# uService – A Personalized and Situation-Aware Recommender System for User-Generated Mobile Services

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**Abstract.** The following short paper describes the mechanisms of the recommender system contained in the prototype of the project uService [1]. uService is a European project which ended in April 2012. The German consortium was funded by the Federal Ministry for Education and Research of Germany (project funding reference number 01IS09020D). A service infrastructure for the mobile super prosumer was developed which enables users to create their own mobile services and provide them to other users. The German Research Center for Artificial Intelligence developed the personalized and situation-aware recommender system for mobile user generated services.

**Keywords:** Recommender Systems, Semantic Search, Ontology Representation

## 1 Introduction

Nowadays, mobile devices enable users to generate their own content and provide it centrally via a server. Soon, this will evolve further, and a mobile device will provide not only contents but user-created services and become a server itself. As a result there will be many little services for many small target groups. The European project uService examined the turn of mobile users into service super prosumers, i.e. producers, providers and consumers of services and examined what mechanisms are necessary to enable a user to consume and provide such user-generated mobile services. This implies millions or perhaps billions of potential sources with valuable services for billions of potential consumers. Due to the particular challenge of the mobile environment, where device resources, interaction possibilities and user attention are much more restricted compared to the fixed web environment, intelligent, context-aware discovery mechanisms are necessary

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## 2 uService Demonstration Description

### 2.1 Search and recommendation mechanisms for services consumption

User-generated mobile services may be valid not only for a specific location- but also for a specific context. This means – given a specific situation - that services are possibly only relevant for hours or maybe even minutes. A user may create a service in order to quickly disseminate information. The type of information to be distributed could be as simple as a text message describing a current traffic situation, or a photo illustrating a natural disaster. Therefore, they are called micro-services in the following.

A simple and shallow domain ontology was defined, that serves the purpose of having an infrastructure for semantic reasoning. The micro service description (e.g. tags and full-text description) is matched to ontology concepts and an ontological representation, i.e. a vector of concept URIs, is saved in the semantic search index. With the semantic reasoning not only concepts which match the micro-service description are added to the ontological representation but also concepts which are a generalization or related in another way. Therefore, relevance weights for each concept indicate in the ontological representation how well it describes the micro-service. Other information such as validity (e.g. date and/or time), availability (e.g. GPS information, network connection), and access rights (e.g. groups ids) is also saved in the index. This information enables a fast filtering for relevant micro-services and reduction from potentially millions of micro-services to a few thousand.

Unlike traditional search engines, relevant services are then not identified using only comparisons how well a user query matches the micro-service description. Instead the search functionality utilizes a phased approach of multiple threshold chains. Thresholds in this context describe the minimally necessary relevance of micro-services for the particular user in a particular situation. Each dimension consists of one or more sub-thresholds, i.e. the distance of the current user location to the location addressed in a location-based service. Only if all thresholds are passed, the service qualifies for display given an overall score calculation. The calculation of this overall score is a weighted sum of five plug-in functions which evaluate aspects such as context, usage, rating and fit with user query. The first plug-in function is the *BooleanKeywordRanker*, which captures the number of matches between the service description and query tags, generalizations of query tags and tags in the user profile. To normalize the value, this number is divided by the number of tags contained in the service description. The *UsageRanker* calculates the ratio of number of the times this service was chosen by other users to the overall number of service choices within the time the service valid. This function can be modified in order to have collaborative filtering aspects by considering not all users but only users with a similar profile. The *RatingRanker* computes the average rating of the given services in percent to the best possible rating value. This function can also be modified in the same way as the UsageRanker for collaborative purposes. To measure the context, the *TimeRanker* and *LocationRanker* compute the ratio between the distance of the time and location of the given service to the current position and time of the user and a threshold distance. As a possible extension, the threshold distance can be personalized.

### 2.2 Search and recommendation mechanisms for service creation

To create a service a user can utilize a service template, which is an editable sample of a service. Search for and recommendation of service templates is similar to search and recommendation of micro-services. Based on a description of the template an ontological representation of the service template is created and saved in the semantic search index. Furthermore, a ranking function evaluates how suitable the service template is for a specific users based on categories such as amount of usage by other users with the same user profile, user ratings or fit with user intention.

Another way to create a micro-service is to combine building blocks. A building block is for instance, a header, a text input field, a map, etc. which can be customized by the user. Ontological representations of building blocks are saved in the semantic search index and a ranking function evaluates how suitable the service a block is based on categories such as match with user query. In addition, collaborative filtering is applied. Depending on the combination of chosen build blocks the list of building blocks displayed to a user is updated by showing building blocks which were historically used most often with the given combination of chosen building blocks.

## 3 Semantic Knowledge Representation to a User

In our approach a user can browse the tree structure contained in an ontology. The approach is similar to tag clouds but personalized for each user, i.e. the higher the relevance of a concept for an individual user the bigger its representation. To hide the complexity from the user, only one level or a fragment of the tree is shown. The navigation is being kept rather simple and supports different interaction modes: A click on a parent concept causes a shift of focus to the concept, which is the super class concept of the concept clicked on. In other words, a click on the concept on top results in an upward movement in the tree structure. A click on one of the concepts in the bottom causes a shift of focus to the selected concept and new concepts are loaded from the ontology which have not yet been displayed. In other words, a click on a concept on the bottom results in a downward movement in the tree structure of the ontology.

As mentioned above the representation of individual concepts is adapted to the user's personal interests which are defined in the user profile. They were rated by the user with a relevance weight in the user profile. Therefore, these concepts are displayed bigger then concepts which are not of interest for the user. For concepts with no relevance weight a recursive algorithm assigns weights according to the sum of weights of its subclasses. Figure 1 shows that a user specified weights for concepts "football", "tennis", "clubbing" and "music. Since there was no weight for sports, the sum of the child concepts "football" and "tennis" is used. As a result concept "sport" is represented biggest, concept "music" second biggest and concept "clubbing" third biggest. Overall rating for concepts is based on subclass relevance weights.

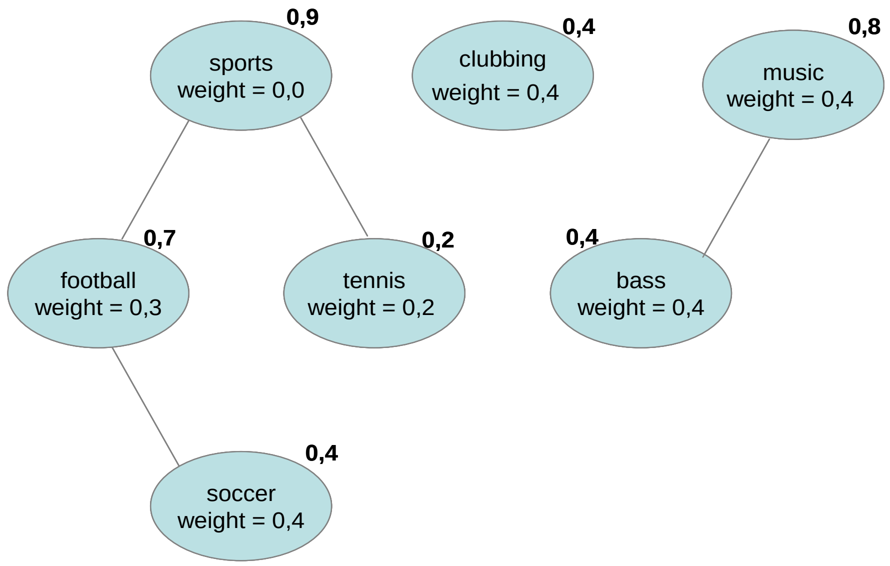


**Figure 1.** Weighting of areas of interest

## 4 Outlook & Conclusion

Research result were presented on several international conferences and published in international journals. For instance mechanisms for personalized recommendations were shown at the Pacific Asia Conference on Information Systems in 2011 (Title: Personalized and Situation-Aware Recommendations for Runners) [2], the 20th European Conference on Information Systems (Title: Personalized and context-aware recommendations of running routes) [3] or at the American Conference on Information Systems (Title: uService – Enabling user-driven fitness services on-the-go) [4]. Further research is planned on the combination of learning mechanisms with recommendation mechanisms in order to enhance personalization over time [5]. The recently started project MENTORbike funded by the Federal Ministry of Education and Research of Germany (project funding reference number 01IS11034D) builds on and further develops the results of uService [6]. MENTORbike researches and develops an adaptive, intelligent, mobile assistance system, which combines an eBike, a wireless body area network, body sensors, a smart phone and a service server to an innovative training device for prevention and rehabilitation of heart diseases. MENTORbike will for instance adapt power support by the eBike automatically based on ECG recordings from the body sensors. Therefore, the recommendation mechanisms developed in uService will be further developed and extended.

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