International Journal of u- and e- Service, Science and Technology
Vol.7, No.2 (2014), pp.221-238
http://dx.doi.org/10.14257/ijunesst.2014.7.2.21

Using Semantic Web for Mobile Services Personalization

Lillian Hella, John Krogstie

Department of Computer and Information Science
Norwegian University of Science and Technology, Trondheim, Norway
{hella, krogstie}@idi.ntnu.no

Abstract

Personalization is a desired functionality for applications within mobile environments. One approach to personalization of mobile services is by the use of contextual information. In this paper we describe an architecture for this purpose where we utilize semantic web technologies representing person-profiles. The developed ontology that covers personal information and food information is based on personas and scenarios from the food shopping domain. The profile covers three levels of information; personal information, long term information and temporary interests. The proposed concept of personalization is illustrated in two scenarios. The personalization concept illustrated in the form of videos showing the scenarios at work is evaluated by using the Technology Acceptance Model (TAM) to identify variables for investigations of mechanisms important for understanding interest in and acceptance of this type of solution.

Keywords: *Personalization, Mobile services, Semantic Web, Evaluation, User acceptance.*

1. Introduction

Personalization of solutions has been recognized as important in both customer relationships and Web strategies [1] and for mobile services and information systems [2]. Personalization is an important feature for both users who are receiving services and for service providers wanting to target their services to the right users. As people are moving around, it is important that services delivered to the user are relevant and appropriate for the situation the user is in. Services with no, or little relevance, will not have a positive effect. For personalization to be successful, information about the specific users is necessary. Available information will play an important role as to being able to find out if a service is relevant or not. It is a prerequisite that the relevant information about the user is used in the personalization process. Also service providers are having difficulties targeting the right user groups, and in this way missing valuable customers having low adoption of services. Hence, successful personalization is a desirable feature for both users and service providers for existing and future services. Being able to provide relevant services for individual users and target services to specified individual users will be regarded positive.

With the use of Semantic Web technologies, known and inferred information about a user can be utilized to target services to a specific user directly. One of the main challenges and potential for future contextualized and personalized support lies in the combination of public and private information and the combination of personalization and contextualization [3]. 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. The core components in the Semantic Web and its applications will be the use of ontologies. An ontology can be seen as an explicit representation of a shared conceptualization [4] that is formal [5].

ISSN: 2005-4246 IJUNESST

In this paper we focus on the personal profile which plays an important role in our personalization architecture that is based on the use of semantic web technology and how this has been evaluated in the case environment. The developed case environment is related to food shopping, where users in some situations have to make non-trivial decisions. Even though many can do their food shopping without any concerns, there are people that need to and want to make decisions of varying complexity on a daily basis. Apps for supporting food shopping starts to appear, but so far these apps have limited personalization features.

The rest of the paper is organized as follows. First, the background for the work is presented. Then we present the personalization architecture and implementation, before the case with developed personas and two scenarios is presented in section 4. In section 5 we present an evaluation of the approach, and in section 6 present concluding remarks.

2. Background

The need for systems to adapt to their users has been recognized in many application areas. So far much focus e.g. in user-modelling [6] has been with regards to applications intended for stationary computers. The increasing popularity of mobile devices has opened new opportunities for personalized mobile services. There is a variety of personalized mobile services ranging from simple personalized interfaces to more complex context-aware personalized mobile services. Personalization for mobile systems has a different focus than similar techniques in the stationary setting, where services and the control and automatic selection of services are important. In the busy life of a mobile user in a world with many distractions, being presented only for the relevant services are important. For a mobile user it is essential to be in charge of the flow of information and services.

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 context is important [7]. 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 [7].

Several solutions of modelling user-profiles are possible. Ontology based user modelling is a direction where ontologies are used to structure user models [8]. There have been several proposals with regards to modelling of users using ontologies. Several ontologies are described to cover a model of personal profiles and are publicly available (for viewing and editing) and referenced in papers. A common feature is that most of the ontologies are built from scratch, and are created for a specific purpose. The following ontologies all exist in the standard ontology-language OWL, and could have been candidates for reuse in over case.

The Friend Of A Friend (FOAF) ontology [9] 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. Cycorp [10] provides technology for intelligence and reasoning. The company has an open source version of the knowledge base, called OpenCyc. 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. The Suggested Upper Merged Ontology (SUMO) [11],was created as part of the IEEE Standard Upper Ontology Working Group (SUO WG). SUMO consists of definitions that are intended for general-purpose use and wants to be a basis for domain ontologies that are more specific [2]. GUMO (General User Model Ontology) [13] is made for the "uniform interpretation of distributed user models in intelligent Semantic Web enriched environments". GUMO is related to UserML (User Model Markup Language), which is a RDF-based language for exchange of user models between decentralized systems [14]. The GUMO ontology can be integrated with ubiquitous applications with the UbisWorld user model service. The main focus of the UbisWorld [15] 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. In addition to those profiles mentioned, there are also many ontologies only described in papers (e.g. [16],[17],[18],[19]), which will not be covered here.

Although as we see several person-ontologies exist, earlier analysis when looking upon these from a reuse perspective is that none of them satisfies requirements as models that can be reused or built on [20], and thus our profile ontology has been created from scratch, as described in section 4. The biggest change regarding personalization compared to the above existing person-ontologies is the focus on a person as one individual, and not as part of a heterogeneous group. Focusing on individuals, other factors are relevant that can be exploited in the personalization process. When one says that personalization is concerned with tailoring specifically to one individual user, other factors than just the user himself will be relevant, e.g. the result of personalization in different settings or contexts should be different. We have earlier presented a personalization architecture using semantic web technology and tailored person-profiles in the form of ontologies [21, 22]. For completeness of the paper, the architecture will be presented briefly in the next section before looking on the detailed evaluation of this approach in a concrete case being the core contribution of this paper.

3. Overview of Personalization Architecture and Implementation

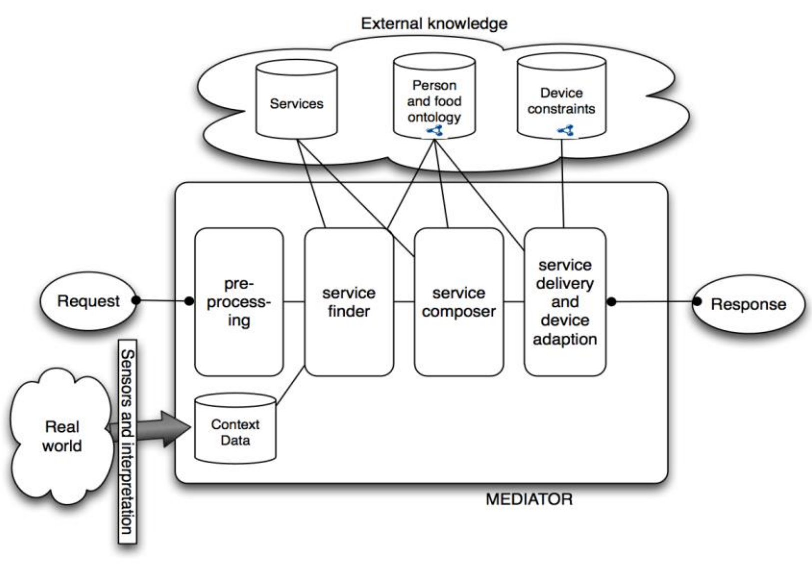

Figure 1. Personalization Architecture

Figure 1 illustrates the main steps and components in the personalization process. The *mediator* is responsible for the personalization and connects the right users with the right services. To do this, the mediator is provided the necessary parts of the profiles, information about the domain and devices etc. These sources of information are used in the different steps in the personalization 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 the user or the service provider). The user poses such a request from his mobile device. The request starts the personalization 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 food and food products. The preferences in the profile are defined in relation to what information that is available about food, e.g. is a person's concern in ecological produced food related to the way we know that a particular product is produced. The main steps of the mediator as the matchmaker are pre-processing of goals, finding services, composing services, and adapting the result to device and delivery. Several sources of available information are involved in the personalization. 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 personalization 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 [23].

A user request represents an explicit or implicit 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 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. However the mediator executes in many cases 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 relevant 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.

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 personalization 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 chose one or more of the results that are relevant to the user. 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.

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 scenarios presented in the next section the system actually finds ten different alternatives, but only presents a selection of the four most relevant results. Since mobile devices have different abilities, the result should be adapted according to device characteristics. When the result has been set according to the user's device, it should be delivered to the user.

We have implemented a prototype as a proof of concept of the personalization in the specific domain (presented below). Our focus is on the mediator, as illustrated in the architecture described in Figure 1. Ontologies are implemented using the Protégé Ontology editor [24], 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 [25] together with the reasoner Pellet [26]. 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 prioritize the different alternatives. 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 the best according to the profile information. Remember that the goal is not necessarily to just provide only the best alternative, but it is also useful to limit the result set so that only alternatives that have a reasonable match with the actual person are selected.

4. Case Environment

As part of the case study, we have defined personas and scenarios, and these have been the main sources of information for the creation of the profile that we have developed. 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 [27]. They work as a basis for communication between stakeholders, and for engagement in the group that are going to use them [27, 28]. By understanding a fictitious user one is better prepared to be able to predict how a different person than oneself would behave in a specific 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 personalization in the scenarios we have created. However, the proposed personalization approach can be applied in other domains too.

4.1. Persona: Bill and his family

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

The daily shopping list can be regarded as a temporary interest, while the preferences for certain makes and brands can be regarded as long term interests.

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.

4.2. Scenario 1 pull: Alternative products

In the first scenario, Bill is out shopping on a Tuesday evening. The shopping list was prepared by his wife in advance, and consists of items for the whole family. Bill finds it difficult to adapt on the spot, and consequently prefers a complete shopping list in advance. Therefore he subscribes to a service we have called Food4U. 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 potentially relevant information related to it. Since Bill has specific concerns regarding the contents of food, it is important for him to avoid certain ingredients. He is also concerned about the way of production (e.g. ecological, fair trade, carbon footprint). Instead of reading the contents declaration for all the available strawberry jams, he provides a request to the personalization system (e.g. by scanning the bar code of an available jam and searching for alternative products). The result of the request is a response from the system, which is a prioritized list of jams according to his preferences and the knowledge about the different jams (and of the jam that is originally preferred).

The result is delivered by Food4U to Bill’s mobile device, and gives Bill sufficient information 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 of 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 personalization later.

4.3. 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 want 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 recognized that he is in the store. The store has a lot of special 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 receives specific 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 in the store. Today a new kind of ecological orange juice of the make 'Sun' is presented. Bill considers the information provided, and decides to buy a bottle of Sun orange juice.

In the implementation, person and food-ontologies are developed. The profile is centred on 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 a person, are his name, his family relations etc. Some of the datatype properties included are *hasName*, *hasAge*, *hasBirthday* and the object properties *hasGender*, *hasFamilyRelations* with subpropeties *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 found in GUMO+UbisWorld [14] and SUMO [11]. 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 marked food. Many of such 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*, *FairTadeAffinity* 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 sub-properties of *hasAffintiy*. 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 personalization process. A person having a high affinity for ecological products, would typically value products that are ecologically produced very positively.

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 the food domain. For this we have used a public food taxonomy [29] 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, although the food-industry has such overviews for internal use. Therefore, the information about jams and its ingredients has been manually collected from the products' list of contents out in actual supermarkets. Information about price has been collected in a similar fashion. 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 in the food-ontology are *Food, FoodInformation* and *NonFood*. The class *Food* has been separated in *Commodity* and *ProcessedFood*. The 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 instances such as *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 be marked as *Ecological* and/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.

5. Evaluation

In this section we present the evaluation performed with regards to potential use of the proposed personalization. For this we have used the Technology Acceptance Model (TAM), and then investigate further some hypothesis relative to the setting used in the evaluation after confirming the quality of the central research variables. The Technology Acceptance Model (TAM) [30] is a widely used research model in the user acceptance literature. Extensions to TAM exist (e.g. TAM2 [31]) Mobile services adoption is one popular area for the application of TAM. TAM focuses on the acceptance of utilitarian systems. Many mobile applications have also hedonic aspects, thus you will find acceptance models in this field (e.g. in [32]) that also include aspects of perceived enjoyment [33].

On the other hand the system in our case can be argued to be primarily utilitarian. The mobile services acceptance model (MSAM) [34,35] is an example of an extended TAM-model that applies in utilitarian mobile settings. It found that user's context can have a direct positive impact on perceived usefulness and perceived ease of use. User's context is utilized in MSAM to personalize the mobile services, and include some contextual elements. MSAM was first very recently validated, hence not available in a validated form when we did our evaluation task. This also applies to other work on more advanced acceptance models that take the particular aspects relevant for our case into consideration. According to [36], personalization is not considered in its full breath in technology acceptance research yet. Prior research shows that the effect of personalization of mobile services is significant, and it can be evident that the personalization has become an essential feature of mobile services, but there is still research needed to come up with good acceptance models for this area. Because of the limited availability and maturity of the specialized TAM models, we choose to use the standard TAM model for our research. The measurement scales and questions used in TAM evaluations have been developed, validated, and extensively pre-tested by Davis [30], showing them to have high reliability and construct validity. When TAM is used, the questions and scales are adapted from Davis` original ones. In our experiment, personal life can be looked upon 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. Our questions will therefore reflect this in the set-up of the experiments.

Before we present the analyzed results, the different steps of the experiment are described in more detail. We needed to set up the experiment and plan for the specification of selection criteria for the test persons we needed. 200 persons were recruited to perform the TAM evaluation. For the selection and practicalities with the experiment we used a commercial survey solution, Norstat. We wanted a selection of persons that was as representative as possible. Therefore we wanted a randomly selection of persons from a Norstat panel, and the persons we selected were in the range of 20-40 years old as we expected that the services we have constructed would fit this range. We had a 50/50 distribution of male and females among the respondents.

The important 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 her job performance. PEOU is related to the effort of use of a system and can be understood as the extent to which an individual believes using a system will be free of effort. Intention 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.

Our personalization ideas for the experiment were presented as two videos that have been created illustrating the above scenarios. Each video lasted approximately one minute and follows Bill through his decision making and the benefits he gets using the system. Before the respondents gave their opinion in our questionnaire, they had to respond to four background questions that covered age, sex, interest in healthy food and interest in ecologically produced food. For each video the participants had to give their opinion in a questionnaire that had 13 questions adapted to the service at hand. The questionnaires were written in Norwegian. An English translation of the questions is found in the below table.

Table 1. TAM Questions for Scenario 1 and 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.

In the questionnaires 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. These questions correspond to items for each of the variables in the traditional TAM-instrument. The questions were built up the same way, but were different when it comes to details about the specific push or pull service in focus. What type of TAM construct a question corresponded to, was not indicated in the questionnaire. The Likert scale we used ranged from 1-5. This range covers opinions from strongly disagree (1) to highly agree (5) with a neutral middle-point (3).

The main hypotheses to investigate using TAM are:

- H1 There is a positive relationship between PEOU and IU.
- H2 There is a positive relationship between PU and IU.

- H3 There is a positive relationship PEOU and PU.

After establishing the validity of the main TAM-variables, we also investigated how in particular familiarity with the use of mobile internet and interest in ecological food and health issues related to food (i.e. the area used to illustrate the positive aspects of the system in the case) influence perceived usefulness, perceived ease of use and intention to use. In particular

- H4: Those familiar with the use mobile internet interpret the services to be more useful
- H5: Those familiar with the use mobile internet interpret the services to be easier to use
- H6: Those familiar with the use of mobile internet have higher intention to use such services
- H7: Those interested in healthy food regard the service to have higher perceived usefulness
- H8: Those interested in healthy food have higher intention to use the service
- H9: Those interested in ecological food regard the service to have higher perceived usefulness
- H10: Those interested in ecological food have higher intention to use the service

We investigate the hypothesis both relative to the pull and the push service independently, but also provide data when combining data from feedback on both services.

5.1. Background Information about Participants

Table 2. Background Question Responses

	Number (N)	**Percent**
Gender		
Male	100	50
Female	100	50
Age		
20-30	100	50
31-40	100	50
Use of mobile internet		
Never/rarely	85	42,5
Monthly	29	14,5
Weekly	38	19
Daily	26	13
Several times a day	22	11
Health concern in food		
1 (Totally disagree)	3	1,5
2	9	4,5
3	44	22
4	67	33,5
5(Fully agree)	77	38,5

Ecological concern		
1 (Totally disagree)	54	27
2	61	30,5
3	50	25
4	22	11
5 (Fully agree)	10	5
Do not know	3	1,5

An overview of the distribution of the responses to the background questions can be seen in Table 2. As requested, the participants are 50% men and 50% females, and they were equally distributed in the age groups 20-30 and 31-40 years. 24% of the respondents use mobile internet daily or several times a day. The majority agree that they are concerned about how healthy the food they eat is. On the other hand, the majority of the respondents do not have any strong preference for ecologically produced food. We note that more than 40% of the respondents never or rarely uses mobile internet. The experiment was run some time ago, and the use of mobile internet has increased since then.

Table 3. Mean of all TAM1 and TAM2 Variables

	N	Minimum	Maximum	Mean	Std. Deviation
PU1	200	1,00	5,00	2,4020	,97321
PEOU1	200	1,00	5,00	3,4767	,80410
IU1	200	1,00	5,00	2,3175	1,20632
PU2	200	1,00	5,00	2,4650	1,07581
PEOU2	200	1,00	5,00	3,3883	,92925
IU2	200	1,00	5,00	2,3525	1,25193
Valid N (listwise)	200				

In Table 3 we see a summary of all the average values for the TAM1 and TAM2 variables. The values for PU and IU are on the average ca. 2.5 while the values for the mean PEOU is higher. There are no significant differences between the similar variables for the push and pull service.

5.2. The TAM evaluation

We want to find out if people are interested in using an application or system that takes the advantage of personal information. As described above we exemplified some possible benefits in two videos. All analyses from the experiment 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). We start with an analysis to verify that we have used a reliable scale and to check that our TAM variables measures separate factors.

5.3. Reliability and validity

Internal reliability between the answers for the items can be measured by Cronbach's alpha. Cronbach's alpha is a measure of internal consistency that measures the pairwise correlation between items in a scale. It should be above 0.60 for exploratory research and above 0.70 for confirmatory research [37]. Because alpha can be interpreted as a correlation coefficient, it ranges in value from 0 to 1. We compute correlations between each item and the total score from the questionnaire. If a reliable scale has been used, items should correlate with the total. From table 4 we see that the lowest value is 0.87, well above the 0.70 threshold for confirmatory research.

Principal component analysis is used to check that the items (questions) for each TAM variable actually measures separate factors. Factorial validity as assessed by factor analyzing the scale items using principal components extraction and oblique rotation. The confirmatory numbers from this analysis is earlier reported in [22] and is not repeated here.

Table 4. Reliability Statistics TAM1 and TAM2

Experiment	**Variable**	**Cronbach's Alpha**	**Cronbach's Alpha s ***	**Number of Items**
TAM1	**PU1**	.922	.927	5
	PEOU1	.868	.873	6
	IU1	.971	.971	2
TAM2	**PU2**	.953	.954	5
	PEOU2	.924	.926	6
	IU2	.973	.973	2

*Based on Standardized Item

5.4. Relationship with intention to use

TAM posits that behavioural intention to use a technology is a function of perceived usefulness and perceived ease of use. We want to find out whether there is a relationship between the responses to the background question with regard to interest in food quality, ecological food and the TAM constructs. For investigation of the linear relationship between the most important background questions and the TAM variables, correlations are computed.

5.4.1. Correlations

Items on a scale are positively correlated with each other if they're all tapping into the same construct; that is, they're all 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. Table 5 and Table 6 illustrate the internal correlations between the TAM variables.

Table 5. Correlations TAM1

		PU1	PEOU1	IU1
PU1	Pearson Correlation	1,000	**,439****	**,834****
	Sig. (1-tailed)		**,000**	**,000**
	N	200,000	200	200
PEOU1	Pearson Correlation	,439**	1,000	**,428****
	Sig. (1-tailed)	,000		**,000**
	N	200	200,000	200
IU1	Pearson Correlation	,834**	,428**	1,000
	Sig. (1-tailed)	,000	,000	
	N	200	200	200,000

*. Correlation is significant at the 0.05 level (1-tailed).

**. Correlation is significant at the 0.01 level (1-tailed).

Table 6. Correlations TAM2

		PU2	PEOU2	IU2
PU2	Pearson Correlation	1,000	**,483****	**,854****
	Sig. (1-tailed)		**,000**	**,000**
	N	200,000	200	200
PEOU2	Pearson Correlation	,483**	1,000	**,452****
	Sig. (1-tailed)	,000		**,000**
	N	200	200,000	200
IU2	Pearson Correlation	,854**	,452**	1,000
	Sig. (1-tailed)	,000	,000	
	N	200	200	200,000

*. Correlation is significant at the 0.05 level (1-tailed).

**. Correlation is significant at the 0.01 level (1-tailed).

5.4.2. Regression

We have used stepwise regression to further investigate the relationship between the variables. We want to find out how PU and PEOU can be used to predict IU and to what extent. We enter PU and PEOU as independent variables, while IU is the dependent variable. The analysis ends up with excluding PEOU as a predictor for IU in both TAM1 and TAM2. The results from the regression analysis are used to draw the structural models for TAM1 and TAM2 found in Figure 2 and 3 respectively.

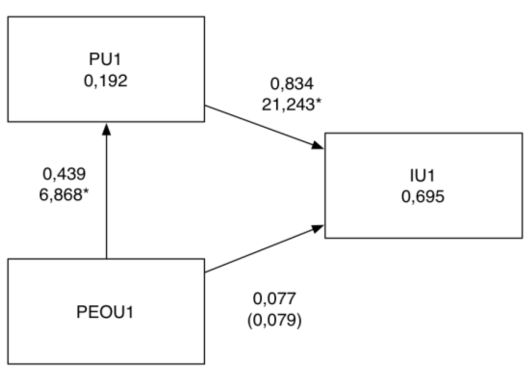

Figure 2. Structural Model for TAM1

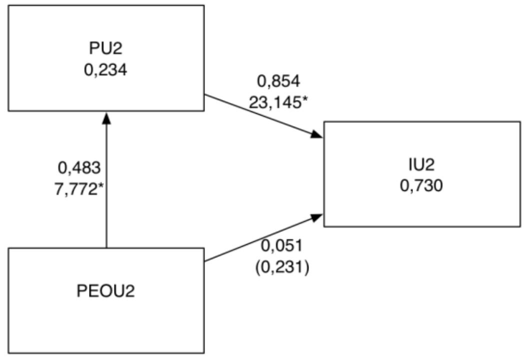

Figure 3. Structural Model for TAM2

The following information is available in the figures:

- coefficients
- t-statistics showing levels of significance (in parentheses)
- R^2 values (in the boxes)

Stepwise regression has also been used to investigate the perceived ease of use relationship with perceived usefulness, as we have predicted in the initial TAM model. We found that PEOU is a predictor for PU in both TAM1 and TAM2.

The structural models for TAM1 and TAM2 in Figure 2 and Figure 3 show that two out of the three hypotheses were supported. The t-statistics for the paths from PEOU to IU indicates that these paths are not significant. The model supports hypothesis H1 and H3 with positive relationship between PU and IU, and PEOU and PU. Overall the model explained about 70% of the variance in usage intentions for TAM1 and 73% of the variance in usage intentions for TAM2.

Table 7. Summary of Hypothesis Test Results

	TAM1		**TAM2**	
	Estimate	**Significance**	**Estimate**	**Significance**
H1 PU -> IU	0,834	**Significant at p < 0,001**	0,854	**Significant at p < 0,001**
H2 PEOU –> IU	0,077	Not significant	0,051	Not significant
H3 PEOU -> PU	0,439	**Significant at p < 0,001**	0,483	**Significant at p < 0,001**

The results from TAM1 and TAM2 are very similar, even though there is a big difference between push and pull services. Both experiments show a positive relationship between PEOU and PU, and PU and IU. However, the relationship between PEOU and IU were very weak and not statistically significant in either TAM1 or TAM2.

We found that PU was the strongest predictor of IU. One reason that PEOU was a weak predictor can be that the videos we have made are better at showing the benefits of the services offered and not similarly good at showing how easy or difficult the services would be to use in practice. By just looking at a video, one does not get to try to actually use the services and experience how it is used and works. This way, it might be challenging to say something about possible challenges in use. Push services can be interpreted to be more intrusive on users, but we notice that the results are very similar for both the pull (TAM1) and push (TAM2) scenarios. We have found a similar effect when comparing the results from such videos with the result of actually using a mobile device in a realistic setting when investigating acceptance of other mobile services [32]. Another effect seen in [32] is that the scores where significantly higher on *e.g.*, PU when testing the application live than what we found when showing prospective users videos similar to what we have used in this work.

Investigating the hypothesis relative to familiarity with mobile internet, we see from table 8 below that for the pull-service that H4-H6 are all accepted, whereas for the push service only H6 is accepted.

Table 8. Investigation of Hypothesis on Use of Mobile Internet

	Use mobile internet weekly or more often Mean (S.D.)		T	Sig.	Hypotheses
	More seldom than weekly (N=114)	**Weekly or more often (N=86)**			
PU1	2.25 (.917)	2.60 (1.01)	**2.56**	**.011***	**H4a accepted**
PU2	2.35 (1.04)	2.61 (1.11)	1.71	.089	H4b rejected
PEOU1	3.30 (.782)	3.70 (.779)	**3.60**	**.000****	**H5a accepted**
PEOU2	3.32 (.917)	3.47 (.943)	1.09	.276	H5b rejected
IU1	2.12 (1.13)	2.57 (1.27)	**2.61**	**.010****	**H6a accepted**
IU2	2.20 (1.21)	2.55 (1.28)	**1.975**	**.050***	**H6b accepted**

The same pattern was found when comparing those using mobile internet daily with those using mobile internet less often, with even more positive average numbers for use of the services

For the rest of the hypothesis we used Spearman correlation to look upon relations of the TAM variables to food interest. We used Spearman rank since the variables we compared with (health concern and ecological concern) were not on a Likert scale thus not interval or ratio variables.

Looking at this closer we find below that we can accept all of H7 to H10. We also notice a positive relation between PEOU for TAM1 and health concern. Detailed results are found in tables 9-12

Table 9. Correlations between Healthy Food Interest and TAM1 Constructs

		PU1	PEOU1	IU1
Health concern	Spearman Correlation	**.123***	**.194****	**.145***
	Sig. (1-tailed)	**.042**	**.003**	**.020**
	N	200	200	200
**. Correlation is significant at the 0.01 level (1-tailed). * Correlation is significant at the 0.05 level (1-tailed).				

Table 10. Correlations between Healthy Food Interest and TAM2 Constructs

		PU2	PEOU2	IU2
Health concern	Spearman Correlation	.097	**.117***	.089
	Sig. (1-tailed)	.086	**.049**	.106
	N	200	200	200
**. Correlation is significant at the 0.01 level (1-tailed). * Correlation is significant at the 0.05 level (1-tailed).				

Table 11. Correlations between Ecological Interest and TAM1 Constructs

		PU1	PEOU1	IU1
Eco-concerned	Spearman Correlation	**.229****	.021	**.249****
	Sig. (1-tailed)	**.001**	.387	**.000**
	N	200	200	200
**. Correlation is significant at the 0.01 level (1-tailed). * Correlation is significant at the 0.05 level (1-tailed)				

Table 12. Correlations between Ecological Interest and TAM2 Constructs

		PU2	PEOU2	IU2
Eco-concerned	Spearman Correlation	**.192****	-.011	**.163***
	Sig. (1-tailed)	**.003**	.442	**.011**
	N	200	200	200
**. Correlation is significant at the 0.01 level (1-tailed). * Correlation is significant at the 0.05 level (1-tailed)				

6. Conclusions and Future Work

In this work we have presented an approach to personalization of mobile services by the use of personal and contextual information represented in semantic web technologies. The ontology in OWL DL is used in a prototype which uses OWL API [25] and the reasoner Pellet [26] for inference, where the information in the ontology is used in the personalization process. The overall goal is to show that successful personalization 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 of the approach to also cover other aspects relative to e.g. a healthy diet for people with high amount of cholesterol in the blood.

In addition to testing of the implementation of the personalization through the mediator, the personalization itself has been evaluated using a TAM-oriented analysis. For the TAM evaluation we have created two videos illustrating the push and pull services we have developed in our scenarios. Our data 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 evaluation shows a correlation between familiarity of the use of mobile internet, interest in healthy food and in ecological food and in particular perceived usefulness and intentions to use of the service.

This research is part of over long-term effort on research and development of mobile services and applications in the Wireless Trondheim Living Lab [38], combining innovation methods with research results [39]. For future research, it can be interesting to combine manual maintenance of the personal profile with automatic evolution and adaption of profile information (e.g. through analysis of what a person or family actually buys, or through opinion mining identifying products with a lot of positive or negative comments), and support of reflection of own shopping-habits. When other people's opinions are to be considered, the opinions of like-minded people should be more valued than general opinions, using results from recommendation systems research [40].

References

[1] H. Fan and M. S. Poole, "What Is Personalization? Perspectives on the Design and Implementation of Personalization in Information Systems", Journal of Organizational Computing and Electronic Commerce, vol. 16, no. 3-4, **(2006)**, pp. 179-202.

[2] J. Krogstie, K. Lyytinen, A. L. Opdahl, B. Pernici, K. Siau and K. Smolander, "Mobile Information Systems - Research Challenges on the Conceptual and Logical Level", Paper presented at the MobiMod'02, Tampere Finland, **(2002)** October.

[3] A. Zimmermann, M. Specht and A. Lorenz, "Personalization and Context Management", User Modeling and User-Adapted Interaction, Springer Netherlands, vol. 15, **(2005)** August 28, pp. 3-4.

[4] T. R. Gruber, "Translation Approach to Portable Ontology Specifications", Knowledge Acquisition, vol. 5, no. 2, **(1993)**.

[5] M. Uschold and M. Gruninger, "Ontologies: Principles, methods and applications", Knowledge Engineering Review, vol. 11, no. 2, **(1996)**.

[6] R. J. Wasinger, J. Wallbank, L. Piazzato, J. Kay, B. Kummerfeld, M. Böhmer and A. Krüger, "Scrutable User Models and Personalised Item Recommendation in Mobile Lifestyle Applications", User Modeling, Adaptation, and Personalization, Springer, **(2013)**, pp. 77-88.

[7] A. Jameson and A. Krüger, "Preface to the Special Issue on User Modeling in Ubiquitous Computing. User Modeling and User-Adapted Interaction", Springer Netherlands, vol. 15, no. 3, **(2005)** August 3-4.

[8] J. Kay and A. Lum, "Ontology-based User Modelling for the Semantic Web", Proceedings of the PerSWeb'05 Workshop on Personalization on the Semantic Web in conjunction with UM'05, Edinburgh, Scotland, **(2005)** July 25-26.

[9] FOAF project Web page, http://www.foaf-project.org. Last visited **(2013)**.

[10] Cycorp, Inc. Web page. http://www.cyc.com/. Last visited **(2013)**.

[11] Suggested Upper Merged Ontology (SUMO) Web page. http://www.ontologyportal.org/. Last visited **(2013)**.

[12] I. Niles and A. Pease, "Towards a Standard Upper Ontology", Proceedings of the 2nd International Conference on Formal Ontology in Information Systems (FOIS-2001), **(2001)**.

[13] D. Heckmann, T. Schwartz, B. Brandherm, M. Schmitz and M. Wilamowitz-Moellendorff, "M. v. GUMO - The General User Model Ontology", Proceedings of UM 2005: International Conference on User Modeling, Edinburgh, Scotland, UK, **(2005)** July 24-30.

[14] D. Heckmann, T. Schwartz, B. Brandherm and A. Kröner, "Decentralized User Modeling with UserML and GUMO", Proceedings of DASUM 2005, Edinburgh, Scotland, **(2005)**.

[15] UbisWorld Web page. http://www.ubisworld.org/. Last visited, **(2013)**.

[16] F. L. Gandon and N. M. Sadeh, "Semantic Web Technologies to Reconcile Privacy and Context Awareness", Journal of Web Semantics, vol. 1, no. 3, **(2004)**, pp. 27.

[17] V. Mendis, "RDF user profiles-bringing semantic web capabilities to next generation networks and services", Proceedings of the ICIN Conference, **(2007)**.

[18] J. Stan, E. Egyed-Zsigmond, A. Joly and P. Maret, "A User Profile Ontology For Situation-Aware Social Networking", Proceedings of the 3rd Workshop on Artificial Intelligence Techniques for Ambient Intelligence, **(2008)**.

[19] R. Ghosh and M. Dekhil, "Mashups for semantic user profiles", Proceedings of the 17th international conference on World Wide Web. ACM, Beijing, China, **(2008)**.

[20] L. Hella and J. Krogstie, "A Structured Evaluation to Assess he Reusability of Models of User Profiles", Proceedings of the EMMSAD'10 Hammamet, Tunisia, **(2010)** June 7-8.

[21] L. Hella and J. Krogstie, "A Profile Ontology for Personalised Mobile Shopping Support Paper presented at the APREWS- Adaptation", Personalization and Recommendation in the Semantic Web, Heraklion, Greece, **(2010)**.

[22] L. Hella and J. Krogstie, "Personalisation by semantic web technology in food shopping", Proceedings of WIMS '11, International Conference on Web Intelligence, Mining: ACM Press, Sogndal, Norway, **(2011)** May.

[23] J. Krogstie, "Requirements Engineering for Mobile Information Systems", Paper presented at the Seventh International Workshop on Requirements Engineering: Foundations for Software Quality (REFSQ'01), Interlaken, Switzerland, **(2001)**.

[24] Protégé Ontology Editor and Knowledge Acquisitions System. http://protege.stanford.edu/. Last visited, **(2013)**.

[25] The OWL API. http://owlapi.sourceforge.net/. Last visited, **(2013)**.

[26] Pellet: OWL 2 Reasoner for Java. http://clarkparsia.com/pellet. Last visited, **(2013)**.

[27] A. Cooper. The Origin of Personas. Cooper Journal May 15; Available from: http://www.cooper.com/journal/2003/08/the_origin_of_personas.html, **(2008)**.

[28] Grudin. Why personas work: The psychological evidence, in The persona lifecycle: keeping people in mind throughout product design, Edited J. Pruitt and T. Adlin, Elsevier, **(2006)**.

[29] Norwegian public food taxonomy - Matvaretabellen - Informasjon om næringsstoffer i maten (in Norwegian). http://www.matvaretabellen.no/ Last visited, **(2013)**.
[30] F. D. Davis, R. P. Bagozzi and P. R. Warshaw, "User acceptance of computer technology: a comparison of two theoretical models", Manage. Sci., vol. 35, no. 8, **(1989)**, pp. 982-1003.
[31] V. Venkatesh, "Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model", Info. Sys. Research, vol. 11, no. 4, **(2000)**, pp. 342-365.
[32] A.-C. Haugstvedt and J. Krogstie, "Mobile augmented reality for cultural heritage: A technology acceptance study", Proceedings ISMAR 2012 247-255, **(2012)**.
[33] H. van der Heijden, "User acceptance of hedonic information systems", MIS Quarterly, vol. 28, no. 4, **(2004)**, pp. 695-704.
[34] S. Gao, J. Krogstie and P. A. Gransæther, "Mobile services acceptance model", Paper presented at the International Conference on Convergence and Hybrid Information Technology (ICHIT'2008), Daejeon, Korea, **(2008)**.
[35] S. Gao, J. Krogstie and K. Siau, "Developing an Instrument to Measure the Adoption of Mobile Services", Mobile Information Systems Journal, vol. 7, no. 1, **(2011)**, pp. 45-67.
[36] M. Asif and J. Krogstie, "Mobile Services Personalization Evaluation Model", International Journal of u- and e- Service, Science and Technology, vol. 6, no. 2, **(2013)**.
[37] D. Gefen, D. W. Straub and M.-C. Boudreau, "Structural equation modeling and regression: Guidelines for research practice structural equation modeling and regression: Guidelines for research practice", Communications of the Association for Information Systems, vol. 4, no. 7, **(2000)**.
[38] S. H. Andresen, J. Krogstie and T. Jelle, "Lab and Research Activities at Wireless Trondheim", Paper presented at the 4th IEEE International Symposium on Wireless Communication Systems (ISWCS'07) Trondheim, Norway, **(2007)**.
[39] J. Krogstie, "Bridging Research and Innovation by Applying Living Labs for Design Science Research", Lecture Notes in Business Information Processing, vol. 124, **(2012)**, pp. 161-176.
[40] K. Stefanidis, N. Shabib, K. Nørvåg and J. Krogstie, "Contextual Recommendations for Groups", Lecture Notes in Computer Science, vol. 7518, **(2012)**, pp. 89-97.

Authors

Lillian Hella, is a PhD student in the Department of Computer and Information Science (IDI), Norwegian University of Science and Technology (NTNU), Norway. **S**he has completed his master's degrees in Information System Engineering in 2003 at Norwegian University of Science and Technology. Her research interests are mobile information systems and semantic web

John Krogstie, holds a PhD (1995) and an MSc (1991) in information systems from the Norwegian University of Science and Technology (NTNU), where he is currently a full professor in information systems. John Krogstie is the Norwegian representative for IFIP TC8 and Chair of IFIP WG 8.1 on information system design and evaluations. He has published around 250 refereed papers in journals, books and archival proceedings since 1991.

