. Figure 4 shows the weighing of the attributes: *small*, *medium*, *large* and *extra large* within the factor *ontology size* to provide an insight into the way properties describing the anatomy case studies are ranked. The process of comparison and weighing of each characteristic pair is however beyond the scope of this paper.

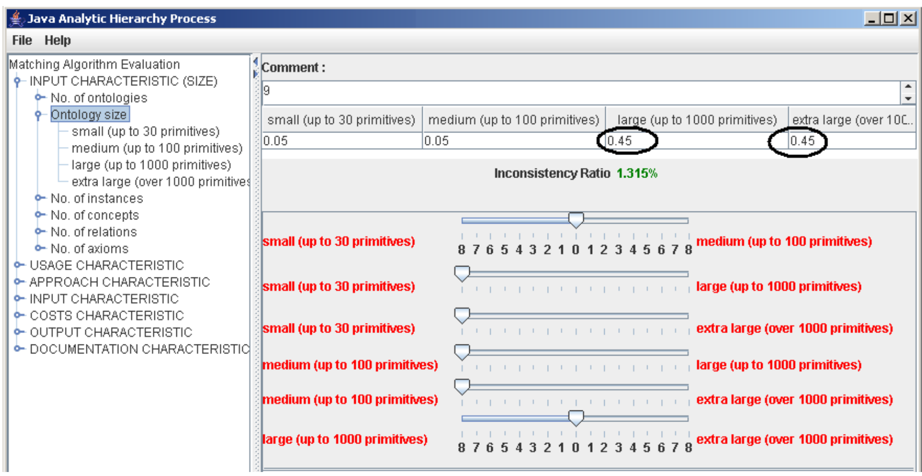
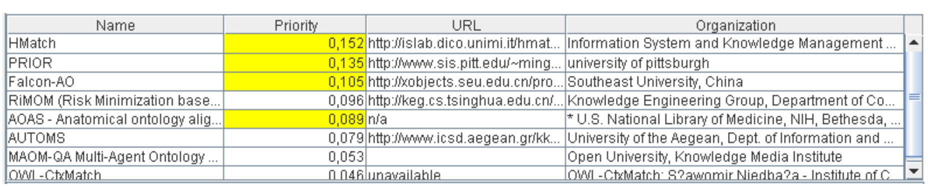


Fig. 4. Weighting of the attributes within the factor "ontology size"

AHP-based results

The last step of the AHP-based methodology for matcher selection is the calculation of the final result. The AHP result is a list of matching algorithms ranked according to their suitability w.r.t the set of requirements defined by the anatomy case study (cf. Fig. 5).



Name	Priority	URL	Organization
HMatch	0,152	http://islab.dico.unimi.it/hmat...	Information System and Knowledge Management ...
PRIOR	0,135	http://www.sis.pitt.edu/~ming...	university of pittsburgh
Falcon-AO	0,105	http://xobjects.seu.edu.cn/pro...	Southeast University, China
RiMOM (Risk Minimization base...	0,096	http://keg.cs.tsinghua.edu.cn/...	Knowledge Engineering Group, Department of Co...
AOAS - Anatomical ontology alig...	0,089	n/a	* U.S. National Library of Medicine, NIH, Bethesda, ...
AUTOMS	0,079	http://www.icsd.aegean.gr/kk...	University of the Aegean, Dept. of Information and ...
MAOM-QA Multi-Agent Ontology ...	0,053		Open University, Knowledge Media Institute
OWL-CtxMatch	0,046	unavailable	OWL-CtxMatch: S?awomir Niedba?a - Institute of C

Fig. 5. Anatomy task: results achieved by the AHP-methodology

Comparison: AHP-methodology vs. OAEI 2006 Campaign

The evaluation of the matching results delivered by the systems that participated in the anatomy tasks have been conducted in a diluted form. The organizers did not attempt at precision or recall of the systems by applying strict measurements but analyzed the result's commonalities and differences including the coverage of the terminology in the ontologies[17]. In other words, the ranking regarding the quality of the matchers within this case study is merely a prediction and indication of tendency and does not provide exact quantitative-based results. Nevertheless we have evaluated our results against the ranking achieved by the OAEI 2006 anatomy task.

The ranking of matchers delivered by the AHP-based methodology is comparable to the results from the OAEI 2006 as shown in Fig. 3. The order of the ISLab HMatch, PRIOR and Falcon approaches is the same in both cases of AHP-based processing as well as real-time execution within the context of the OAEI Campaign 2006. Although during the contest the NIH (AOAS) approach had the highest number of mappings along with a high number of mappings that have been also found in other systems, it achieved only fifth place in the ranking delivered by the AHP-based methodology. However, if we take into account that during the OAEI 2006 the NIH approach had a significant amount of mappings not found in any other system, this result then seems more comprehensible.

Results / Ranking - Anatomy Ontologies				
OAEI Campaign 2006			**AHP methodology**	
Approach	**Terms mapped**	**Ranking**	**Approach**	**Ranking**
NIH (AOAS)	2966	1	-	-
ISLab HMatch	2963	2	ISLab HMatch	1
PRIOR	2590	3	PRIOR	2
Falcon	2204	4	Falcon	3
-	-	-	RiMOM	4
-	-	-	NIH (AOAS)	5

Table 3. Anatomy task: OAEI 2006 Campaign vs. AHP-based results

3.2 Food - SKOS Thesaurus

Another test case during the OAEI 2006 was the food task[18] in which the contestants **automatically** aligned **two** SKOS **thesauri** using relations from the SKOS **mapping vocabulary**. One of the sources was the AGROVOC[19] **thesaurus**, a **multilingual** structured and controlled vocabulary designed to cover the terminology of all the subject fields of agriculture, forestry, fisheries, food and related **domains**. AGROVOC is available in **9 languages**, contains ca. **16,000 terms** and is made up of terms consisting of one or more words representing always one and the same concept. For each term, a word block is displayed showing the **hierarchical relation** to other terms: BT (broader term), NT (narrower term), RT (related term), UF (non-descriptor).

[17] OAEI 2006 results for the anatomy task: `http://oaei.ontologymatching.org/2006/results/`

[18] cf. Food task at `http://oaei.ontologymatching.org/2006//`

[19] `http://www.fao.org/aims/ag_intro.htm`

The second source, the NAL Agricultural Thesaurus[20], is an online vocabulary reference tool for **agricultural and biological terms**. The **thesaurus** is organized into 17 subject categories, indicated by the "Subject Category" designation in the thesaurus and contains ca. **41,000 terms**. The NAL includes **hierarchical**, **equivalence** and **associative relationships** among its concepts.

Although the description of the food test case was not as detailed as the description of the anatomy task we managed to isolate certain issues relevant to the selection of the appropriate matching approach and can be used within the AHP tool. In the brief text above we have marked in bold important information that has been translated into the terms from our multilevel characteristic of matching approaches. For the food task we conducted the same process as for the anatomy task (cf. Tab. 2) and determined, for example, that: (i) the absolute *important attribute* (cf. the AHP scale in Tab. 1) within the very important factor *input category* is the attribute thesaurus, (ii)the *large* and *extra large* attributes have the *absolute importance* in comparison with other attributes of the *ontology size* factor, and (iii) the *absolute important* attribute regarding the *absolute important* matcher *processing* factor (within the dimension "approach characteristic") is *black box paradigm* (For detailed description of the dimensions, factors and attributes see [13]).

AHP-based results

After weighing all the relevant (regarding the information gleamed from the test-case description) dimensions, factors and attributes the AHP tool calculated the results and delivered the ranking of the most suitable matching approaches.

Name	Priority	URL	Organization
HMatch	0,169	http://islab.dico.unimi.it/hm...	Information System and Knowledge Managem...
Falcon-AO	0,113	http://xobjects.seu.edu.cn/p...	Southeast University, China
PRIOR	0,101	http://www.sis.pitt.edu/~min...	university of pittsburgh
RiMOM (Risk Minimization bas...	0,1	http://keg.cs.tsinghua.edu.c...	Knowledge Engineering Group, Department of ...
AUTOMS	0,092	http://www.icsd.aegean.gr/k...	University of the Aegean, Dept. of Information a...
AOAS - Anatomical ontology ali...	0,068	n/a	* U.S. National Library of Medicine, NIH, Bethes...
MAOM-QA Multi-Agent Ontology...	0,059		Open University, Knowledge Media Institute
OWL-CtxMatch	0,041	unavailable	OWL-CtxMatch: S?awomir Niedba?a - Institute

Fig. 6. Food task: results achieved by the AHP-methodology

Comparison: AHP-methodology vs. OAEI 2006 Campaign

Like the medical task in the previous section we also compared the food test case ranking provided by the AHP tool with the results achieved by the OAEI 2006 Campaign. However, in this case, instead of taking into account the number of mapped terms, we considered the "all-round" OAEI 2006 presicion[21] obtained by the participating systems of this task (cf. Fig. 4).

In the AHP selection process the approaches Falcon, Prior and RiMOM achieved the ranks 2, 3 and 4, respectively, though they differ slightly from their scores within the OAEI 2006 Campaign. Nevertheless, this discrepancy can be overlooked due to the fact that the difference between the results obtained by these three approaches in each method is minute. Furthermore, it is important to note

[20] `http://agclass.nal.usda.gov/agt/agt.shtml`

[21] OAEI 2006 results of the food task: `http://oaei.ontologymatching.org/2006/results`

that all approaches [22], which participated within the food task, and therefore have proved their relevance and suitability for this test case, achieved the first four places within the ranking list conducted by the AHP-based methodology.

Results / Ranking - Food sources			
Approach	**"all-round" OAEI-precision**	OAEI ranking	AHP ranking
Falcon	0.83	1	2
RiMOM	0.81	2	4
PRIOR	0.71	3	3
ISLab HMatch	0.61	4	1
COMA++[23]	0.54	5	-

Table 4. Food task: OAEI Campaign 2006 vs. AHP-methodology results

4 Related Work

The matching problem is inherently multicriteria therefore various authors have considered a number of solutions to choosing an adequate matching system. The filling of these criteria can be obtained by the qualitative evaluation of tools as shown before or the quantitative tests like in the *Ontology Alignment Evaluation Initiative*. Once the value for the criteria are known several solutions have been considered to analyze them and oppose them to task-dependent criteria.

In particular all techniques that can be used in information retrieval for aggregating precision and recall have also been used to compare matchers [3]. Since precision and recall are intrinsically different measures, they must be reconciled by using, for example, the F-measure which can both equally balance the precision and recall as well as emphasize only one of them.

Due to the fact that F-measure considers only two criteria, it is neither adequate to describe matching approaches nor choose the appropriate system, a method using weighted linear aggregation has been proposed [5]. In the utilized weighted linear aggregation several criterion can be balanced depending on the application requirements taking into account not only precision and recall measures but also speed and automation. Although, the method has been further promoted in the context of different applications and under consideration of additional attributes [6], it has retained only a relatively small set of criterion and the proposed linear function is not used to compare different systems but merely to tune one particular approach. For this reason both the weighted linear aggregation and the F-measure mentioned before, seem to us not to be a sophisticated way to make a decision regarding suitable matching approaches which depends on multiple criteria.

Some work, which in our opinion is even more related to the research presented in this paper, has been carried out in the context of the *Interoperability Research for Networked Enterprises Applications and Software (INTEROP) Network of Excellence* [11]. INTEROP aims to develope a didactic system, OntoMas[24], to

[22] 8 of 10 developer teams which participated in OAEI 2006 Campaign have filled out our questionnaire; their matchers have been took into account during the processing of our AHP-based methodology

[24] `http://www.polytech.univ-nantes.fr/ontomas/`

assist and teach how to carry out matching. Since the integrated tools strive to help users to find an adequate matching approach for a given task, a particular classification of tools and a characterization of methods have also been developed. Even though the matching tools classification based on [18] is comparable to the one presented in this paper and the positioning of tools within the classification is assessed through questionnaires as in case of the AHP-based methodology, the description of the approaches is much more rudimentary. This basic description that considers only the syntactic aspects of the input ontologies is motivated by the fact that the tool must be usable by novice users who do not know the task in depth. Contrary to our work presented here, the multicriteria decision is based on ad hoc rules, whereby some rules are filters that eliminate unsuitable systems while others increase or decrease the score of the considered methods (usually by one point). Since also this approach is equivalent to an equi-weighted linear aggregation, which we have identified as unsuitable for the matcher selection, as far as we can tell, no other work have considered proved multicriteria decision techniques for "matching matchers to particular matching tasks".

5 Conclusion and Future work

The proposed methodology for the selection of relevant matching approaches adapts the Analytic Hierarchy Process (AHP) to detect the suitable matchers. It is based on multilevel characteristic of matching approaches, which covers features of particular algorithms along with the appropriate incoming sources. Since the evaluation of the AHP-based methodology within the context of the two test cases from OAEI 2006 Campaign reveals that matcher candidates can be ranked regarding their effective suitability for the given set of requirements, the methodology can rapidly enables, for instance, domain experts or Semantic Web-based application developers with little expertise in Ontological Engineering and alignment field to get an overview of existing and, particularly, the most suitable matchers w.r.t their applications requirements. The future work will be dedicated to the collection of further matcher alternatives (with help of the online questionnaire) and the application of the AHP tool into the various Semantic Web scenarios.

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