A Structured Evaluation to Assess the Reusability of Models of User Profiles

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Abstract. In the creation of an adaptive mobile personalisation system it is useful to investigate whether existing models are applicable. Such models are usually structured as ontologies. We view existing ontologies from a reuse perspective, and have chosen to specialise the SEQUAL quality framework for evaluation of existing models. SEQUAL has previously been used for the evaluation of modelling languages and approaches, including the evaluation of ontologies. Using the semiotic quality categories in SEQUAL, an evaluation has been made of potential ontologies. The result of the evaluation is that none of the evaluated ontologies satisfies requirements as models that can be reused or built on, and the profile ontology has been created from scratch.

Keywords: Profile, ontologies, reusability, evaluation, quality of models.

1 Introduction

The vision for the next generation Web as the semantic Web [1], is now often combined with Web 2.0 technology to predict Web 3.0. Information is accompanied by metadata about its interpretation, so that more intelligent and more accessible information-based services can be provided. A central component in the semantic Web and its applications is information modelled as ontologies. An ontology can be seen as an explicit representation of a shared conceptualisation [2] that is formal [3], and will encode the semantic knowledge and enable sophisticated services.

The first step of creating an ontology is to define the domain. The next step is to consider reuse of existing ontologies [4], to see if they can be reused as is or as a basis for customisation. Our goal for this work has been to investigate the possibility of reuse or building on ontologies in the domain of personalisation of mobile services. Similar ontologies have been evaluated in [5]. However, this evaluation is not using a structured evaluation framework. A classification of evaluation methods for ontology quality is presented in [6]. Five aspects for ontology quality are mentioned: syntax, vocabulary, structure, population of classes and usage statistics. Existing approaches cover at most three of these. We do not find these five aspects sufficient for the evaluation of reuse of ontologies with regards to the domain an ontology is modelling. Our approach is to specialise the model quality part of the semiotic quality framework SEQUAL [7]. SEQUAL has been used for similar evaluations in a number of related

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areas, such as ontologies [8], ontology languages and tools [9], object-oriented modelling languages [10], goal-models [7], requirements models [11], ontology building methods [12],[13] and interactive models [14]. As in our work, SEQUAL has in these cases been used by specialising the generic framework to the relevant domain and goal of modelling.

The rest of the paper is organised as follows. First, personalisation and needs for the profile ontology are described. Then, the specialisation of SEQUAL is presented. Third, the existing ontologies to be evaluated are described. Applying SEQUAL, the quality evaluation of the ontologies is presented. Finally, conclusions are drawn.

2 Personalisation and Profile Ontology Representation Needs

The main goal with personalisation is to improve the user's experience of a service. Personalisation is often needed to overcome information overflow and is important for service providers to acquire better knowledge of their end-users and for achieving improved business results [15]. Personalisation usually requires the user to directly interact with a service, and any preferences are usually kept by the service provider and not the user. However, it is essential for the decision on personalisation to refocus from the service provider to the user if the personal preferences of the user depend on context and one wants to protect the privacy of the user [16]. One of the main challenges for future personalised support lies in the combination of public and private information, and the combination of personalisation and contextualisation [17]. To provide personalised mobile services, different types of information are useful. Here we focus on users' personal profiles. The profile contains all the information related to a person as an actor, its goals etc., and follows the user everywhere independently of the context. Then we have information about the capabilities of the mobile device (as described in e.g. W3C Delivery context ontology [18]). The environment of the person using the device will we term the context of use. We note that many that work on mobile applications include parts of the information we have in the personal and device profiles in the term context (e.g. in relation to the definition of context by Dey and Abowd [19]), but we find it fruitful to more clearly distinguish these terms, since the profile information follows the user as he change context.

In the work leading up to the need for ontology reuse, we have looked in particular on a case of personalised information support for food shopping. Even though we have focused on a specific domain, with personas and scenarios with characteristics related to this, the concept of a personal profile with regards to how it is to be communicated with the world is what we want to evaluate. We have categorised the different types of information we find necessary for such a profile to model. The information that is to be captured in the personal profile can be divided in three main parts. 1: Personal information consists of categories of information that is common for all users. This change very seldom and typical examples are name, birth date and address. 2: Stable interests. It is called stable because the type of information does not change frequently, due to importance and relevance. Once a user has an interest, he is likely to have this interest for a longer time span, e.g. favour a specific producer of jam, finding it positive that food is ecologically produced or price is not considered crucial. Because of the personal value of expressing this and keeping this type of information updated, a user

would typically have motivation to do this by himself if it would change. 3: Temporary interests. For a limited time period a user could be interested in for example buying a new digital compact camera. In our case the daily shopping list represents the temporary interests, so it should be possible to create a shopping list. As soon as the goal is fulfilled, it is no longer part of the personal profile.

3 Evaluation Framework – SEQUAL Specialisation

We view ontologies as models that can be reused or built on, and apply a framework for evaluating model quality, SEQUAL [7], to provide a systematic analysis of the quality of ontologies. In this section we will present the specialisation of SEQUAL.

The main concepts or sets of the SEQUAL framework and their relationships are described below. For each set we refer to the ontology to be evaluated in general and specify what the desired qualities are:

G – The goal is reuse as is or as a basis of an existing ontology in the relevant domain (see **D** below) to be able to provide personalised services.

K - The knowledge of the evaluators.

L - The language the profile ontology is represented in.

M - The model (ontology) to be evaluated.

D - The modelling domain covered by the evaluated ontology. We need an ontology that supports the description of a user to be able to receive personalised services.

T - All the statements in the ontology represented and interpreted by a tool.

I - Social actor interpretation is the set of all statements which the externalised model consists of, as perceived by the evaluator.

The quality categories described next are used as requirements for the evaluation:

- **Physical quality.** The ontology should be physically available and it should be possible to make changes to it. An available ontology should be possible to open in an ontology editor. In this way it will be possible to view and access the ontology, and further make changes to it if necessary. We have decided to use Protégé [20], a free, open source ontology editor with an active community.
- **Empirical quality.** If a visual representation of the ontology is provided it should be intuitively and easy to understand. It is an advantage that the structural quality of the ontology is good. High empirical quality will support the achievement of pragmatic quality.
- **Syntactic quality.** The ontology should be represented according to the syntax of a preferred machine readable language. More specifically, we prefer OWL DL. It is a W3C recommendation, and provides ensured decidability. WonderWeb OWL Ontology Validator [21] has been used for OWL sublanguage specification.
- **Semantic quality.** The ontology should cover the area of interest fully or partially, as specified in section 2, so that it is possible to easily extend it to do that (completeness). It could also be possible to take out a subset of the ontology so that it does not cover more than what is necessary (validity). Terms used in the ontology should be congruent with words used in the domain. It is important that there is good correspondence between the concepts needed and the ones provided by the existing ontology. Our goal is not to create a new standard personal profile, but to

be able to reuse an already tested and used model. Semantic quality is the most important quality category in this evaluation.

- **Pragmatic quality.** It should be possible to understand what the ontology contains, and being able to use it for our purpose. The pragmatic quality category also includes provision of necessary documentation. Documentation that is easy to understand is advantageous, and it should be consistent with the actual ontology.
- **Social quality.** The ontology should have a relatively large group of followers and parts should be used by other ontologies (this can be judged through metadata, e.g. recognition annotation, efficiency annotation).
- **Organisational quality.** The ontology should be freely available and accessible through a freely available tool. It should be available in a standard format and it should be available and supported for the coming years.

4 Existing Profile Models and Ontologies

An upper ontology [22] is an attempt to create an ontology describing general concepts that are equal across all domains. The aim is semantic interoperability between ontologies created under such an upper ontology. A domain ontology [22] models a specific domain, and represents the knowledge about the domain. We have considered both. We have only looked into ontologies that are publicly available and referenced in papers. Ontologies only mentioned in papers [23],[24],[25],[26],[27] are not considered. In the following sections we will describe the ontologies assessed.

4.1 FOAF

The Friend Of A Friend (FOAF) [28],[29] ontology has a simple vocabulary for describing people, what they do and their relations to other people. Hence, it is often used for describing people's social connections and networks. FOAF is represented using RDFS and OWL [29],[30]. FOAF is a popular, much used, and discussed use of semantic Web technology [31]. Its popularity is evident from related activities. A set of communities and projects are mentioned at their project Web page, but are not described in detail and not linked to. In addition, FOAF related news is available at delicious [32]. Other communication channels are IRC and mailing lists.

The terms defined are categorised as *FOAF basics, Personal info, Online accounts/IM, Projects and Groups* and *Documents* and *Images*. FOAF is situated around the class *Person* [33]. The FOAF vocabulary is intended to be uncomplicated, pragmatic and designed to allow simultaneous deployment and extension. FOAF is intended for wide scale use. Personal information is made accessible by having people publishing information about them in the FOAF format. When the person information is published, machines will be able to use it. FOAF core is considered stable [29].

4.2 OpenCyc

Cycorp [34] provides the Cyc technology, for intelligence and reasoning. Cycorp has an open source version of the knowledge base, called OpenCyc [35]. It consists of hundreds of thousands of terms, together with millions of assertions that relate terms

to each other. The OpenCyc upper ontology covers the domain of all of human consensus reality. Since it tries to cover everything in the world, the ontology is large.

The formal language CycL is used to represent the original version. Its syntax derives from first-order predicate calculus. The knowledge base consists of modules that are called microtheories. Such microtheories are a kind of subontologies. This knowledge base is possible to download, and accessed through a Web browser. However, OpenCyc is now also represented in an ontology language and OWL versions of the OpenCyc ontology can be downloaded.

Online concept browsers [36],[37] are available. In [36] concepts are separated into collections and predicates. A search result is a written definition, of the term, together with its unique tag and aliases. In addition super concepts, sub concepts, and instance of concepts are listed. The concept browsers have no tree structure to view the relation between concepts. There is also a more general OpenCyc blog [38].

4.3 SUMO

The Suggested Upper Merged Ontology (SUMO) [39] was created as part of the IEEE Standard Upper Ontology Working Group (SUO WG). SUMO consists of definitions that are intended for general purpose terms and wants to be a basis for domain ontologies that are more specific [40]. The original SUMO is specified using SUO-KIF [41], Standard Upper Ontology - Knowledge Interchange Format, and is a simplified form of the knowledge representation language KIF. Later SUMO has been translated into OWL. SUMO has been referenced in many papers independent of its funders. A selection of referenced papers are presented in [42].

SUMO's initial goal was to construct a single, consistent, and comprehensive ontology. Now SUMO has been put together with Mid-level Ontology (MILO) and several domain ontologies. Domain ontologies that are included are for example the ontology of Communications, Countries and Regions, Economy, Finance, Geography.

It is possible to browse the content of the knowledge base in their online browser. SUMO is connected to the WordNet lexicon [43],[44]. In the SUMO online browser [45] one can navigate from a SUMO concept to the corresponding WordNet term. In SUMO, a person is modelled as class *Human* which is equivalent to WordNet's person as a human being or a human body.

SUMO consists of around 1000 well-defined and well-documented concepts [46],[45]. The concepts are interconnected into a semantic network together with a number of axioms. The class hierarchy can be viewed in [47]. The axioms are common-sense notions that are generally recognised among the concepts. Open source toolset for browsing and inference can be downloaded with KIF knowledge engineering environment [48].

4.4 GUMO+UbisWorld

GUMO (General User Model Ontology) developed in OWL is made for the "uniform interpretation of distributed user models in intelligent Semantic Web enriched environments" [49]. GUMO is related to UserML (User Model Markup Language), which is a RDF-based exchange language for user modelling between decentralised systems [50]. The GUMO ontology can be integrated with ubiquitous applications with the UbisWorld user model service.

The main focus of the UbisWorld [51] approach lays on research issues of user modelling, ubiquitous computing and semantic Web. UbisWorld can also be used for simulation, inspection and control of the real world. UbisWorld is a version of GUMO that includes additions that can be used for the ubiquitous computing area.

GUMO+UbisWorld have the following basic user dimensions with differing time span: *emotional state, characteristics* and *personality*. A user model service manages the information about users and gives more advantages than a user model server would do. GUMO and UserML together focus on creating a common language and ontology for communication of user models [52].

gumo.org [49] and ubisworld.org [51] share a common interface. To get access to provided features it is necessary to sign up as a member. The ontologies in different versions, among them static and dynamic versions, exist. The Ontology Bowser presents a set of ontologies that can be viewed as foldable class trees. External ones (e.g. SUMO, GUMO, OpenCyc) can also be viewed.

5 Ontology Evaluation

In the next sections the evaluation is presented. It is a result of a comparison of what the ontologies are and represent, and the expectations for the different quality categories according to the desired personal profile ontology specified in section 3.

5.1 FOAF

Physical quality. FOAF is available with a vocabulary specification and an OWL-file. The OWL file opens in Protégé, and changes can be made.

Empirical quality. FOAF is not presented visually in the information found, and there is no overview figure provided. Even though FOAF is a small ontology with relatively few classes and relationships, it would be advantageous with a graphical representation of how the concepts relate. Classes and properties are described in writing and with some practical examples. Access to much related information is available from main Web page.

Syntactic quality. The OWL validator classifies FOAF to OWL Full.

Semantic quality. FOAF covers the class *Person* that is disjoint with *Project*, *Document* and *Organization*. The *Person* class has amongst others these properties: *family_name, firstName, surname, gender, geekCode, interest, knows, made, maker, publications, workInfoHomepage, birthday, dnaChecksum, name, phone, homepage, isPrimaryTopicOf, msnChatID, assurance*. Most of the properties are related to the online world of a user, and not the life as a physical actor. Some are also not relevant, e.g. the property *interest* that in FOAF implies a persons interest in a document. Parts of the basic types of information correspond to our definition of personal information. However, it is not complete. Little of FOAF is superfluous. For example, in relation to recommendation solutions, information or relations to other persons could be relevant. There are several aspects from the person domain that are missing.

Pragmatic quality. Documentation of FOAF terms is provided. Classes and properties are described in relation to what they are used for. There is documentation for the decisions that has been taken and explanations to the created ontology. Examples for each class are available, and make it easier to understand what a class or concept is intended for. The reference to the OWL file could be more visible. Some of the names of the properties are not very intuitive.

Social quality. FOAF have a relatively large group of followers. It is possible to chat about FOAF related subjects at an IRC channel #foaf. FOAF also has a mailing list and is used in many social networks and projects. FOAF is included as a part of GUMO.

The organisational quality. FOAF is freely available. It is available in a standard format, and will probably be available and supported for the coming years.

5.2 OpenCYC

Physical quality. OWL-files are freely available in a downloadable zip-file. The OpenCYC ontology is very big, and was too large to open in Protégé. Online concept browsers made it possible to search and view concepts.

Empirical quality. OpenCyc does not have any visual representation, hence it is difficult to get an understanding of the content of the ontology. Concepts are described in writing, but the relation to other concepts can not intuitively be discovered other than through direct relations to other concepts.

Syntactic quality. The OWL sublanguage used has not been detectable because of the file size.

Semantic quality. Difficult with a more detailed analysis because it could not be viewed in Protégé, the concept browser does not show the information hierarchically, and manual inspection is difficult. Therefore, this is based on the written documentation and the concept browser. The initial impression of the concept *person* is that there could be an overlap with our needs. However, as only class and axioms and not attributes are included in the concept browser, its completeness is hard to assess. Also, it is difficult to understand the model based on the OWL file itself.

In general, it seems like OpenCyc describes more about the world than we need, e.g. OWL constructs (e.g. owl class, owl datatype property) and CycL terms have been specified in the same way as other OpenCyc concepts. Hence, it seems like concepts are modelled at a very low level. In addition, it would be difficult to extract the parts that were needed because of all the dependencies and the size of OpenCyc.

Pragmatic quality. There is limited documentation for how to use and understand OpenCyc. Documentation about the original OpenCyc model is available, but it would take great effort to become familiar with it. It is not clear whether the information is intended for the original version, the OWL version, or both. Training material exists, but is for the use of the original version only. Parts of a handbook are not available (e.g. section 7), and the last update was done in 2002. The concept browsers do not give much insight into the model, other than very long written descriptions

which only give an overview. Missing hierarchical representation is a drawback, as one can not view the entire structure. The separation of concept in collections and predicates in [36] is not explained, and what kinds of concepts belong to which term is not clear. All these factors, and the lack of user manual intended for the OWL version, makes it difficult to start using OpenCyc.

Social quality. It is difficult to know how many followers there are and to what degree the OpenCyc ontology is used in other projects. They have a discussion forum. However, this is a forum with little activity. OpenCyc also have an IRC Channel and a blog with little activity. Last update was November 2008. However, it seems like the original OpenCyc has higher priority than the OWL version. All these social forums are mostly intended for the original version.

The organisational quality. The OpenCyc ontology is freely available in a standard format, and will probably be available and supported for the coming years. Might be stable, but updates are probable.

5.3 SUMO

Physical quality. SUMO has been translated into OWL, and a selection of domain ontologies is also included. Opens in Protégé.

Empirical quality. The visual overview does not separate SUMO, MILO, and domain ontologies. The complete class hierarchy makes it possible to view all the relations between classes. Because of its size, crossing lines in the figure are inevitable. The figure is still readable, and ok to navigate.

Syntactic quality. The OWL validator classifies SUMO as OWL Full.

Semantic quality. The figure depicted in the description about SUMO and the class hierarchy does not correspond with the classes found in the OWL file. SUMO is detailed enough to include the class *Human* that corresponds to our concept of a person. Other classes that could be relevant are also included. *Human* is a subclass of both *Hominid* and *CognitiveAgent*, and has subclasses *Man* and *Woman*. These classes have a number of properties. Large parts of the ontology are irrelevant (poor validity). The same applies to attributes. Neither personal information, stable interests, or temporary interests are fully supported. More constructs are necessary to be able to cover our domain fully. In general, the most visible overlap is in connection to the leaf nodes we have mentioned, and not so much to the higher level concepts.

Pragmatic quality. In the Protégé tree structure there are two other classes on the same level as the class Entity, which are left out of overview figures. We do not know for what reason. Papers referencing to SUMO give an easy to understand overview of the upper levels of SUMO. The specific domain ontologies that have been included are not described, but seem to be an integrated part of SUMO. No tutorial or user manual is found for the ontology. Material found relates only to the KIF version of SUMO and tools. Several of the attribute names are not intuitive, and do not indicate which classes or types the relation connects. Also they say little about the direction of the relationship (e.g. whether a man IS a son, or HAS a son).

Social quality. SUMO is assumed mature since there is little activity related to it. We have not found documentation covering how much used it is in other projects.

Organisational quality. SUMO is freely available. It is available in a standard format, and will probably be available and supported for the coming years. It is difficult to know whether it is used in other projects.

5.4 GUMO+UbisWorld

Physical quality. Different versions of OWL-files are available. Opens in Protégé.

Empirical quality. A visualisation as foldable trees in online browser is available. The full ontologies cannot be viewed, as only smaller parts can be viewed at a time.

Syntactic quality. The OWL validator classifies GUMO+UbisWorld to OWL Full.

Semantic quality. Considering the general description we would expect several similarities with what we need in relation to a person profile. However, concepts we would think of as relations are modelled as classes, independently of the person class. In GUMO, classes that describe a person and his surroundings are modelled, e.g. *DomainDependentDimensions* with subclass *Interest*, and *BasicUserDimensions* with the subclass *Demographics*. In the UbisWorld extension, a *Person* class is included. Hundreds of Person instances are defined, but do not have properties. Few properties are modelled, and none are relevant for us. From this we find that there is a mismatch in how the domain and the related concepts are modelled. Therefore, personal information, stable interests, and temporary interests can not be fully modelled.

Pragmatic quality. Several OWL versions of GUMO and UbisWorld exist, but when to use which one is not specified. The Web sites do not provide any tutorial or user manual. The online ontology browser provides foldable trees of selected parts, together with elements and statements about them in a separate window. It is unfortunate that the browser in the tree structure includes symbols that are not explained (e.g. grey/orange squares, auxiliaries, ranges), and that the assumed corresponding concepts in the OWL versions are modelled as classes. Information presented in the browser contains different, sometimes more, knowledge and different representation of concepts than the OWL versions. This inconsistency between browser and OWL versions is confusing.

Social quality. GUMO is still under development. It is difficult to know how many followers there are, but several papers about GUMO and the environment have been published [52],[53] from a group of people related to its development.

Organisational quality. Need a user profile and password to access available files, but freely available once logged in. It is available in a standard format, and will probably be available and supported the coming years. Might not be stable.

5.5 Summary of Evaluation

The result of the evaluation is summarised in Table 1. We see that for physical quality all providers have available OWL files for download. Even the knowledge bases that

have not initially been created as OWL-ontologies have been translated into OWL. All can be viewed and edited in Protégé except OpenCyc.

Only SUMO provides a visual view of the structure of the ontology, hence giving an idea of content and class relationships. Empirical quality for FOAF is also ok since it is the smallest ontology, and therefore has a structure that can be understood without visualisations. Even though GUMO+UbisWorld provide a foldable tree structure, it only gives a partial view and is inconvenient to use. OpenCyc and concept browsers do not give much insight on overall structure.

When it comes to semantic quality we find differing. The large ontologies have a wider view on a person than what is useful for our purpose. We view a person as a physical actor that needs to be described so that he can act in the world. The personal information category of the profile has been best covered by FOAF and SUMO. Stable and temporary interests have not been covered completely by any of the ontologies. GUMO+UbisWorld have modelled many relevant aspects of a person, but they are not connected to a person class, therefore causing a semantic mismatch relative to our specification. Also FOAF and GUMO+UbisWorld have irrelevant elements, but not to the same extent as the large ontologies.

Table 1. Summary of evaluation

Quality category	FOAF	OpenCyc	SUMO	GUMO+ UbisWorld
Physical	Available	Available, but too big to open	Available	Available
Empirical	Ok	Less satisfactory	Ok	Less satisfactory
Syntactic	OWL Full	Not decidable	OWL Full	OWL Full
Semantic	Partial overlap but not complete, ok validity	Difficult to decide relevancy, poor validity	Partial overlap but not complete, poor validity	Overlap, but modelling mismatch
Pragmatic	Ok	Not satisfactory	Not satisfactory	Not satisfactory
Social	Mature and widely used	Assumed mature, not specified how much it is used	Assumed mature, not specified how much used it is	Not mature, but referenced
Organi-sational	Free, accessible, and stable	Free, not accessible, and probably stable	Free, accessible, and probably stable	Free, accessible, and not stable

Unfortunately it is difficult to understand the logic behind the structure of the ontologies. In general, the models are difficult to read and there are few practical examples where they are used. Hence, the pragmatic quality for particularly OpenCyc, SUMO and GUMO+UbisWorld is poor. Browsers that describe separate concepts are not sufficient to understand the model as whole, and how the different fragments are connected. More documentation directly related to the ontologies and explanations would be advantageous. FOAF has the best pragmatic quality.

The social quality also differs. FOAF is the only ontology explicitly stated as stable, while OpenCyc and SUMO are based on stable knowledge bases. However, whether the OWL versions themselves are prone to changes is not mentioned. FOAF is the most mature ontology, based on its use and number of adaptors. There are small

variances regarding the organisational quality of the ontologies. All ontologies are freely available and are likely to be available in the future. However, with differing indications for how stable they will be.

6 Conclusions

In this paper we have developed an approach to evaluate reuse potential of ontologies. The approach consists of the use of a specialisation of a generic quality framework, SEQUAL, which we have developed and used for the evaluation of FOAF, OpenCyc, GUMO+UbisWorld and SUMO. Reusable ontologies have several potential benefits. Most important, reuse of an existing model is advantageous to save time and resources. In addition, evolution in a later stage benefits from reused ontologies as they would support development based on a shared terminology and understanding that has already been used.

The result of the evaluation is that reuse of these ontologies will not be straight forward. None of the ontologies satisfy the majority of quality requirements. Therefore, it will also be time consuming if parts of any of the ontologies were to be built on. As a result, the ontology has been created from scratch using OWL DL.

In addition to being useful for evaluating ontologies for a particular domain (here profile ontology), the approach gives general insight and information about the evaluated ontologies and about reuse of ontologies in general. It seems like the evaluated ontologies are not made to be easily reusable. Particularly the creation of ontological versions in OWL of existing knowledge bases seems not well thought-through. In the first place, they are created in OWL Full, which gives no computational guarantee. Second, little documentation is available for the modelling decisions and how to use and understand the ontologies.

Our evaluation of reuse of these ontologies is in accordance with the two "rules of three" in software development introduced by Glass [54]: "It is three times as difficult to build reusable components as single use components, and a reusable component should be tried out in three different applications before it will be sufficiently general to accept into a reuse library". This contradicts the purpose of ontologies enabling understanding and reuse. When an ontology has been created for a specific purpose by a set of modellers it is shared between them. A different set of modellers would probably have a different view of the world. For an ontology to be reusable more effort is needed in the construction, and it should be used in several applications.

The created profile ontology is applied in an implementation using OWL API [55] and the reasoner Pellet [56] for access and manipulation of ontologies. The implementation will be evaluated according to developed personas and scenarios. In addition, the personalisation concept will be tested using mock-ups with test people through the RECORD Living Lab [57].

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