PersonLink: A Multilingual and Multicultural Ontology Representing Family Relationships

Noura Herradi[1,2], Fayçal Hamdi[1], Elisabeth Métais[1] and Assia Soukane[2]
[1]*Cedric Lab, Conservatoire National des Arts et Métiers (CNAM), Paris, France*
[2]*Ecole Centrale d'Electronique (ECE), Paris, France*

Keywords: Semantic Web, Ontology, Linked Data, Vocabulary, Multicultural, Multilingual, Interpersonal Relationships.

Abstract: Many existing open linked datasets include descriptions of real world persons, with the relationships between them. For some traditional and/or emerging relationships, existing ontologies do not provide the adequate links. This paper represents PersonLink, an ontology that defines rigorously and precisely family relationships, and takes into account the differences that may exist between cultures, including new relationships emerging in our societies nowadays. Moreover, the transition from one culture/language to another one cannot be solved with a simple translation of terms, especially when concepts do not intersect in different languages; thus our solution refers to a multicultural meta-ontology of concepts and associated mechanisms. A validation has been performed on two linked datasets DBpedia and Freebase.

1 INTRODUCTION

In the context of Linked Data (Bizer et al., 2009) (Berners-Lee, 2012), a huge and growing number of data representing persons and relationships between them are published (e.g., data available in DBPedia[1], Freebase[2], Yago[3], etc.). Different ontologies have already been proposed in order to describe and enable sharing family relationships. Some of these ontologies such as FOAF (Brickley and Miller, 2010), Relationship (Davis and Vitiello, 2005), Agrelon (Litz et al., 2012), Bio[4] are widely used. FOAF for example defines these relationships through the predicate "*foaf:knows*" that links together two individuals. However, this representation is very limited because it does not provide more information about the nature (e.g., family, friendship, etc.) of these links. Thus, it is not possible to know what is the real relationship between these two individuals. FOAF relationships have already been extended as we will show in the related works section, but these extensions remain not sufficient. This is because relationships are evolving, both in scientific and cultural dimensions. As a result, many new relationships have emerged and therefore it becomes more complex or impossible to express them with existing ontologies.

[1]http://dbpedia.org/
[2]https://www.freebase.com/
[3]http://www.mpi-inf.mpg.de/yago/
[4]http://vocab.org/bio/0.1/.html

In addition to the lack of precision in the definition of interpersonal relationships in existing vocabularies, an important research issue is added, which is the problem of the language used for this representation which may not necessarily reflect the exact meaning of the term used in another language/culture. Currently, the majority of existing ontologies are in English. We argue that several family relationships cannot be expressed in this language or reversely cannot be translated (samples are given in the motivating examples section). Interesting works have been proposed for translating terms in ontologies (Hellrich and Hahn, 2014). However, a simple translation remains insufficient, since the meanings of the concepts depend not only on the language but also on the culture defining them. Thus, the definition of the concept may be different between cultures.

To deal with this issue, we propose a novel ontology, called PersonLink, that considers the richness of the cultures/languages it represents. For this purpose, we conducted a study to define the interpersonal relationships according to their presence or absence in different cultures/languages. For this study, we chose three languages: French, Arabic and English to show how concepts may differ from one culture to another and even between countries on the same culture. We sought for each interpersonal relationship its concept,

Herradi, N., Hamdi, F., Métais, E. and Soukane, A..
PersonLink: A Multilingual and Multicultural Ontology Representing Family Relationships.
In *Proceedings of the 7th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (IC3K 2015) - Volume 2: KEOD*, pages 147-154
ISBN: 978-989-758-158-8

and if possible, the definition that has been assigned to this concept in the three cultures/languages, as well as the term that has been attributed to this concept in the languages related to these cultures. Note that some translation engines (e.g. wiktionary, google translate, etc.) offer different translations for most terms (e.g. surrogate mother in Arabic), but these translations have no meaning in the target culture.

The paper is organized as follows. In the next section, we present some motivating examples to show relationships differences in three cultures/languages. In section 3 we present our PersonLink ontology and in section 4 experiments that we performed in the context of linked data. In section 5 we present some related works. Finally, we conclude and give some perspectives in section 6.

2 MOTIVATING EXAMPLES

Family links are completely dependent on the culture and the language. Thus, the terms corresponding to the concepts they define depend also on this culture/language.

For instance, the surrogate mother carries the child of a couple who gave its embryos.

- In the United States, there is no federal legislation for Surrogacy. Each state has its own rules, based on jurisprudence. So the Surrogacy is licensed in 14 states. The term used in English for this mother is "*Surrogate*";
- In France, the law n^{o} 94-653 of 29 July 1994 on the respect of the human body explicitly, prohibits surrogacy. The term used in French for this mother is "*Mère porteuse*";
- In Arabic countries, there is no law authorizing or prohibiting the Surrogacy, and such a practice remains marginal, due to the weight of tradition. In Arabic, this relationship does not exist and there is no term to express it.

Another example is about some concepts that may not exist in certain languages, for example "*Godmother*" does not exist in some cultures/languages. Even if concepts are sometimes similar in different languages/cultures, they may differ in their constraints. For instance, depending on the culture, the "spouse" relationship may be defined between 1 man and 1 woman, or between 1 man and several women, etc. Moreover, the accuracy in the definitions of concepts can change from one language/culture to another. We take for example the cousinship relationship. In English the term used to define a cousin relationship is "*cousin of*". In French a degree of precision is added to this definition, which is the gender, so there are two terms defining the relationship: "*cousin*" for male and "*cousine*" for female. In Arabic, another layer of precision joins the last one, which defines the cousin (male or female) from the side of the mother or the father. So, there are eight terms defining the relationship of cousinship in Arabic:

- "إِبن عم ل": the cousin (male), son of their father's brother;
- "إِبن خَال ل": the cousin (male), son of their mother's brother;
- "إِبن خَالة ل": the cousin (male), son of their mother's sister;
- "إِبن عمة ل": the cousin (female), son of their father's sister;
- "إِبنة عم ل": the cousin (female), daughter of their father's brother;
- "إِبنة خَال ل": the cousin (female), daughter of their mother's brother;
- "إِبنة خَالة ل": the cousin (female), daughter of their mother's sister;
- "إِبنة عمة ل": the cousin (female), daughter of their father's sister.

Thus, It is not possible to carry out a translation of terms to switch from a language/culture to another one, since the concept could not exist or could have another definition in the target culture.

3 THE PersonLink ONTOLOGY

Our main objective is to represent interpersonal relationships in a precise manner and in different cultures/languages in order to be both generic and adaptable to users. That is why the PersonLink ontology represents and defines the concepts according to the considered culture, and expresses them by using terms of the appropriate language. In order to do so, the first step consists in considering culture in the definition of the concept. For each culture, we look at whether the concept exists or not. If it exists, we describe it using its definition in this culture/language. So, in the ontology, only if the concept exists in the culture, a term is assigned to it using the language related to this culture. We obtain as a result a kind of sparse ontology that we have called "*lace* ontology" because it contains many null values as we show in Fig. 1. Then, from this precise definition of concepts related to culture, we proceed to the formal representation of these relationships using the fragments of OWL2 (Hitzler et al., 2012) corresponding to the description logic $\mathcal{SROIQ}(\mathcal{D})$ (Horrocks et al., 2006). Finally, we enrich these relationships by a set of DL-safe rules (Motik et al., 2005) (ensuring decidability) to have more inference possibilities.

3.1 The Lace Meta-ontology

The problem that arises in the representation of properties that describe interpersonal relationships, lies in the description of the property in three different languages/cultures. Taking the example of the property defining cousins. In French there exist two specific terms that represent this relationship according to the gender of cousin and eight possible terms in Arabic capturing in addition to the gender of the cousin, the mother/father lineage as well as its gender. However only a generic term exists to define this relationship in the English language/culture whereas this generic term does not exist in the French and Arabic cultures/languages.

In the PersonLink ontology, we define each concept with a unique number, so each number represents a concept defining a relationship. This will allow us to have a hierarchy with multiple levels of accuracy which combines different languages/cultures. We can move from one concept to another in the level of accuracy (vertically), and therefore from a culture/language to another. Besides, the true meaning of the concept represented by a term for each language (obviously, if it exists in the associated culture) is preserved. We get as a result a *lace* meta-ontology (because of the null values it may have) of concepts with their representations in different cultures/languages.

The concepts represented in the lace meta-ontology for the cousinhood relationship of a person, shown in Fig. 1, have the following definitions:

- *Concept* #2: the descendant (regardless of gender) of the uncle or of the aunt (both mother's or father's side);
- *Concept* #2.1: the female descendant of the uncle or of the aunt (both mother's or father's side);
- *Concept* #2.2: the male descendant of the uncle or of the aunt (both mother's or father's side);
- *Concept* #2.1.1: the female descendant of the mother's male sibling;
- *Concept* #2.1.2: the female descendant of the father's male sibling;
- *Concept* #2.1.3: the female descendant of the mother's female sibling;
- *Concept* #2.1.4: the female descendant of the father's female sibling;
- *Concept* #2.2.1: the male descendant of the mother's male sibling;
- *Concept* #2.2.2: the male descendant of the father's male sibling;
- *Concept* #2.2.3: the male descendant of the mother's female sibling;
- *Concept* #2.2.4: the male descendant of the father's female sibling.

3.2 The Translation Algorithm

The main objective of our PersonLink ontology is to express rigorously family relationships by considering the culture/language aspect. Nevertheless, note that to express a source relationship in a different culture, and in order to get the term(s) used to express this relationship in the target related language, we apply an algorithm using our meta-ontology. Given a source language $L_{\mathcal{S}}$ and a target language $L_{\mathcal{T}}$, given $C_{\mathcal{S}}$ a concept in the source language $L_{\mathcal{S}}$ and $C_{\mathcal{L}}$ a concept in the target language $L_{\mathcal{T}}$, and given $T_{\mathcal{S}}$ a term in the source language $L_{\mathcal{S}}$ and $T_{\mathcal{T}}$ a term in the target language $L_{\mathcal{T}}$. We proceed by cases:

- Case 1: $T_{\mathcal{T}} \neq \emptyset$, which means that in our meta-ontology, the term corresponding to the concept exists in the target language $L_{\mathcal{T}}$. So we use it;
- Case 2: $T_{\mathcal{T}} = \emptyset$, which means that in our meta-ontology, the term corresponding to the concept $C_{\mathcal{S}}$ does not exist in the target language $L_{\mathcal{T}}$:
  - We go down in the meta-ontology to find a more specific concept C_I defining this relationship in the target language $L_{\mathcal{T}}$ (that may imply to get further information about the person, e.g. the gender of the person) and we use the term(s) associated to this C_I to express the $T_{\mathcal{T}}$ in the $L_{\mathcal{T}}$;
  - If a more specific concept C_I does not exist, we go up in the meta-ontology to find the first generic concept $C_{\mathcal{J}}$ and we use the term corresponding to this $C_{\mathcal{J}}$ to express this relationship.

For our example of cousinhood, using the algorithm based on the *lace* meta-ontology, we can express the "*cousineDe*" (female cousin) relationship in English. We note that for this relationship, the $L_{\mathcal{S}} = (Fr)$ and $L_{\mathcal{T}} = (En)$. In our meta-ontology, we have $T_{\mathcal{T}} = \emptyset$, so we go down in the meta-ontology to look for the first more specific concept C_I, we found it, but the $T_{\mathcal{T}}$ is still $= \emptyset$ (we are then in the case 2 of the translation algorithm). We look, in this case, for

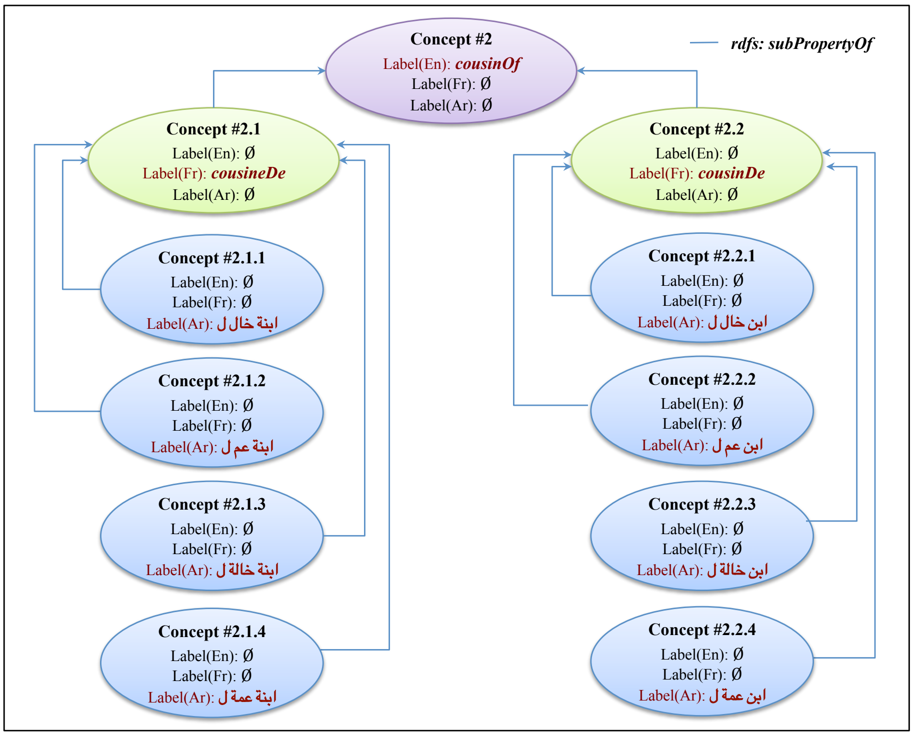

Figure 1: Excerpt of the meta-ontology for cousinhood in English, French, and Arabic.

Algorithm 1: Translation algorithm.

$C_\mathcal{S} \mathrel{\widehat{=}} T_\mathcal{S} \mid T_\mathcal{S} \equiv label(C_\mathcal{S}, L_\mathcal{S})$
$T_\mathcal{T} = T_\mathcal{T} + \{label(C_\mathcal{S}, L_\mathcal{T})\}$
if $T_\mathcal{T} = \emptyset$ **then**
  for all $C_\mathcal{I} \mid C_\mathcal{I} \sqsubseteq C_\mathcal{S}$ **do**
    $T_\mathcal{T} = T_\mathcal{T} + \{label(C_\mathcal{I}, L_\mathcal{T})\}$
    if $T_\mathcal{T} = \emptyset$ **then**
      $T_\mathcal{T} = T_\mathcal{T} + \{label(C_\mathcal{J}, L_\mathcal{T})\} \mid C_\mathcal{S} \sqsubseteq C_\mathcal{J}$

the first generic concept $C_\mathcal{J}$ used to express this relationship, and we use the term corresponding to it, which is $T_\mathcal{T} = cousinOf$.

3.3 Formal Definition of the Relationships

Interpersonal relationships in the PersonLink ontology are represented in a structured way with the OWL2 language that corresponds to the description logic $\mathcal{SROIQ}(\mathcal{D})$. The use of OWL2 is privileged because it provides a high expressiveness and allows us to represent relationships that we were not able to represent in OWL1. In addition, OWL2, with this logic description, allows semantic reasoners to verify the consistency of data, to derive new knowledge or to extract information already present. Besides, the reasoning in OWL2 is complete and decidable.

In predicate logic, the hierarchy represented in Fig. 1 means that:

$$2(?x,?y) \Leftrightarrow 2.1(?x,?y) \vee 2.2(?x,?y)$$
$$\textbf{and } 2.1(?x,?y) \Leftrightarrow 2.1.1(?x,?y) \vee 2.1.2(?x,?y) \vee 2.1.3(?x,?y) \vee 2.1.4(?x,?y)$$
$$\textbf{and } 2.2(?x,?y) \Leftrightarrow 2.2.1(?x,?y) \vee 2.2.2(?x,?y) \vee 2.2.3(?x,?y) \vee 2.2.4(?x,?y)$$

This representation means that the most specific concept implies automatically the generic one, for example whenever (x *cousinDe* y), it implies that (x *cousinOf* y): $2.2(?x,?y) \Rightarrow 2(?x,?y)$ and also whenever (z إبنة عم ل w), we deduce that (z *cousineDe* w) and (z *cousinOf* w) as following:

$$2.1.2(?z,?w) \Rightarrow 2.1(?z,?w) \textbf{ and } 2.1.2(?z,?w) \Rightarrow 2(?z,?w)$$

In addition, in order to have more precision about the relationship going from the most generic concept ("*cousinOf*" in our example) to a specific one ("*cousineDe*") (which means: a female cousin), we have to get more information about the instance (female in our example) from the knowledge base. The specific concept would be inferred from the SWRL (DL-Safe) rules that we would have previously created:

$$2(?x,?y) \wedge Female(?x) \Rightarrow 2.1(?x,?y)$$

Note that we need the information $Female(?x)$ to deduce that the type of the relationship $2(?x,?y)$

Table 1: Entities having parent, child, and sibling relationships in DBpedia.

Relationship	DBpedia Relationship	Number of Entities
Parent	dbpedia-owl:parent	1675
Child	dbpprop:children	5117
Sibling	dbprop:sibling	4
Sibling's child	–	0
Cousin	–	0

Table 2: Entities having parent, child, and sibling relationships in Freebase.

Relationship	Freebase Relationship	Number of Entities
Parent	/people/person/parents	2000
Child	/people/person/children	5155
Sibling	/people/sibling_relationship/sibling	1815
Sibling's child	–	0
Cousin	–	0

("*cousinOf*") is, in this case, the $2.1(?x, ?y)$ relationship (in French "*cousineDe*"). However, if we want to get a more specific concept for this relationship of cousinhood (for example: in Arabic z إبنة عم ل w) (which means that the instance is a female cousin on the father's side), in this case we need to get further information that will indicate, in addition of the gender information, if the person is a cousin on the side of the father or on the mother's one. This information, could be deduced by using the DL-Safe rules previously defined. It is worth noting that, for some relationships, the application of SWRL (DL-Safe) rules is not necessary, because OWL2 allows us to deduce information through the objectPropertyChain function as following:

subPropertyOf(objectPropertyChain(:sonOf :siblingOf :parentOf):cousinOf)

The whole PersonLink ontology is available and published in a dereferenceable manner[5] (and thus, would be referenced by the Linked Open Vocabulary) at: http://cedric.cnam.fr/~hamdif/ontologies/PersonLink.owl

4 VALIDATION

To test the validity of our reasoning and translating mechanism, we have taken as a sample persons described in the context of the Linked Open Data (LOD). We chose as datasets Freebase, which is a large collaborative knowledge base built mainly from data provided by its community members and DBPedia, which is a knowledge base built from extracted and structured data from Wikipedia. We show as relationship example, the cousinship relation presented in section 3. First, we searched in the Freebase and DBPedia ontologies properties that could express the "*cousinOf*" relationship. In the current versions, none of Freebase or DBpedia uses include properties to express this kind of relationship. However, we found other relationships (parental and sibling) that, combined, could be used to express implicitly the cousinship relation. Hence, we extract from a subset (due to the user queries limitations) of DBpedia and Freebase, entities that are linked to each other by a parent and/or sibling relationships, as well as the relationships themselves. This extraction process is done automatically using scripts running SPARQL (SPARQL Protocol And RDF Query Language) and MQL (Metaweb Query Language) queries. The obtained results are presented in Table 1 and Table 2.

From DBpedia, we extracted 1675 entities that, having as type "person" and linked to other ones by the "parent" relationship. We extracted also 5117 persons having children and 4 having siblings. However, as we explained above, no sibling's child or cousin relationships were found. From Freebase, we extracted 2000 entities "person" that have parent relationships. From theses entities, 5155 children and 1815 are generated. There too, no sibling's child nor cousin relationships were found.

In the result of these tests, we note that the sibling's children and the person children could be candidates to be cousins. Thus, we integrated entities and relationships that we obtained, on the PersonLink ontology to populate our knowledge base, then we applied automated reasoning to get new relationships. For DBpedia, the reasoner produces as expected "*cousinOf*" relationships. The results are presented in Table 3.

[5]http://www.w3.org/TR/swbp-vocab-pub/

Table 3: Inferred “cousinOf” relationships.

PersonLink Relationship	DBpedia Entities	Freebase Entities
cousinOf	3	16426

Table 4: Inferred relationships using Freebase properties.

FreeBase Relationship	Number of Entities	Inferred Relationship	Number of Entities	Null gender value
/people/person/parents	2000	*motherOf*	717	8
		fatherOf	1275	
/people/person/children	5155	*daughterOf*	2100	269
		sonOf	2786	
–	5117	*nieceOf*	2069	230
		nephewOf	2818	

In the case of Freebase, the reasoner is able to infer much more rigorous relationships. For instance, the “*fatherOf*” and “*motherOf*” relationships are inferred by exploiting the “parent” and “gender” properties describing Freebase entities (DBpedia does not provide these kind of properties). The “*daughterOf*” and “*sonOf*” relationships are inferred by exploiting the “children” and “gender” properties. We note that there are some people with null gender values (this is because data available on these datasets are not always complete). The results we got by reasoning on data are presented in Table 4.

Among the 2000 Freebase person, 717 could be represented using the “*motherOf*” relationship and 1275 the “*fatherOf*” one. These results show that our PersonLink ontology has the particularity of using properties much more expressive than those present in DBpedia or Freebase.

We also proceeded to translate relationships using our translation algorithm based on the lace meta-ontology showed in Fig. 1. So, for the inferred Freebase “*cousinOf*” relationships (cf. table 3), the algorithm specifies, in the case of french translation, if this cousin is a “*cousineDe*” (female cousin) or a “*cousinDe*” (male cousin). The results we got for this case are gathered in Table 5. This table, showed that among 16426 “*cousinOf*”, the translation algorithm found 5986 relationships of “*cousinDe*” (male cousin) and 4116 “*cousineDe*” relationships (female cousin) in French. 6324 represents the number of cousins that we cannot specify if they are male or females, due to the absence of the gender property in their descriptions.

Table 5: “cousinOf” relationships translated to the French language.

cousinOf (En)	16426
cousinDe (Fr)	5986
cousineDe (Fr)	4116
null gender value	6324

5 RELATED WORKS

Different ontologies have been proposed to describe family relationships in the web. The most famous one is FOAF (Brickley and Miller, 2010) which defines relationships between people through the predicate “*foaf:knows*” that links together two individuals. However, this representation is very limited because it does not provide the nature (e.g., family, friendship, etc.) of these links. That’s why some extensions have been proposed for this property. For instance, the Relationship[6] ontology (Davis and Vitiello, 2005) which extends FOAF by introducing several sub-properties to the property “*foaf:knows*”, that provide some terms representing parenthood, childhood, siblinghood and a generic term representing marriage “*SpouseOf*”. The Agrelon (Agent Relationship Ontology)[7] ontology (Litz et al., 2012), designed in the context of the CONTENTUS Project (Nandzik et al., 2013), presents a more precise set of terms that distinguish between the different types of relationships extending the property “*knows*” of FOAF. For example, siblings and half siblings can be distinguished by the two distinct properties “*hasSibling*” and “*hasHalfSibling*”. The Relationship and Agrelon ontologies bring more clarity to the relationships. Nevertheless, they remain very generic, lack precision, and they do not support multiculturalism. The Bio[8] ontology, aims to describe biographical information about people. In this ontol-

[6] http://vocab.org/relationship/.html

[7] http://www.contentus-projekt.de/fileadmin/download/agrelon.owl

[8] http://vocab.org/bio/0.1/.html

Table 6: Excerpt of the comparison table of the representation of certain family relationships in different existing ontologies.

Family Relationship	FOAF	Relationship	AgRelOn	Bio
Surrogate Mother	*knows*	*parentOf*	*has parent*	*mother*
Half Brother	*knows*	/	*has half sibling*	/
common-law wife	*knows*	*live with*	*has cohabitee*	/

ogy, there are some relationships that may be interesting, such as "*Father*", "*Mother*", etc. This ontology gives more precise definitions than the two previous ones. However, in addition of being incomplete and not multilingual, it is intended to store events and not links. Therefore, "Bio" can not be used to interpret interpersonal relationships linking different individuals.

The table 6 shows an excerpt of the comparison between the four previously mentioned ontologies, depending on how they express different relationships. Generally, these ontologies use generic properties (e.g. parentOf, hasParent etc. for the "Surrogate mother" concept), also when there is no generic property to define these relationships, the existing ontologies use approximative meanings' properties (e.g. Agrelon:hasCohabitee when talking about common-law wives). Moreover, they offer very short and generic definitions to describe interpersonal relationships whereas this kind of relationships has to be rigorously described to give exact meaning when displaying information about interpersonal relationships.

In addition to the lack of precision, the majority of existing ontologies about family relationships are in English. However, ontologies should be used in different cultures. Some projects aim to solve the issue related to the "syntactic" translation (Chalupsky, 2000) (Dou et al., 2005). But as we saw with motivating examples, a literal translation is not always relevant. Besides that, other important studies targeted the "cultural" translation issue, like the recent European project MONNET which has proposed a model named LEMON to deal with this issue. The authors of this work (Montiel-Ponsoda et al., 2011) developed a translation module which is intended to link between concepts coming from various language/culture ontologies. First, they provide a literary translation of the concept in the target language. Then they seek its equivalent in the associated target culture, when the term used in the target culture is different from the literary given one, they link between the source concept and its equivalent one by using a "CulturalEquivalentTranslation" class. But this solution does not consider the absence of the equivalent term representing the concept in the target culture and still gives a literal translation to the concept even if it may be incorrect since we consider culture and language are completely bound when defining interpersonal relationships. Moreover, the different languages are not merged into a single ontology; their solution is based on ontology alignment including cultural equivalences.

Some ontologies have been introduced with the purpose of structuring web resources including description of persons. YAGO (Suchanek et al., 2007) is an ontology derived from Wikipedia, WordNet and GeoNames. Its goal is to structure Wikipedia as a linked Database. Thus, an important sub-thematic of YAGO concerns relationships between persons. However, all the relationships are expressed in English and are limited regarding expressiveness. Freebase and DBpedia are two projects similar to YAGO (except that Freebase gathers its information from the community of users), and thus present the same issue.

6 CONCLUSION AND FUTURE WORKS

In this paper we have presented a new ontology called PersonLink, that enables users and applications to represent interpersonal relationships. PersonLink provides a precise definition for each relationship and takes into consideration the culture/language aspect. We have introduced the notion of lace meta-ontology that facilitates the expression (by refinement of concepts and specification of contraints), in multiple cultures/languages of each relationship and allows to switch between languages and find the right terms expressing the relationships. The particularities of our solution compared to usual ontology translation methods are on the one hand that it merges all concepts and terms in a single ontology rather than providing ontology alignments and on the other hand the translation is perfectly reversible. This solution is particularly suitable for our domain application where concepts are very closed but not similar in the different languages, and depend on the context (culture, law, gender of the person, etc.).
A set of inference rules allows to deduce new links from the given ones, and to check the consistency of inputs. The current version of PersonLink includes 3 classes (Person, Male and Female), 86 properties, and 582 SWRL rules.

We have experimented the reasoning mechanism and the translation algorithm of the PersonLink ontology in the context of Linked Open data. Tests conducted on DBpedia and Freebase datasets show that the use of PersonLink enables inferring much more rigorous relationships than those already present in these datasets.

As the PersonLink ontology is available and published in a dereferenceable manner and will be referenced by the Linked Open Vocabulary) it can be used by any Linked Data publishers who need family relationships and should comply with the W3C best practices. In our laboratory, two on-going applications are using the PersonLink ontology:

- The first one is a memory prosthesis called CAPTAIN MEMO devoted to persons with memory impairments. This application need to store all family relationships of the owner of the prosthesis. Thus, an ontology with a fine-grained relationships definitions is mandatory to allow storing all possible links. Moreover, the reasoning mechanism contributes to check the consistency of the inputs, that is a great help, especially for persons with memory impairments and cognitive discordances.
- The second one aims to integrate PersonLink in the SIGIL electronic books editing system. SIGIL allows to edit an electronic book in the Epub format. PersonLink can structure the metadata concerning the genealogy of main characters. Concerning this application, the main interest of PersonLink is its availability to switch from one language to another, by providing links corresponding to different cultures and to ensure a smart translation.

Future work will be mainly devoted to enrich the ontology with convivial links between people (neighbours, friends, care givers, etc.) and to take into account time variance.

REFERENCES

Berners-Lee, T. (2012). Design Issues: Linked Data. Retrieved March 1, 2012, from http://www.w3.org/DesignIssues/LinkedData.html.

Bizer, C., Heath, T., and Berners-Lee, T. (2009). Linked data - the story so far. *Int. J. Semantic Web Inf. Syst.*, 5(3):1–22.

Brickley, D. and Miller, L. (2010). FOAF Vocabulary Specification 0.97. Namespace document.

Chalupsky, H. (2000). Ontomorph: A translation system for symbolic knowledge. In Cohn, A. G., Giunchiglia, F., and Selman, B., editors, *KR 2000, Principles of Knowledge Representation and Reasoning Proceedings of the Seventh International Conference, Breckenridge, Colorado, USA, April 11-15, 2000.*, pages 471–482. Morgan Kaufmann.

Davis, I. and Vitiello, E. J. (2005). RELATIONSHIP: A vocabulary for describing relationships between people. Technical report, vocab.org.

Dou, D., McDermott, D. V., and Qi, P. (2005). Ontology translation on the semantic web. *J. Data Semantics*, 3360:35–57.

Hellrich, J. and Hahn, U. (2014). Enhancing multilingual biomedical terminologies via machine translation from parallel corpora. In Métais, E., Roche, M., and Teisseire, M., editors, *NLDB*, volume 8455 of *Lecture Notes in Computer Science*, pages 9–20. Springer.

Hitzler, P., Krötzsch, M., Parsia, B., Patel-Schneider, P. F., and Rudolph, S. (2012). OWL 2 Web Ontology Language Primer (Second Edition). W3C Recommendation, World Wide Web Consortium.

Horrocks, I., Kutz, O., and Sattler, U. (2006). The Even More Irresistible SROIQ. In Doherty, P., Mylopoulos, J., and Welty, C. A., editors, *KR*, pages 57–67. AAAI Press.

Litz, B., Löhden, A., Hannemann, J., and Svensson, L. (2012). Agrelon - an agent relationship ontology. In Dodero, J. M., Palomo-Duarte, M., and Karampiperis, P., editors, *MTSR*, volume 343 of *Communications in Computer and Information Science*, pages 202–213. Springer.

Montiel-Ponsoda, E., Gracia, J., de Cea, G. A., and Gómez-Pérez, A. (2011). Representing translations on the semantic web. In Montiel-Ponsoda, E., McCrae, J., Buitelaar, P., and Cimiano, P., editors, *Proceedings of the 2nd International Workshop on the Multilingual Semantic Web, Bonn, Germany, October 23, 2011*, volume 775 of *CEUR Workshop Proceedings*, pages 25–37. CEUR-WS.org.

Motik, B., Sattler, U., and Studer, R. (2005). Query Answering for OWL-DL with rules. *J. Web Sem.*, 3(1):41–60.

Nandzik, J., Litz, B., Flores-Herr, N., Löhden, A., Konya, I. V., Baum, D., Bergholz, A., Schönfuß, D., Fey, C., Osterhoff, J., Waitelonis, J., Sack, H., Köhler, R., and Ndjiki-Nya, P. (2013). Contentus - technologies for next generation multimedia libraries - automatic multimedia processing for semantic search. *Multimedia Tools Appl.*, 63(2):287–329.

Suchanek, F. M., Kasneci, G., and Weikum, G. (2007). Yago: A core of semantic knowledge. In *Proceedings of the 16th International Conference on World Wide Web*, WWW '07, pages 697–706, New York, NY, USA. ACM.