

Personalisation by Semantic Web Technology in Food Shopping

Lillian Hella, John Krogstie

Department of Computer and Information Science (IDI)
Norwegian University of Science and Technology (NTNU)
Sem Sælands vei 7-9
NO-7491 Trondheim
NORWAY

+47 7359 3440

{hella, krogstie}@idi.ntnu.no

ABSTRACT

Personalisation is a desired functionality for applications within mobile environments as we are moving towards a ubiquitous world. One approach to personalisation of mobile services is by the use of personal and contextual information. In this paper we describe an architecture for this purpose where we utilize ontologies. The developed ontology that covers personal information and food information is based on, and evaluated relative to, personas and scenarios from the food shopping domain. The profile covers three levels of information; personal information, long term interests and temporary interests. The proposed concept of personalisation is illustrated in two developed pull and push scenarios. The personalisation concept in the form of videos is evaluated using the Technology Acceptance Model (TAM), and the initial findings of the analysis are presented here.

Categories and Subject Descriptors

K.8.m [Personal Computing]: *miscellaneous*.

General Terms

Design, Experimentation, Human Factors, Legal Aspects, Verification.

Keywords

Personalisation, Semantic Web, Personal profile, Ontology, Technology Acceptance Model.

1. INTRODUCTION

New types of networks and devices bring the Internet into everyday lives through wireless and mobile technologies. Users of mobile technologies are getting exposed to information and

services, without being able to control the flow of services. The goal is to be able to connect accessible and mobile devices collecting context and eventually provide service provisioning for the users through the sharing of information in a ubiquitous computing environment [1]. Such a change will involve technical, social and organisational challenges [2]. As we move towards a ubiquitous and social world with both new opportunities and challenges, the concept of personalisation and relevant services will play a role in the everyday life of many persons.

The vision for the next generation Web as the Semantic Web [3], 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. With these new possibilities we need to increase users' abilities to express what information and services they want and need. For our proposed personalisation we will use Semantic Web technology as the enabler. The core components in the Semantic Web and its applications will be the ontologies. An ontology can be seen as an explicit representation of a shared conceptualisation [4] that is formal [5].

Personalisation is a feature that is needed to overcome information overflow and the traditional one size fits all approach. By knowing the user it is possible to improve the quality of services delivered. With the use of Semantic Web technologies, known and inferred information about a user can be used to target services directly to a specific user. One of the main challenges and potential for future contextualised and personalised support lies in the combination of public and private information and the combination of personalisation and contextualisation [6]. Research has been done on adapting information according to the context the user is in. However, little research has been done in focusing on offering the right services at the right time.

In this paper we focus on the personal profile which plays an important role in our personalisation architecture and on the initial evaluation of the proposed case environment for our personalisation concept. The developed case environment is related to food shopping, where users in some situations have to make non-trivial decisions. Even though many people can do their food shopping without any concerns, there are people that need to make decisions of varying complexity on a daily basis. Currently

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.

WIMS'11, May 25-27, 2011 Sogndal, Norway
© 2011 ACM 978-1-4503-0148-0/11/05... \$10.00

there is not much information or mobile services related to food, but mobile services within the food shopping domain is currently being investigated by e.g. the GS1 MobileCom [7].

While being on the move it is important for users to receive the right information at the right time, and at the same time being able to exchange and control information that is necessary to make this possible. We want the personalisation system to be able to decide what can be relevant in a particular situation for an individual user. Depending on what the goal for a specific user is, varying parts of profile and context information will assist in the personalisation process which is the matching process of available services and users.

The rest of the paper is organised as follows. First, the background for the work is presented. Then we present the developed personas and two scenarios for our food shopping case environment. Before we present the ontology, we describe how personal information can be used for personalisation in Section 4. Fifth, the overall architecture is presented together with the developed ontologies and the necessary types of information about a person. In Section 6 we present shortly information about the implementation, and Section 7 consists of the initial results of the analysis of our concept of personalisation. Finally, conclusions are drawn.

2. BACKGROUND

The need for systems to adapt to their users has been recognised in many application areas. So far much focus has been with regards to applications intended for stationary computers. Personalisation for mobile systems has a different focus, where services and the control and automatic selection of services are important. In the busy life of mobile users in a world with many distractions, relevant services are important. For a mobile user it is essential to be in charge of the flow of information and services. Exactly what personalisation will mean for future mobile services and how it should be done is still more open. However, personalisation is a compelling feature for mobile communication systems for both end users and service providers.

Lately there has been an increase in ubiquity of mobile and embedded devices. Hence, it has become apparent that in many cases the recognition and modelling of the user's external context is important [8]. On the one hand, the field of user modelling is said to contribute significantly to the enhancement of the effectiveness and usability of ubiquitous computing systems. On the other hand, the field of ubiquitous computing is building the technological basis for these systems. This new technological basis offers the user modelling community opportunities to apply their methods to new kinds of systems. The combination of user modelling and the technological basis of ubiquitous computing can contribute to extending the methods themselves in the process [8].

Ontology based user modelling is a direction where ontologies are used to structure user models [9]. There have been several proposals with regards to models of users using ontologies. Some ontologies are described to cover a model of personal profiles and are publicly available (for viewing and editing) and referenced in papers. Such available ontologies are described in the next paragraphs. However, there are also many ontologies only described in papers (e.g. [10],[11],[12],[13]), and these will not be described here. A common feature is that most of the

ontologies are built from scratch, and are created for a specific purpose.

The Friend Of A Friend (FOAF) ontology [14],[15] 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 markup [15],[16]. FOAF is situated around the *Person* class [17]. The FOAF vocabulary is intended to be uncomplicated, pragmatic and designed to allow simultaneous deployment and extension. FOAF is simple and intended for wide scale use. Personal information is made accessible by having people publishing information about them in the FOAF document format. When the information is published, machines will be able to make use of it. The core of FOAF is considered stable [15]. According to Golbeck and Rothstein FOAF is a very popular, much used, and discussed use of Semantic Web technology [18].

Cycorp [19] provides technology for intelligence and reasoning. (Cyc technology). The company has an open source version of the knowledge base, called OpenCyc [20]. 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 very large, consisting of hundreds of thousands of terms, together with millions of assertions that relate terms to each other. It also defines the concept of a person. The original version is represented in the formal language CycL. However, OpenCyc is now also represented in an ontology language and OWL versions of the OpenCyc ontology can be downloaded.

The Suggested Upper Merged Ontology (SUMO) [21], [22] 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 [23]. The original SUMO ontology is specified using SUO-KIF [24], 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'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. The available OWL version consists of all these domain ontologies.

SUMO consists of around 1000 well-defined and well-documented concepts [25],[26]. The concepts are interconnected into a semantic network together with a number of axioms. The class hierarchy can be viewed in [27]. Open source toolset for browsing and inference can be downloaded with KIF knowledge engineering environment [28]. SUMO has been referenced in many papers independent of SUMO and its founders. [29].

GUMO (General User Model Ontology) developed in OWL is made for the "uniform interpretation of distributed user models in intelligent Semantic Web enriched environments" [30]. GUMO is related to UserML (User Model Markup Language), which is a RDF-based exchange language for user modelling between decentralised systems [31]. The GUMO ontology can be integrated with ubiquitous applications with the UbiWorld user model service. The main focus of the UbiWorld [32] approach lays on research issues of user modelling, ubiquitous computing and Semantic Web. UbiWorld can also be used for simulation,

inspection and control of the real world. UbiWorld is a version of GUMO that includes additions that can be used in the ubiquitous computing area [32].

GUMO+UbiWorld have the following basic user dimensions with differing time span: emotional state, characteristics and personality. What they call 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 [30].

In the creation of an adaptive mobile personalisation system it is useful to investigate whether existing models are applicable. We have viewed the existing ontologies that are available from a reuse perspective, and have chosen to specialise the SEQUAL quality framework [33] for evaluation of these. The result of the evaluation was that none of the evaluated ontologies described satisfies requirements as models that can be reused or built on [34], and our profile ontology has been created from scratch, as described in Section 5.

The biggest change regarding personalisation is the focus on a person as one individual, and not as part of a heterogeneous group. Focusing on individuals, other factors than before can be relevant and used in a positive way in the personalisation process. When one says that personalisation is concerned with tailoring specifically to one individual user, other factors than just the user himself will be relevant, e.g. the result of personalisation in different settings or contexts should be different.

3. FOOD SHOPPING CASE ENVIRONMENT

In our work we use personas and scenarios, and these have been the main sources of information for the creation of the profile that we have developed. A persona describes users quite detailed, while the scenarios put the persona in a realistic situation. Both push and pull services for mobile users in the food shopping domain are used to illustrate the simple, but efficient benefits of the proposed personalisation in the scenarios that we have created. However, the proposed personalisation can be applied in other domains too. We first present what a persona is and the persona in focus, and then we present the two different scenarios where this persona is out shopping food.

3.1 Persona: Bill and his Family

A persona is a description about an imaginary user that explains who he is, his beliefs and goals etc. Such a description can therefore explain the decisions and choices he makes. Personas can be used as an interaction design technique with significant influence on development of new software [8]. They work as a shared basis for communication, and for engagement in the group that are going to use them [8, 9]. By understanding a fictitious user, one is better prepared to predict how a different person would behave in a specific situation.

Our family of personas consists of five persons; a mother, a father and three children constituting a household. Members of the family have preferences and wishes, and sometimes the individuals have conflicting interests. When preferences are in a conflict, the parents have the last word and make the final decision. In our work we focus on the father, Bill, but we also

know that one of the children has ADHD which for example makes some additives in food unwanted and therefore affects the whole family. The following keywords describe Bill and are important sources of information for the creation of personal and long term interests for Bill; 39 years old, conscious about contents of food, prefers healthy, non-harmful food, prefers ecologically produced food, with a small carbon footprint if possible, Fair Trade is regarded positive, price is an issue, but not the most important one, likes to have a preset shopping list and finds it difficult to adapt on the spot.

The shopping list of the day can be regarded as a temporary interest, while the preferences for certain makes and brands can be regarded as long term interests. Note that the temporary interest relative to today's shopping list is recurrent at different intervals (e.g. if milk is bought today, it will typically turn up again the week after. Products that one does not get, might be replaced, or might stay on the list).

We understand that Bill and his family are interested in what they eat, and they also need to take into consideration a physical condition like ADHD when they do their food shopping. With these preferences it is important to easily find relevant information about products. However, it can often be challenging and time consuming to find this information manually on the declaration on products or on the Internet. Therefore assistance in the food shopping process is highly relevant for Bill.

3.2 Scenario 1 Pull: Alternative Products

In the first scenario, Bill is out shopping on a Tuesday evening. The shopping list was prepared in advance, and consists of items for the whole family. Bill finds it difficult to adapt on the spot, and consequently he prefers a complete shopping list in advance. Therefore he subscribes to a service we have called Food4U. The scenes in the scenario are illustrated in Figure 1. Bill has strawberry jam on the list, but the type they usually buy is out of stock. On the shelf there are many alternatives, and Bill does not know which one to choose. A jam has typically more than ten different types of information related to it, e.g. price, ingredients, producer, nutrition, weight. Since Bill has specific concerns regarding the contents of food, it is important for him to avoid certain ingredients. Instead of reading the declaration of contents and other product information for all the available strawberry jams, he provides a query for alternatives, a request, to the personalisation system (e.g. scanning the bar code of an available jam and search for alternative products). The result of the request is a response from the system, which is a prioritised list of jams according to his preferences and the knowledge about the different jams (and of the jam that is originally preferred).

The result of four alternatives is delivered by Food4U to Bill's device, and gives Bill information enough to make a well-founded choice. The rest of the alternatives have been excluded due to low relevance. Bill chooses the second alternative because he does not mind the additive potassium sorbate. The reason several alternatives are given is that the preferences only give an indication for what the system thinks might be most relevant, and there is not necessarily one correct answer. Presenting only one result could eliminate other relevant products. By presenting the most relevant ones and providing information about them, it is up to the user to make a final decision, information that can be used for further personalisation later.

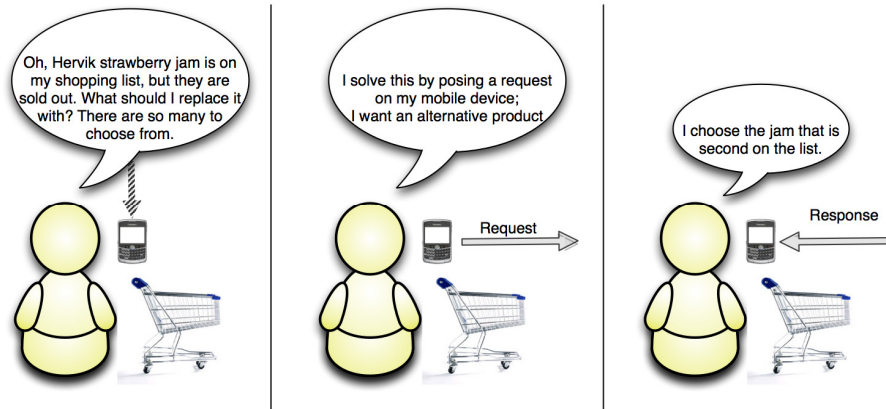


Figure 1. Scenes from Scenario 1 pull: Alternative products

3.3 Scenario 2 Push: Matching of Relevant Service

Bill is out shopping again. Bill also subscribes to a service called Relvansa, as he always is interested in new relevant products and does not have the energy to actively search for them himself. Relvansa finds relevant products and information about them, and provides information about these in situations that are considered useful for the individual subscribers. He has his shopping list prepared, and as he enters the food store it is recognised that he is in the store. The store has a lot of offers, but not all are interesting to Bill. As a subscriber of Relvansa, Bill does not have to worry about getting swamped with information about products he is not interested in. When he enters the store, he therefore receives information about new ecological products that have arrived in the store. The information can for example be presented graphically, and illustrate where the products can be found physically. Today a new kind of ecological orange juice is presented. Bill considers the information provided, and decides to buy a bottle of Sun orange juice. If the store would have been sold out for this particular product, this should ensure that such an offer would not be considered relevant because of the mismatch in availability.

4. PERSONAL INFORMATION FOR PERSONALISATION

Characteristics described in the personas are partly used for structuring of the necessary profile information for this domain. They give indications for necessary properties and classes in the ontology to be created, particularly with regards to personal information and long term interests. We also use the scenarios to extract information that is necessary or useful to achieve the personalisation we propose. To do this, the scenarios have been analysed in more detail with regards to the personalisation process. The scenarios also tell much about the long term and temporary interests.

The goal is not to create a complete profile (that can be used for all kinds of domains), and we focus on general concepts that make it possible to achieve the successful personalisation we aim for.

Therefore, the profile will only consist of a portion of the information that should be part of a complete profile. The contents will be constrained by our scenarios, but could be extended to cover other areas and more details.

Since we focus on mobile food shopping support we have limited the scope for what is modelled. We look at the food domain that can be related to local supermarkets in our neighbourhood. Figure 3 illustrates the top level of classes in the ontology, while Figure 4 illustrates top level relations. Some of these will be referred to in the examples in Section 5.2. Many of the defined classes will not be mentioned since they are included for reasoning purposes related to useful classifications used in the personalisation process by the mediator. We focus on the classes that are relevant for the described persona and scenarios in Section 3, and which are used to define a person and related parts of the food domain.

The information in the personal profile can be divided in three main parts. The first category is termed personal information. Personal information consists of categories of information that is common for all users. Personal information is therefore useful to identify the demographic properties of users. Many of these can be derived from the persona description. They change very seldom and typical examples are name, birth date and address. This type of information is particularly useful when connecting to a new service provider who is interested to know who you are and where you live or what your phone number is etc.

The second category is termed long term interests. It is called long term 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 or type of product. The interest for this producer is the same from one week to another.

Sometimes it is useful to be able to specify interests or activities that do not last over a longer time span. Therefore, the third category is termed temporary interests. For a shorter time period a person could be interested in for example buying a new digital compact camera. In our case the daily shopping list represent the temporary interest. As soon as the goal is fulfilled, it is no longer part of the temporary interests in the personal profile.

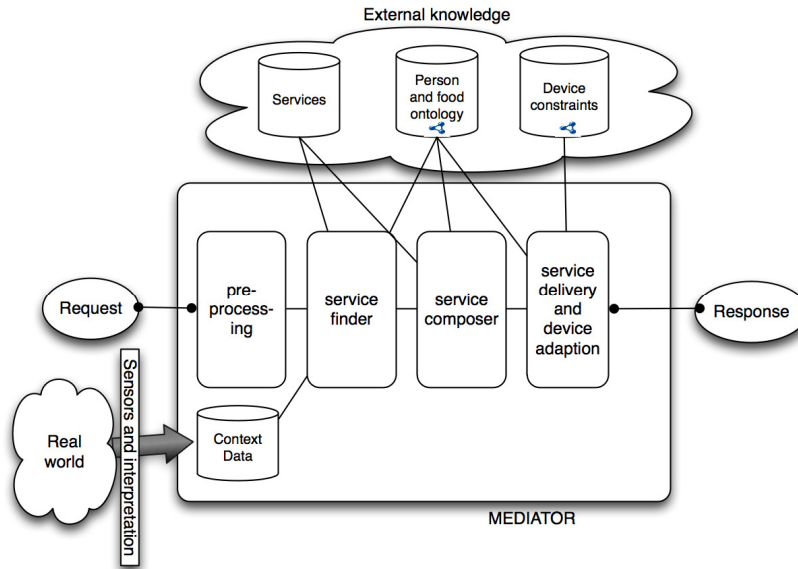


Figure 1. Personalisation architecture

5. PERSONALISATION ARCHITECTURE

Here we present the personal profile in relation to the other components in the full personalisation architecture.

5.1 Main Components

The *mediator* is responsible for the personalisation and connects the right users to the right services. To do this, the mediator is provided the necessary parts of the profiles, information about the domain and devices etc. These information sources are used in the different steps in the personalisation process. All the service agreements and searches for services (providers) are done through the mediator.

The process is initiated by the expression of a request which represents the user's goal in a particular situation (by user or service provider). The user poses such a request from his mobile device. The request starts the personalisation process performed by the mediator. The profile, which should be stored at a trusted third party, will be available in the process providing the mediator with relevant profile information. This profile information will be used together with the information about the domain, which in our case is about food and food products. The preferences in the profile are defined in relation to what information that is available about food, e.g. a person's concern in ecological produced food is related to the way we know that a particular product is produced. The main steps of the mediator as the matchmaker are pre-process of goals, find services, compose services, and adapt result to device and delivery. Several sources of available information are involved in the personalisation. External knowledge represents information sources that the mediator has access to, but not necessarily owns and administers. Where these sources of information are physically stored is not the focus of the current paper. The important thing here is the use of available information in a machine-readable format, and the benefits gained in the personalisation in the form of relevant services. The real world is observed by sensors, and parts of it can be perceived and interpreted as context information. Context information can for

example be a user's location, location of other users, the weather and time of the day.

A user request represents an explicit or implicit need or goal of the user, and corresponds to pull services as the user is the active part in the request. Requests are sent directly to the mediator which is responsible for the matching. In addition to explicit and implicit requests posed by users, it is also possible for the mediator to support users' implicit goals without the user initiating the process. Trying to satisfy a user's implicit goal in this way corresponds to push services, where the user is a passive part. In such cases the mediator is able to find matches between available services and users' profiles that match a particular service or group of people the provider is interested in. For both types of requests it is important that the response provides a result that is relevant for the user. In the presented scenario, Bill proposes an explicit pull request in scenario 1, and an implicit goal is identified in scenario 2.

While the user perceives the personalisation process in scenario 1 as one step with one input and one output, the mediator actually performs a set of steps to be able to return a response to the user according to the initial request. Hence, from the user's side, the communication with the mediator in scenario 1 will be perceived as a simple service that retrieves an alternative product based on the request he poses. Figure 2 illustrates the main steps and components in the personalisation process. However, in the steps of the personalisation process to produce relevant results for the user, the mediator in many cases executes more than one service to produce the result that is to be delivered. Non-functional requirements (performance, throughput, response time etc.) are also important, but our focus has been on the functionality that is to provide services to the user.

When the mediator receives the request it has to do some pre-processing before the request can be handled. This depends on how the requests are expressed, and how they are going to be used in the search for alternative services. If several services are needed to fulfil the request, then the request needs to be split up in

separate parts so that smaller services can be found. These parts will be called sub-requests. A request or sub-requests should make it possible to find services that imply the possibility of delivery of relevant results to the user.

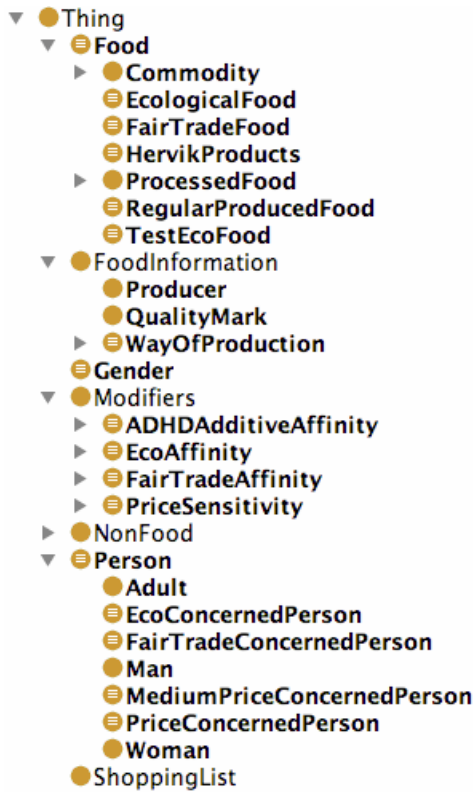


Figure 3. Protégé class hierarchy

After the request has been transformed, it will be used to search for services that can satisfy the request. It is necessary for the success of the personalisation that the services retrieved, which will lead to the delivered response, are relevant for the user. Services can be relevant at two levels. At the first level of the matching we are concerned with finding relevant services according to the request. In this matter a relevant service is a service that can satisfy the request fully or partially. On the next level we speak about the relevance of the result of the execution of a service. This is particularly useful when the service delivers multiple results. In cases where a service gives several results, it is necessary to choose one or more that are relevant. To do this, personal information is an important factor to be able to decide what is relevant and how relevant it is. In this step, sorting of the information is important. Like in the presented scenario, several smaller services are necessary to produce a prioritised list of alternative jams, e.g. find all alternative products, find out to which degree a specific jam satisfy a user's preferences, sort alternatives by relevance.

When a service (or several services) has been found, it will be used to find or reason over information in the knowledge base. The selection of which information to be chosen to be a part of the result is influenced by this information. In some cases retrieved information needs to be ranked. Then the most relevant information should be selected to be a part of the delivery of the response. In the presented scenario the system actually finds ten

different alternatives, but only presents a selection of the four most relevant results. Since devices have different abilities, the result should be adapted according to device specification. When the result has been set according to the user's device, it should be delivered to the user.

5.2 The Person and Food Ontology

The profile is centred around the *Person* class, which will be the main part with regards to representing a person in the ontology. Bill will be represented as an instance of the *Person* class. The properties we have included to describe who a person is, are name and family relations etc. Some of the datatype properties included are *hasName*, *hasAge*, *hasBirthday* and the object properties *hasGender*, *hasFamilyRelations* with subproperties *isMarriedTo* and *hasChild*. A person can be either a *Man* or a *Woman* (not both), and are connected through the *hasGender* relation. Many of the relations related to personal information correspond to relationships also modelled in GUMO+UbisWorld [30] and SUMO [21]. We have not used these unabridged though, since an earlier analysis [34] has shown that existing ontologies in this area are not directly reusable.

The personal information part has not been very important in our scenarios, and therefore we only include basic personal information. This part can be extended as in many situations it is useful to exchange detailed and extensive personal information (address, account information, phone number etc.) in an easy and controllable way. Personal information is used in many situations, and in the connection to new service providers controlled exchange or shared access of personal information can be useful.

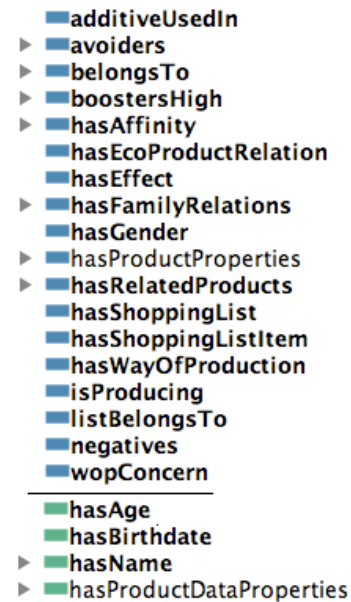


Figure 4. Protégé top level properties hierarchy

Long term interests are the most important type of information as to being able to find out the relevance of a specific service or information, and to target services to individual users. All the different preferences for a person belong to this group.

From the persona and scenario we see that it is useful to be able to indicate relative interest. As we can see from the persona Bill, we want to be able to specify to what degree he prefers for example

ecologically produced food and fair trade food. Many of these preferences of a person are relative to how well he prefers or likes something or not. Such value partitions in our model are intended to indicate that a specific relation can have different levels of intensity or degree. We have chosen to select levels corresponding to high, medium and low for the different gradings. We have modelled this as value partitions that later can be further subdivided if necessary. Our value partitions belong to the class *Modifiers*, and all the different modifiers are modelled as disjoint classes which exhaustively partition the parent class representing the feature. The class *Modifiers* has the subclasses *ADHDAdditiveAffinity*, *EcoAffinity*, *FairTradeAffinity* and *PriceSensitivity*. Each modifier can be connected to the *Person* class through object properties *hasEcoAffinity* and similar for the other affinities. All affinity properties are subproperties of *hasAffinity*. The combination of different affinities makes it possible to use them together in different ways in the search for relevant services, and this is done by the mediator during the personalisation process. A person having a high affinity for ecological products, would typically value products that are ecologically produced very positive.

While many of the persona characteristics indicate what the personal information and the long term interests are, the shopping list indicates the father's and the household's temporary interests. Temporary interests are important to understand the particular situation the user is in and his needs at the moment. To make it possible for Bill to specify which items are on the shopping list, there is a class *ShoppingList*, where Bill's list can be registered.

In addition to representing people, there are classes that have been included to describe concepts about the food domain. For this we have used a public food taxonomy [35] for information about existing processed food and commodities. It seems that there is currently no complete overview of products and list of contents of products online e.g. in relation to GS1 MobileCom as mentioned in the introduction. Therefore, the information about jams and its ingredients have been manually collected from the products' list of contents and label out in actual supermarkets. Due to the political focus on food-safety, it is not unlikely that such information will be made publicly available in a digital form in the future. What we then need is to connect the information we have about food and the actual persons that are modelled in the *Person* class.

The main classes are *Food*, *FoodInformation* and *NonFood*. The class *Food* has been separated in *Commodity* and *ProcessedFood*. Class *Additives* is a subclass of *NonFood*. The class *Jam* is a subclass of *ProcessedFood*, which is a subclass of *Food*. The jam that Bill is looking for is typically an instance of one of *Jam*'s subclasses *StrawberryJam*. We have named the instance *HervikStrawberryJam*.

FoodInformation has subclasses *Producer* and *QualityMark*. The class *Producer* represents all the different kinds of producers, e.g. like the ones producing jam in the scenario; *Nora*, *Ica* and *Hervik*. These are represented as individuals. Food can only be marked as *Ecological* or *FairTrade*, which are the instances of *QualityMark*. Types of *Food* are connected to *Producer* through the properties *hasProducer*. Whether a product is ecologically produced or not, is specified through the property *hasQualityMark* (which is a subproperty of *hasProductProperties*). All products that have the

quality mark ecological are considered ecologically produced food.

6. IMPLEMENTATION

We have implemented a simple prototype as a proof of concept of the personalisation in the food shopping scenarios presented. Our focus is on the mediator, as illustrated in the architecture described in Figure 2. Ontologies are implemented using the Protégé Ontology editor [36], and information in the personal profiles at the instance level are based on the details from personas and scenarios. The prototype itself is implemented in Java, and for accessing and using the ontology we use the OWL API [37] together with the reasoner Pellet [38]. In this implementation we use the information in the profile to match the actual service. Our implementation consists of a simplified mediator, which is the one using the ontology which is stored locally as an OWL file. As an implementation of the mediator we focus on the matching itself between the information about an individual user and the available service or services. Based on the available service, relevant profile information is used to be able to prioritise the different alternatives. In the food shopping scenario 1 concerning alternative products we know that the object in focus is jam, and therefore we know that the alternative jams must be of the same type as the object in focus. When we have all the different alternatives available it is the profile information that is used to find out which product that matches the user best according to the profile information. Remember that the goal is not necessarily to provide the one and only best alternative, but it is also useful to limit the result set so that alternatives that have a match with the actual person are selected, as described in scenario 1.

7. EVALUATION OF PROPOSED PERSONALISATION

The scenarios developed are simple, but show potential benefits in the food shopping domain which can be of high importance for some people because of the effect. In this section we present the evaluation performed with regards to potential use of the personalisation proposed in the food shopping scenarios in Section 3. For this we use the Technology Acceptance Model (TAM) where we base the evaluation and questions on the scenarios we have created.

7.1 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) is a widely researched model with regards to user acceptance. The idea behind TAM is that users' intentions are good indicators of actual use of a system. The strong relationship between intention and the actual behaviour with regards to information systems and other areas are supported by research.

The constructs in TAM are perceived ease of use (PEOU), perceived usefulness (PU) and intention to use (IU). PU is defined as the extent to which the individual believes that using a system will enhance his job performance. PEOU is related to the effort of use of a system; the extent to which an individual believes using a system will be free of effort. IU to use a technology is a function of perceived usefulness and perceived ease of use, and is therefore considered to be a function of PU and PEOU. IU a technology is the strongest predictor of usage behaviour.

The measurement scales and questions used in TAM evaluations have been developed, validated, and extensively pretested, showing them to have high reliability and construct validity, by Davis. When TAM is used, the questions and scales have been adapted from Davis' original ones [39]. Personal life can be looked upon as a type of performance with tasks and goals that needs to be fulfilled and reached. In this respect we are considering what an individual needs to get done.

Table 1. TAM questions for scenario 1 and scenario 2

PU 1	Using Food4U/Relvansa would increase my efficiency in everyday life.
PU 2	Food4U/Relvansa would allow me to easier find the products I want.
PU 3	Food4U/Relvansa would allow me to better schedule my time.
PU 4	Food4U/Relvansa would enhance my effectiveness in daily life.
PU 5	A service like Food4U/Relvansa would be useful for me in my everyday life.
PEOU 1	Learning to operate and use the service would be easy for me.
PEOU 2	I would easily find the information I am looking for using Food4U/Relvansa.
PEOU 3	I would find the user interface of Food4U/Relvansa clear and intuitive.
PEOU 4	I would find the service to be flexible to interact with.
PEOU 5.	I would find the Food4U/Relvansa easy to use (user-friendly).
PEOU 6	To me it seems like Food4U/Relvansa easily would do what I wanted it to.
IU 1	Assuming I have access to the service, I intend to use it.
IU 2	Given that I have access to the service, I predict that I would use it.

7.2 Settings for the Analysis

Before the evaluation could be executed, we needed to set up the experiment and plan for the specification of selection criteria for the test persons we needed. The selection criteria for finding test persons are important. One does not want to narrow it too much down, and one does want it to be too general.

200 persons were recruited to perform the TAM evaluation. We wanted a selection of persons that was as representative as possible. Therefore we wanted a randomly selection of persons, and the persons we selected were in the range of 20-40 years old, and had a 50/50 distribution of male and females. The selction were chosen from a Norstat panel and the experiment was run in Norstat's survey solution [40].

Our personalisation ideas for the experiment were presented as two videos. The videos where based on the push and pull scenarios (described in Section 3), where the persona Bill played a leading role. Each video lasted approximately one minute. For each video the participants had to give their opinion in a

questionnaire that had 13 questions per video. The questionnaires were written in Norwegian. The questions were in the form of 5 PU questions (PU1_1-PU1_5 for scenario 1 and PU2_1-PU2_5 for scenario 2), 6 PEOU (PEOU1_1-PEOU1_6 for scenario 1 and PEOU2_1-PU2_6 for scenario 2) questions and 2 IU (PU1_2-PU1_2 for scenario 1 and IU2_1-PU2_2 for scenario 2) questions for each of the videos. The translated questions can be viewed in Table 1. The questions were built up the same way, but were different relative to details about the specific push or pull service. What type of TAM construct a question corresponded to, was not indicated in the questionnaire. In the Likert scale we use ranges from 1-5. This range covers opinions from strongly disagree (1) to highly agree (5) and neutral in the middle (3).

7.3 Main Results of TAM Evaluation

We wanted to find out if people are actually interested in or see the benefits from using an application that takes the advantage of personal information. If nobody would find any benefits from its use or would be potential users, the concept of personalisation by the use if personal information and context should be revised. All analysis have been performed using the statistical tool SPSS. TAM1 relates to the TAM evaluation of the pull scenario (scenario 1), while we will use TAM2 to refer to the push scenario (scenario 2).

The answers to the background questions states that the mean age of the participants were 30 years. The participants have an interest in health and food (mean 4,03), while there are fewer that are interested in ecological food in particular (mean 2,36) and three participants did not know what their relationship to ecological food was.

For reliability and validity of what we have collected, we compute the inter-item reliability and do factor analysis on our data. Internal reliability between the answers for the items within each TAM construct can be measured by Cronbach's α . Cronbach's α is a reliability coefficient based on the average covariance among items in a scale.

Table 2. Reliability statistics TAM1 and TAM2

Variable	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
PU1	.922	.927	5
PEOU1	.868	.873	6
IU1	.971	.971	2
PU2	.953	.954	5
PEOU2	.924	.926	6
IU2	.973	.973	2

Items on a scale are considered to be positively correlated with each other if they are tapping into the same construct; that is, they are measuring a common entity. The average correlation of an item with all other items in the scale tells us about the extent of the common entity.

Because α can be interpreted as a correlation coefficient, it ranges in value from 0 to 1. Negative α values can also occur, and this happens when items are not positively correlated among themselves and the reliability model is violated.

Correlations are computed between each item for the different constructs and the total score from the questionnaire. If the scale is reliable, items for a construct should correlate with the total. The computed Cronbach's Alpha for our variables can be seen in Table 2. We observe that all our variables for both TAM1 and TAM2 have Cronbach's Alpha higher than 0.8 which shows that the items for each TAM construct correlates.

Table 3. Principal component analysis TAM1

Component Matrix^a

	Component	
	1	2
PU1_1	.765	-.495
PU1_2	.780	-.189
PU1_3	.718	-.571
PU1_4	.757	-.542
PU1_5	.804	-.329
PEOU1_1	.483	.564
PEOU1_2	.779	.089
PEOU1_3	.657	.431
PEOU1_4	.539	.717
PEOU1_5	.650	.593
PEOU1_6	.714	.299

Extraction Method: Principal Component Analysis.

a. 2 components extracted.

Principal component analysis is used on all items of PU1 and PEOU1 in TAM1 and PU2 and PEOU2 in TAM2 to check that the items for each construct actually measures separate factors. Factorial validity as assessed by factor analysing the scale items using principal components extraction. As we can see from Table 3 and Table 4, the factor analysis shows that two factors are identified for both TAM1 and TAM2, and indicates that the constructs are measuring separate factors. The resulting two factor solution is consistent with distinct, unidimensional usefulness. This shows that we have been able to measure that the questions asked for each TAM construct are related to this particular variable in both TAM1 and TAM2. Average values for all TAM constructs are presented in Table 5.

We want to find out whether there is a relationship between the answers to the background question with regards to interest in quality food, ecological food and the TAM constructs. It is useful to know what the relationships between variables are. In this respect, a correlation is a measure of the linear relationship between the variables. For investigation of the linear relationship between the most important background questions and the TAM variables, correlations are computed.

The correlations between variables are presented in Table 6-Table 9. We are particularly interested if a person's interest in health and the contents of food and ecologically produced food correlates with the reply with regards to the TAM constructs. We believed that a person interested in what he consumes and the contents of food he eats (q5_1), would also be positive towards usefulness, perceived ease of use and intention to use. Table 6 shows that for TAM1 there was a positive relationship between health and food interest (q5_1) and PU1, $r = 0.135$, PEOU1, $r = 0.162$ and IU1 $r = 0.161$ all p (one-tailed) < 0.5 . For TAM2 and Table 8, there was not such a relationship found. Therefore, we could only find this correlation for the pull scenario.

Table 4. Principal component analysis TAM2

Component Matrix^a

	Component	
	1	2
PU2_1	.807	-.485
PU2_2	.795	-.335
PU2_3	.760	-.543
PU2_4	.778	-.532
PU2_5	.797	-.450
PEOU2_1	.616	.558
PEOU2_2	.814	.161
PEOU2_3	.751	.492
PEOU2_4	.708	.617
PEOU2_5	.719	.591
PEOU2_6	.804	.170

Extraction Method: Principal Component Analysis.

a. 2 components extracted.

Table 5. Average values for all TAM constructs

	Mean	Std. Deviation
PU1	2.4020	.97321
IU1	2.3175	1.20632
PEOU1	3.4767	.80410
PU2	2.4650	1.07581
PEOU2	3.3883	.92925
IU2	2.3525	1.25193

We also believed that high interest in ecological food would correlate with high PU, PEOU and IU. However, we could not find such a correlation from the computations.

In TAM1 we see that there is a high correlation between PU1 and IU1, and the same can be seen for TAM2 with regards to PU2 and

IU2. PEOU is also highly correlated with IU in TAM1 and TAM2, but not as highly correlated as with PU. This is the case for both TAM1 and TAM2, also with regards to preferences to ecologically produced food.

Table 6. Correlations health and food interest TAM1 constructs

		q5_1	PU1	PEOU1	IU1
q5_1	Pearson Correlation	1.000	.135*	.162*	.161*
	Sig. (1-tailed)		.028	.011	.011
PU1	Pearson Correlation	.135*	1.000	.439**	.834**
	Sig. (1-tailed)	.028		.000	.000
PEOU1	Pearson Correlation	.162*	.439**	1.000	.428**
	Sig. (1-tailed)	.011	.000		.000
IU1	Pearson Correlation	.161*	.834**	.428**	1.000
	Sig. (1-tailed)	.011	.000	.000	
*. Correlation is significant at the 0.05 level (1-tailed).					
**. Correlation is significant at the 0.01 level (1-tailed).					

Table 7. Correlations eco interest and TAM1 constructs

		q5_2	PU1	PEOU1	IU1
q5_2	Pearson Correlation	1.000	-.003	-.061	.011
	Sig. (1-tailed)		.484	.196	.440
PU1	Pearson Correlation	-.003	1.000	.439**	.834**
	Sig. (1-tailed)	.484		.000	.000
PEOU1	Pearson Correlation	-.061	.439**	1.000	.428**
	Sig. (1-tailed)	.196	.000		.000
IU1	Pearson Correlation	.011	.834**	.428**	1.000
	Sig. (1-tailed)	.440	.000	.000	
**. Correlation is significant at the 0.01 level (1-tailed).					

8. CONCLUSIONS AND FUTURE WORK

A world where people have the possibility to be connected to the Internet everywhere and anytime poses new challenges as how to provide relevant information and services to mobile users. Today users have no way of controlling and providing necessary

information that can improve the quality of services they receive. Personalisation by the use of personal and contextual information is what we propose to improve the situation and open up for new possibilities for users and service providers.

When mobile personalisation is successful, it has several positive effects. Service providers can personalise services according to user needs and interests to reach the right customers, and users can receive services and information that are actually relevant. An effect of relevant services and information can be a wish to be loyal to the provider (lock-on). On the opposite we have lock-in, which can be characterised as a situation where the effort of changing provider exceeds the advantages of such a change. Sharing of information between users and providers can lead to an increase of trust when the information leads to delivery of relevant services for the user.

Table 8. Correlations health and food interest TAM2 constructs

		q5_1	PU2	PEOU2	IU2
q5_1	Pearson Correlation	1.000	.085	.115	.079
	Sig. (1-tailed)		.117	.052	.133
PU2	Pearson Correlation	.085	1.000	.483**	.854**
	Sig. (1-tailed)	.117		.000	.000
PEOU2	Pearson Correlation	.115	.483**	1.000	.452**
	Sig. (1-tailed)	.052	.000		.000
IU2	Pearson Correlation	.079	.854**	.452**	1.000
	Sig. (1-tailed)	.133	.000	.000	
**. Correlation is significant at the 0.01 level (1-tailed).					

In our work we have used personas and scenarios. Personas and scenarios have worked well in the process of visualising the personalisation process, and in the possible use of the profile information that is available. In addition to understanding the steps in the process, the personas and scenarios have been useful in the modelling of the profile. The information in the profile is an important factor when the personalisation is to rank different alternatives available and for exchanging personal information, for example when joining a new social community. From the simple scenarios presented here we see the benefits the father achieves by having shared his profile information and subscribing to selected services. When Bill receives a list of relevant strawberry jams available, he can by himself make a choice of which one to buy, and he is able to filter out irrelevant information and receive information that is a match to him and the situation he is in.

Several solutions of modelling a profile are possible. Since many different types of information about a person can be included, we have used the personas and scenarios to limit the scope. The

profile has been created to cover the areas of developed personas and scenarios, and can therefore be extended and developed further. For the creation of the ontology, the parts related to food and food products have been the easiest to model as they are physical concepts. It was challenging to represent what we have termed long term and temporary interests, and decide how they were to be related to the actual food products so that relevance could be computed in a matching process by the mediator. Logical class names and names of relations are more troublesome to define, and at the same time one has to comply with the ontology language and tool. Several iterations have been necessary.

Table 9. Correlations eco interest and TAM2 constructs

		q5_2	PU2	PEOU2	IU2
q5_2	Pearson Correlation	1.000	.004	-.055	.014
	Sig. (1-tailed)		.476	.218	.420
PU2	Pearson Correlation	.004	1.000	.483**	.854**
	Sig. (1-tailed)	.476		.000	.000
PEOU2	Pearson Correlation	-.055	.483**	1.000	.452**
	Sig. (1-tailed)	.218	.000		.000
IU2	Pearson Correlation	.014	.854**	.452**	1.000
	Sig. (1-tailed)	.420	.000	.000	
**. Correlation is significant at the 0.01 level (1-tailed).					

The ontology in OWL DL is used in a prototype which uses OWL API [37] and the reasoner Pellet [38] for inference, and where the information in the ontology is used in the personalisation process. The overall goal is to show that successful personalisation can be enabled where the user is provided with relevant services. We believe this can be achieved by the combination of personal and contextual information.

The implementation has been evaluated according to developed personas and scenarios, and the information in the profiles and about the food can be applied to target information to an individual user in both pull and push initiatives. The personas can be useful with regards to future extensions.

In addition to testing of the implementation of the personalisation through the mediator, the personalisation itself has been evaluated using TAM. For the TAM evaluation we have created two videos illustrating the push and pull services we have developed in our scenarios. Our data seems to fit into the TAM model, and the measured values are reliable and valid. The analysis also shows that the items for each construct measure separate factors. The result of the TAM evaluation shows that correlation between an interest in health and the content of food and the TAM constructs is only identified in TAM1 which handles the pull scenario.

Correlations are useful, but to be able to predict variables we will use regression analysis. Next in our analysis we will therefore fit

our data to the original TAM model and use it to predict values for the dependent variable IU1 and IU2 in the TAM1 and TAM2 evaluations.

For future use, it can be feasible to combine manual maintenance of the personal profile with automatic building and adaption of profile information (e.g. through analysis of what a person or family actually buys, or through opinion mining finding identifying products with a lot of positive or negative references). When other people's opinions are to be considered, the opinions of like-minded people should be more valued than general opinions.

In addition to the TAM evaluation of the concept of personalisation, we will use the same videos for testing in collaboration with actual people through the RECORD Living Lab [41]. Using RECORD Living Lab we will get feedback on the developed material in the form of discussions in a forum.

9. ACKNOWLEDGMENTS

Our thanks to Asbjørn Følstad, SINTEF, for his contributions to the TAM evaluation and for the use of the RECORD Living Lab and to all respondents to the questionnaires.

10. REFERENCES

- [1] Sachin, S., Puradkar, S. and Lee, Y. Ubiquitous computing: connecting Pervasive computing through Semantic Web. *Information Systems and E-Business Management*, 4 (4), 2006.
- [2] Lyytinen, K. and Yoo, Y. Issues and challenges in ubiquitous computing. *Communications of the ACM*, 45 (12), 2002.
- [3] Berners-Lee, T., Handler, J. and Lassila, O. The Semantic Web. *Scientific American*, May 2001.
- [4] Gruber, T. R. A Translation Approach to Portable Ontology Specifications. *Knowledge Acquisition*, 5(2), 1993.
- [5] Uschold, M. and Gruninger, M. Ontologies: Principles, methods and applications. *Knowledge Engineering Review*, 11 (2), 1996.
- [6] Zimmermann, A., Specht, M. and Lorenz, A. Personalization and Context Management. *User Modeling and User-Adapted Interaction*, Springer Netherlands, 15, 3-4 August, 2005, 28.
- [7] *Mobile in Retail Getting your retail environment ready for mobile*. A GS1 MobileCom White Paper. 2010.
- [8] Jameson, A. and Krüger, A. Preface to the Special Issue on User Modeling in Ubiquitous Computing. *User Modeling and User-Adapted Interaction*, Springer Netherlands, 15, 3-4 August, 2005, 3.
- [9] Kay, J. and Lum, A. Ontology-based User Modelling for the Semantic Web. In *Proceedings of the PerSWeb'05 Workshop on Personalization on the Semantic Web in conjunction with UM'05* (Edinburgh, 25-26 July, 2005).
- [10] Gandon, F. L. and Sadeh, N. M. Semantic Web Technologies to Reconcile Privacy and Context Awareness. *Journal of Web Semantics*, 1, 3 2004, 27.
- [11] Mendis, V. Rdf user profiles - bringing semantic web capabilities to next generation networks and services. In *Proceedings of the ICIN Conference* (2007)

- [12] Stan, J., Egyed-Zsigmond, E., Joly, A. and Maret, P. A User Profile Ontology For Situation-Aware Social Networking. In *Proceedings of the 3rd Workshop on Artificial Intelligence Techniques for Ambient Intelligence* (2008).
- [13] Ghosh, R. and Dekhil, M. Mashups for semantic user profiles. In *Proceedings of the 17th international conference on World Wide Web* (Beijing, China, 2008). ACM.
- [14] FOAF project Web page. <http://www.foaf-project.org>.
- [15] FOAF Vocabulary Specification 0.98. <http://xmlns.com/foaf/spec/>, 2010.
- [16] *Introducing FOAF*. <http://www.foaf-project.org/original-intro>.
- [17] Dodds, L. *An Introduction to FOAF*. 2004.
- [18] Golbeck, J. and Rothstein, M. Linking Social Networks on the Web with FOAF: A Semantic Web Case Study. In *Proceedings of the 23rd national conference on Artificial intelligence* (Chicago, Illinois, 2008). AAAI Press.
- [19] Cycorp, Inc. Web page. <http://www.cyc.com/>.
- [20] OpenCyc Web page. <http://opencyc.org/>.
- [21] Suggested Upper Merged Ontology (SUMO) Web page. <http://www.ontologyportal.org/>.
- [22] SUMO Web Page. <http://suo.ieee.org/SUO/SUMO/index.html>.
- [23] Niles, I. and Pease, A. Towards a Standard Upper Ontology. In *Proceedings of the 2nd International Conference on Formal Ontology in Information Systems (FOIS-2001)* (2001).
- [24] Standard Upper Ontology Knowledge Interchange Format. <http://suo.ieee.org/SUO/KIF/suo-kif.html>.
- [25] Sevchenko, M. Online presentation of an upper ontology. In *Proceedings of the Znalosti 2003* (Ostrava, Czech Republic, 2003).
- [26] SUMO online browser. <http://sigma.ontologyportal.org:4010/sigma/Browse.jsp?kb=SUMO&lang=EnglishLanguage>.
- [27] SUMO classes. <http://www.ontologyportal.org/images/SUMOclasses.gif>.
- [28] Sigma Knowledge Engineering Environment. <http://sigmakee.sourceforge.net/>.
- [29] SUMO Publications. <http://www.ontologyportal.org/Pubs.html>.
- [30] Heckmann, D., Schwartz, T., Brandherm, B., Schmitz, M. and Wilamowitz-Moellendorff, M. v. GUMO - The General User Model Ontology. In *Proceedings of UM 2005: International Conference on User Modeling* (Edinburgh, Scotland, UK, July 24-30, 2005). Springer Berlin / Heidelberg.
- [31] Heckmann, D., Schwartz, T., Brandherm, B. and Kröner, A. Decentralized User Modeling with UserML and GUMO. In the *Proceedings of DASUM 2005* (Edinburgh, Scotland, 2005).
- [32] UbiWorld Web page. <http://www.ubisworld.org/>.
- [33] Krogstie, J. A Semiotic Approach to Quality in Requirements Specifications. In *Proceedings of the Working Conference on Organizational Semiotics* (Montreal, Canada, 2001). Proceedings of IFIP 8.1
- [34] Hella, L. and Krogstie, J. A Structured Evaluation to Assess the Reusability of Models of User Profiles. In *Proceedings of the EMMSAD'10* (Hammamet, Tunisia, June 7-8, 2010).
- [35] Norwegian public food taxonomy - Matvaretabellen - Informasjon om næringsstoffer i maten (in Norwegian). <http://matportalen.no/matvaretabellen>.
- [36] Protégé Ontology Editor and Knowledge Acquisitions System. <http://protege.stanford.edu/>.
- [37] The OWL API. <http://owlapi.sourceforge.net/>.
- [38] Pellet: OWL 2 Reasoner for Java. <http://clarkparsia.com/pellet>.
- [39] Davis, F. D. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, 13, 3 1989), 319-340.
- [40] Norstat Web Interviews (CAWI). http://www.norstatgroup.com/en/what_we_offer/products/web_interviews/.
- [41] RECORD Living Lab. <http://www.recordproject.org/>.